Development of a Selection Program for Additive Manufacturing Systems

by

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Declaration

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March 2010

Opsomming

Toevoegende vervaardiging verwys na al die tegnologie wat rekenaargesteunde ontwerp data gebruik om plastiek, metaal, keramiek, papier, saamgestelde materiale en waks parte te vervaardig. Die vermoë van die tegnologie om dun lae vloeistof, poeier of plaatmateriaal op mekaar te verbind laat die vervaardiging van parte wat moeilik of selfs onmoontlik is, deur die gebruik van ander vervaardigingsmetodes. Alhoewel hierdie tegnologieë nog in 'n ontwikkelingsfase is, word dit as 'n reuse deurbraak vir die bedryf beskou.

Die verbetering, verspreiding en voordele van die tegnologie word hoofsaaklik belemmer deur 'n tekort aan inligting daaroor. Baie lande, akademiese en industrieële organisasies is nog nie eens bewus dat sulke tegnologieë bestaan nie. Die tekort aan inligting veroorsaak dat kostes hoog bly en verhoed die vinnige uitbreiding van nog meer gevorderde tegnologieë en materiale. Verder bemoeilik dit ook die bemarking van die tegnologieë.

Die aantal toevoegende vervaardigingsmasjiene groei jaarliks met beter vermoëns, laer kostes en 'n groter verskeidenheid van toepassings. Tans is daar meer as 40 vervaardigers wat meer as 100 verskillende masjiene vervaardig in Kanada, China, Frankryk, Duitsland, Israel, Italië, Japan, Suid-Korea, Swede en Amerika. Al die masjiene verskil ten opsigte van hul funksies, beperkings en ook ten opsigte van sterkte, materiale en toepassings van parte. Die groei het gelei tot 'n toename in gebruik van die tegnologie deur huidige en potensiële nuwe gebruikers van beide die vervaardigings en akademiese sektore. Die keuse van 'n geskikte sisteem wat aan al 'n gebruiker se vereistes voldoen, raak elke dag meer kompleks.

Die doel van hierdie studie is die ontwikkeling van 'n seleksie program vir toevoegende vervaardigingmasjiene. Die program sal dien as 'n opleidingshulpmiddel en as 'n basis vir masjienseleksie deur potensiële kopers. Die program bestaan uit twee dele: die opleidingsgedeelte en die selekteringsgedeelte. Die opleidingsgedeelte beskryf die verskeie toevoegende prosesse en motiveer gebruikers om die tegnologie aan te skaf weens die voordele. 'n Agtergrond oor die verskeie tegnologieë stel die gebruiker in staat om ingeligte besluite te neem en tegniese vrae te kan stel aan verskaffers. Die selekteringsdeel het 'n besluitnemingstruktuur wat help om die regte masjien te kies ten opsigte van verlangde vereistes.

Hierdie studie kan help met die bevordering van toevoegende tegnologieë en hul voordele, veral vir lande en organisasies wat nog nooit voorheen sulke tegnologieë gebruik het nie.

Abstract

Additive Manufacturing (AM) refers to the technologies that use Computer Aided Design (CAD) data to produce plastic, metal, ceramic, paper, wax or composite materials parts. Their ability to join thin layers of liquid, powder or sheet materials together permits the production of parts, which are difficult or even impossible to produce, using any other manufacturing method. Even though these technologies are still developing, they are considered a major breakthrough in industry.

One of the main problems that is facing the improvement and the spread of AM technologies, and its benefits worldwide, is the lack of knowledge about them. Still a lot of countries, educational and industrial organizations do not even know about AM technologies. This lack of knowledge of such technologies is keeping their cost artificially high, which is limiting the access to more AM advanced technologies and materials. It also makes it difficult to market the technologies and those who do not use AM technologies yet become unable to compete against those who do.

The numbers of AM systems are continually growing, their capabilities and applications are improving and their cost is decreasing. Today there are more than 40 companies that produce over 100 different systems in Canada, China, France, Germany, Israel, Italy, Japan, South Korea, Sweden and the United States. These systems vary in their strengths, defects, applications, functions and limitations. This growth has led to an increase in current and potential users of AM from both the manufacturing and educational sectors. These users are however facing increasing complex problems when it comes to selecting the most appropriate commercial system(s) to suit their needs.

The aim of this study is to develop an AM system selection program. The program will serve both as an educational tool and a decision making support tool to assist any potential purchasers in both the educational and industrial sectors. The AM system selection program is divided into two sections: the learning section and the selecting section. The learning section introduces the AM technologies by imparting knowledge to the new users; moreover, it inspires them to start using these technologies to get their benefits. Having a background in AM technologies enables the new users to make educated decisions and to discuss technical issues about the systems with the providers. The selecting section offers

a decision making support tool to help the users to decide which system best suits their needs. This study can contribute to the promotion of AM technologies and their benefits worldwide, especially for the countries and organizations that have not yet used such technologies.

Acknowledgements

1- ALLAH: Who created me and gave me all my abilities and supported me to complete this degree.

2- My mother: Who gave me birth, made me her first priority in life and always prayed for me.

3- My oldest brother Easam: Who was the one responsible on me after the death of my father when I was 7 years old.

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1.1 Problem statement

"As one of the informed, you have already discovered the lack of information on rapid prototyping. Somehow you managed to find the information that you needed. I bet that for many of you, it came the hard way...first-hand experience. You had the motivation, you invested the time and effort to find the facts that you needed and you spent the time to learn the topic. How many others would go through this effort? You have experienced the scarcity of information and you recognize the barrier that it imposes.

The problem is huge and multifaceted. Everyone must take some responsibility and everyone must do something about it. Users, non-users, companies, vendors, the media and trade associations can take action to rectify the situation." [1]

As explained in the previous paragraphs, having a sufficient knowledge about rapid prototyping (the old name of Additive Manufacturing (AM) technologies) is hard to come by. Only highly motivated people make the time and effort to get such background. The lack of information available makes education about AM an increasingly complex problem, taking into account the remarkable improvements in these technologies on an ongoing basis.

Because AM technologies offer the opportunities to make high quality products faster and at lower costs than using conventional technologies, the lack of knowledge about these technologies affects both the users and the non-users. The users will be affected by the high cost and the slow rate of improvements of AM technologies and materials. It is clear that when the number of AM system users increases, the cost of developing new and improved AM technologies and materials will decrease. The non-users will be affected by not having the correct education about these technologies as a country or educational organization, moreover, by being left behind their competitors in their industry.

The best way of solving this lack of knowledge is to introduce AM technologies into the educational sector in order to establish themselves in any country. This means using AM systems in educational organizations. The increasing number of AM systems with the constant improvement in their functionality and their capabilities is making the selection process of the most suitable commercial system(s) for specific needs more and more complicated. AM systems also vary in their strengths, weaknesses, functions and limitations. More than 100 systems are commercially available today produced by more than 40 companies in the United States, Japan, Germany, France, China, Sweden, South Korea, Italy, Israel and Canada [2].

There are many factors that need to be considered when selecting the most suitable AM system. Some factors relate to the produced part (size, features, material) and others to the AM technology (accuracy, part strength, part surface finish, application). There are also factors related to the AM system itself (cost, system size, system style, build speed). All or only some of these factors may be used to select the best system, depending on the user's needs. The selection process requires a massive amount of information that needs to be administered in a proper and efficient manner to the user to read, understand and decide.

The conventional way of learning about AM technologies in order to select an AM system is by reading text books, reviewing papers and benchmarking studies.

Many review papers and text books explain the principles of AM technologies and describe the differences between AM systems [2-28]. Although these sources contain good information, the fast growth of the technologies has made it difficult for them to include the most up-to-date information. The learning and the selection processes can therefore be difficult and time-consuming, especially when the selection process needs to be repeated several times and in different ways.

Benchmarking studies on AM systems have been done by user companies and independent researchers [29-37]. In these studies, a specific shaped part is made using different AM systems in order to compare the capabilities of the different systems. Numerous inspection and measurements need to be taken to determine the differences. Benchmarking studies can be quite expensive and time consuming. Furthermore, the studies need to be carried out under ideal laboratory conditions to be accurate [38]. Several modules are required to ensure the repeatability check. In critical cases, for example, when having to compare very expensive systems before purchasing one, benchmarking studies can be used to facilitate the decision. Otherwise, these studies are difficult to justify, moreover, disagreement of AM systems manufacturers on a common part to use for benchmarking limited the success of the existing studies [38].

A new way of solving the problem of introducing and selecting an AM system is by using computer programs. Computer aid is usually useful when it comes to design problems. The AM system selecting program should introduce the AM technologies and encourage the new users to start getting the benefits of these technologies. This program should also have information about all commercially available AM systems, and be able to compare them. The AM system selecting program will offer clear and reliable results much quicker than the conventional methods.

1.2 Project objectives

"To break the cycle of ignorance, we must work on both sides of the issue. We must motivate the uninformed to take another look at rapid prototyping and to become knowledgeable on the topic. At the same time, we must generate more information for these investigators to absorb." [1]

The general aim of this study is to develop a computer selection program for AM systems to contribute to the promotion of AM technologies and their benefits worldwide, especially for the countries and organizations that have not yet used such technologies. This program will be a tool to encourage those who have not made use of AM technologies to try and educate those who are unaware of AM technologies.

The specific aim of the study is to introduce AM technologies to the decision makers in the education sector in Libya. Furthermore, try to persuade them to start making use of the benefits of these technologies and assist them in selecting the most appropriate system to establish AM technologies in the country.

To achieve the aim of this study, the objectives of the selection program are:

1. To introduce the AM technologies to potential users. The tutorial of the program will serve as an educational tool explaining the principles of the AM technologies to new users.

2. To persuade any potential users in both the educational and industrial sectors to use AM technologies by buying AM systems or at least to deal with service bureaus. The tutorial will also answer specific questions about AM.

3. To assist the users to decide which AM technology and system suits their needs. The program offers a decision-making support tool to assist potential purchasers in the educational or industrial sector to select the most appropriate system to suit their needs.

1.3 Programme design requirements

For the development of an AM system selection program the Visual Basic computer language was chosen. In order to reach the objectives of the project the main advantage of Visual Basic is its ability to create powerful and professional looking application with less time and coding. Visual Basic provides powerful features such as graphical user interface, error handling, structured programming and much more. Visual Basic programs are clearer than unstructured programs, easier to test, debug and can be easily modified. The developed program shall meet the following requirements:

1. User friendliness

The program shall be as uncomplicated as possible to operate and easy to understand. This is relevant to the method of inputting data, controlling the program and getting the results. The ease of being able to find sufficient information about AM technologies is also vital.

2. Ability to introduce the AM technologies to any new users

Gives sufficient information in a concise manner to save the user’s time. The program shall offer a summarized text with graphs, photos, drawings and videos to ensure that there is adequate background, to better understand the technologies.

3. Ability to inspire new users’ interest in AM technologies

Certain knowledge should be introduced to the user to encourage him to deal with AM technologies. This contains information about the existing and future applications of AM, the properties of AM parts, which industries have been served by AM, the relations between CNC and AM and the economic feasibility of AM. When the user discovers how AM can serve his purposes then they will decide to use AM in their field.

4. Ability to compare different factors to select the best AM system

The main factor of selecting the best system in this program is the applications of AM technologies. The other factors are: raw material, AM technology, part maximum size, system price.

5. Provision of sufficient information as an output

The program shall contain all information regarding the 100 different commercial systems worldwide. The output screen of the program contains: explanation of the system's technology, system characteristics, part characteristics, facility requirements, producing company's characteristics and the raw material's characteristics.

6. Accessibility

The program shall not need special requirements and shall work easily with any computer whether Windows XP or Windows Vista compliant.

7. Update ability

The program should have the ability to be up-dated regularly with the information about AM technologies.

2. Overview of additive manufacturing technologies and selection models

2.1 Introduction

Issues like: reducing the production cost, reducing the production time, increasing the product quality, caring about customer satisfaction and being responsive to brining new products to the market are essential to survive and progress in today's highly competitive market. AM technologies are one of the best methods to reach these goals. AM converts three dimensional (3D) Computer-Aided Design (CAD) data into a solid object. AM is the ideal solution for form, fit and function prototypes, it is also ideal for producing low volumes of patterns, moulds and ready-to-use parts [4].

A huge amount of money can be saved by using AM technologies before investing in new production facilities or assembly lines. The speed of introducing new products to the market will be also guaranteed using the AM technologies to produce form, fit and functional prototypes in the design phase. The traditional methods of producing prototypes need highly skilled people and normally take long periods of time to produce parts, depending on their complexity. AM has no limit when it comes to the complexity of the part shape, it can produce any shape including those which are more difficult and sometimes impossible using any other method. AM offers the potential to completely revolutionize the process of manufacturing.

AM is a relatively new manufacturing technology. It was developed in 1987 by 3D Systems Company in the United State using stereolithography (SLA) technology [2] the SLA- 1 system was the first commercially available AM system in the world. Asia started in 1988 with NTT Data CMET from Japan (now part of Teijin Seiki, a subsidiary of Nabtesco), this company commercialized its Solid Object Ultraviolet Plotter (SOUP) system with the SLA technology. Germany from Europe began to contribute to the technology in 1990, when Electro Optical Systems (EOS) and Qadrx commercialized their SLA systems [2].

After 1991 several new AM technologies were established and more new commercial systems went into the market. The cost of AM systems is continually decreasing, the number of vendors and users are continually increasing and, furthermore, the used raw materials are always improving with better properties and lower cost. The applications of AM have advanced from producing prototypes and patterns for moulds to finally being used in end-use parts manufacturing. Today there are about 32,000 systems working worldwide and produced mainly by Stratasys, Z Corporation, 3D Systems and Solidscape companies [2].

The following graph shows the growth trend of AM system sales per year worldwide.

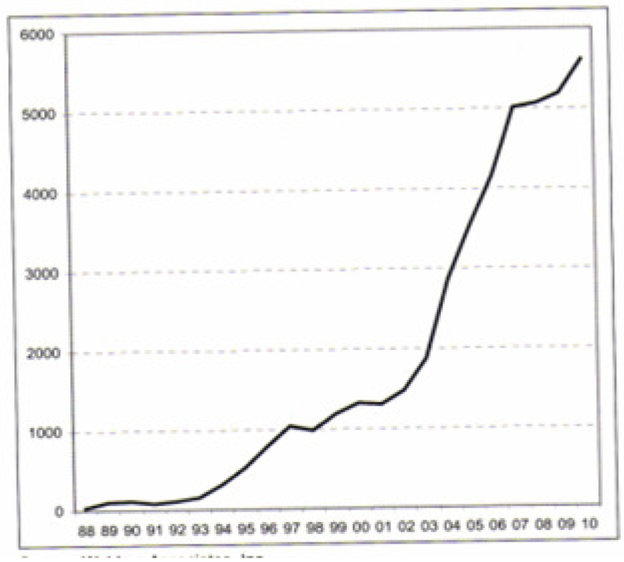

Figure 1 The growth trend of AM system sales per year worldwide [2]

2.2 Additive manufacturing process

Pre-requisite for all AM methods is a CAD model. The second step is converting the CAD file into an STL file which is a faceted version of the model's surface. Third, a layered model equal to the layer thickness will be created by slicing the STL model. The next step is to create the physical model using one of the different AM technologies. Finally, post-processing operations sometimes need to be done, depending of the AM technology. Figure 2 illustrates the steps of an AM process.

2.2.1 Creating the solid model

The solid model can be created virtually using any of the mechanical drawing software such as AutoCAD, Pro/Engineer, CATIA, SolidWorks, or any other commercially available solid modelling programs. The solid model can also come directly from 3D sensors (such as laser, sonic, or optical digitizers), medical imaging data and any other source of 3D point data [4].

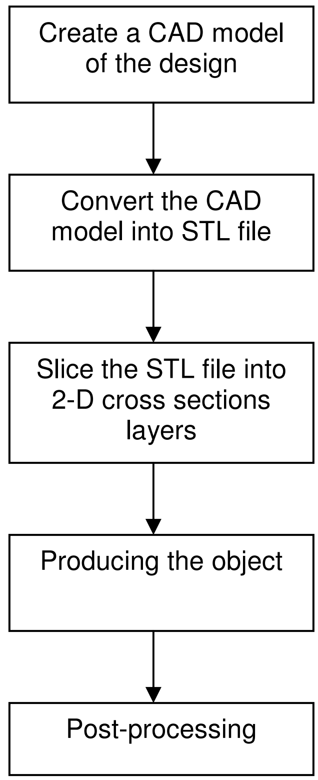

Figure 2 The steps of the additive manufacturing process

2.2.2 Converting the CAD model into a STL file

In 1988, 3D Systems Company created the STL (Standard Triangulation Language) file as a neutral format between the CAD systems and the software supporting the AM system. The STL format is now defined and accepted as a neutral format for all AM systems, because most of the CAD software packages already use triangulation for different reasons.

2.2.3 Slicing the STL file into 2-D cross sections layers

In this step, a series of closely spaced 2D cross sections of the 3D model is created. The layer thickness is equal to the layer thickness that the AM system can produce. This sliced model is saved in the STL file. The size of this file will increase if the complexity of the object increases.

2.2.4 Producing the object

When the AM system's computer receives the sliced file, the system is ready to run, unattended, until the object is ready. All AM systems build their objects layer by layer using different principles, different raw materials, different layer thickness and different building time. (For more information see section 2.4).

2.2.5 Post-processing

The requirement for post-processing operations on the produced parts of AM depends on the AM technology used and the application. Some of these technologies have support structures that need to be removed. Other technologies need post curing or sintering to have better structure. Manual or mechanical finishing may be required to yield a product with better surface finish of the produced part.

2.3 Advantages and disadvantages of additive manufacturing

2.3.1 Advantages of additive manufacturing:

AM technologies have advantages that no other technologies have. Some of these unique advantages are:

1. **Unlimited geometrical complexity.**

   Very complex parts with very complex, hollow structures that are difficult and sometimes impossible to produce, using conventional manufacturing processes, can be easily produced by AM technologies.

2. **Reducing the production cost by up to 50% and the processing time by up to 75% using rapid prototyping and rapid tooling [39].**

3. **Low cost of low-volume products and for rapidly changing high-volume products using rapid manufacturing.**

4. **Waste-less fabrication**.

   Instead of wasting the entire negative space of a product by a subtractive process, most of the AM systems eliminate this waste (except the laminated object manufacturing (LOM) process that creates the same amount of waste as a subtractive process).

5. Unattended operation.

The fundamentals of AM technologies as a layer manufacturing process allowed fully-automated operation. The operator need just to start the system and then get the part when it is ready.

6. Consolidation of parts.

Combining two or more parts into one part is one of the main advantages of AM technologies. This leads to the use of fewer tools, making the assembly easier and reducing the product cost.

7. Customer-driven design.

AM technologies allow customers to have direct involvement in the design process. The customer can design his product using any 3D CAD software or select between different drawings that have already been prepared. Moreover, a functional prototype of the product can be produced and the customer can give his feedback. This is an expensive exercise if a conventional manufacturing process is used.

2.3.2 Disadvantages of additive manufacturing:

1. The lack of very complex designs.

Using very complex designs that can only be produced by AM technologies will ensure the competitiveness of these products in the market.

2. Limiting of raw materials.

Comparing to the conventional methods of production AM technologies has very limited raw materials that can be used to produce parts. But there is always improving new materials coming to the market.

3. Surface finish.

The produced parts by AM technologies need finishing before they can be used.

4. Not economic for high volume production.

AM technologies still can not compete with the conventional production methods when it comes to the mass production. AM still economic when it comes to the design phase or for low volume products or rapidly changing high volume products.

5. Limitation of the part size.

The produced parts by AM technologies still have very limited sizes. On the other hand, a lot of improvements happing to overcome this problem in the new AM systems.

2.4 Additive manufacturing technologies

AM technologies can be divided into three different categories according to the raw material used in the process. These categories are:

2.4.1 Liquid-based processes

Liquid-based processes represent all the formation technologies that selectively cure regions of photosensitive polymers.

2.4.1.1 Stereolithography

In stereolithography, the laser beam will move according to the layered model to selectively cure the layer surface, then the platform will be lowered and a new polymer liquid layer will be spread on the previously created layer. This process is repeated until the part will finish, see Figure 3.

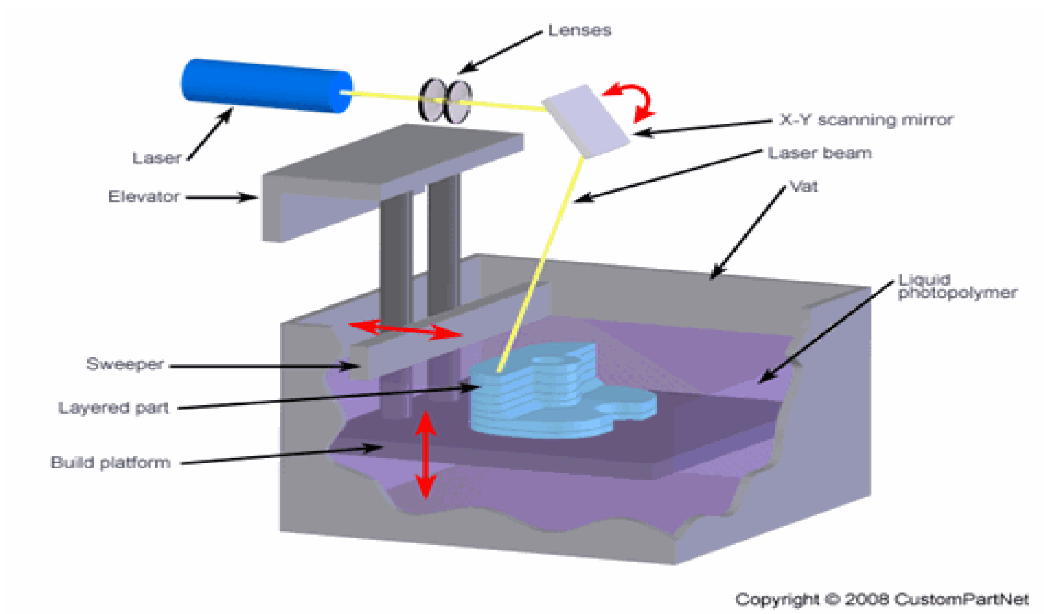

Figure 3 The working principle of stereolithography [40].

2.4.1.2 Jetting systems

These systems use an array of printing heads to selectively spray an acrylate-based photopolymer on the material, after that a UV lamp will cure the sprayed parts of the layer. Finally, a second series of jets will cure the supporting material into a gel that can be removed by a water jet after the part is finished. In some systems jetting wax is also used for building of support structure (Figure 4).

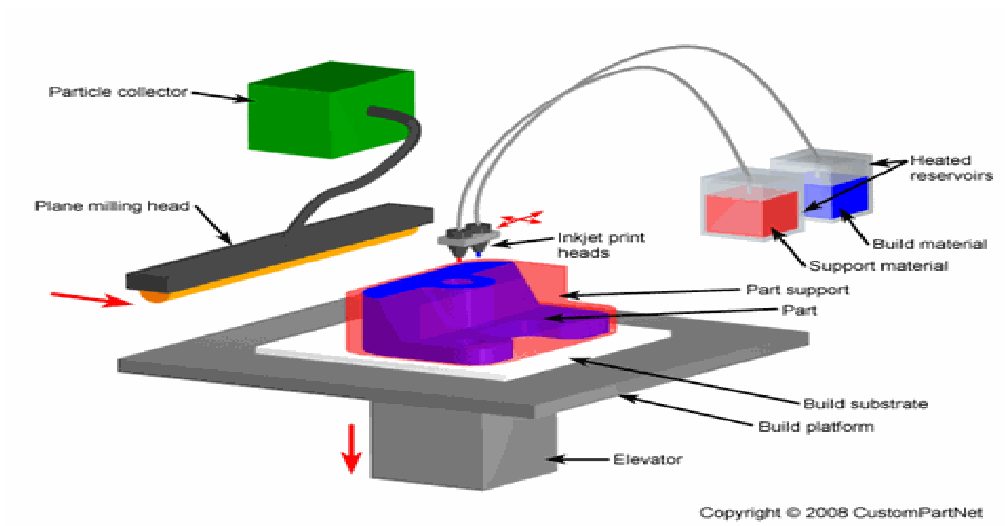

Figure 4 The working principle of Polyjet [40]

2.4.2 Powder-based processes

Powder-based processes can use polymer, ceramic or metal as raw material. Moreover, combining powders can be used as graded materials. These technologies offer good end-use part properties that make them lead the rapid manufacturing technologies.

2.4.2.1 Laser Sintering

Laser Sintering (LS) uses lasers to melt the powder layer selectively. The powder bed is heated before laser sintering to increase the powder temperature to a few degrees below the melting temperature of the powder. After creating the first layer, the carrying platform is lowered and the new powder layer spread. Continuing these processes will build the part and the un-sintered powder forms the support material which is easy to remove. Selective Laser Sintering (SLS) is the trade name of the technology invented by 3D Systems company but it has the same principles of laser sintering.

This technology can be used to produce polymer and metal parts. Coated metal powder with polymer will produce steel parts in the green state (not ready to use and need to be heated in an oven). These parts must be heated in a furnace to burn away the polymer binder (Figure 5).

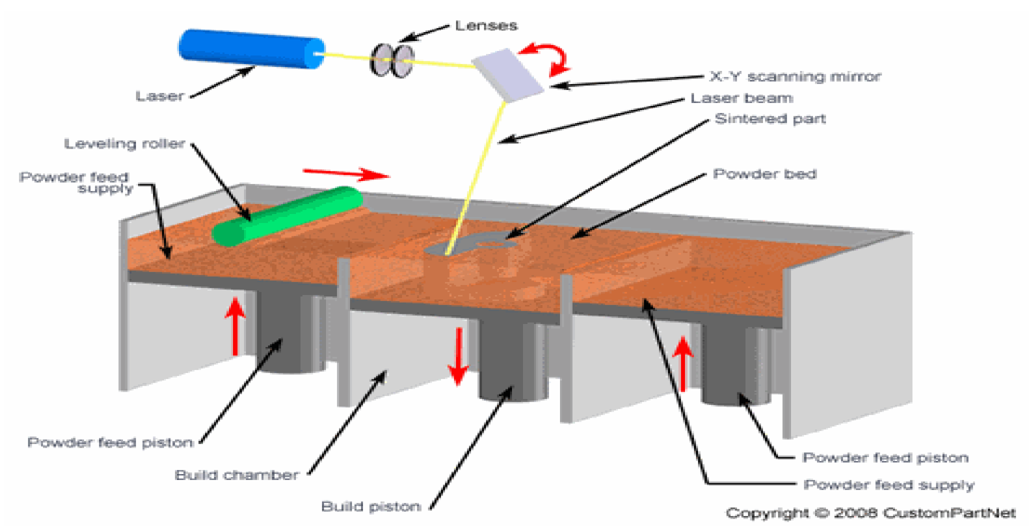

Figure 5 The working principle of laser sintering [40].

2.4.2.2 Selective Beam Melting

Selective Beam Melting is a general term that contains different types of AM technologies such as: Selective Laser Melting (SLM), Laser-Cusing, Direct Metal Laser Sintering (DMLS) and Electron Beam Melting (EBM).

Direct Metal Laser Sintering

Direct Metal Laser Sintering differs from the previous technology (SLS) as it does not require a polymer binder. The metal powder that is used contains various components that have different melting temperatures. Hence, the laser will melt the lower melting temperature component first which will form the part. The part in this case can be the end-use part with no need for post-heating.

Laser Cusing and Selective Laser Melting

The difference between the Laser Cusing process and the previous two processes (SLS and DMLS) processes is that here a single component metallic powder is used which allows the production of a fully dense component without stress or deformation. The used raw material can be aluminium, stainless steel, tooling steel, titanium and others.

Laser Cusing and selective laser melting have the same working principle and they just differ in names because they are not from the same company.

Electron Beam Melting

The principle of Electron Beam Melting technology is similar to that of SLS but a laser is substituted with an electron beam. This replacement has some important affects. Firstly, using the electron beam will increase the scanning speed (up to 1 km/s) by changing the electromagnetic field through which it passes. Secondly, the very high power this electron beam offers assures a full melt of wide range of metals.

2.4.2.3 Three-dimensional Printing

In three-dimensional printing (3D), a printing head selectively sprays a binder onto the powder. The final product will be in the green state, which means it needs post-processing, similar to SLS (Figure 6).

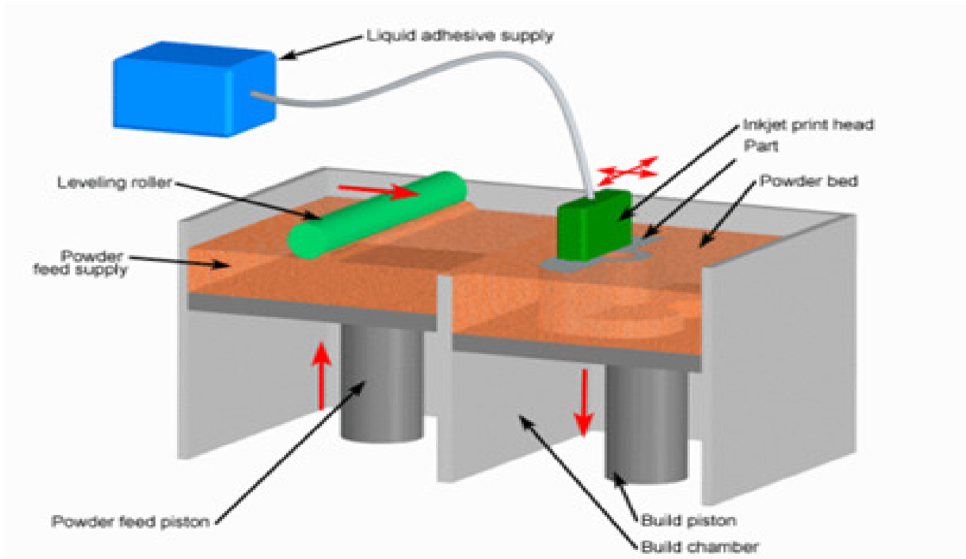

Figure 6 The working principle of 3D Printing process [40].

2.4.2.4 Fused Metal Deposition

Fused Metal Deposition uses a deposition head to melt metallic powder using a high power laser. The laser is focused using lenses. Moving the laser beam and the table will create the part layer by layer. The metallic powder can be fed by gravity or using a pressurized gas. In both cases the gas is used to provide a non-oxygen environment for the laser. Various commercial systems use the principle of this technology, for example systems produced by POM, Optomec and Aeromet (Figure 7).

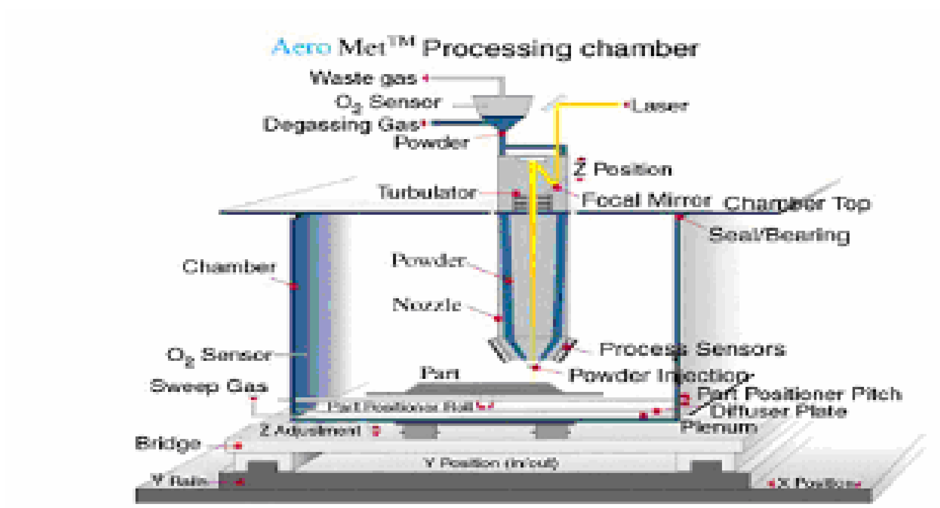

Figure 7 The working principle of Fused Metal Deposition [11]

2.4.3 Solid-based processes

Solid-based processes mean the processes that use non-powder solid materials. These technologies are the most used AM technologies worldwide nowadays [2].

2.4.3.1 Fused Deposition Modelling

Fused Deposition Modelling (FDM) uses a nozzle to heat the raw material (normally a thermoplastic polymer) to just above its melting temperature. Moreover, moving the nozzle in two dimensions to extrude the material in the selected areas of the part creates a layer that will solidify immediately and stack with the previous layer. Supports that are easy to remove manually or water soluble may be used; the support layers are created using nozzles other than the ones used for building the part itself (Figure 8).

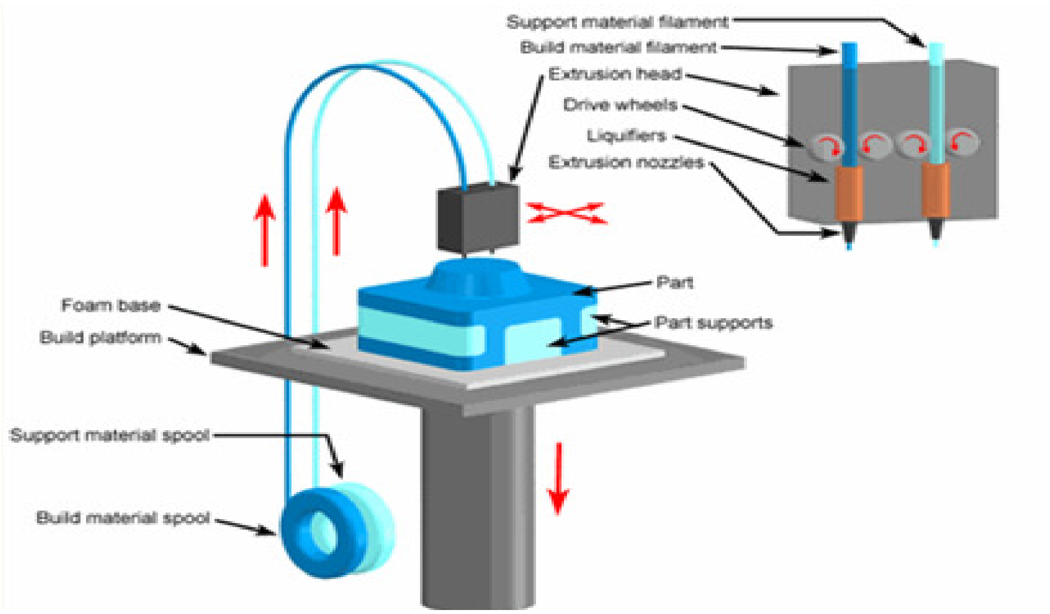

Figure 8 The working principle of Fused Deposition Modelling [40].

2.4.3.2 Laminated Object Manufacturing

In Laminated Object Manufacturing (LOM), sheets of paper, plastic, metal or composites are used. The sheets are formed layer by layer, using a laser and then a hot roller to bond the new layer to the previous one. On completion of the process the unwanted material is removed. (Figure 9).

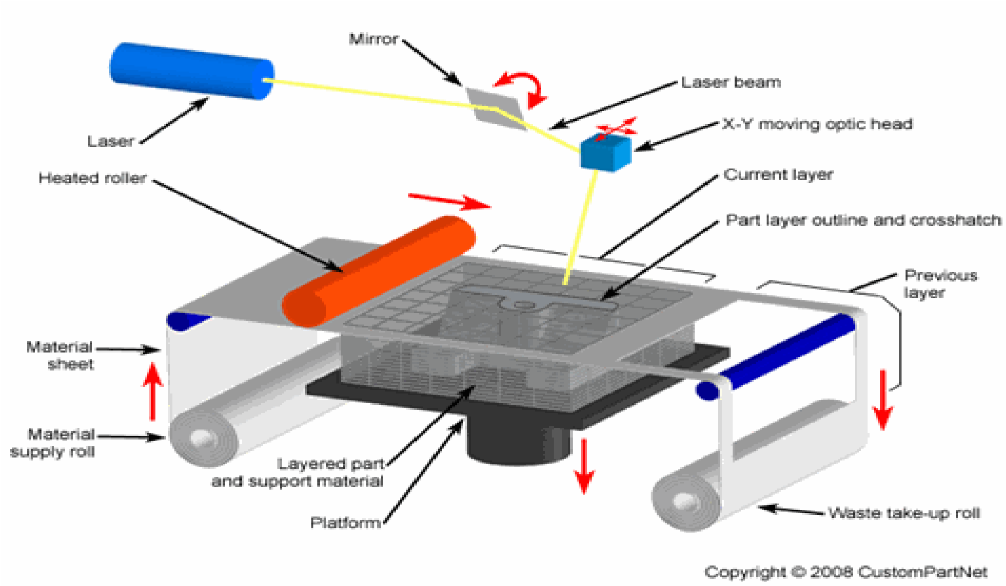

Figure 9 The working principle of Laminated Object Manufacturing [40].

2.5 Applications of additive manufacturing

2.5.1 Rapid prototyping

All new products have a development and manufacturing cycle that starts with prototyping. Having prototypes is an essential step to ensure that the shape, measurements, fit and functionality of a part are suitable, and hence to the cost of commercial production is reduced. Before the emergence of rapid prototyping (RP), the only way of making prototypes was manually done by professional and highly skilled people, but this could delay the development cycle for weeks, and sometimes months (CNC can be considered as a rapid prototyping, tooling and manufacturing tool) [10]. Due to this, the ability to re-prototype a design was highly limited, therefore, parts may have problems in assembling and performance, adding to the production cost.

Rapid prototyping can produce accurate parts automatically, using the suitable AM technologies, in a couple of hours. Hence, re-prototyping is quick and relatively easy and leads to shorter development and manufacturing cycle times and reduces long-term costs. It has been reported that rapid prototyping technologies can reduce the required time to market by 90%, and the part cost by up to 70% [10].

The main applications of rapid prototyping are:

Concept modelling

AM technologies can produce concept models much faster and cheaper than conventional methods - this allows the designers to check their design early and make any necessary modifications to it before commercial production starts. Concept models can be used as a communication tool between the designers themselves; this tool will also assist the production team to plan the best way of manufacturing the part. The concept models can also be used to get early feedback from potential customers about the future product or component.

Form, fit and checking

Form, fit and checking is an essential step for any new product, this check allows the designers to test for problems of form and fit and ensuring that all parts are complementary and fit properly.

Functional models

This application is always improving with the upgrading of AM raw materials. Some AM technologies can produce fully-functional parts to be used in any functional test. Semi-functional parts can also be made by some AM technologies but they are used mainly for performance tests that rely only on the geometry of the part.

Visual prototypes

Visual prototypes can be used for packaging articles (bottles), jewellery and art products to illustrate the shape of the product. Using visual prototypes as examples for any design such as buildings or structures can also be helpful.

2.5.2 Rapid tooling

RT is a natural expansion of RP. When producing large numbers of prototypes, in a variety of commercially available materials, RT is the best way to achieve that.

There are two methods of achieving rapid tooling: indirect tooling and direct tooling. Indirect tooling means using patterns or moulds to cast tools in a variety of materials, including epoxy, kirksite (a low-melting-point alloy), aluminium, and metal alloy blends. Direct tooling means producing tools or tooling inserts directly from the AM system. Materials for direct tooling include many metal alloys, alloy blends, ceramics, composite materials and plastics.

2.5.3 Rapid manufacturing

Rapid manufacturing (RM) is the manufacturing process that produces ready-to-use parts applying AM technologies without using other tools, except for some finishing requirements.

The use of RM for producing end-use parts is increasing. It is being achieved mainly with systems designed for prototyping and not for manufacturing. There are some limitations to existing AM processes that restrict the increased use of RM in manufacturing. Limitations related to surface finish, repeatability, material properties, machine cost and raw material costs need to be overcome. In spite of the transitional phase of the AM technologies these days, RM systems can relatively easily produce custom-made and low-volume parts. The requirement of RM systems with high speed, quality production at a low cost is still not commercially available but it is not far off [6]. Several industrial companies and research institutes are already working on improving the capability of RM systems. It is believed that the required RM systems will be available within the next 10 years.

The ability of RM to produce complex shapes, without the need for any tooling, is considered a breakthrough in industry. This manufacturing method offers geometrical freedom for designers; they can now combine different pieces into one part, and use combinations of materials to obtain parts with different functionality. It also offers advantages to customers in industry: a customer can design whatever he/she requires, send their drawings to the factory by e-mail (or other communication methods), and receive the finished product within a few hours or days.

Rapid manufacturing is having a significant impact on many industries, including aerospace, military, motor sports, automotive, industrial machinery, medicine, dentistry, consumer products, art and jewellery. It is also affecting games and entertainment, marine products, sporting goods, electronics, forensics, archaeology, construction and even clothing. As RM continually evolves, it will develop and emerge in other industries. As functionality is up-graded and multiple-phase material solutions appear, it will have entirely new and endless applications.

2.6 Overview and analysis of previously developed selection programmes

Several studies have been carried out to develop a computer program to promote AM technologies and aid the selection process to suit specific AM commercial system to the needs of the user, employing different methods of analysis. These studies also vary in the targeted sectors, comparing factors, the user interface (the program's screens that the user will deal with), the background required to deal with the program and the manner in which results are shown.

The RP program developed by Hornberger in 1993 was the first effort in developing a computer program to assist RP users [38]. The program includes four RP systems, which were the commercial systems available at that time: 3D Systems' SLA, Stratasys' 3D Modeller, Cubital's Solider 5600 and Light Sculpting Inc.'s LSI. To provide general information about RP processes, as an educational tool, was the main aim of this program.

Later, studies were carried out where different selecting factors were combined in order to choose the most suitable commercial system, using different methods of analysis. A rapid prototyping system selector program was developed in 1995 by Muller [38] using the relational database management system MS Access. The selecting process used a ''benefit value analysis'' method to compare between the systems using a database. This database included information about materials, machines, processes, defined prototypes and weight factors. The program was used both as a decision making support tool and as an educational tool.

Phillipson [42] in 1996 developed a rapid prototyping machine selection program. The program compared six RP systems that were available at that time from 3D Systems, Stratasys, Helisys, DTM, Schroff Corporation and Sanders Prototype. The software used was MS Access and the selecting process used multicriterial optimization theory. The selecting factors used were build time, cost and part quality.

In 1996, Campbell and Bernie [43] created a database of rapid prototyping system capabilities. This database also used MS Access and included many RP systems in terms of their capabilities. It was developed to assist the designers to acquire information in a fast and easy way. This database aimed to select the appropriate RP system to adapt a given part geometry. The input data was therefore related to the part's features more than anything else. The final result is that the database will select the system(s) that would be able to produce a specific part.

In 1999 Bibb and others [44, 45] developed a computer based RP design advice system. This system has two types of rules: decision rules and calculation rules. Decision rules deal with input data derived from the STL file of the part. The comparing factors in this program were the required accuracy and minimum wall thickness. Calculation rules were applied to calculate the build time and the part cost for all the RP systems used.

Byaun and Lee [46] used multiple-attribute decision making (MADM) with a modified TOPSIS method to develop their selection tool. Two years later Venkata Rao and Padmanabhan [39] used graph theory and matrix approach for the same purpose and employed the same solving sequences (the only difference is the analyzing method). Using these methods result in a compromise between the conflicting selecting factors. In the work of Venkata Rao and Padmanabhan, in order to compare data, it is required to select from a number of AM systems and requirement selecting factors, which include a hierarchy of relative importance. (Tables 1 and 2). The selection process analyzes the different alternatives with their selecting factors and the relative importance inputs to yield ranking systems that appear in descending order (Table 3). These two programs succeeded as decision making support tools to rank the AM selection systems. On the downside, the user needs to enter the information about the AM systems to be compared, which requires the user to be an expert in the field of AM technologies.

Table 1 Relative importance of AM process selection factors [39]

Class description	Relative importance
One attribute is very less important over the other	0.115
One attribute is less important over the other	0.295
Two attributes are equally important	0.495
One attribute is more important over the other	0.695
One attribute is much more important over the other	0.895

Table 2 Data of the AM process selection attributes [39]

RP Process	Accuracy (μm)	Surface roughness (μm)	Tensile strength (MPa)	Elongation (%)	Cost of the part	Build time
SLA3500	120	6.5	65	5	Very high	Medium
SLS2500	150	12.5	40	8.5	Very high	Medium
FDM8000	125	21	30	10	High	Very high
LOM1015	185	20	25	10	Slightly high	Slightly low
QuadraT	95	3.5	30	6	Very high	Slightly low
Z402	600	15.5	5	1	Very very low	Very low

Table 3 The output of RP system selector [39]

Quadra	10.7085
SLA3500	9.4606
SLS2500	8.0812
LOM1015	7.6081
FDM8000	7.5736
Z402	6.6198

Masood and Soo [38, 47] developed a computer program that uses the Visual Basic module of the M4 expert system shell. This program deals with 39 AM systems, made by 21 AM system manufacturers worldwide. The authors used vendor questionnaires and a user questionnaire to obtain information about the attributes that should be considered. As a result of this research, the program offers four different selection options: quick selection, detailed selection, build technology and machine style. The quick selection method selects the system using the attributes: price, accuracy in the X–Y axis, working envelope dimensions, and build material (Figure 11). The detailed selection method selects the system using the attributes: price, accuracy in the X–Y axis, accuracy in the Z axis, surface finish, working envelope dimensions, build material, build thickness and build speed (Figure 11). The build technology method selects the system using one of two options: (a) laser or non-laser system. It uses the attributes: price, accuracy in the X–Y axis and working envelope dimensions (Figure 12). The machine style method offers three options: office environment type, desktop type or normal commercial type. Then uses the attributes: price, accuracy in the X–Y axis and working envelope dimensions (Figure 13). The program uses IF-THEN rules for searching, being loaded with the required input. Consequently the program compares the exact values of the different systems and chooses the most appropriate one. The program will ask the user questions as inputs and then select the proper system (Figure 14). The results then appear on a result screen that contains the total specification of the chosen AM system (Figure 15). Other information also appears, such as sales record, market share and warranty period. If the program found more than one system to suit the same purpose, then a list of these systems appears to the user to select from.

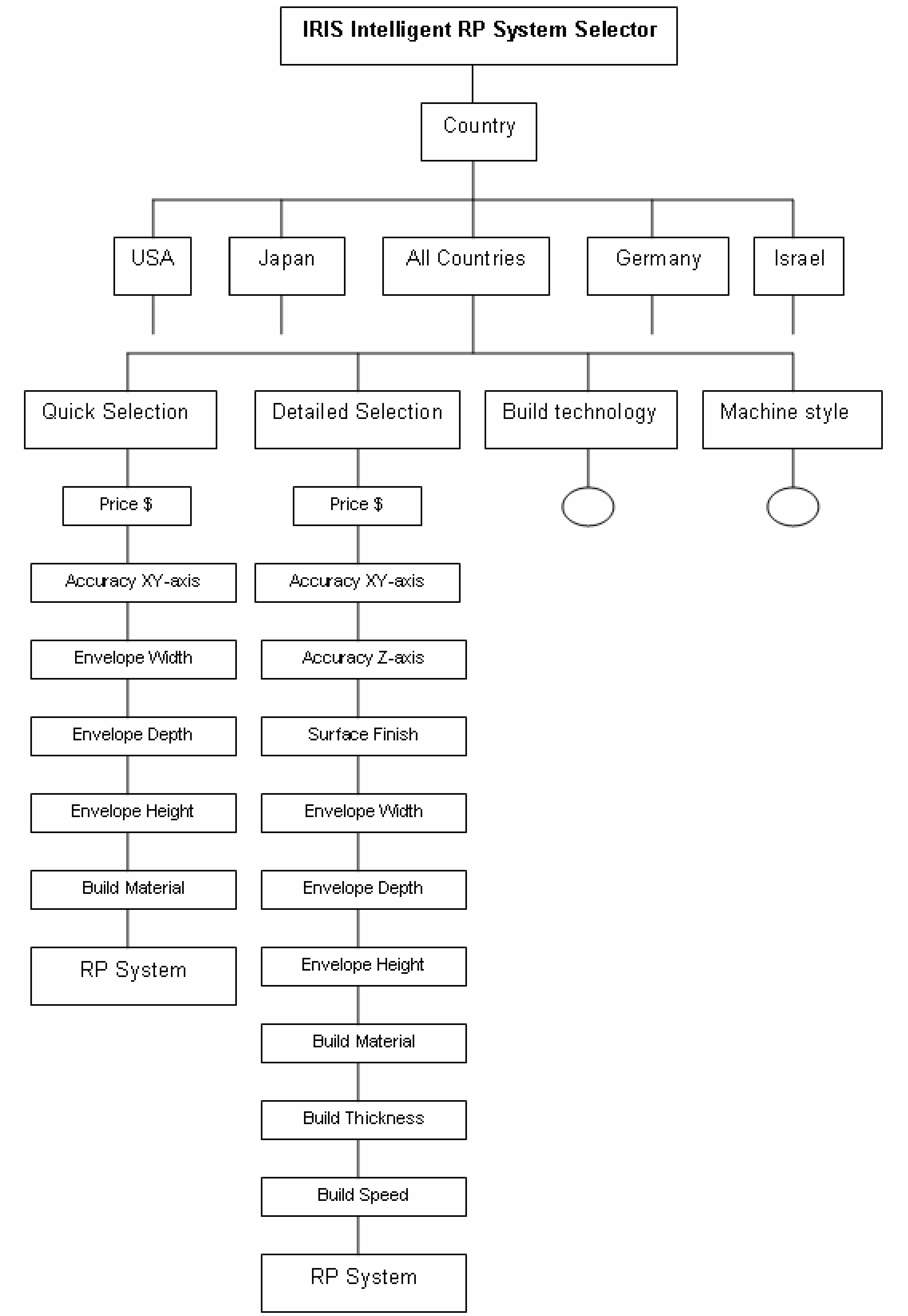

Figure 10 Main tree structure of the RP system selector [38]

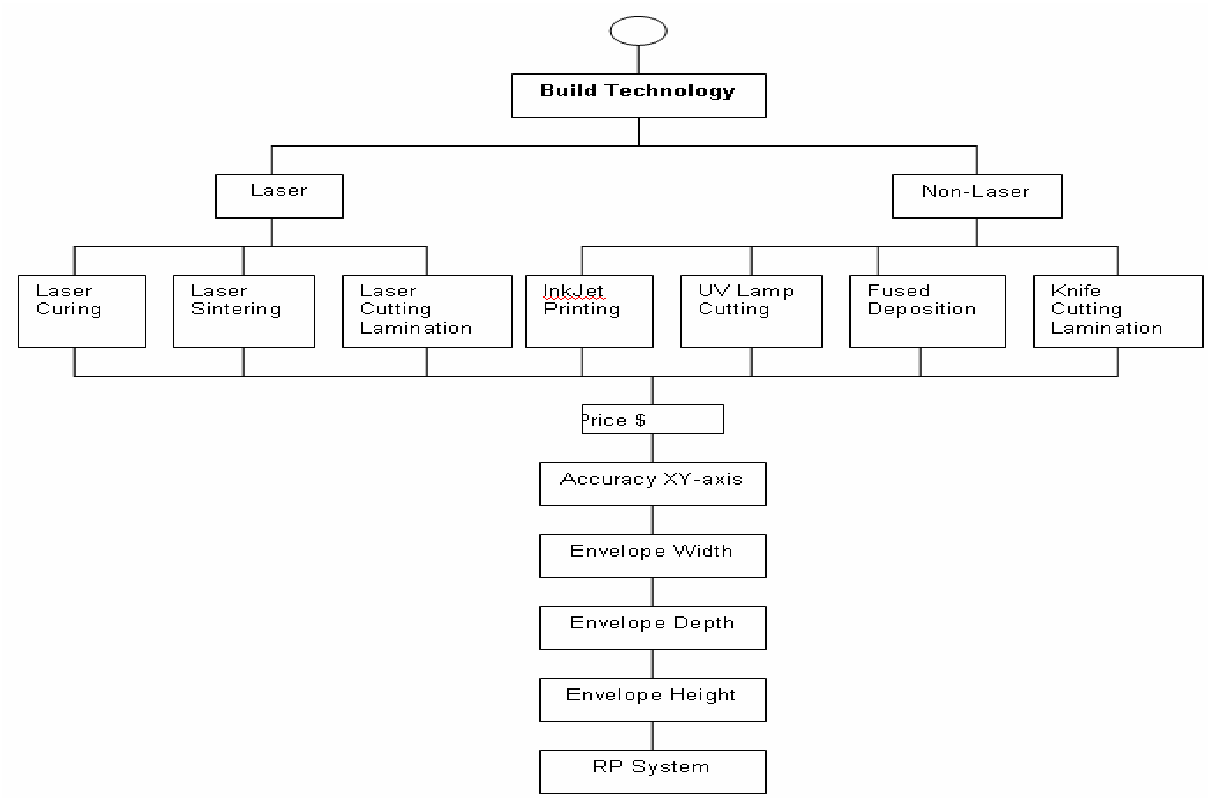

Figure 11 Building technology branch of the main tree structure [38]

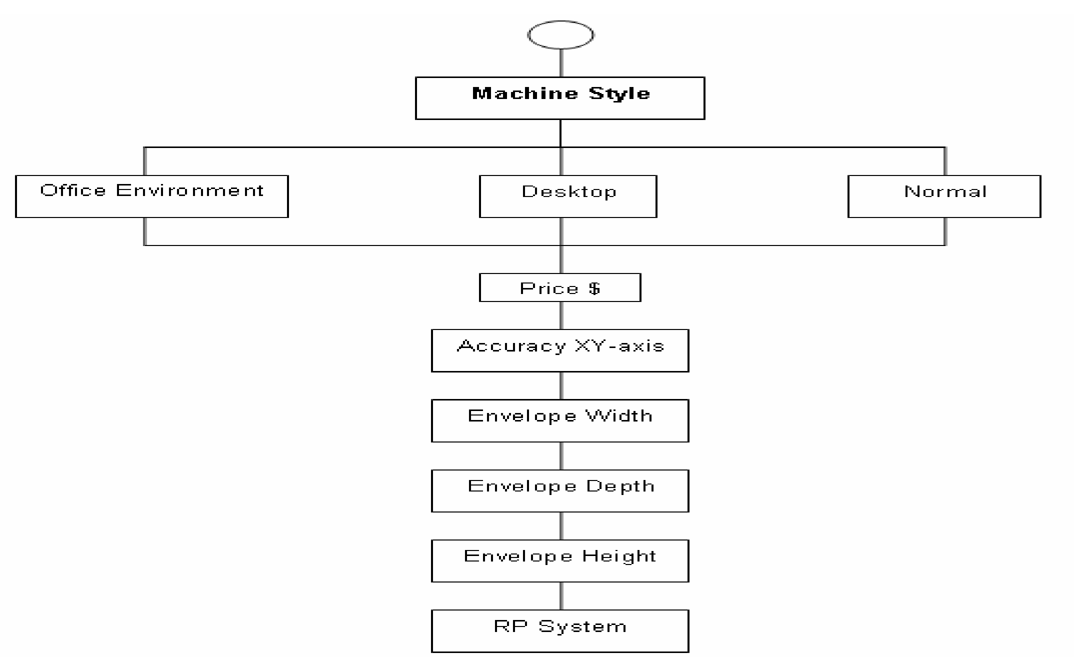

Figure 12 Machine style branch of the main tree structure [38]

```
if    country = usa and
      method = quick-selection and
      uprice=PD1 and
      PD1>=200000 and
      uaccuracyXY = AXY and
      AXY>=0.15 and
      uenvelopeW = EW and
      EW<=250 and
      uenvelopeD = ED and
      ED<=250 and
      uenvelopeH = EH and
      EH<=250 and
      umaterialtype = epoxy-photopolymer and

then rpsystem = sla250hr.
```

Figure 13 The interface of the RP system selector [38]

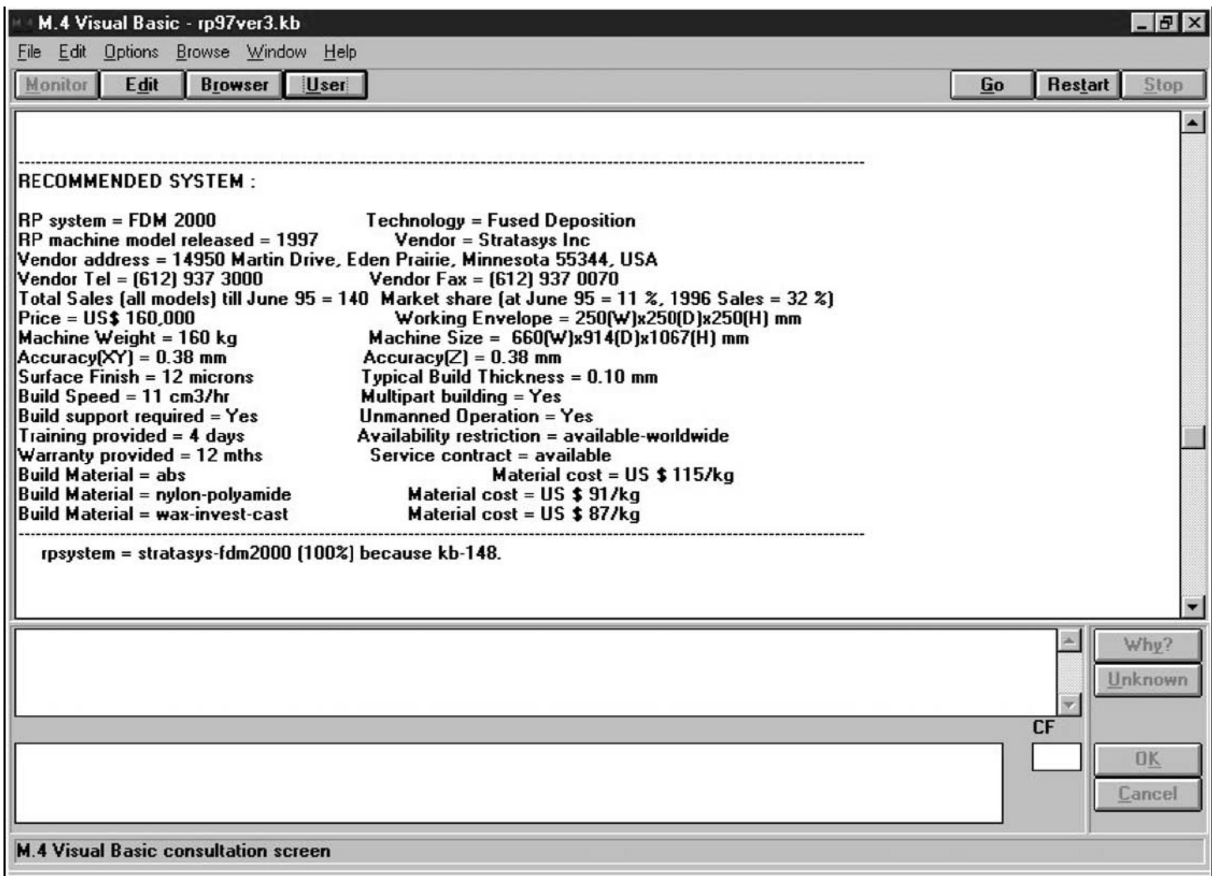

Figure 14 The output screen of the RP system selector [38]

Wilson [48] described the selection of the most suitable rapid manufacturing system as epistemic uncertainty, this uncertainty is mainly attributed to the lack of information known about what the customer's specific requirements and preferences are at the time of production. He developed a computer program to select the appropriate RM system to use to produce certain parts. This program was focused on the industrial sector. Three different RM techniques, divided into 11 different systems, were compared. The technologies are: 1. Stereolithography (SLA) with five different systems (SLA 250, SLA 3500, SLA 5000, SLA 7000 and Viper SLA). 2. Selective Laser Sintering (SLS) with two different systems (Sint HiQ and Sint HiQ+HS) and 3. Fused Deposition Modeling (FDM) with four systems (Prodigy Plue, FDM Vanlage, FDM Titan and FDM Maxium). The build time and part cost were the only attributes used to compare between the systems. The build time and the part cost were calculated using certain equations which depend on the inputs (Appendix .1). The program interface has one screen containing the inputs (Figure 16). Outputs are displayed as numbers and as a graphical (chart), also on one screen (Figure 17). The input data is arranged in two categories: part characteristics (part volume, part width, part height and part length), and RM build characteristics (gap between parts and build angle). The output displays the build time and part cost in all 11 systems which is elaborated using a chart to visually compare the 11 results.

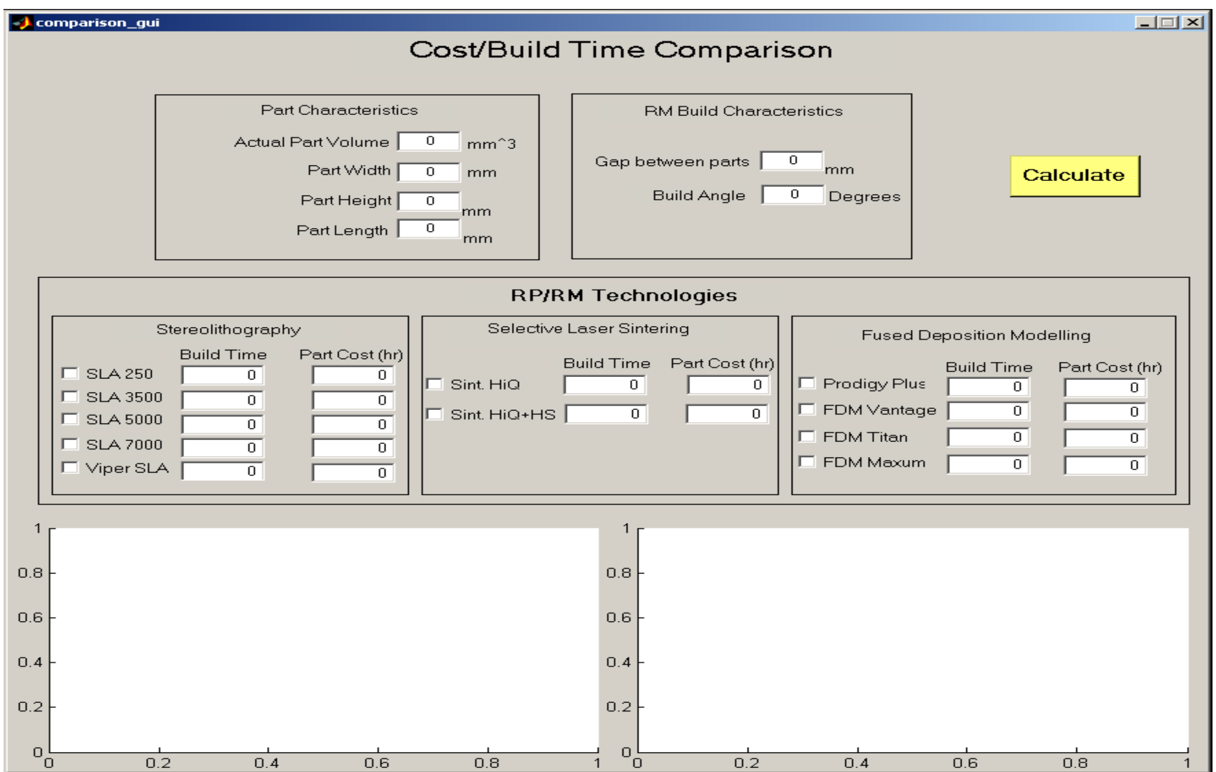

Figure 15 The interface of Wilson's program [48]

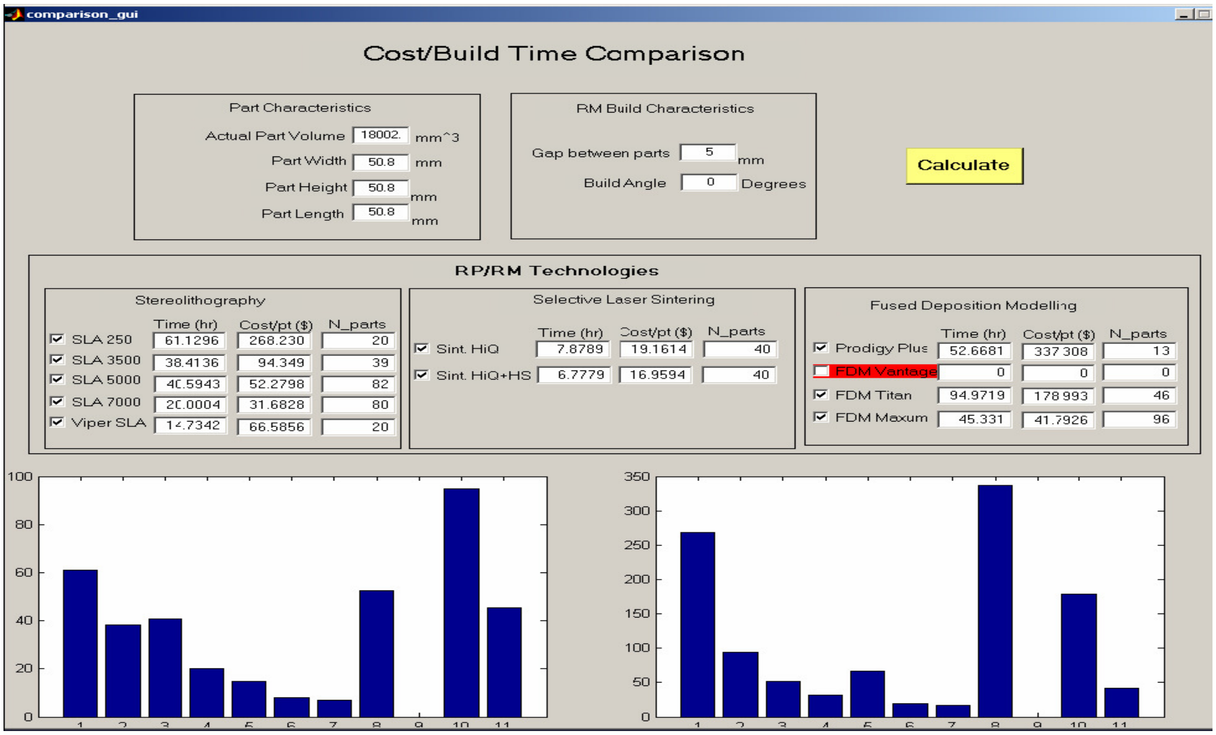

Figure 16 The output screen of Wilson's program [48]

The only study aimed at selecting the proper AM technology, and not the system, to produce a specific part, was done by Antonio Armillotta [41]. He developed a selection of AM technologies using an adaptive AHP decision model (a multi-objective decision methodology that provides a logical formulation of the selection problem and reduces the inherent ambiguity of scoring methods) - sixteen technologies were compared. The featured AM processes were: stereolithopraphy (SLA), powder sintering (SLS), extrusion of thermoplastics (FDM), sheet lamination (LOM), and all technologies based on the ink-jet principle: jet-wax (IJM), jet-thermoplastic (MJM), jet-photopolymer (PJ) and jet-binder (3DP). The direct and indirect tooling processes were: mask exposure (DLP), direct metal (SLS-metal), direct sand (SLS-sand), RTV tooling, epoxy tooling, SLA tooling, sintered tooling and CNC Al tooling. The focus of the program was how to discriminate between the abilities of different technologies to suit the targeted application. His selection criteria contained eleven attributes: compliance to an office environment, high build speed, low/no need of setup operations (e.g., construction of special tooling), low/no need of secondary treatment (post-processing) on prototypes, availability of either functional or high-strength materials, good dimensional and geometric accuracy, good surface finish (possibly after post-processing), economical processing of large/massive geometries, low cost of material, low cost of system usage and low/no cost of setup (e.g., special tooling). The interface of the program is one screen (Figure 10). The input data are: selecting category, response time, quantity and undercuts as dependent choices that the user should select from the available choices. Additionally, overall part size (in mm), average part thickness (in mm) and detail size (in mm) as further Independent choices. The program's output will appear on the screen showing: on the left side the final comparison of the alternatives in chart form, and on the right side, also in chart form, showing the percentage of all the technologies with all the required factors.

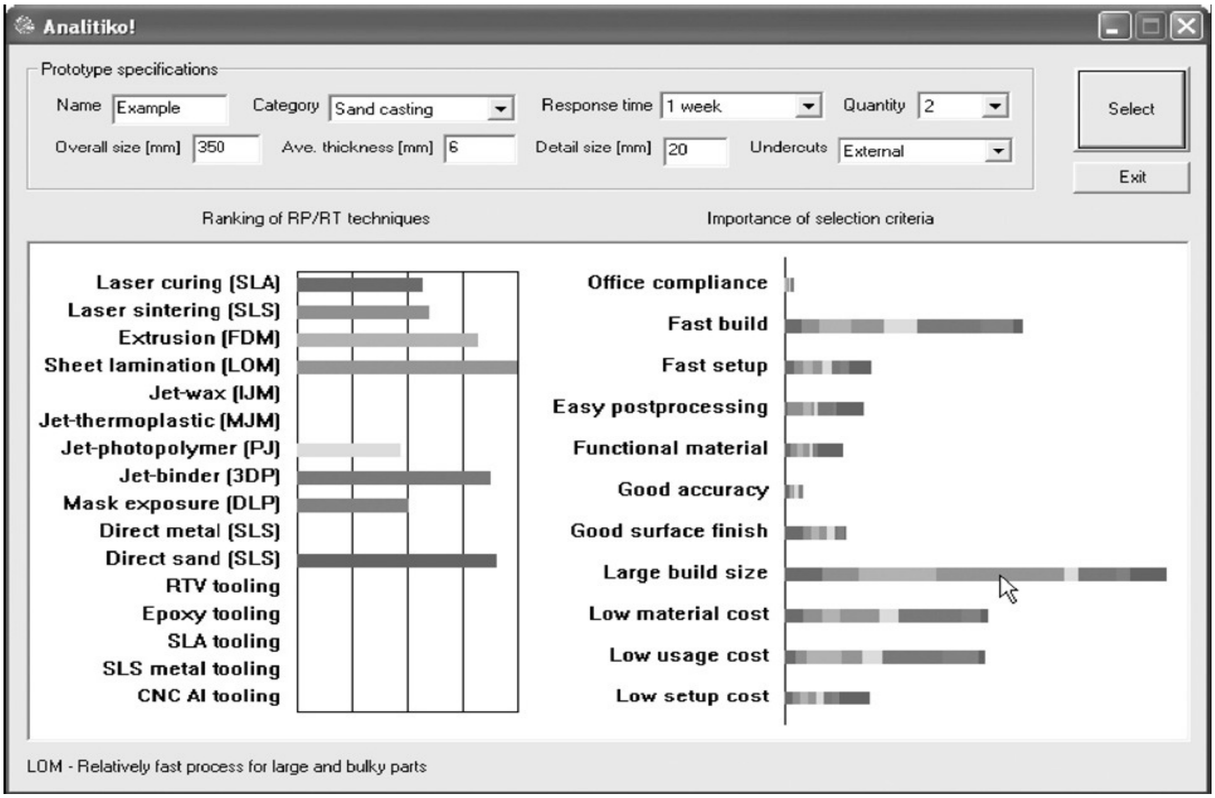

Figure 17 The interface of Antonio's program [41]

All the previous computer programs have their own advantages and disadvantages. The weak points of these computer programs are:

I- Some of them do not offer any information about AM technologies to present them to users who need training before they use them.

II- They did not try to inspire people to start using AM technologies by informing them about the benefits and applications of AM.

III- They are not adequately focused on the educational sector.

IV- Some of them are not promoting the new applications of AM (RT and RM).

V- Some are not user-friendly as it is clear from their user interfaces.

VI- There is no commercial program available.

VII- They do not contain sufficient information about all the current technologies and systems.

VIII- They do not use drawings, photos, figures and videos to elaborate the value of AM technologies and their applications.

IX- Require a lot of knowledge.

Table 4 shows a comparison matrix between the previous programs and this program:

Table 4 Comparison table

	Armillotta	Muller	Phillipson	Campbell	Bibb	Byaun	Venkata	Masood	Wilson	Shames
User interface	3	3	3	3	3	1	1	1	3	3
Result pages	1	3	3	3	3	1	1	2	3	3
Including all AM systems	0	1	1	1	1	1	1	2	1	3
Offering background	0	2	0	0	0	0	0	0	0	3
Dealing with all AM applications	N	N	N	N	N	N	N	N	N	Y
Targeting the educational sector	N	Y	Y	Y	Y	N	N	Y	N	Y
Targeting the industrial sector	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Inspiring information	0	2	0	0	0	0	0	0	0	3
Using drawings, photos and figures	0	0	0	0	0	0	0	0	0	3

(3) Means: very good or strong.

(2) Means: good or medium.

(1) Means: bad or low.

(0) Means: no value.

(Y) Means: yes.

(N) Means: no.

3. Development of the selection program for additive manufacturing systems

3.1 Introduction

The development of a computer program is a process of designing the architecture of the program, designing and developing the user interface, writing and testing the code and finally maintaining the code.

The development of this program starts with designing the main tree structure and its branches. This stage shows the information flow of the program and gives a clear idea of the components of the program and its inputs and outputs.

Secondly, collating the most up-to-date information about all the commercially available AM systems. This takes a considerable amount of work and time because it requires reading and learning everything about all the AM technologies such as: advantages and disadvantages, all the information about the systems and the system producers. The main objective of this program is to save money and time and make the information, collected at this stage, available in a user-friendly manner.

The next stage would be to design and develop the user interface. In this stage, designing and developing the proper user interface is essential for the success of the program. The user should be able to easily and effectively use the program to get the results that he needs.

The final stage is the program build - coding, testing and maintaining. Coding the program is required to enable the user-interface to be effective. Testing is required to ensure the program is effective under different conditions to confirm the success of the code.

3.2 Development of the program tree structures

The program is designed to be user-friendly and requires no background in AM and no input data from the user. To achieve that, the program has two main sections: learning section and selecting section (Figure 18).

The learning section will aid the user to learn about AM and about the main facts relating to these technologies. This section introduces the user to AM technologies, promoting and encouraging AM non-users to take an interest in these technologies (Figure 19).

The selecting section leads the user through a selection process. The selection process starts by selecting one of the two main groups from the main screen which are: general selection and detailed selection. The factors available in the selection process are: AM applications, process material, AM technology, system dimensions, system price and finally the dimensions of the produced part (Figure 23).

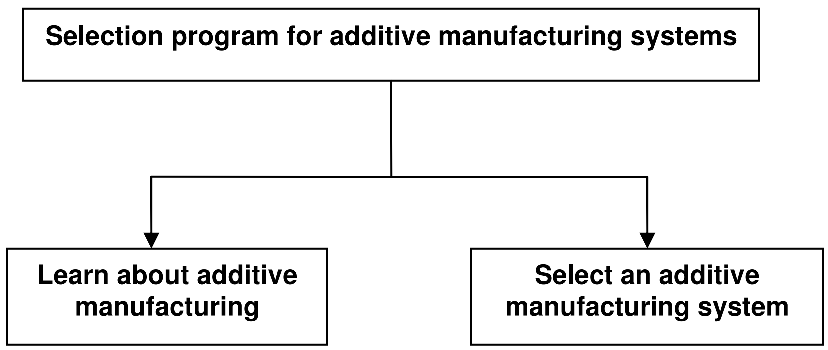

Figure 18 The main tree structure of the program.

3.2.1 The learning section of the program

As mentioned before, effort and time is required in order to learn about AM. Reading books, scientific papers and browsing on the internet is not an easy process to encourage people to learn about AM, especially for those who are not aware of the technologies and therefore do not have the motivation to put in such effort. Making use of the learning section of the program will introduce condensed information that is summarised from different information sources. This information will be supported by photos, drawings and video files to illustrate and deliver a clear understanding of AM. (see Appendix A).

The learning section of this program is based on a question and answer manner and divided into two main categories: informing part and attracting part. The informing part introduces AM to the user by answering the question of what is AM. The attracting part attempts to motivate and persuade the new users to use AM technologies by providing answers for six questions. These questions are explained in section (3.2.1.2). Selecting any question will lead to a PowerPoint file that has the answer (Figure 19).

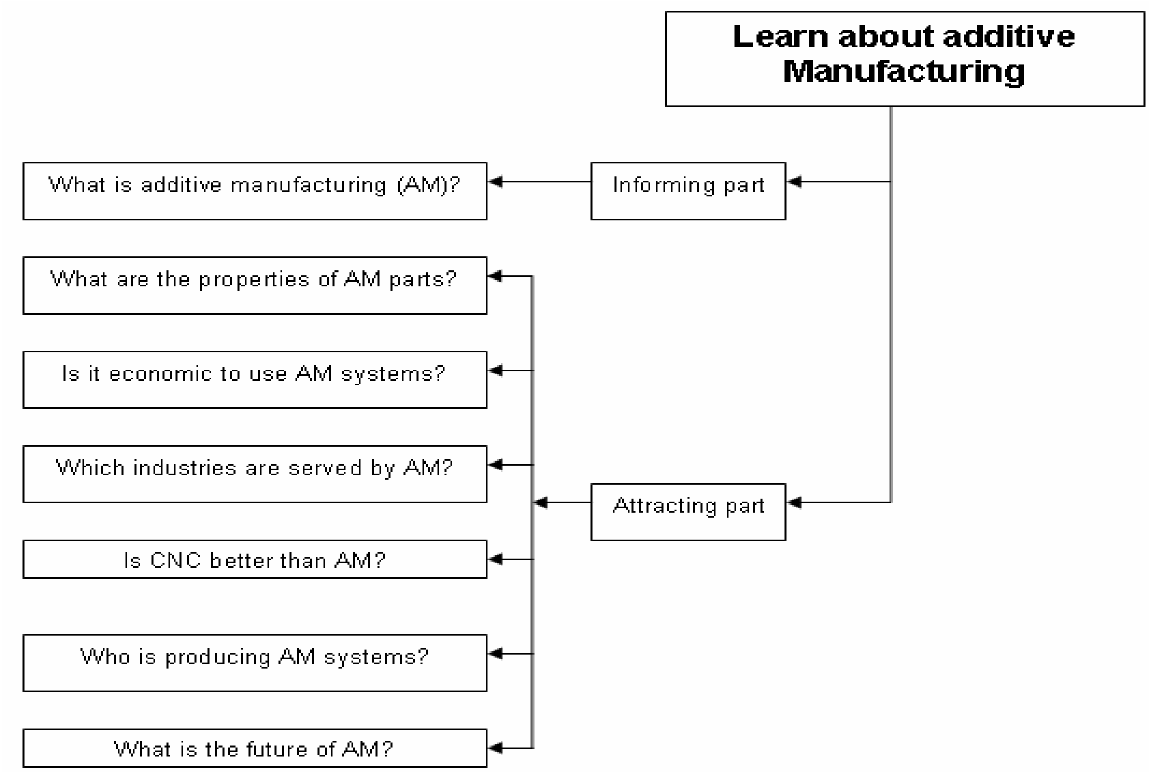

Figure 19 The tree structure of the learning section of the program

3.2.1.1 The informing part of the program

Figure 20 shows the main information that the informing part has. This part gives enough knowledge and background to the user. The informing part starts with the definition of AM, and then explains the principles of AM technologies. The need for AM has been dealt with in a subsequent part, after which, the main advantages of AM has been discussed. A historical background has also been included with an explanation about the main AM applications.

Figure 21 shows the five main steps of AM processes. Almost all AM technologies have the same steps, however, they differ in the last step which is the post-processing. Not all the parts produced by AM technologies need post-processing - it depends on the AM technology used.

Figure 22 is attached to Figure 21 to give more detail about each AM technology. The part of "additive manufacturing technology" contains the following: video about the technology, the raw materials used, the technology's applications, the advantages and disadvantages of the technology, the manufacturers of AM technology systems, an overview of the company with its contact information and the system names.

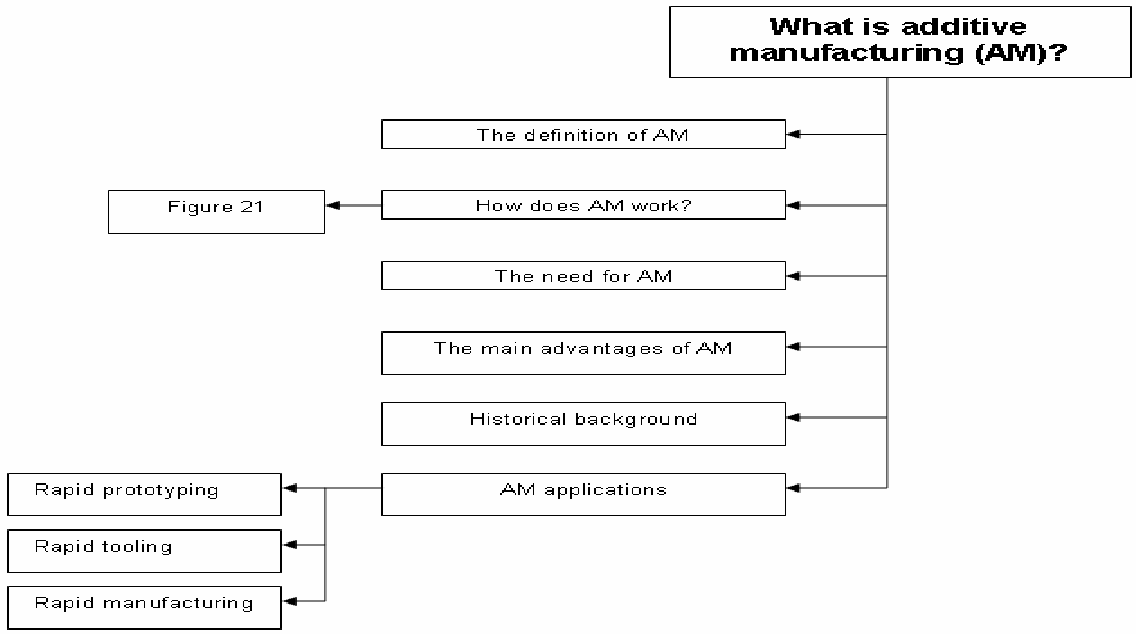

Figure 20 The tree structure of the informing part of the program

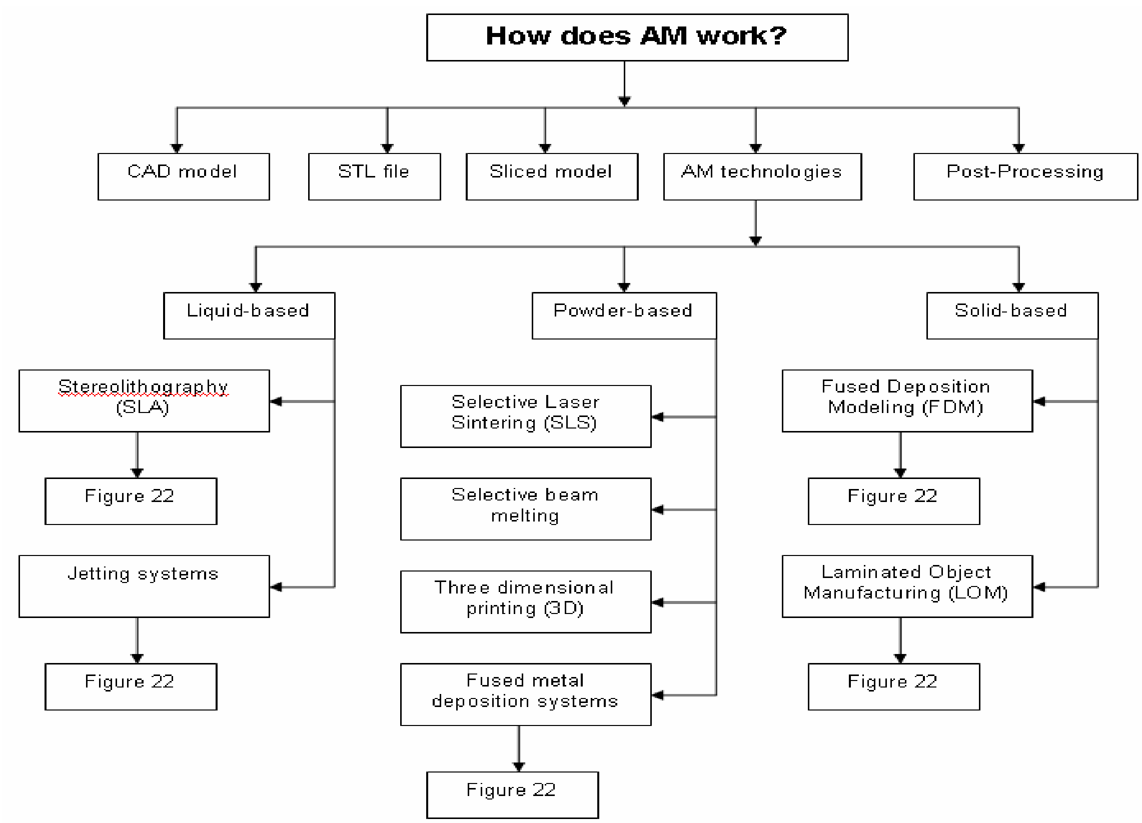

Figure 21 "How does AM work?" branch of the informing part tree structure

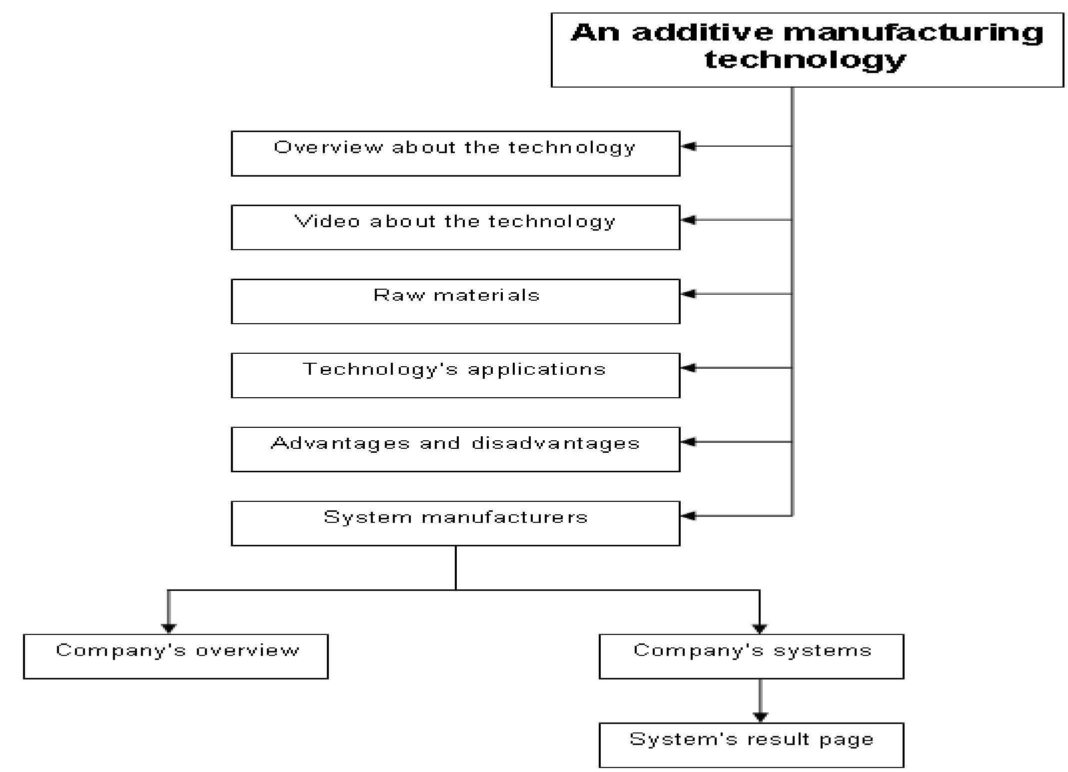

Figure 22 AM technology branch of "How does AM work?" tree structure

3.2.1.2 The attracting part of the program

"With the limited size of the rapid prototyping industry, there is not enough external motivation to dig in and learn the technology. And with the limited informational resources on the topic, there is little that sparks an internal motivation to become knowledgeable." [1]

The decision of employing AM technologies obviously depends on its reliability, cost, properties of produced parts, AM applications in industry and the future of these technologies. So, offering clear information about the previous factors will inspire the non-users to start using AM technologies and getting the benefits of their different applications. The attracting part of the program is explained through the following questions:

<u>What are the properties of AM parts?</u>

The properties of AM parts are quite different from the properties of conventional manufacturing process parts. The difference does not depend purely on the raw material used but also on the means of assessing the parts. The three main properties will be discussed in this part, i.e. surface roughness, dimensional accuracy and mechanical capability.

<u>Is it economic to use AM systems?</u>

This part contains an overview about the economic feasibility of AM systems. An overview regarding: the industry growth, revenue growth and comparative costs between rapid manufacturing and injection moulding have been discussed in this part.

<u>Which industries are served by AM?</u>

This part shows examples where AM currently serves different industries. The examples of these industries are: medical, jewellery, military and defence, consumable products, automotive and aerospace.

<u>Is CNC better than AM?</u>

As CNC is the most common used computer aid manufacturing technology today, the comparison between CNC and AM is essential for new users to know when to use CNC alone or to combine with AM or alternatively use AM alone.

<u>Who is producing AM systems?</u>

This part contains information about the producers of AM systems and their locations. This part will assist the new user to choose a company they might prefer for different reasons.

<u>What is the future of AM?</u>

The dramatic improvements of AM technologies and materials have resulted in improved applications for rapid prototyping in the design phase, to rapid tooling for the design phase and low-volume production and finally to rapid manufacturing as a final product phase. Knowing about the future of AM will guide the user to invest in the proper AM system that suits his future needs.

3.2.2 The selecting section of the program

The selecting section of the program is divided into two categories. The first category is the general selection category that depends on the general applications of the AM technologies which are Rapid Prototyping, Rapid Tooling and Rapid Manufacturing (Figure 24). The second category is the detailed selection category. The detailed selection category uses the applications of Rapid Prototyping (Figure 25), Rapid Tooling (Figure 26) and Rapid Manufacturing (Figure 27) as their main selection factors. The detailed selection category serves more precise choices.

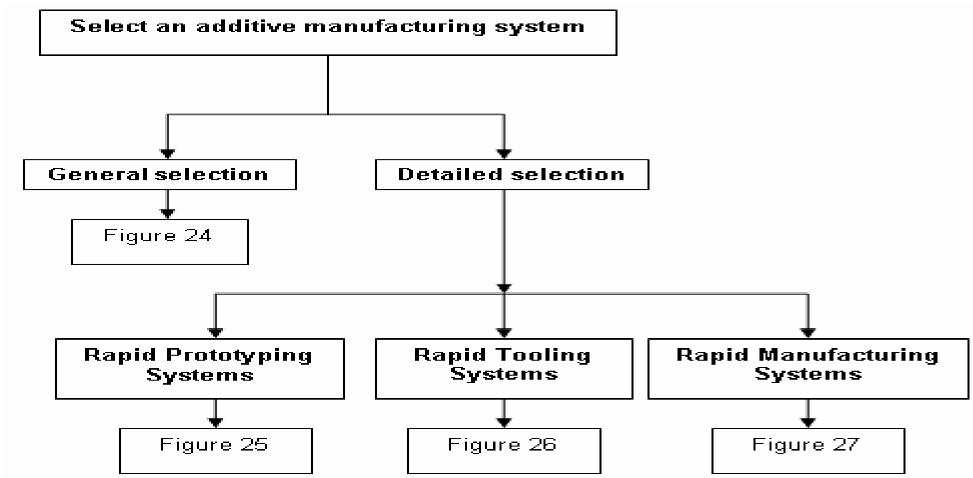

Figure 23 The tree structure of the selecting section

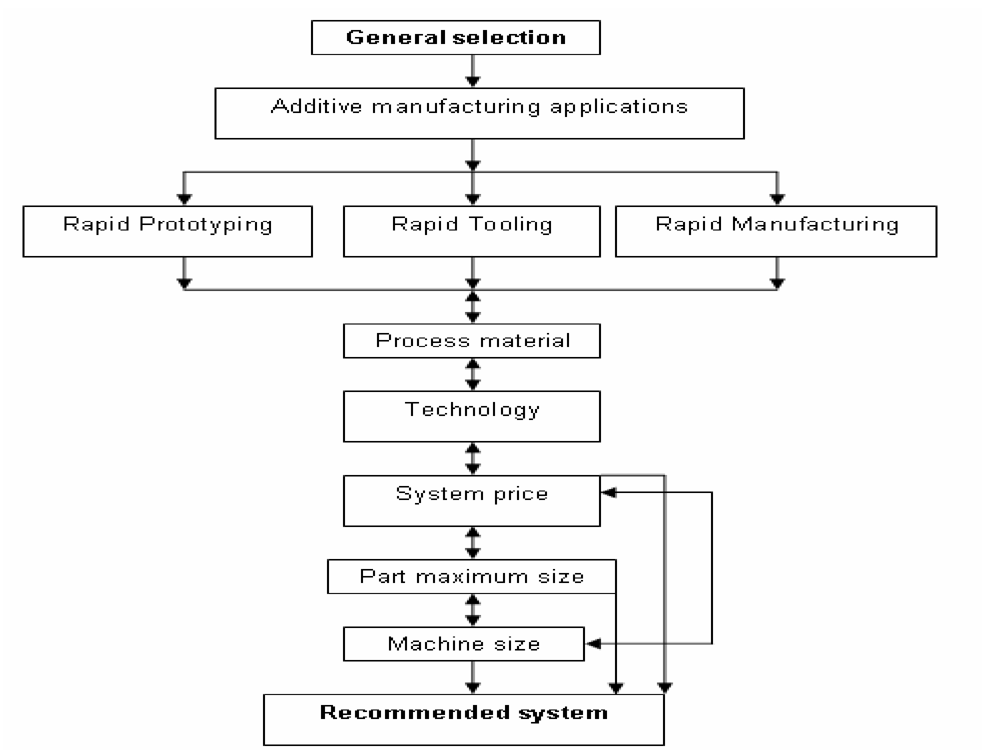

Figure 24 The general selection branch of the selecting section tree structure

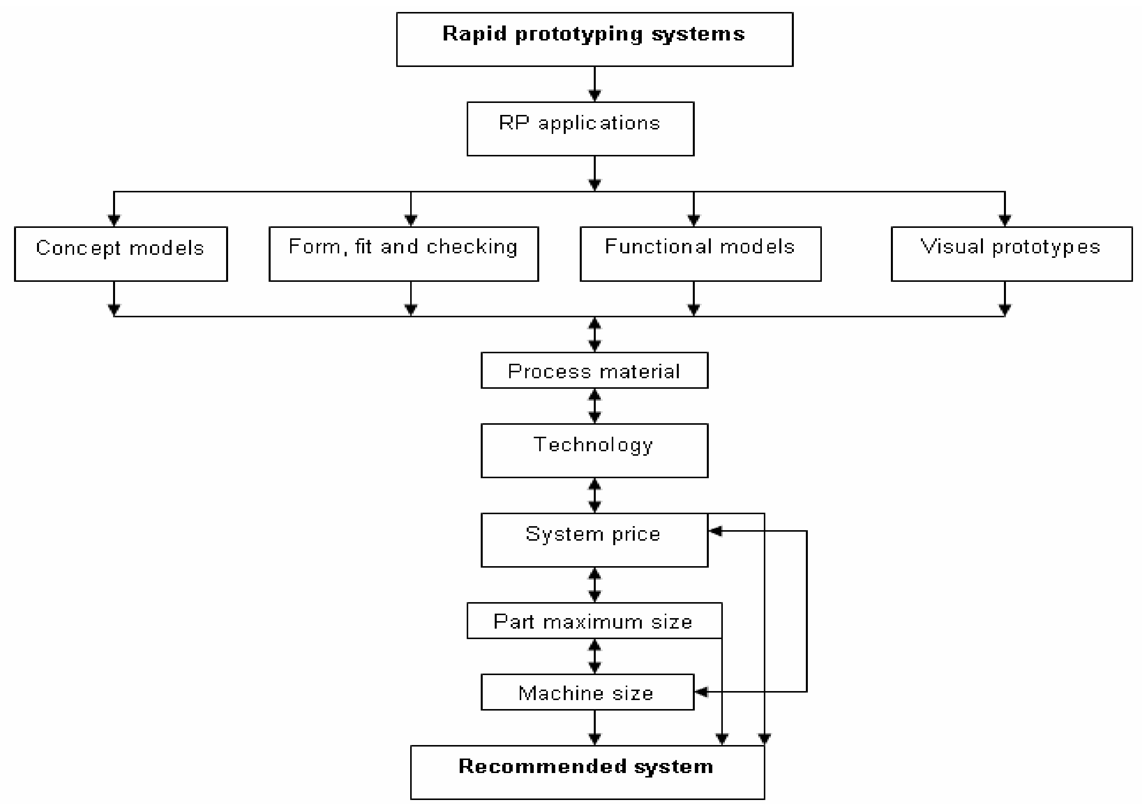

Figure 25 The RP systems branch of the selecting section tree structure

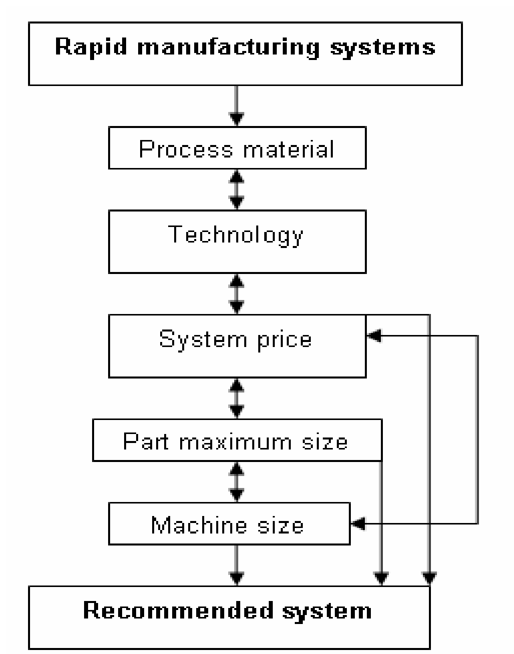

Figure 26 The RM systems branch of the selecting section tree structure

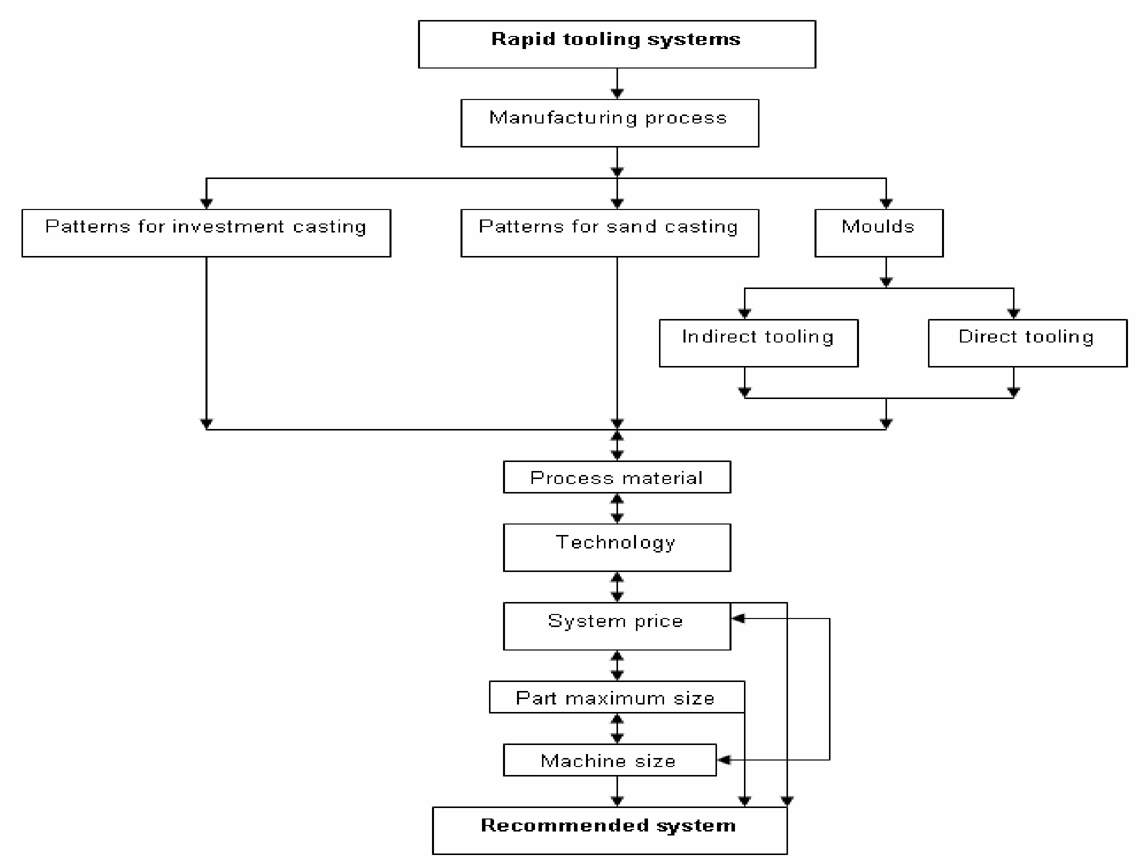

Figure 27 The RT systems branch of the selecting section tree structure

3.3 Collecting the up-to-date information about all the commercially available AM technologies and systems

An essential source of information about AM technologies and systems is the internet. Very few text books and scientific papers have up-to-date information about AM. Almost more than 1000 PDF files about AM systems are available on the internet [49-101] and have been collated with the relevant text books. That is why this step of collecting the up-to-date information literally took months - to read, understand and summarize. The main problems faced were:

1. The lack of the up-to-date information.

The best source of information about AM is Wohlers report, which is an annual report that covers all the new facts about AM. This book alone does not have all the required information about all the different AM technologies and systems. Moreover, there are just too few new articles about the state of the art of AM which makes the learning process about AM a real effort taking much time and energy.

2. The confusion between different words when describing the AM.

Just this year it has been agreed that additive manufacturing is the name that encompasses all manufacturing methods produces parts layer by layer. Before this year, names like: rapid prototyping, free form manufacturing, additive fabrication and layer manufacturing were used to describe additive manufacturing. Other example is the confusion that happens when describing the applications of AM. RT and RM are used sometimes to describe AM technologies and sometimes RT used as an RM and RM as RT.

3. Most information available is not arranged in a logical and easily understood manner.

There is no source that offers sufficient information to any new user in a step-by-step manner. Most of the information sources confuse new users resulting in them feeling that the AM technologies are too difficult and they are incapable of dealing with it.

4. None existed of independently verified system specifications.

The available information about AM systems is based on the companies that produce the AM systems. The need for independent source of information is important because the companies normally make very optimistic statements.

Table 5 contains the systems used in this program which are established and developed by well known companies.

Table 5 Additive manufacturing systems that are used in the program

	Company	**System**	**Technology**	**Country**
1	3D systems	sintersation Pro 230	SLS	USA
2	……..	sintersation Pro 140	SLS	……..
3	……..	DM100	SLS	……..
4	……..	DM250	SLS	……..
5	……..	HiQ	SLS	……..
6	……..	HiQ +HS	SLS	……..
7	……..	Viper Pro RDM	SLA	……..

		1500XL		
8	……..	Viper Pro RDM 650M	SLA	……..
9	……..	Viper Pro RDM 750F	SLA	……..
10	……..	Viper Pro RDM 750H	SLA	USA
11	……..	Viper SLA	SLA	……..
12	Stratasys	FDM 200 mc	FDM	……..
13	……..	FDM 360 mc	FDM	……..
14	……..	FDM 400 mc	FDM	……..
15	………	FDM 900 mc	FDM	……..
16	Z corporation	spectrum Z510	3DP	……..
17	…………	Z printer 310 Plus	3DP	……..
18	……..	Z printer 450	3DP	……..
19	Solidscape	T612	Jetting systems	……..
20	……….	R66	Jetting systems	……..
21	………..	T76	Jetting systems	……..
22	POM	105D	DMD	……..
23	……..	44R	DMD	……..
24	……	66R	DMD	……..
25	Desktop factory	125ci	3DP	……..
26	cubic technologies	SD 300	LOM	……..
27	ProMetal	R1	3DP	……..
28	MCP	MCP Realizer M250	SLM	Germany
29	Concept	M1 Cusing	Laser Cusing	……..

30	…..	M2 Cusing	Laser Cusing	……..
31	…….	M3 linear	Laser Cusing	……..
32	EOS	EOSINT M 270	SLS	……..
33	……..	EOSINT P 780	SLS	Germany
34	……..	EOSINT P 700	SLS	……..
35	……..	EOSINT P 730	SLS	……..
36	……..	EOSINT S 750	SLS	……..
37	……..	FORMIGA P 100	SLS	……..
38	Voxeljet	VX 500	Jetting systems	……..
39	……..	VX 800	Jetting systems	……..
40	Envisiontec	Perfactory 3D-Bioplotter	Jetting systems	……..
41	……..	Perfactory SXGA standard UV with integrated ERM	Jetting systems	……..
42	……..	Perfactory SXGA standard Zoom with intergrated ERM	Jetting systems	……..
43	……..	Perfactory SXGA W/ERM Multi Lens	Jetting systems	……..
44	……..	PerfactoryXede	Jetting systems	……..
45	……..	PerfactoryXtreme	Jetting systems	……..
46	D-MEC	SCS-1000HD	SLS	Japan
47	……..	SCS 6000	SLS	……..
48	……..	SCS 8100	SLS	……..
49	……..	SCS 8100D	SLS	……..
50	Cmet	RM3000	SLA	……..
51	……..	RM6000	SLA	……..

52	……..	SCS 9000	SLS	……..
53	Kira corporation	KATANA	LOM	……..
54	Wuhan Binhu	HRPS IIA	SLS	China
55	……..	HRPS IIIA	SLS	China
56	……..	HRPS IV	SLS	……..
57	……..	HRP IIB	LOM	……..
58	……..	HRP IIIA	LOM	……..
59	……..	HRPL I	SLS	……..
60	……..	HRPL II	SLA	……..
61	……..	HRPL III	SLA	……..
62	Beijing longyuan	AFS 320	SLS	……..
63	……..	AFS 500	SLS	……..
64	Beijing Yinhua	AURO-350	SLA	……..
65	……..	MEM-450	FDM	……..
66	……..	MEM-320	FDM	……..
67	……..	PLCM-1200	3D	……..
68	shanighi union	RS4500	SLA	……..
69	……..	RS6000	SLA	……..
70	……..	RS3500	SLA	……..
71	Shaanxi Hengtong	SPS800	SLA	……..
72	……..	SPS600	SLA	……..
73	……..	SPS450	SLA	……..
74	……..	SPS350	SLA	……..
75	Guangzho Comac	HT-300	FDM	……..

76	……..	HT-400	FDM	……..
77	Trump	ELITE3500	SLS	……..
78	……..	ELITE5000	SLS	……..
79	Arcam	A2	EBM	Sweden
80	…….	S12	EBM	……..
81	fcubic	C50	Jetting systems	……..
82	……..	C300	Jetting systems	……..
83	Accufusion	LC 105	Laser Consolidation	CANADA
84	Phenix	RM 100	SLM	France
85	…….	RM 100 Dental	SLM	…….
86	………	RM 250	SLM	………..
87	Next factory	DigitalWax 010	SLA	Italy
88	…..	DigitalWax 010 Plus	SLA	……..
89	…..	DigitalWax 015	SLA	……
90	………	UltraViolet 020	SLA	…………
91	….	UltraViolet 025	SLA	………
92	….	DigitalWax 029	SLA	………
93	Menix	VLM 300	LOM	Korea
94	……..	VLM 400	LOM	………
95	Inss Tek	MX-3	Fused metal deposition	………
96	Objet	Connex500	Jetting systems	Israel
97	….	Eden250	Jetting systems	….
98	…….	Eden260	Jetting systems	….
99	….	Eden350	Jetting systems	…..
100	…..	Eden500V	Jetting systems	…..

3.4 Design and development of the user interface

It is essential for a computer program to have the right user interface. If the user of a program is not able to use it effectively, the program will be unsuccessful. Very clear and user-friendly interfaces have been designed to reach the objectives of this program. The program contains 6 main screens with PowerPoint files in the learning section. The main screens of the program are:

Welcome screen: It appears for 15 seconds before bringing up the program's main screen

On this screen appears the name of Stellenbosch University, the details of the Industrial Engineering Department and that of Rapid Product Development Labs as seen in Figure 28. The details of the name of the program, the name of the developer of the programs and his study leader's name also appear here. Three different logos are on the screen: on the upper left side there is the logo of the Department of Industrial Engineering, on the upper right side there is the logo of Stellenbosch University and in the middle of the page there is the logo of the Rapid Product Development Labs which is part of the Industrial Engineering Department, at Stellenbosch University, which is interested in AM and its applications. Clicking on the logo of the University, the Industrial Engineering Department and of Rapid Product Development Labs leads to their respective websites.

Figure 28 The welcoming page.

<u>The main screen:</u>

It has been mentioned previously that the main screen is divided into three sections. The first one is the learning section in the form of questions, the second section is the general selection section and the third one is the detailed selection section (Figure 29).

This screen also contains a "How to use the program?" button that leads the user to instructions needed to be followed to get the benefits of the program. On the upper left side there is a button that has the logo of the Rapid Product Development Labs.

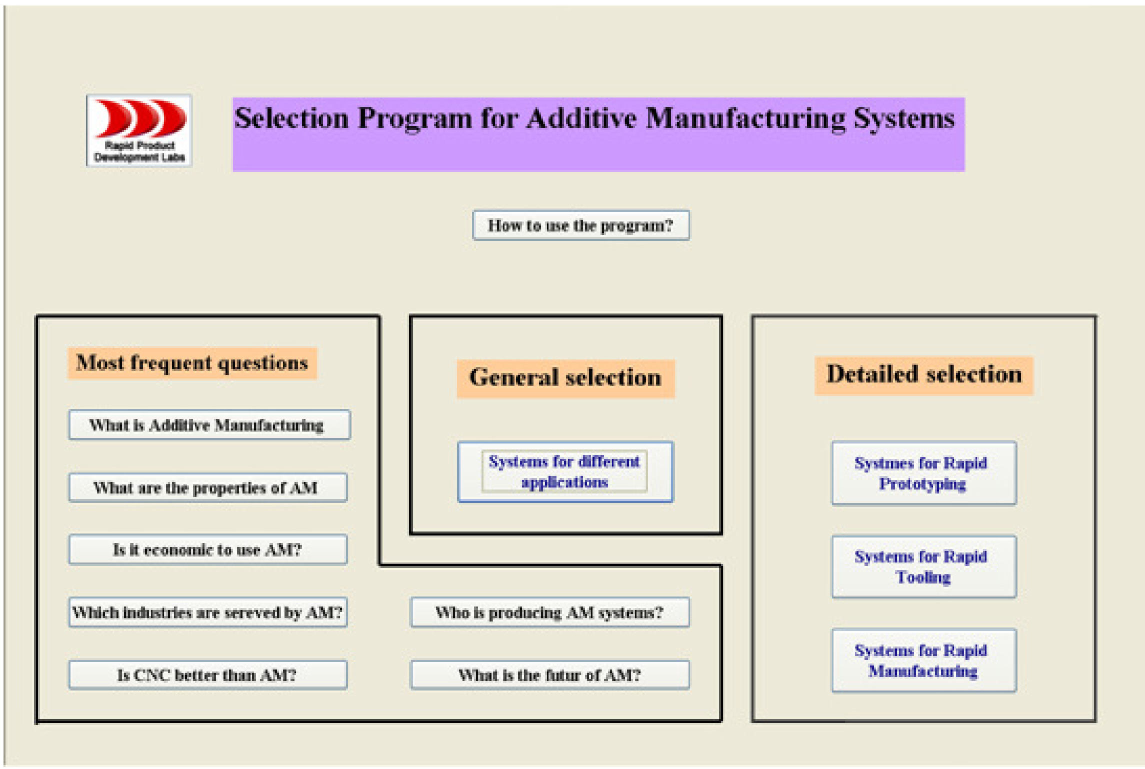

Figure 29 The program's main screen.

<u>Learn about AM</u>

As has been mentioned before, this part acts as the educational tool of the program. Clicking on any question button will lead to a PowerPoint file that has the answer in an understandable format.

For instance, selecting the link that explains AM technologies from "How does AM work?" in Figure 21 leads to the screen that appears in Figure 30. This Figure shows how AM technologies have been divided into three categories depending on the state of its raw material. Clicking on any AM technology process leads to the screen that appears in Figure 31. The AM technology screen that appears in Figure 37 has been designed to give sufficient background to the user about the most common AM technologies that are used commercially. This screen contains the information that has been discussed in Figure 22.

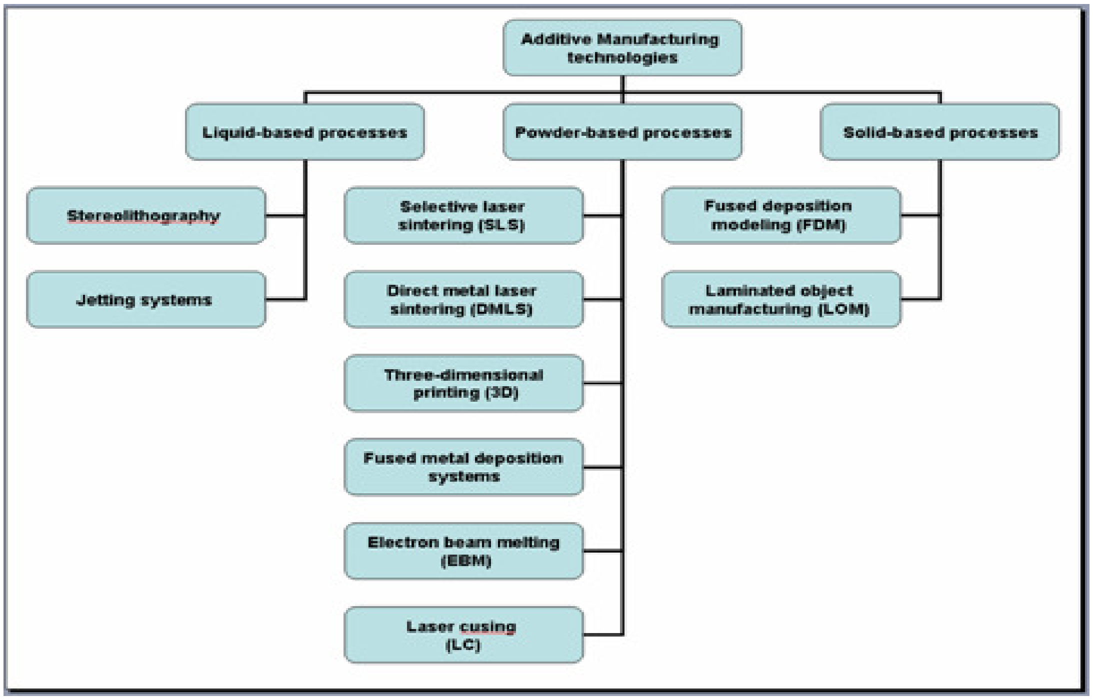

Figure 30 AM technologies screen.

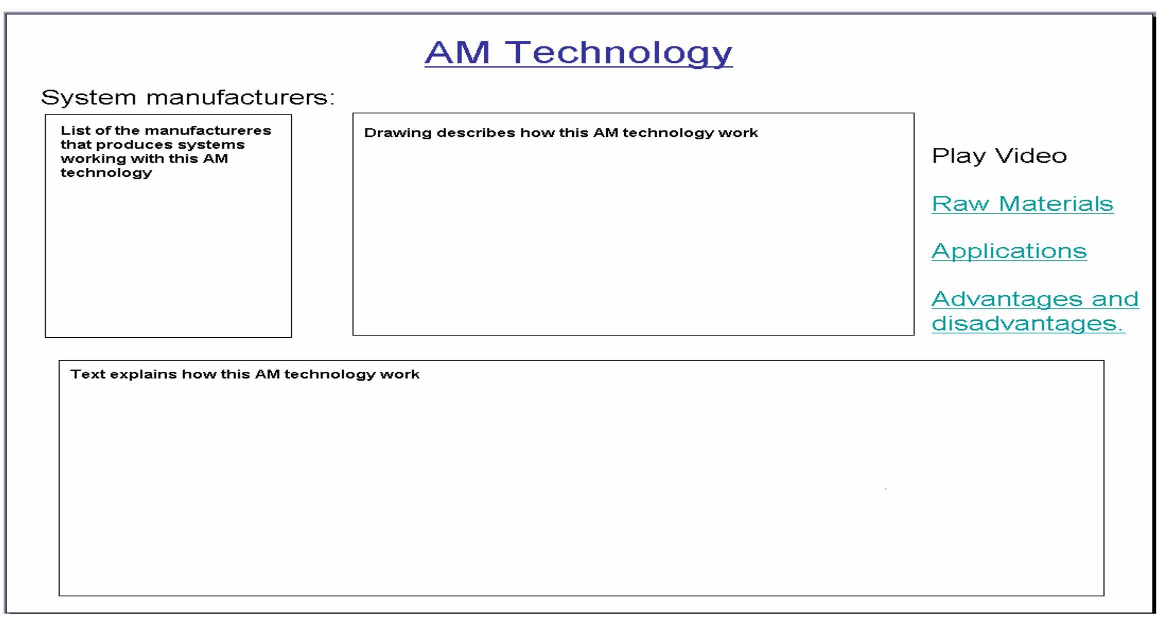

Figure 31 The screen that explains any AM technology.

<u>General selection screen</u>

As shown in Figure 32 there are different attributes used in this page which have been explained previously. Every attribute has a drop-down list of choices. To select a choice, click on the arrow on the right side of the box and a list will appear that contains all options.

When this screen appears, the only enabled combo box list that can be used is AM application - the others are disabled but these will become enabled as the process progresses step by step starting from the top to the bottom. After finishing the selection process, the recommend button will be enabled to allow the user to go to the result screen.

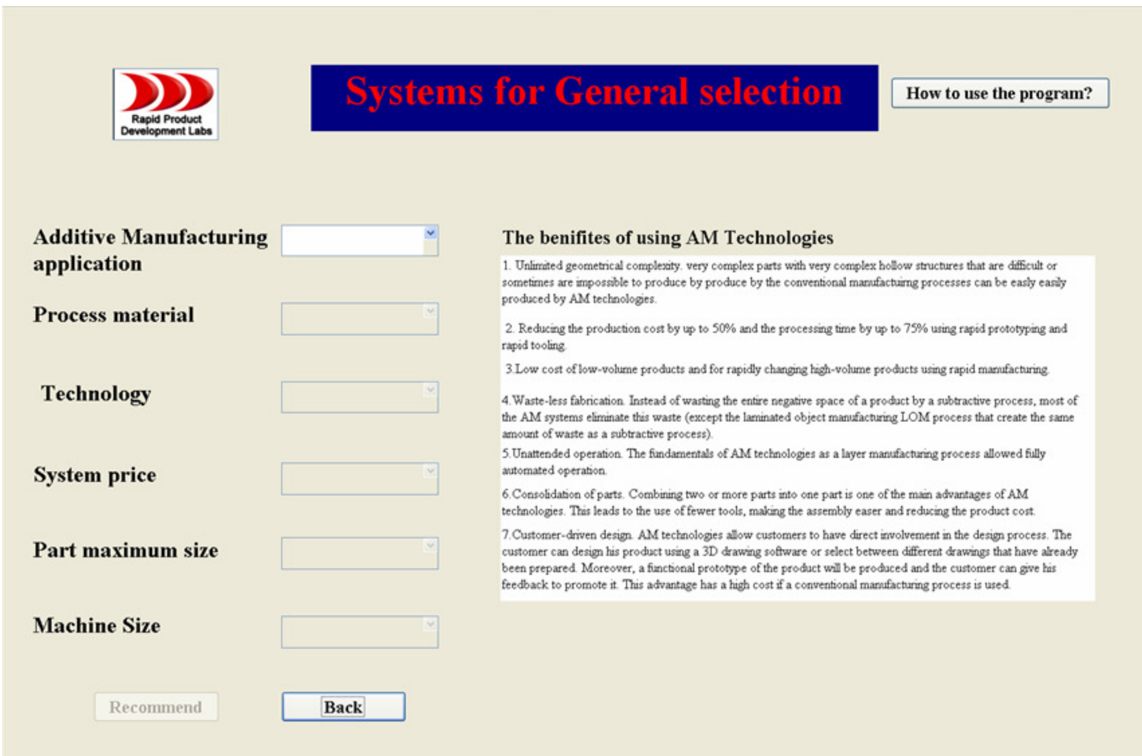

Figure 32 Systems for general selection screen.

<u>Rapid prototyping, rapid tooling and rapid manufacturing screens</u>

As shown in Figures (33, 34 and 35), these screens contain all the available commercial additive manufacturing systems in: rapid prototyping, rapid tooling and rapid manufacturing fields. It also provides a summarized text about the meaning of RP, RT or RM and shows some of their applications.

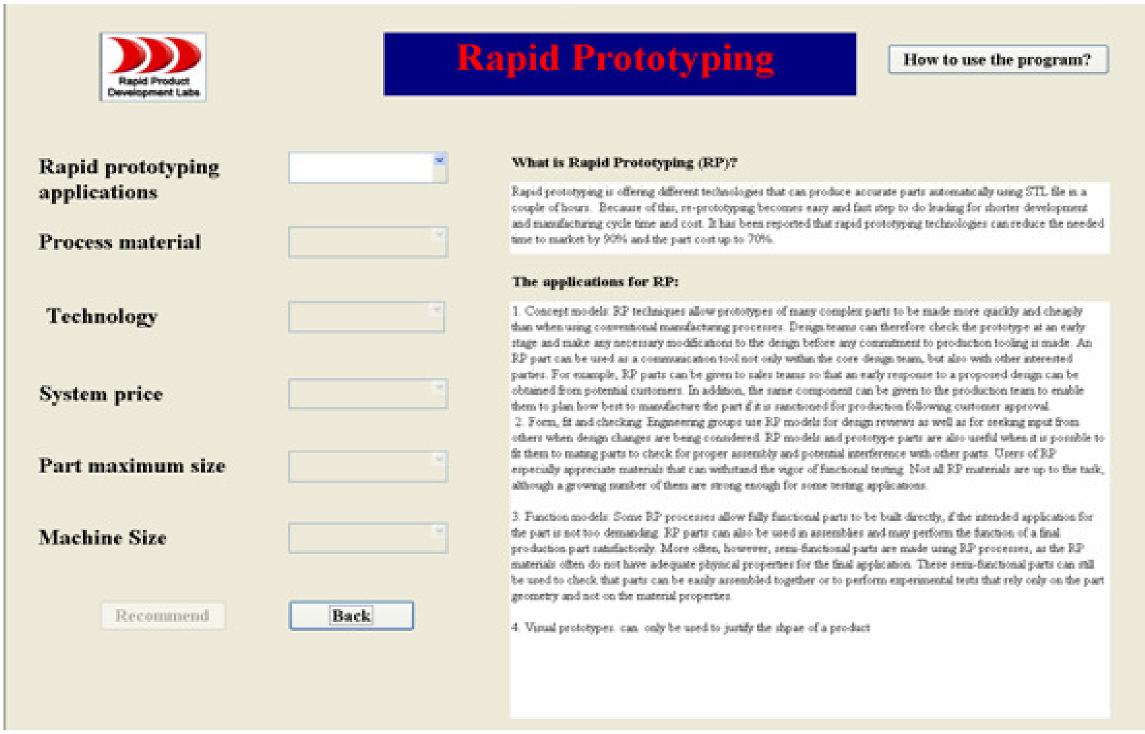

Figure 33 The screen of rapid prototyping system

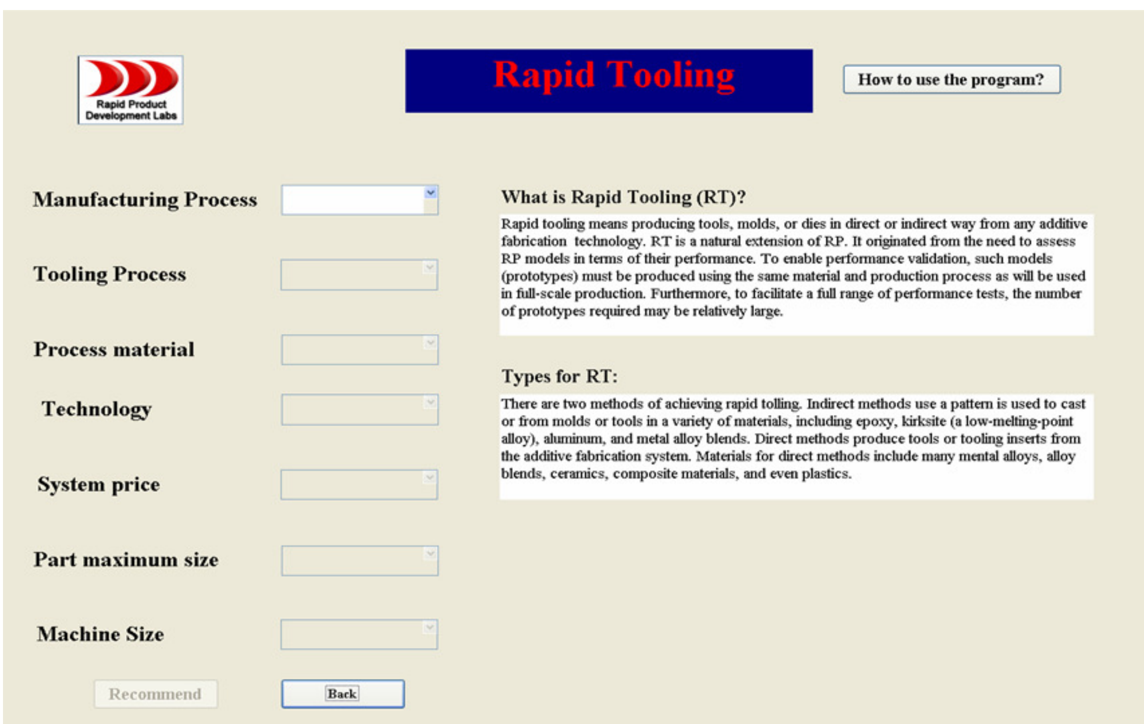

Figure 34 The screen of rapid tooling system

Figure 35 The screen of rapid manufacturing system

<u>The results page</u>

As shown in Figure 36, this page contains the name of the additive manufacturing technology used in the selected system, a “Back” button to go back to the previous page, other system components button which will lead to a page that contains any other needed components for the selected system and five main categories as following:

- System characteristics

Contains: system commercial name, the system’s price in US Dollars, building speed, the layer thickness, the machine’s weight in kg, machine type, the machine size (mm^3), the machine’s ability to produce final functional parts, the number of printing heads and other characteristics.

- Part characteristics

Contains: part maximum size in mm, part accuracy in mm, surface finish, the need of the part for pre or post-processing, tensile strength and elongation.

- Company characteristics

Contains: the company's name, the company's website address with all the contact information such as physical and mail address, with telephone and fax number.

- Raw materials characteristics

Contains: what the raw material is, its commercial name, the supplier(s) of the materials and the cost, if it is available.

- The system's applications

In this category there are two different buttons: one that will lead to any rapid manufacturing applications and the other one for rapid tooling applications.

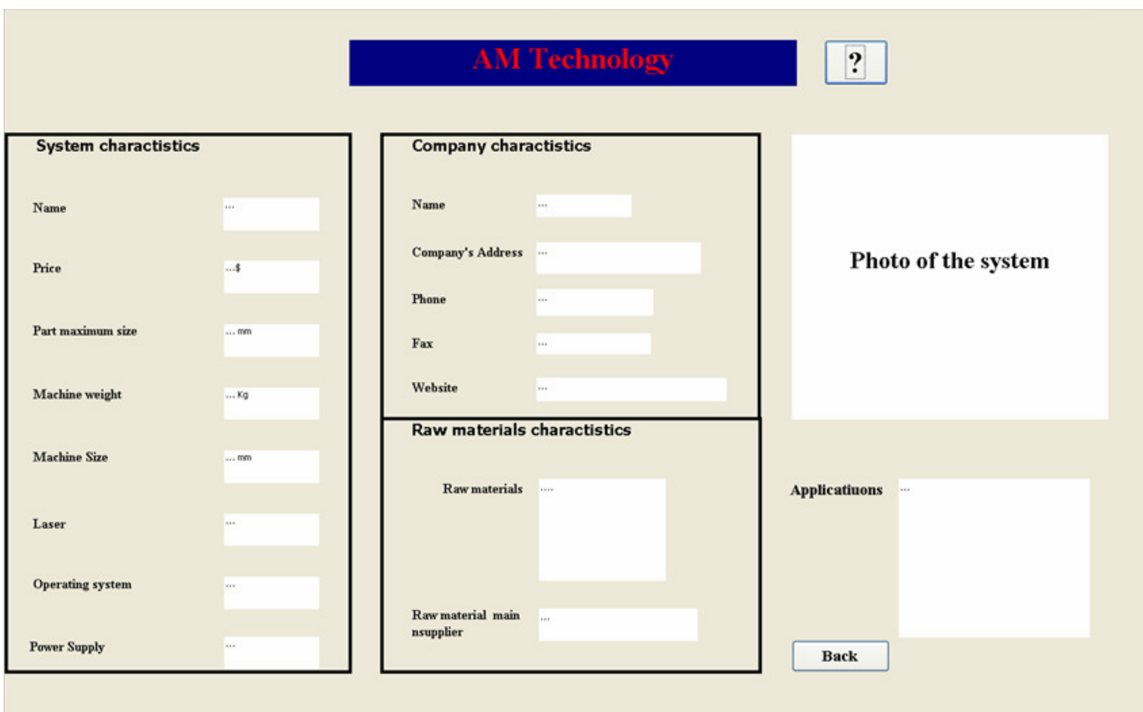

Figure 36 The general result page

For every system, there are specific results pages. In the program there are 100 stored result pages. Not all the result pages have exactly the same information because of the lack of relevant information, but they can be further developed.

3.5 Program coding, testing and maintaining

Coding is the process of analyzing the input data from a user and producing results. In this program, the code is divided into two main categories: coding that controls the user interface and coding that leads into the result screen.

Code that controls the user interface

This part of the program covers the code for any buttons that may be clicked on in any of the user interface screen. Moreover, controlling the appearance of the combo box lists from beginning to end of the four main selection screens and the sequence which selection decisions take the user from starting with only one enabled combo box at the top of the first screen will lead to immediate enablement of the other combo box lists employing more than 500 IF – THEN rules. After selecting from one of the three main selecting attributes, the recommend button will appear to allow the user to get into the result screen.

Code that controls the user interface covers the code for the question mark (?) buttons that delivers the required background information to the user and the “Back” button that returns the user to the previous screen.

Code analyzing the inputs and leads to the result screen

The code for viewing the result screen appears as a result of analysis of inputs. The result screen contains all the facts about the selected system at the click of the “Recommend” button.

No error messages or confidence factors have been used because the program does not use outside input data and it doesn’t compare between possibilities, it compares factual exact values. Testing of all possible scenarios has been done on the program and most of the mistakes have been corrected.

Appendix B has the Visual Basic code of the program.

4. User's guide

4.1 Introduction

The two objectives of this user's guide are:

1. To guide the user throughout the program. This step will ensure that the user will get all the benefits of the program, not just by showing how to deal with the interface of the program but even by suggesting a plan that should be followed before using the program.

2. To serve as a case study and example for a real University that need to select the most appropriate AM systems to fulfil its needs. This example tries to be a ready-to-use project to promote AL Fateh University in Libya by using AM systems.

4.2 Minimum and recommended requirements

The additive manufacturing system selection program has been designed to work within the Microsoft Access 2003 environment. It is recommended that at least Windows XP should be used to operate the program due to some Visual Basic requirements. The program has been tested on Windows XP and Windows Vista using Microsoft Access 2003 and Microsoft Access 2007.

A minimum resolution of 800x600 and a recommended resolution of 1024x768 or larger can be used to view forms. Other resolution values will not prevent the function of the program, but might cause problems with navigation. In the case that a specific resolution does not meet these requirements, it might be necessary to adjust the forms using software available on the market.

4.3 Setting up and installing the program

The program comes in a single, standard Access package (AFSSProgram.mdb). This 35 Mb file can be copied from any source to any hard drive and opened with MS Access (Figure 37).

Additional to the required MDB document, there will be an optional folder with videos and documents linked to the program. For example, videos describing the technology's principles are not stored in the program, only the LINK or PATH to the file. Therefore it's of great importance to make sure that all linked data remain available to the program. If the program is moved to a different computer, all linked data will be lost if it can't be accessed from the new destination. It's recommended all videos and linked files are stored in a single folder prior to linking it to a specific field in the program. The program will still function, but the 'optional' data will be lost and not displayed.

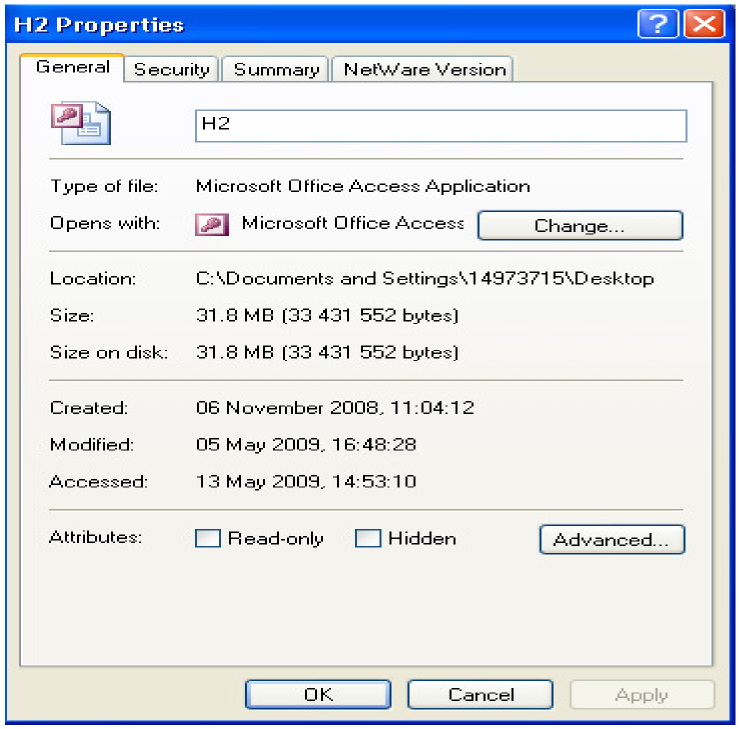

Figure 37 The general requirement of additive manufacturing system selection program.

4.4 Why use AM system in education

The lack of awareness associated with AM technologies differs from country to country, and from organization to organization, worldwide. In the increasingly competitive world we live in today, not using AM technologies means that the educational or industrial organization efficiency is increasingly lagging behind. To make use of these technologies in industry, highly skilled people are needed. To prepare such skilled people, involving these technologies with education is essential. To effectively use AM technologies, having sufficient knowledge about them is vital. Employing the additive manufacturing technologies in the educational sector would ensure the following benefits:

1. Training highly skilled manpower: Students that have studied AM courses will be much better prepared and able to use these technologies when they enter industry. Having the

knowledge of how to apply AM has now become essential in most engineering design and manufacturing applications.

2. Continually providing students with the state of the art in industry.

3. Creating technology transfer of AM technologies and establishing new industries: the educational sector will provide the industrial sector with trained engineers, designers, scientists and managers.

4. Guaranteeing the competitiveness of the industrial and educational sectors.

5. Improving the existing AM technologies and establishing new ones.

Many universities, worldwide, have developed and now offer courses about AM technologies as part of their curriculum. Moreover, they have enabled their students to use these technologies practically by purchasing AM systems and using them in their laboratories (see Appendix C).

In Africa, the first country that used AM was South Africa. Various educational institutions now use these technologies: the Centre for Rapid Prototyping and Manufacturing (CRPM) at Central University of Technology in Free State, the Advanced Manufacturing Technology Laboratory (AMTL) at Cape Peninsula University of Technology (CPUT) and the Rapid Product Development Laboratories (RPD Labs) at Stellenbosch University. RPD Labs unit functions as one of the branches within the Global Competitiveness Centre in Engineering (GCC), to fulfil its purpose and meet the needs of both industry and students. The GCC operates within the Department of Industrial Engineering at the engineering faculty of Stellenbosch University as a Centre for applied research and technology transfer, promoting and facilitating competitiveness of the SA industry.

Further examples are: in North America, several universities have already developed courses related to AM. For instance, Missouri-Rolla has developed a rapid product design course, Georgia Institute of Technology has developed rapid prototyping in engineering, and other universities are offering a one or two semester elective on AM. The University of Waterloo in Canada has a rapid prototyping lab, where focus is on the medical and microsystems applications of AM technologies [3]. In Europe, AM courses are being offered at several universities. For instance, De Monfort University in the UK is offering a Master of Science in rapid product development, and Cluj-Napoca Technical University in Romania is offering a postgraduate programme in rapid prototyping [3].

Colleges and universities have played an essential part in the development of AM technologies, including use in applications other than prototyping: some have created the foundation for many currently commercially successful systems. Many colleges and universities are pushing the limits of these technologies and continually supporting and furthering their growth. The educational sector will continue to play a significant role in AM technologies in the future.

4.5 How to select the proper AM system to suit specific needs

Before using the program there is a suggested plan which should be followed to get the maximum benefit from the program. Using the program without following this plan might mean that the objective of the program is not met. The suggested plan has the following steps:

1. Having enough background about AM technologies and their applications.

As mentioned previously, the program has an educational section which offers sufficient background information about AM technologies. In the case that the user already has enough background he can ignore this option and immediately move to the selection section.

2. Setting objectives for using AM technologies.

Before using new technologies, formalising the motivations and the objectives is an essential starting point. These motivations and objectives would differ between the educational sector and the industrial sector.

- In industry, every manufacturer has its own goals and plans for development and promotion. The manufacturer can make use of one or more AM systems to suit his needs. Alternatively, he can use one of the businesses which offer AM services (service bureaus).

- In the case of education, having clear objectives would save money and would earn more funds for the educational organization. Using AM technologies in an educational organization would be for various reasons and with different objectives:

- Using AM systems to teach the students about the technologies and undertake research on the applications of the technology. This should be the minimum objective for any university - to offer education about any new technology in order for the students to have first hand experience of such technologies. Course(s) encompassing AM technologies should be

established, if they are not already offered. The absence of education about AM technologies would render any AM system useless and eradicate the need for such systems.
- The university can work as a service provider for other educational organizations in order to provide education in AM technologies. This would satisfy the first objective of this study. This would create an additional income for the university.

- The university can offer training for the industry sector, satisfying the first two objectives of this study. This would create a further income for the university.

When taking cost into account with objectives the first choice would be a low cost system which would be suitable for mostly non-functional prototypes. The second choice would be a more expensive system which would be suitable for rapid prototyping and rapid tooling. The final choice would be the more advanced and obviously more expensive systems which would be suited for rapid manufacturing applications.

3. Being ready to adapt AM technologies

To know if the organization is ready to adapt AM systems there are some instructions to help make such a decision:

a. Having the proper staff to deal with such technologies

Highly trained staff need to be used to get the full benefit of these technologies.

b. Having a suitable space and environment to locate the system(s)

The location that will house the system should be identified and ascertained whether its environment is suitable for the system.

c. Having the proper hardware and software to deal with AM technologies

Some of AM systems have their own computers and software, others do not. The requirements for each system need to be established, e.g. a university might just need to upgrade their computers and software, which they need to identify. In other instances new equipment and software will need to be purchased.

4. Dealing with the right vendor

It is essential to deal with the proper vender when it comes to AM systems. Things to take into consideration are: maintenance, training and reliability are very important. To select the proper vendor there are a few points which need to be taken into account:

a) The training offered with the system and the cost thereof, if any.

b) Whether the vendor would supply the relevant hardware, software and raw materials.

c) Do they offer guarantees, warranties, regular maintenance visits or upgrades.

d) The vendor reputation.

f) The financial stability of the vendor.

e) The vendor should offer high quality service and support.

5. Selecting systems that would suit individual needs

Making use of the selection part of the program will assist the user in making the most educated decision about their required system(s).

6. Contacting the producers or the service agents of the systems

Producers or service agents of the systems would be able to provide other important information in relation with system selection such as training costs, delivery costs, installation cost…etc. In the case of selecting more than one system they will be able to provide you with comparisons between the selected systems.

7. Calculating the total cost of different systems to compare between them

Cost is always important and selecting the best, most economic system is always the objective of any AM systems user. It is important to ensure that all extras are taken into account in this process.

8. Repeating the selection process

The repetition of the selection process is one of the main advantages of this program; it takes little time to repeat the whole selection process taking other selection factors into account.

9. When the program is not sufficient to be used?

Current users of AM and the experts in the field would not need to use the learning section of the program. The selection section of the program (database of systems and their criteria) can be used by both non-expert and expert people in the AM filed. In some cases when having to compare very expensive systems or the capabilities of different systems to produce a specific part, benchmarking studies will be the most efficient if not the only way to assist in making the decision.

4.6 How to use the program

4.6.1 How to use the learning section of the program

As discussed previously, clicking on any button in the learning section of the program leads to PowerPoint files that contain the relevant information. These PowerPoint files have been designed to be user-friendly and every file can be a presented on its own. Therefore, the learning section of the program can be used separately as a learning tool.

4.6.2 How to use the selecting section of the program

This program enables the users to select between data that has been input into the program. This data has been arranged in a list format. The steps to select an AM system in the general selection part of the program are:

- Selecting the applications that relate to the relevant part.
- Selecting the raw material of the produced part.
- Selecting the preferred technology to produce the part.
- Now the three other lists (system price, part maximum size and machine size) will appear and will be enabled to be used. Using one of the above three lists to select the part will immediately show the relevant information on the other two lists. For instance, in the case of using the system price list, once one is selected, the part maximum size and the

machine size will appear in the other two lists but will be disabled. The "Recommend" button will be enabled on the screen at this stage to allow the user to get to the final page.

- If the user changes his mind and wants to use one of the other two selecting lists, selecting the "none" choice on the used list will give the used list no value and will let the other two lists appear and enable them with no value inserted.

- If the selected value of one of the three selecting factors is the same as two or more systems, the list in question will be disabled and the other two lists will change to two new lists that contain the information about these systems. For example, if a selected system price of three systems is the same, the system price list will be disabled having that price value on, and the other two lists will change to new lists that have the part maximum size and the system size of the three systems ready to be selected from.

4.7 Case study (Selecting an additive manufacturing systems for Al Fateh University in Libya)

Al Fateh University is the largest and most important university in Libya. It is located in the capital Tripoli. This university provides undergraduate, graduate and post-graduate levels of study in most of the scientific fields. Al Fateh University was founded in 1957 with one faculty and few students - today there are 11 faculties and more than 25,000 students.

To install AM technologies at Al Fateh University will require a lot of effort. Arranging meetings with teaching staff and the faculty head of the engineering department, especially in mechanical and industrial engineering will prove difficult. In these meetings, AM technologies should be introduced in a professional manner and a trial copy of the program should be given to as many people as possible to inform them of the need for this training.

To have AM systems selected and installed at Al Fateh University, the previous discussed plan in section 4.3 needs to be followed:

1. Delivering concise information about AM technologies for the decision makers in the university.

Delivering the concise information about AM technologies to the decision makers in the engineering faculty and the department of industrial and mechanical engineering. This information will enable these decision makers to understand what AM technologies are? Why they need to deploy such technologies? And what the benefits of these technologies are?

The learning section of this program will play an essential role in delivering sufficient information about AM technologies. Clicking on the "What is AM technologies?" button in the main screen of the program as shown in Figure 29 will lead to a PowerPoint file as shown in Figure 38. This PowerPoint file will introduce AM technologies to the user.

Figure 38 The main page of what are AM technologies file

The main part of this file describes the different AM technologies (Figure 39). For example if stereolithography (SLA) technology is selected the following figure will be shown:

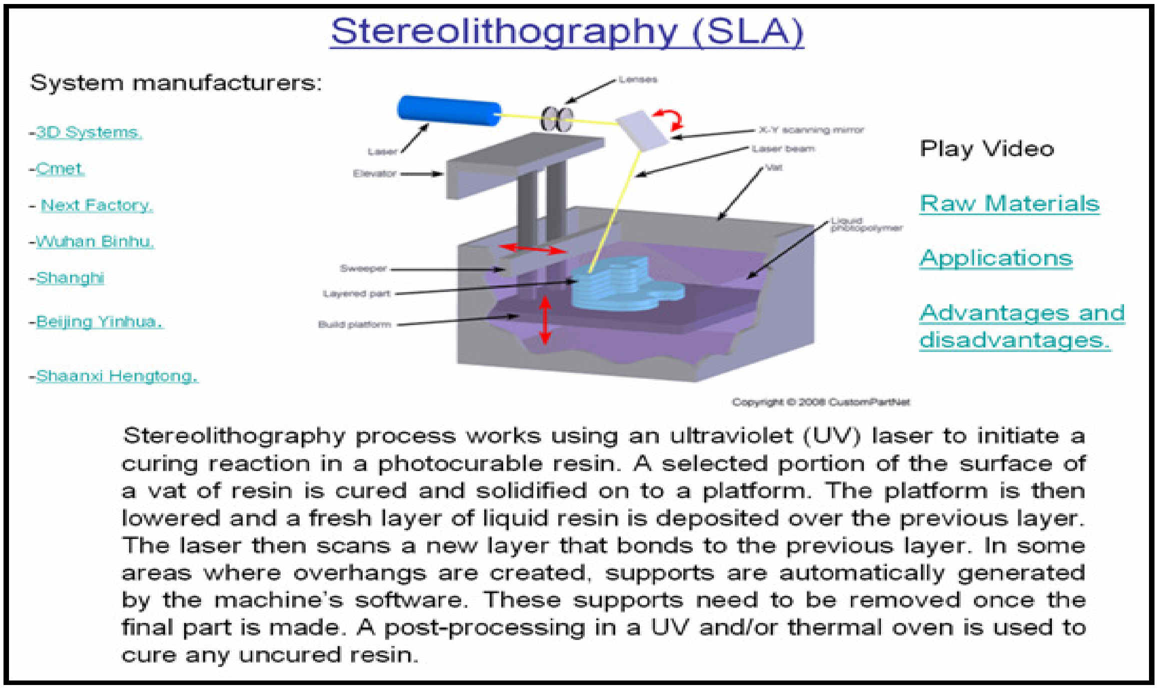

Figure 39 Stereolithography technology (SLA)

Pressing the (play video) link will lead to a video file that explains the principles of SLA technology. Pressing the (raw material) link leads to another page as shown in Figure 40.

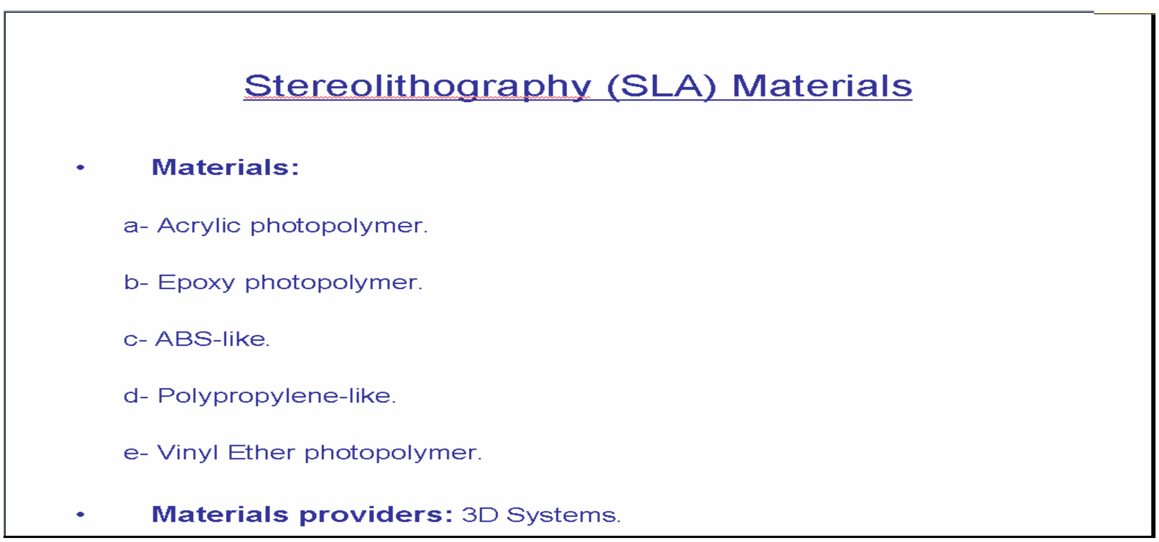

Figure 40 Stereolithography (SLA) materials

Pressing on the applications link leads to the screen on Figure 41, and pressing on the advantage/disadvantages link leads to the screen on Figure 42.

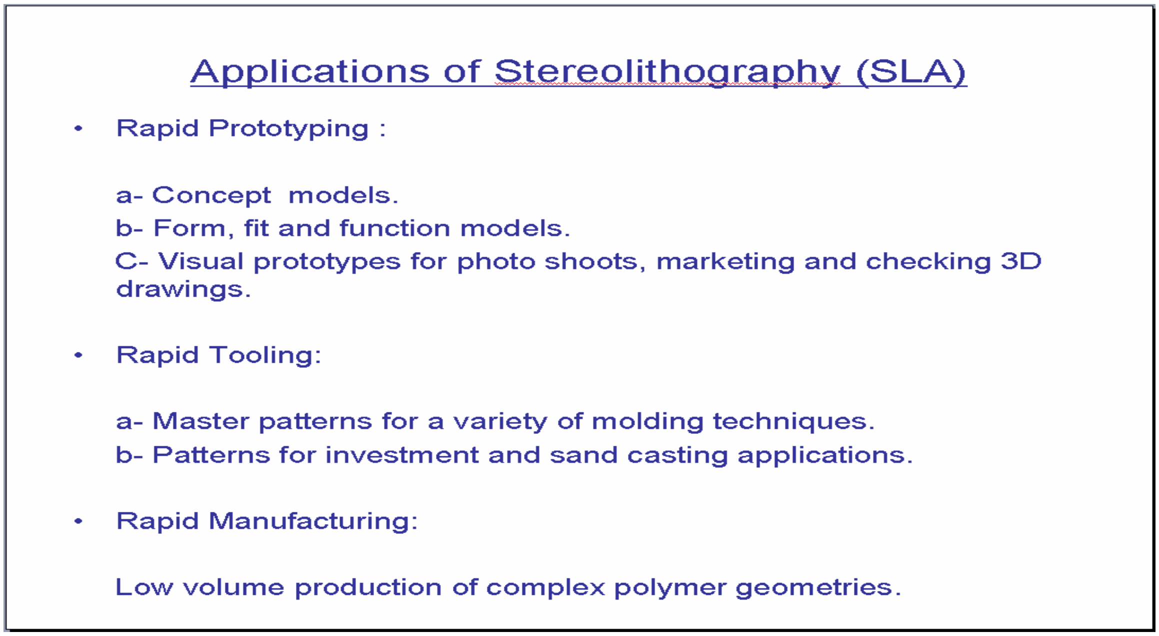

Figure 41 Applications of Stereolithography (SLA)

Figure 42 Stereolithography (SLA) advantages and disadvantages

Selecting any of the system manufacturers on the left side of Figure 43 leads to a screen that contains an overview about the company and the names of the systems that they produce. Figure 43 is an example of selecting the 3D Systems company link. Clicking on any of the names of the systems leads to the result page of the program that contains all available information about the system.

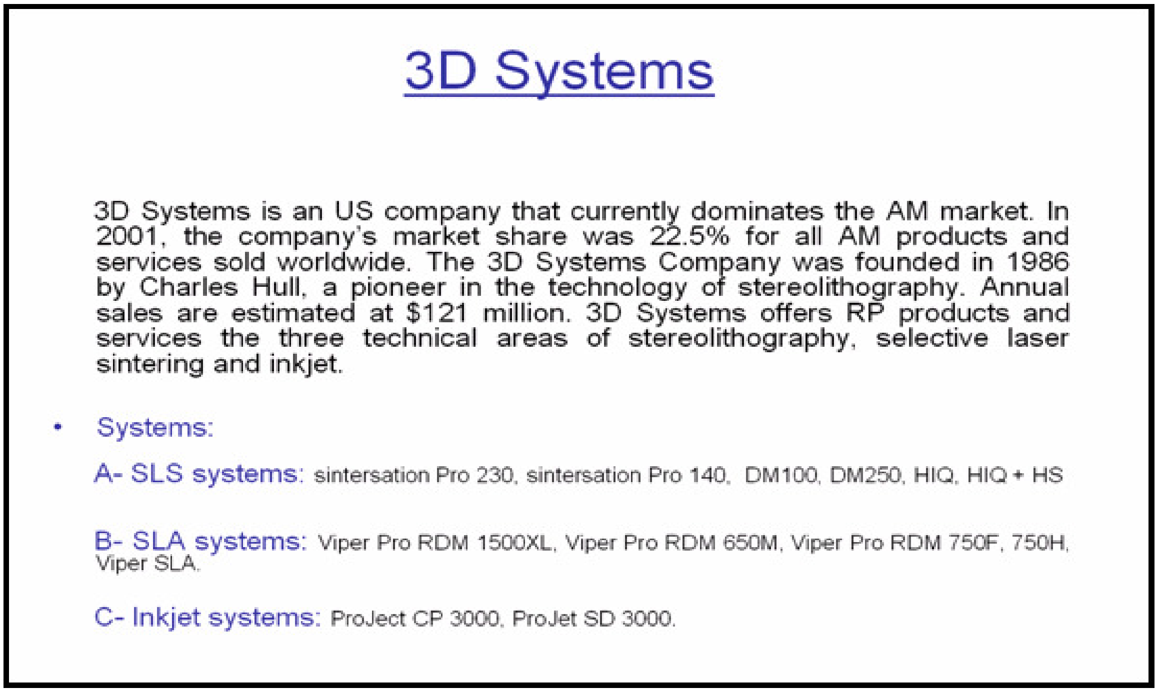

Figure 43 The screen of 3D Systems company

2. Setting objectives for using AM technologies at the University.

As there are no AM systems in the country, the best objective that the university should have is:

- To be the first educational organization that offers information about the AM technologies for the public in Libya.

- To act as a service agent for other educational institutions in the country.

- To act as a service agent to serve the industrial sector in the country.

To achieve the above goals, at least two systems need to be used. One systems that produces plastic parts and can be used for concept applications to teach the students about the technologies and another system that produces metal parts and can be used for RM applications.

3. Preparing the University to adapt to such technologies.

a) Establishing module(s) to teach about AM technologies.

At least one module should be established to teach AM technologies for under-graduate students in the department of mechanical and industrial engineering in the Faculty of Engineering as a first step of spreading the knowledge of these technologies.

b) Having the proper staff to deal with such technologies.

Highly trained staff need to be available to get the full benefit of these technologies - these staff should be:

- Staff with a degree in AM technologies (MSc or PhD) to teach the established teaching modules about these technologies.

- Staff with a college degree to operate the systems - normally training programs are offered by the vendors.

- Staff with enough knowledge of different CAD software such as SolidWorks.

c) Having sufficient space and the correct environment to house the system(s)

The location where the system will be placed should be analyzed to ensure the environment is suitable for the system.

d) Having the proper hardware and software to deal with AM technologies

Some AM systems have their own computers and software while others do not. Each system needs to be assessed. The University might just need to upgrade their computers and software, and therefore will need to know the requirements for that. They may have to, however, purchase other computers and software.

4. Dealing with the right vendor.

To decide which system producer or vendor to deal with, the nationality of this company could be one of the main factors to select the best vendor. A comparison between the services that different vendors provide (such as maintenance, training and guarantee) is essential to select the best vendor to deal with.

5. Using the program to select different systems.

To achieve the objectives of the University for using AM, making use of the RP selection section of the program would be the right choice. In the next few paragraphs there is an example about one of the scenarios that can be made by using the RP selection part of the program.

When selecting the combo box list of RP applications, four choices are given: concept models, form fit and checking, function models and visual prototypes. In this example, form fit and checking is the right choice to be made (Figure 44).

After selecting the RP application, the second combo box list, which is the process material, will be enabled (Figure 45). In this case, four different materials are offered which are: ceramic, plastic, paper and metal. In this example, the chosen material is the plastic.

The third step is to select from the technology combo box list that has been enabled. For this case five different AM technologies are offered which are: SLA, jetting systems, FDM, LOM and 3D printing. For this example the 3D printing technology has been chosen (Figure 46).

After selecting the 3D printing technology, the program enables three combo box lists which are: system price, part maximum size and machine size. The user can use any of these three combo box lists to select the proper system to use. Pressing on the system price combo box list for instance shows different system prices, in this example the price of $20,000 have been chosen (Figure 47).

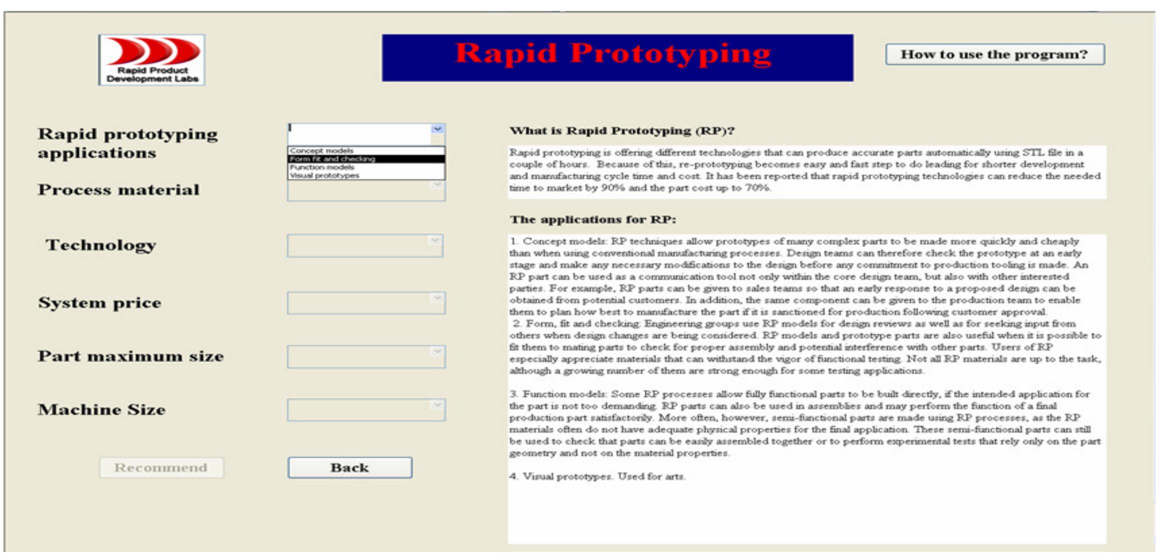

Figure 44 Selecting RP applications

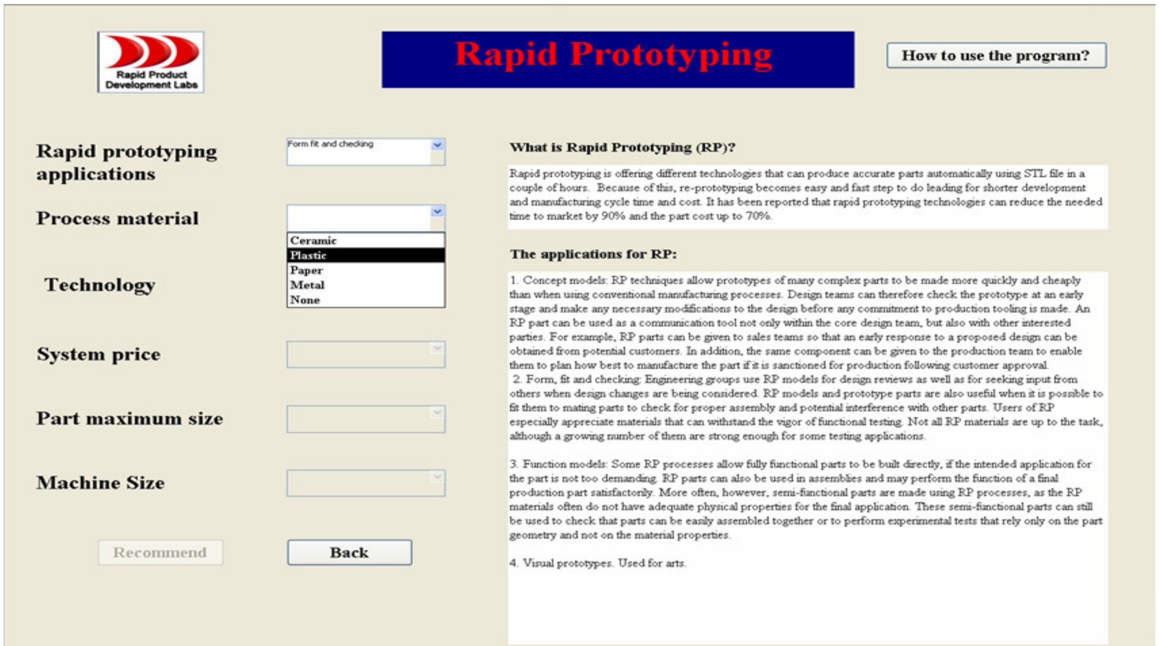

Figure 45 Selecting the process material

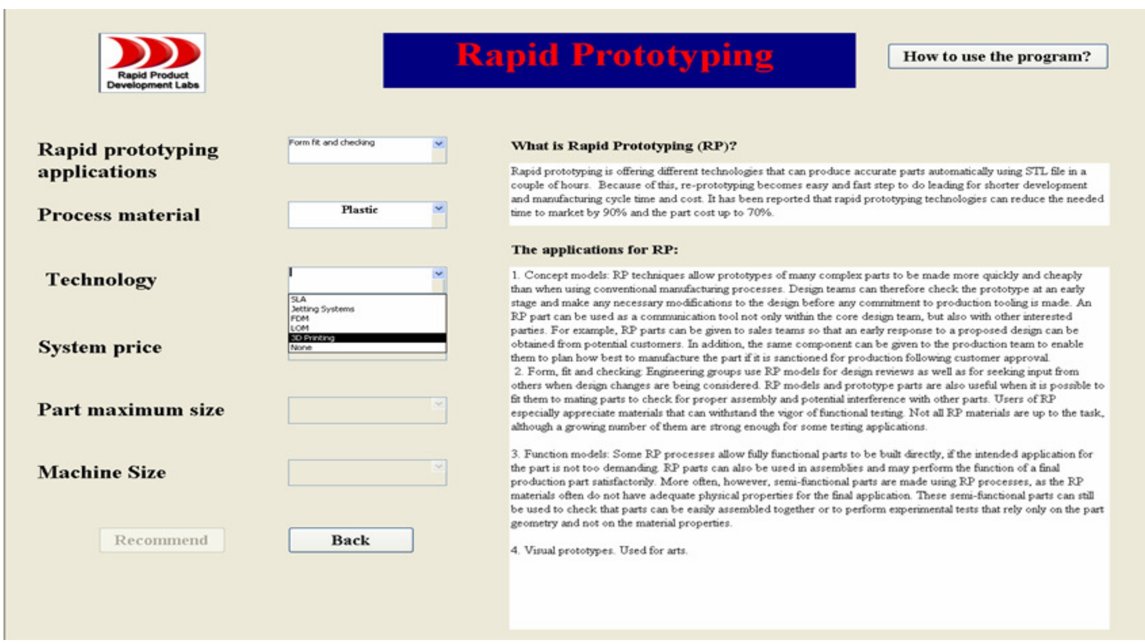

Figure 46 Selecting AM technology

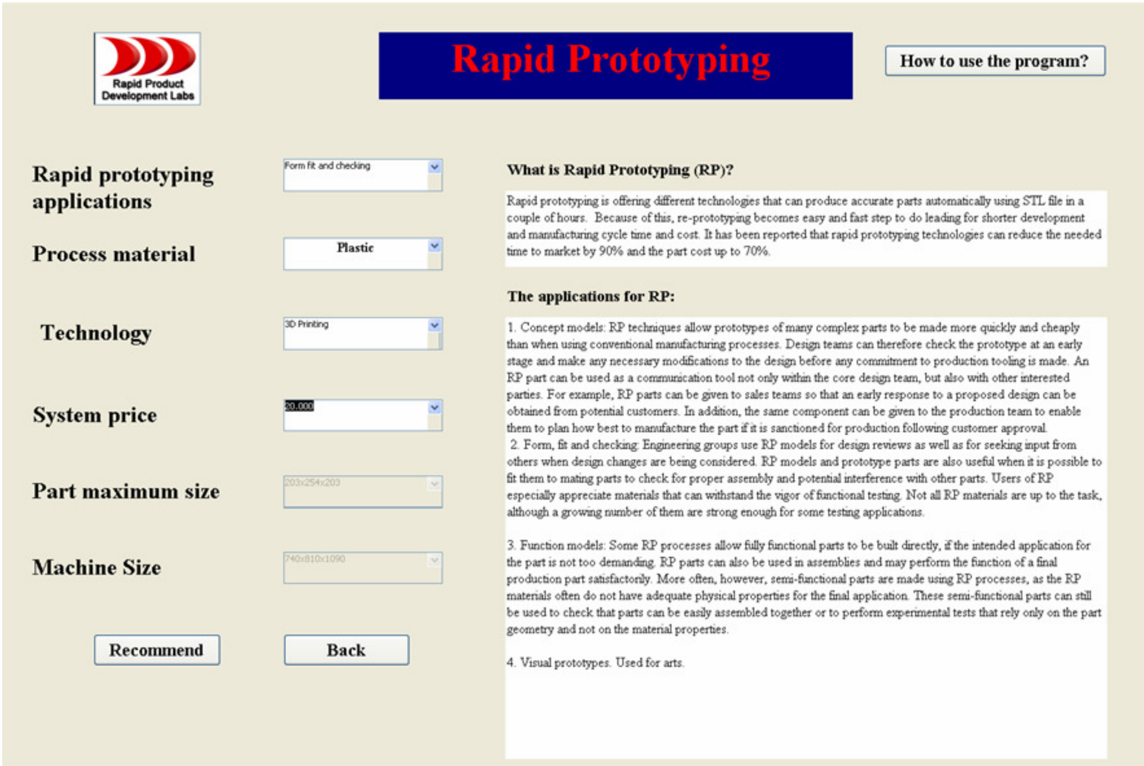

Figure 47 Selecting system price

As shown in Figure 47, after selecting the $20,000 price the other two combo box lists, part maximum size and machine size, have been disabled with certain values in them which are specific values of the same $20,000 system. The "Recommend" button has been enabled and clicking on that button will lead to the result screen as in Figure 48.

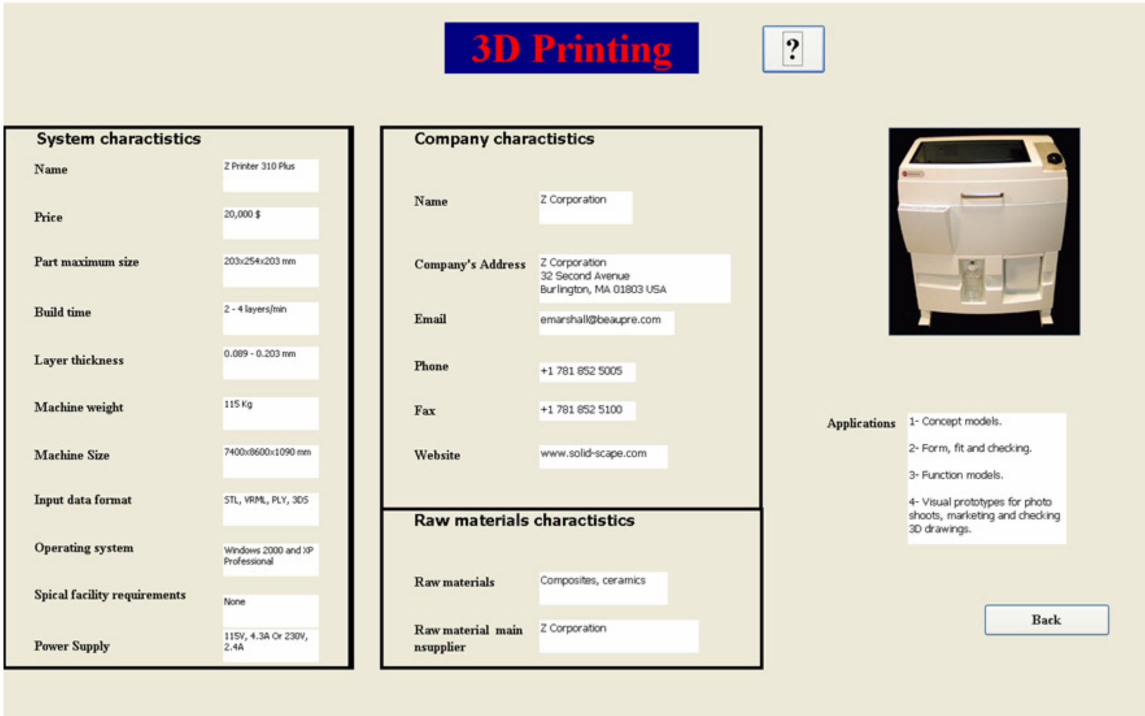

Figure 48 The result page of the $20,000 choice

Should the user decide to select another system due to the part maximum size for example, clicking on the "Back" button will lead the user to the same RP selection page on Figure 47. Selecting "None" value in the system price will enable the other two combo box lists, the part maximum size and the machine size (Figure 49).

Now the user can select a certain size from the part maximum size combo box list, in this example "203x254x203" mm has been chosen. It is clear from Figure 50 that instead of having specific values in the system price and the machine size combo box lists and having them disabled, these combo box lists have been enabled with two different values on both of them. This happened because there are two systems which can produce the same part maximum size. Selecting one of the two different values of the system price combo box list or machine size combo box list will enable the "recommend" button. Clicking on the "recommend" button will lead to the relevant result screen, as described before.

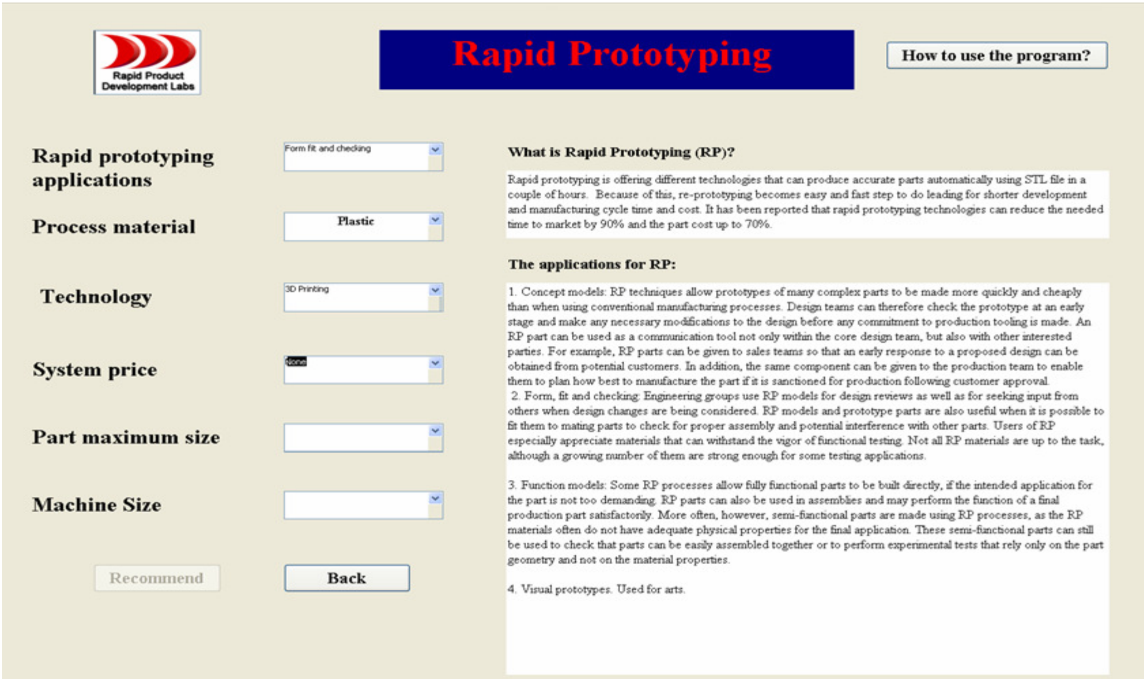

Figure 49 Re-select the system price

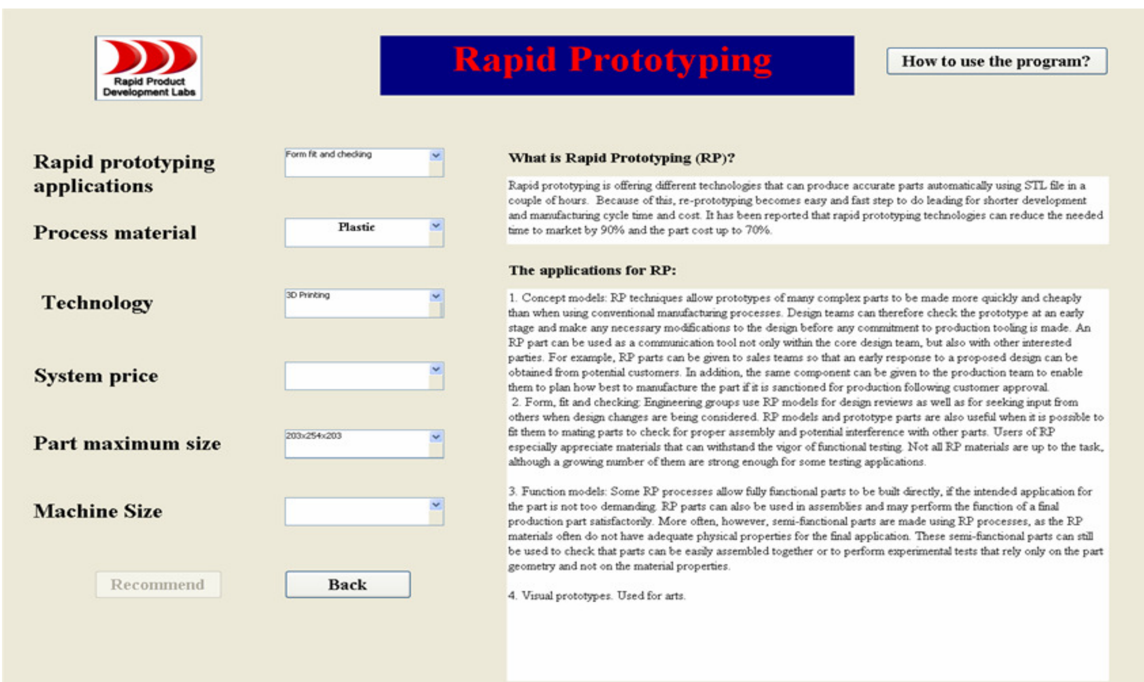

Figure 50 Re-selecting the part maximum size

6. Contacting the vendors.

After selecting different AM systems from the information that is available in the result pages, quotations needs to be requested from the correct vendors. These quotations should have all the relevant technical and cost data to assist in taking the final decision of which AM system should be used.

7. Calculating the total cost.

Calculating the total cost of the different selected systems is an essential step in making the right choice. Sometimes, other factors take priority over cost especially if the difference in the cost is small.

8. Purchasing and using the AM systems.

Finally, the reason for this process is to ultimately purchase the selected systems and start using them. Using AM systems in Al Fateh University and any other University will advance the quality of the educational services that should be provided to the public. The industrial sector in Libya and in any country uses AM systems will also advanced and become more effective and competitive.

5. Conclusion

Quality, cost and time are the essential factors for any manufacturer to remain competitive. Additive manufacturing technologies offer the ability to make high quality products faster and at lower costs than using conventional technologies. Even though these technologies are still developing, they are considered a major breakthrough in industry.

It is vital to use additive manufacturing technologies to ensure the effectiveness of the education sector and the competitiveness of the industrial sector. AM technologies have been around for over 20 years and still a lot of countries, educational and industrial organizations around the globe do not know about them. There is a real problem due to lack of knowledge about AM technologies. The main reasons for this lack of knowledge are: lack of up-to-date information, lack of standards (started to be developed only in 2009), the confusion in jargon when describing the additive manufacturing technologies, and finally the need for information to be arranged in a logical and user-friendly manner.

A basic knowledge about additive manufacturing can inspire the non-users to start using these technologies. This basic knowledge about additive manufacturing should address issues like: its economic feasibility, its produced part properties, which industries are already served by these technologies, which countries and companies control these technologies, comparing these technologies with CNC and what the future of these technologies holds.

The lack of knowledge about additive manufacturing is affecting both the users and non-users. The development of these technologies is highly dependant on the amount of systems deployed. When the number of additive manufacturing systems deployed increases, their cost will decrease and the advancement in the technologies and their materials will also improve. That is why solving this problem of limited knowledge is an important mission that every user of additive manufacturing technologies should take. Otherwise the development of these technologies might take a long time.

As additive manufacturing systems are continually growing in numbers, improving in their capabilities and applications and reducing in their cost, the task of selecting the proper system to be used to suit a specific need is an increasingly complex one. More than 100 commercial systems are produced today by about 40 companies from Canada, China, France, Germany, Israel, Italy, Japan, South Korea, Sweden and United State and these numbers are constantly increasing.

The first step to introduce any new technologies, like additive manufacturing, into any country is to adapt it to the education sector. This will result in trained students with experience of these technologies and knowledge of how to apply them in their lives. Huge opportunities for establishing new industries and of ensuring the competitiveness of any industry are associated with using additive manufacturing technologies.

This study developed a selection program for additive manufacturing systems. This program acts as an educational tool and as a decision making support tool. The educational section of the program introduces the additive manufacturing technologies to any new users in both education and industrial sectors. It also enables new users to be confident in their decisions, moreover, enables them to address different technical issues about the systems with the providers. This section also try to persuade these new users to use additive manufacturing technologies due to their benefits. The decision making support section of the program will assist these users to decide which system would suit their needs.

In conclusion, such breakthrough technologies like additive manufacturing should be used worldwide; it is believed that one day these technologies will enter all the offices and houses like the PC computers today. This study is an effort to contribute to the promotion of additive manufacturing and its benefits especially for developing countries and organizations that have not yet used such technologies.

6. Recommendations

In summary, the following recommendations can be drawn:

1. Additive manufacturing technologies and their applications should be studied and used world wide to get their benefits.

2. Any country wants to employ additive manufacturing should start with the education sector as a first step. The colleges and universities should establish training modules about additive manufacturing to ensure the effectiveness of the education. Additive fabrication system selection program has a learning section that can be used as a learning tool. It is recommended that the universities become service agents to engage with industry.

3. Additive manufacturing technologies and applications must be used in an effective manner to get all their benefits. They should only be used when appropriate; the most suitable system is selected for specific need. Additive manufacturing system selection program is a tool that helps to achieve the required objectives.

4. Spreading the knowledge about additive manufacturing technologies needs the backing of the media and conferences to inform the public and the industrial sector about the benefits of employing such technologies.

5. Keeping up-to-date with additive manufacturing developments is essential to ensure the most economic and suitable additive manufacturing technology is used in the appropriate manner.

6. Additive manufacturing system selection program should be used by the decision makers in countries and organizations that have not used additive manufacturing technologies yet.

7. Countries that do not rank high against industrial countries should be among the first countries to use additive manufacturing because it offers huge opportunities for different kinds of industries to achieve low cost and less need for numbers of highly skilled people.

7. Implementation road map

To get the benefits of using the selection program for AM systems, a road map has been drawn as following:

1. Make the program available free on the internet for everyone.

2. Arranging meetings with the people in charge in the mechanical and industrial engineering departments at different educational organizations in Libya to introduce AM technologies and giving them copy of the program.

3. Arranging meetings with the people in charge in the industrial sector in Libya to introduce AM technologies and giving them copy of the program.

4. Based on the program, papers in Arabic shall be written about the benefits of AM technologies and the prospective of use them in Libya.

5. Based on the program, a book in Arabic about AM technologies and its applications shall also be written.

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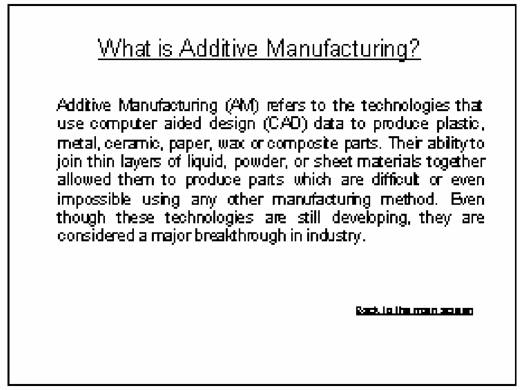
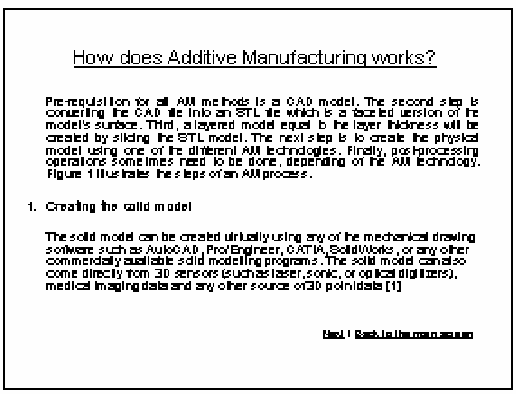
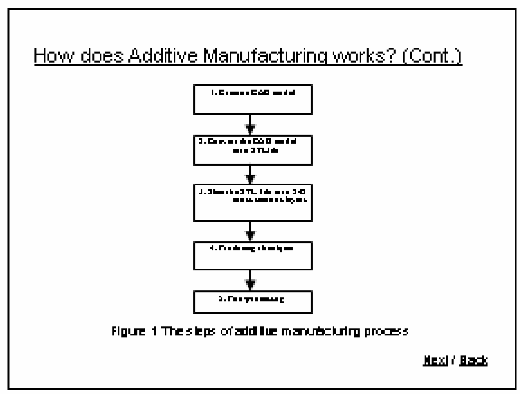
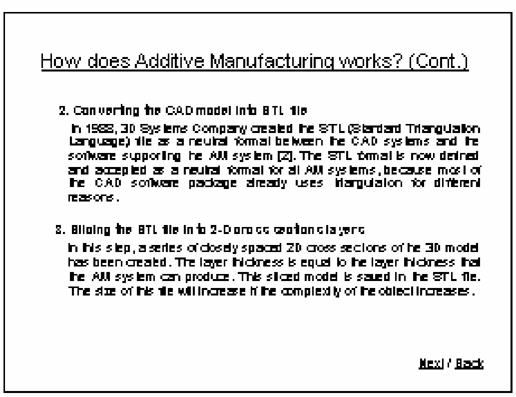
Appendix A The learning section of the program

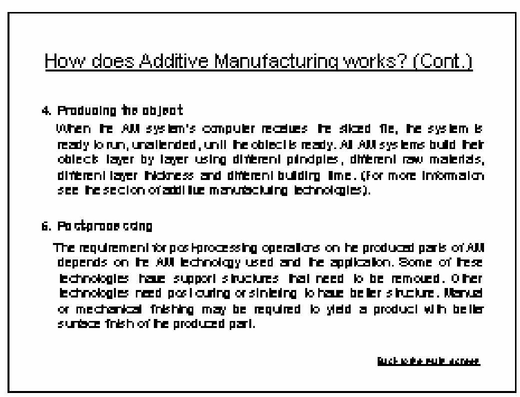

Learn about Additive Manufacturing
The definition of additive manufacturing
How does additive manufacturing work?
Additive manufacturing technologies.
Benefits of additive manufacturing.
Historical background.
Additive manufacturing applications.


What is Additive Manufacturing?
Additive Manufacturing (AM) refers to the technologies that use computer aided design (CAD) data to produce plastic, metal, ceramic, paper, wax or composite parts. Their ability to join thin layers of liquid, powder, or sheet materials together allowed them to produce parts which are difficult or even impossible using any other manufacturing method. Even though these technologies are still developing, they are considered a major breakthrough in industry.
Back to the main screen


How does Additive Manufacturing works?
Pre-requisition for all AM methods is a CAD model. The second step is converting the CAD file into an STL file which is a faceted version of the model's surface. Third, a layered model equal to the layer thickness will be created by slicing the STL model. The next step is to create the physical model using one of the different AM technologies. Finally, post-processing operations sometimes need to be done, depending on the AM technology. Figure 1 illustrates the steps of an AM process.
1. Creating the solid model
The solid model can be created virtually using any of the mechanical drawing software such as AutoCAD, Pro/Engineer, CATIA, SolidWorks, or any other commercially available solid modelling programs. The solid model can also come directly from 3D sensors (such as laser, sonic, or optical digitizers), medical imaging data and any other source of 3D point data [1]
Next / Back to the main screen


How does Additive Manufacturing works? (Cont.)
Figure 1 The steps of additive manufacturing process
Next / Back


How does Additive Manufacturing works? (Cont.)
2. Converting the CAD model into STL file
In 1988, 3D Systems Company created the STL (Standard Triangulation Language) file as a neutral format between the CAD systems and the software supporting the AM system [2]. The STL format is now defined and accepted as a neutral format for all AM systems, because most of the CAD software package already uses triangulation for different reasons.
3. Slicing the STL file into 2-D cross section layers
In this step, a series of closely spaced 2D cross sections of the 3D model has been created. The layer thickness is equal to the layer thickness that the AM system can produce. This sliced model is saved in the STL file. The size of this file will increase if the complexity of the object increases.
Next / Back


How does Additive Manufacturing works? (Cont.)
4. Producing the object
When the AM system's computer receives the sliced file, the system is ready to run, unattended, until the object is ready. All AM systems build their objects layer by layer using different principles, different raw materials, different layer thickness and different building time. (For more information see the section of additive manufacturing technologies).
5. Postprocessing
The requirement for post-processing operations on the produced parts of AM depends on the AM technology used and the application. Some of these technologies have support structures that need to be removed. Other technologies need post curing or sintering to have better structure. Manual or mechanical finishing may be required to yield a product with better surface finish of the produced part.

Additive manufacturing technologies

Additive Manufacturing technologies can be divided into three different categories according to the raw material used in the process. These categories are:

A - Liquid-based

Liquid-based processes represent all the formation technologies that selectively curing regions of photosensitive polymers.

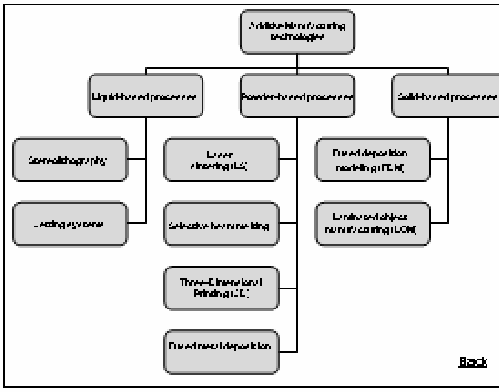
B- Powder-based

Powder-based processes can use polymer, ceramic or metal as raw material. Moreover, combining powders can be used as graded materials. These technologies offering good end-use parts properties that made them lead the rapid manufacturing technologies.

C- Solid-based

Solid-based processes mean the processes that use non-powder solid materials. These technologies are the most used additive fabrication technologies worldwide.

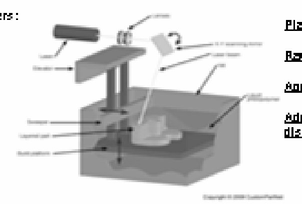
Next | Back to the main screen



Stereolithography (SLA)

Back

System manufacturers:



Play Video

Raw Materials

Applications

Advantages and disadvantages.

In stereolithography, the laser beam will move according to the layered model to selectively cure the layer surface, then the platform will be lowered and a new polymer liquid layer will be spread on the previously created layer. This process is repeated until the part will finish.

Stereolithography (SLA) Materials

Back

- Materials:

a- Acrylic photopolymer.

b- Epoxy photopolymer.

c- ABS-like.

d- Polypropylene-like.

e- Vinyl Ether photopolymer.

Applications of Stereolithography (SLA)

Back

- Rapid Prototyping.

a- Concept models (Excellent).

b- Form, fit and checking models (Excellent).

C- Function models (Fair).

C- Visual prototypes for photo shoots, marketing and checking 2D drawings (Very good).

- Rapid Tooling.

a- Patterns for sand casting applications (Excellent).

b- Patterns for investment casting applications (Excellent).

C- Direct-Tooling (Can not be used).

- Rapid Manufacturing.

Low volume production of complex polymer geometries (Good).

Stereolithography (SLA) - Advantages/Disadvantages

Advantages:	Disadvantages:
a- Large building area.	a- Limited to photo-curable resins.
b- Good accuracy.	b- Needs post-processing curing.
c- No supervision necessary.	c- Resin creeps over time.
d- Good surface finish.	d- Resins need careful handling.

Back

Jetting systems

Back

System manufacturers

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- [illegible]
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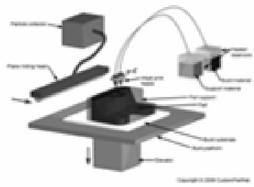
- [illegible]
- [illegible]



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Raw Materials

Applications

Advantages and disadvantages.

These systems use an array of printing heads to selectively spray an acrylate-based photopolymer on the material, after that a UV lamp will cure the sprayed parts of the layer. Finally, a second series of jets will cure the supporting material into a gel that can be removed by a water jet after the part is finished. In some systems jetting wax is also used for building of support structure

Jetting systems materials

Back

- Materials:

a- Thermo plastic blend.
b- Proprietary acrylate photopolymer.
d- Epoxy hybrid.

Applications of Jetting systems

Back

- Rapid Prototyping .

a- Concept models (Excellent).
b- Form, fit and checking models (Excellent).
C- Function models (Fair).
C- Visual prototypes for photo shoots, marketing and checking 2D drawings (Very good).

- Rapid Tooling.

a- Patterns for sand casting applications (Excellent).
b- Patterns for investment casting applications (Excellent).
C- Direct-Tooling (Can not be used).

- Rapid Manufacturing.

Low volume production of complex polymer geometries (Poor).

Jetting systems - Advantages/Disadvantages

Advantages:

a- Accuracy.
b- Feature detail.
c- smooth surface.
d- Semi-transparent.
e- Flexible materials.
f- Can be removed right after printing.
g- Machines can be used in an office environment.

Disadvantages:

a- Support pillars must be broken off.
b- Bottom surface finish is very poor.
c- Strength of finished parts is poor.

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Laser Sintering (LS)

Back

System manufacturers

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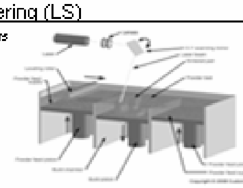
- [illegible]
- [illegible]
- [illegible]



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Raw Materials

Applications

Advantages and disadvantages.

Laser Sintering (LS) uses lasers to melt the powder layer selectively. The powder bed is heated before laser sintering to increase the powder temperature to a few degrees below the melting temperature of the powder. After creating the first layer, the carrying platform is lowered and the new powder layer spread. Continuing these processes will build the part and the un-sintered powder forms the support material which is easy to remove.

This technology can be used to produce polymer and metal parts. Coated metal powder with polymer will produce steel parts in the green state (not ready to use and need to be heated in an oven). These parts must be heated in a furnace to burn away the polymer binder

Selective Laser Sintering (SLS) materials

Back

- Materials:

a- Carbon steel with polymer binder.
b- Nylon.
c- Polystyrene.
d- Polycarbonate.
e- Wax.
f- Ceramic coated with binder.
g- Zirconium sand coated with polymer.
h- Flexible elastomer.

Applications of Selective Laser Sintering (SLS)

Back

- Rapid Prototyping .

a- Concept models (Fair).
b- Form, fit and checking models (Fair).
C- Function models (Excellent).
C- Visual prototypes for photo shoots, marketing and checking 3D drawing (Fair).

- Rapid Tooling.

a- Patterns for sand casting applications (Fair).
b- Patterns for investment casting applications (Fair).
C- Direct-Tooling (Excellent).

- Rapid Manufacturing.

Low volume production of complex polymer and metal geometries (Excellent).

Selective Laser Sintering (SLS) - Advantages/Disadvantages

Advantages:	Disadvantages:
a- Materials range from plastics, ceramic to metals.	a- Long cooling times before part can be removed.
b- Ideal for rapid manufacturing.	b- Poor surface finish.
c- No need for support structure.	

Back

Selective beam melting

Back

Selective Beam Melting is a general term that contains different types of AM technologies such as:

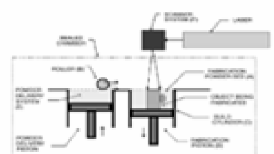
- Direct Metal Laser Sintering (DMLS)
- Electron Beam Melting (EBM)
- Laser-Cusing
- Selective Laser Melting (SLM)

Direct Metal Laser Sintering (DMLS)

Back

System manufacturers:

- EOS



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Raw Materials

Applications

Advantages and disadvantages.

Direct Metal Laser Sintering differs from the previous technology (SLS) as it does not require a polymer binder. The metal powder that is used contains various components that have different melting temperatures. Hence, the laser will melt the lower melting temperature component first which will form the part. The part in this case can be the end-use part with no need for post heating.

Direct Metal Laser Sintering (DMLS) materials

Back

- Materials: (EOS)

a- Proprietary bronze powders.
b- steel-based powders.
c- Cobalt-chrome steel based powders.

Applications of Direct Metal Laser Sintering (DMLS)

- Rapid Prototyping .

a- Concept models (Fair).
b- Form, fit and checking models (Fair).
C- Function models (Excellent).
C- Visual prototypes for photo shoots, marketing and checking 3D drawing (Fair).

- Rapid Tooling.

a- Patterns for sand casting applications (Fair).
b- Patterns for investment casting applications (Fair).
C- Direct-Tooling (Excellent).

- Rapid Manufacturing.

Low volume production of complex metal geometries (Excellent).

Back

Direct Metal Laser Sintering (DMLS) - Advantages/Disadvantages

Advantages:

a- Materials range from plastics, ceramic to metals.
b- No post curing of the part is needed.
c- No need for support structure.
d- Ideal for rapid manufacturing.

Disadvantages:

a- Long cooling times before part can be removed.
b- Poor surface finish.

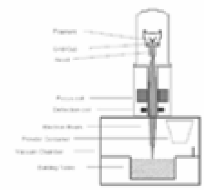
Back

Electron Beam Melting (EBM)

Back

System manufacturers:

- Arcam



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Raw Materials

Applications

Advantages and disadvantages.

Electron beam melting technology has the same principle like SLS but substitute a laser with an electron beam. This replacement has some important effects: Firstly, using the electron beam will increase the scanning speed (up to 1 Km/s) by changing the electromagnetic field through which it passes. Secondly, the very high power this electron beam offering will assure a fully melt of wide range of metals.

Electron Beam Melting (EBM) materials

- Materials:
  - a- Titanium.
  - b- Stainless steel.
  - c- Cobalt-chrome.
  - d- Supper alloys.
  - e- Copper.
  - f- Aluminum.
  - g- Niobium.
  - h- Beryllium.
  - i- Amorphous.
  - j- Tool steel.
  - k- hard metals.

Back

Applications of Electron Beam Melting (EBM)

- Rapid Prototyping.

  a- Concept models (Fair).
  b- Form, fit and checking models (Fair).
  C- Function models (Excellent).
  C- Visual prototypes for photo shoots, marketing and checking 3D drawing (Fair).

- Rapid Tooling.

  a- Patterns for sand casting applications (Fair).
  b- Patterns for investment casting applications (Fair).
  C- Direct-Tooling (Excellent).

- Rapid Manufacturing.

  Low volume production of complex polymer and metal geometries (Excellent).

Back

Electron Beam Melting (EBM) - Advantages/Disadvantages

Advantages:

a- Higher efficiency in generating the beam of energy resulting in lower power consumption as well as lower maintenance and installation costs

b- High actual overall power resulting in high build speeds

c- Deflection of the beam can achieved without moving parts resulting in high scanning speed and low maintenance.

Disadvantages:

a- Required vacuum system.

b- Produces gamma rays while in operation.

c- Requires electrically conductive materials.

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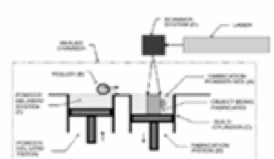
Laser Cusing

Back

System manufacturers:

- Concept



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Raw Materials

Applications

Advantages and disadvantages.

The different between this process and the previous two (SLS & DMLS) processes that it deals with a single component metallic powder which allow it to produce a fully dense component with no stress or deformation. The used raw material can be aluminum, stainless steel, tool steel, titanium and others. Laser Cusing and selective laser melting have the same principle and they just differ in the names because there are not from the same company.

Laser Cusing materials

- Materials:

a- CL 20ES stainless steel (1.4404).
b- CL 50WS Hot-Work steel (1.2709).
c- CL 60DG Hot-Work steel for pressure die casting (1.2709).
d- CL 91RW stainless Hot-Work steel.
e- CL 30AL Aluminum (AlSi 12).
f- CL 31AL Aluminum (AlSi 10Mg).
g- CL 40TI Titanium (TiAl6V4).
h- CL 100NB Nickel-based alloy (Inconel 718).

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Applications of Laser Cusing

- Rapid Prototyping.

a- Concept models (Fair).
b- Form, fit and checking models (Fair).
C- Function models (Excellent).
C- Visual prototypes for photo shoots, marketing and checking 3D drawing (Fair).

- Rapid Tooling.

a- Patterns for sand casting applications (Fair).
b- Patterns for investment casting applications (Fair).
C- Direct-Tooling (Excellent).

- Rapid Manufacturing.

Low volume production of complex metal geometries (Excellent).

Back

Laser Cusing Advantages/Disadvantages

Advantages:

a- Materials range from plastics, ceramic to metals.
b- No post curing of the part is needed.
c- No need for support structure.
d- Ideal for rapid manufacturing.

Disadvantages:

a- Long cooling times before part can be removed.
b- Poor surface finish.

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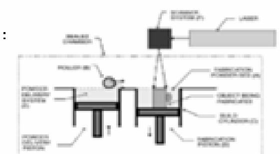
Selective Laser Melting (SLM)

Back

System manufacturers:

- Realizer



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Raw Materials
Applications
Advantages and disadvantages.

The different between this process and the previous two (SLS & DMLS) processes that it deals with a single component metallic powder which allow it to produce a fully dense component with no stress or deformation. The used raw material can be aluminum, stainless steel, tool steel, titanium and others. Laser Cusing and selective laser melting have the same working principles and they just differ in names because they are not from the same company.

Selective Laser Melting (SLM) materials

- Materials:

a- 316L stainless steel.
b- H13 tool steel.
c- Titanium alloys.
d- Cobalt chrome.
e- Aluminum (AlSi12Mg).

Back

Applications of Selective Laser Melting (SLM)

- Rapid Prototyping.

a- Concept models (Fair).
b- Form, fit and checking models (Fair).
C- Function models (Excellent).
C- Visual prototypes for photo shoots, marketing and checking 3D drawing (Fair).

- Rapid Tooling.

a- Patterns for sand casting applications (Fair).
b- Patterns for investment casting applications (Fair).
C- Direct-Tooling (Excellent).

- Rapid Manufacturing.

Low volume production of complex metal geometries (Excellent).

Back

Selective Laser Melting (SLM)- Advantages/Disadvantages

Advantages:

a- Materials range from plastics, ceramic to metals.
b- No post curing of the part is needed.
c- No need for support structure.
d- Ideal for rapid manufacturing.

Disadvantages:

a- Long cooling times before part can be removed.
b- Poor surface finish.

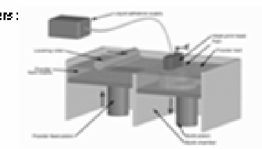
Back

Three Dimensional Printing (3D)

Back

System manufacturers:

- Z corporation
- ProMetal
- [illegible]



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Raw Materials

Applications

Advantages and disadvantages.

In this technology, a printing head selectively sprays a binder onto the powder. The final product will be in the green state, which means it needs post-processing, similar to SLS

Three Dimensional printing (3D) materials

- Materials:

a- Corn starch.
b- Plaster.
c- Wax.
d- Molding sand.
e- Ceramics.
f- Plastic.
g- Metals (stainless steel + bronze, tool steel, gold).

Back

Applications of Three Dimensional printing (3D)

- Rapid Prototyping.

a- Concept models (Excellent).
b- Form, fit and checking models (Very good).
C- Function models (Poor).
C- Visual prototypes for photo shoots, marketing and checking 3D drawings (Excellent).

- Rapid Tooling.

a- Patterns for sand casting applications (Excellent).
b- Patterns for investment casting applications (Excellent).
C- Direct-Tooling (Can not be used).

- Rapid Manufacturing.

Low volume production of complex polymer geometries (Poor).

Back

Three Dimensional printing (3D)- Advantages/Disadvantages

Advantages:

a- Fast.
b- Office compatible.
c- Low price.
d- Color surface printing.
e- Inexpensive raw materials.

Disadvantages:

a- Relatively rough surface finish.
b- Fragile parts (until post-processed).
c- Its functional testing very limited.
d- Can't print plastic parts.
e- Metal part printing requires different machines

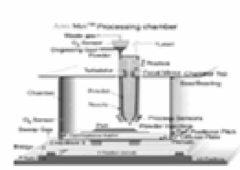
Back

Fused metal deposition

Back

System manufacturers:

- POM
- [illegible]



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Raw Materials

Applications

Advantages and disadvantages.

Fused Metal Deposition uses a deposition head to melt metallic powder using a high power laser. The laser is focused using lenses. Moving the laser beam and the table will create the part layer by layer. The metallic powder can be fed by gravity or using a pressurized gas. In both cases the gas is used to provide a non-oxygen environment for the laser. Various commercial systems use the principle of this technology, for example systems produced by POM, Optomec and Aeromet.

Fused metal deposition materials

- Materials:

a- 316,304 and 420 stainless steel.
b- J- H13 tool steel.
c- CP Ti, Ti-6Al-4V Titanium.
d- CPM1V and CPM10V.
e- C250 and C276.
f- IN625 and IN718.
g- Stellite6, Stellite21 and Stellite31.

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Applications of Fused metal deposition

- Rapid Prototyping .

a- Concept models (Fair).
b- Form, fit and checking models (Fair).
C- Function models (Excellent).
C- Visual prototypes for photo shoots, marketing and checking 3D drawing (Fair).

- Rapid Tooling.

a- Patterns for sand casting applications (Fair).
b- Patterns for investment casting applications (Can not be used).
C- Direct-Tooling (Good).

- Rapid Manufacturing.

Low volume production of complex metal geometries (Good).

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Fused metal deposition - Advantages/Disadvantages

Advantages:	Disadvantages:
a- High strength engineering metals.	a- Uses only metal parts.
b- Complex parts.	b- Large physical system size.
c- Gradient material.	c- High power consumption.
d- Fully dense functional parts.	d- Low dimensional accuracy.
e- Porous structures.	e- Required successive finishing.

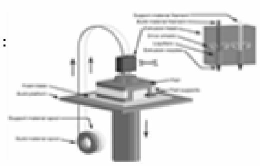
Back

Fused Deposition Modeling (FDM)

Back

System manufacturers:

- Stratasys
- [illegible]
- [illegible]



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Raw Materials

Applications

Advantages and disadvantages.

Fused Deposition Modelling (FDM) uses a nozzle to heat the raw material (normally a thermoplastic polymer) to just above its melting temperature. Moreover, moving the nozzle in two dimensions to extrude the material in the selected areas of the part creates a layer that will solidify immediately and stack with the previous layer. Supports that are easy to remove manually or water soluble may be used; the support layers are created using nozzles other than the ones used for building the part itself.

Fused Deposition Modeling (FDM) materials

- Materials:

a- ABS.
b- Polycarbonate.
c- Polyphenylsulfone.
d- Polyester.
e- Wax.
f- Elastomer.

Back

Applications of Fused Deposition Modeling (FDM)

- Rapid Prototyping .

a- Concept models (Excellent).
b- Form, fit and checking models (Excellent).
C- Function models (Very good).
C- Visual prototypes for photo shoots, marketing and checking 3D drawings (Excellent).

- Rapid Tooling.

a- Patterns for sand casting applications (Excellent).
b- Patterns for investment casting applications (Excellent).
C- Direct-Tooling (Can not be used).

- Rapid Manufacturing.

Low volume production of complex polymer geometries (Very good).

Back

Fused Deposition Modeling (FDM) - Advantages/Disadvantages

Advantages:

a- Use a variety of thermoplastics.
b- No post-processing required.
c- Tough parts for functional usage.
d- Machines can be easily set up.
e- Use office environment.

Disadvantages:

a- Only thermoplastics.
b- Slow.
c- Support structure are needed.
d- Poor surface finish.
e- Parts have poor strength in the vertical direction.

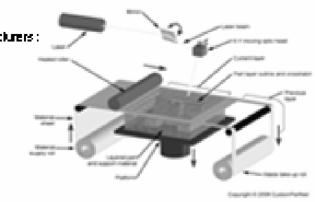
Back

Laminated Object Manufacturing (LOM)

Back

System manufacturers:

-[illegible]
-[illegible]
-[illegible]
-[illegible]



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Raw Materials
Applications
Advantages and disadvantages.

In Laminated Object Manufacturing (LOM), sheets of paper, plastic, metal or composites are used. The sheets are formed layer by layer, using a laser and then a hot roller to bond the new layer to the previous one. On completion of the process the unwanted material is removed.

Laminated Object Manufacturing (LOM) materials

- Materials:

a- Paper.
b- PVC.
c- ABS.
d- Polycarbonate.
e- Polyester.
f- Misc Metals.
g- Aluminum.

Back

Applications of Laminated Object Manufacturing (LOM)

- Rapid Prototyping.

a- Concept models (Excellent).
b- Form, fit and checking models (Excellent).
C- Function models (Fair).
C- Visual prototypes for photo shoots, marketing and checking 2D drawings (Very good).

- Rapid Tooling.

a- Patterns for sand casting applications (Excellent).
b- Patterns for investment casting applications (Excellent).
C- Direct-Tooling (Can not be used).

- Rapid Manufacturing.

Low volume production of complex geometries (Good).

Back

Laminated Object Manufacturing (LOM) - Advantages/Disadvantages

Advantages:

a- Very low material cost.
b- The produced parts have the look and feel of wood and can be worked and finished in the same manner.
c- No need for support structure.
d- High speed process.
e- Use office environment.

Disadvantages:

a- Finish, accuracy and stability of parts are not as good.
b- Raw materials are very limited.
c- Built parts absorb moisture quickly.
d- Deficiency in building thin shape parts.
e- Breaking out of parts can be difficult.

Back

Benefits of additive manufacturing

Additive manufacturing technologies have advantages that no other technologies have. Some of these unique advantages are:

1. Unlimited geometrical complexity
   Very complex parts with very complex, hollow structures that are difficult and sometimes impossible to produce, using conventional manufacturing processes, can be easily produced by AM technologies.
2. Reducing the production cost by up to 60% and the proceeding time by up to 76% using rapid prototyping and rapid tooling [3]
3. Low costs of low-volume products and for rapidly changing high-volume products using rapid manufacturing.

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Benefits of additive manufacturing (cont.)

4. Waste-less fabrication

Instead of wasting the entire negative space of a product by a subtractive process, most of the AM systems eliminate this waste (except LOM process that create the same amount of waste as a subtractive process)

6. Unattended operation

The fundamentals of AM technologies as a layer manufacturing process allowed fully-automated operation. The operator need just to start the system and then to get the part when it is ready.

8. Consolidation of parts

Combining two or more parts into one part is one of the main advantages of AM technologies. This leads to the use of fewer tools, making the assembly easier and reducing the product cost.

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Benefits of additive manufacturing (cont.)

7. Customer driven design

Additive manufacturing technologies allow customers to have direct involvement in the design process. The customer can design his product using any 3D CAD software or select between different drawings that have already been prepared. Moreover, a functional prototype of the product can be produced and the customer can give his feedback. This is an expensive exercise if a conventional manufacturing process is used.

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Historical background

Additive manufacturing is a relatively new manufacturing technology. It was developed in 1987 by 3D Systems Company in the United State using stereolithography (SLA) technology the SLA- 1 system was the first commercially available AM system in the world. Asia started in 1988 with NTT Data CMET from Japan (now part of Teijin Seiki, a subsidiary of Nabtesco), this company commercialized its Solid Object Ultraviolet Plotter (SOUP) system with the SLA technology. Germany from Europe began to contribute to the technology in 1990, when Electro Optical Systems (EOS) and Quadrax commercialized their SLA systems [2].

After 1991 several new AM technologies were established and more new commercial systems went into the market. The cost of AM systems is continually decreasing, the number of vendors and users are continually increasing and, furthermore, the used raw materials are always improving with better properties and lower cost. The applications of AM have advanced from producing prototypes and patterns for moulds to finally being used in end-use parts manufacturing. Today there are about 32,000 systems working worldwide and produced mainly by Stratasys, Z Corporation, 3D Systems and Solidscape companies [2].

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Additive Manufacturing applications

- Rapid Prototyping (RP)
- Rapid Tooling (RT)
- Rapid Manufacturing (RM)

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1- Rapid Prototyping (RP)

All new products have a development and manufacturing cycle that starts with prototyping. Having prototypes is an essential step to ensure that the shape, measurements, fit and functionality of a part are suitable, and hence to the cost of commercial production is reduced. Before the emergence of rapid prototyping (RP), the only way of making prototypes was manually done by professional and highly skilled people, but this could delay the development cycle for weeks, and sometimes months (CNC can be considered as a rapid prototyping, tooling and manufacturing tool) [4]. Due to this, the ability to re-prototype a design was highly limited, therefore, parts may have problems in assembling and performance, adding to the production cost.

Rapid prototyping can produce accurate parts automatically, using the suitable AM technologies, in a couple of hours. Hence, re-prototyping is quick and relatively easy and leads to shorter development and manufacturing cycle times and reduces long-term costs. It has been reported that rapid prototyping technologies can reduce the required time to market by 90%, and the part cost by up to 70% [4].

Next / Back

1- Rapid Prototyping (RP) (Cont.)

The main applications of rapid prototyping are::

1. Concept models.AM technologies can produce concept models much faster and cheaper than conventional methods - this allows the designers to check their design early and make any necessary modifications to it before commercial production starts. Concept models can be used as a communication tool between the designers themselves, this tool will also assist the production team to plan the best way of manufacturing the part. The concept models can also be used to get early feedback from potential customers about the future product or component.
2. Form, fit and checking.Form, fit and checking is an essential step for any new product, this check allows the designers to test for problems of form and fit and ensuring that all parts are complementary and fit properly.
3. Function models.This application is always improving with the upgrading of AM raw materials. Some AM technologies can produce fully-functional parts to be used in any functional test. Semi-functional parts can also be made by some AM technologies but they are used mainly for performance tests that rely only on the geometry of the part.
4. Visual prototypes. Visual prototypes can be used for packaging articles (bottles), jewellery and art products to illustrate the shape of the product. Using visual prototypes as examples for any design such as buildings or structures can also be helpful.

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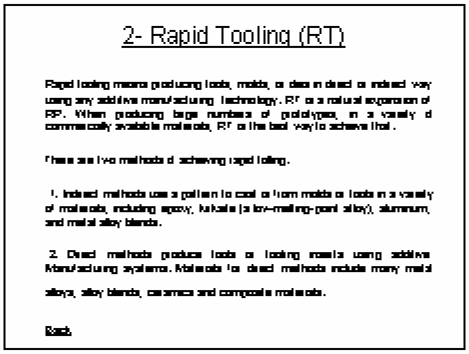
2- Rapid Tooling (RT)
Rapid tooling means producing tools, molds, or dies in direct or indirect way using any additive manufacturing technology. RT is a natural expansion of RP. When producing large numbers of prototypes, in a variety of commercially available materials, RT is the best way to achieve that.
There are two methods of achieving rapid tolling.
1. Indirect methods use a pattern to cast or form molds or tools in a variety of materials, including epoxy, kirksite (a low-melting-point alloy), aluminum, and metal alloy blends.
2. Direct methods produce tools or tooling inserts using additive Manufacturing systems. Materials for direct methods include many metal alloys, alloy blends, ceramics and composite materials.
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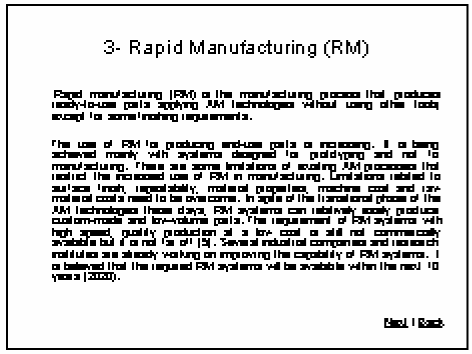
3- Rapid Manufacturing (RM)
Rapid manufacturing (RM) is the manufacturing process that produces ready-to-use parts applying AM technologies without using other tools except for some finishing requirements.
The use of RM for producing end-use parts is increasing. It is being achieved mainly with systems designed for prototyping and not for manufacturing. There are some limitations of existing AM processes that restrict the increased use of RM in manufacturing. Limitations related to surface finish, repeatability, material properties, machine cost and raw material costs need to be overcome. In spite of the transitional phase of the AM technologies these days, RM systems can relatively easily produce custom-made and low-volume parts. The requirement of RM systems with high speed, quality production at a low cost is still not commercially available but it is not far off [5]. Several industrial companies and research institutes are already working on improving the capability of RM systems. It is believed that the required RM systems will be available within the next 10 years (2020).
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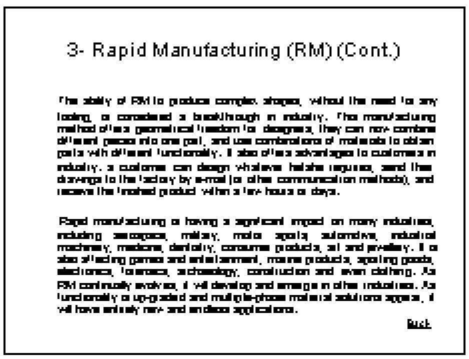
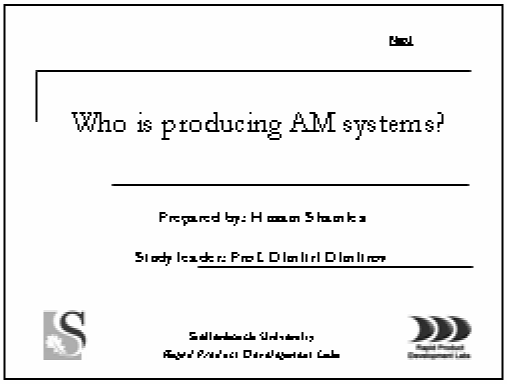
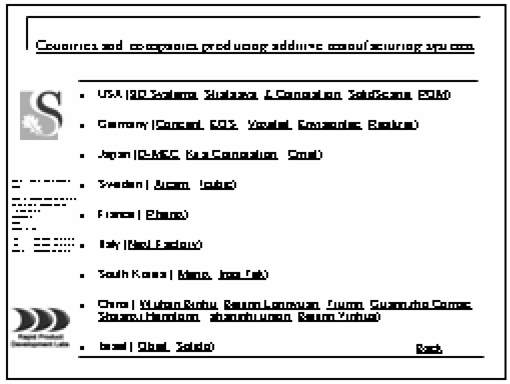
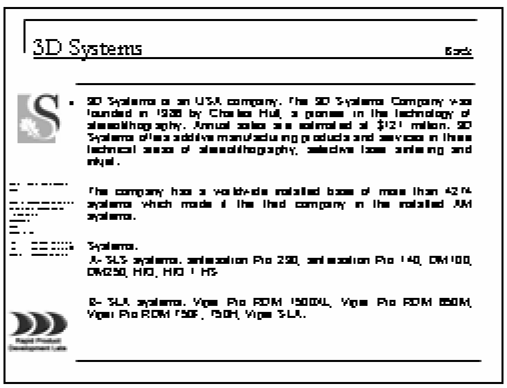
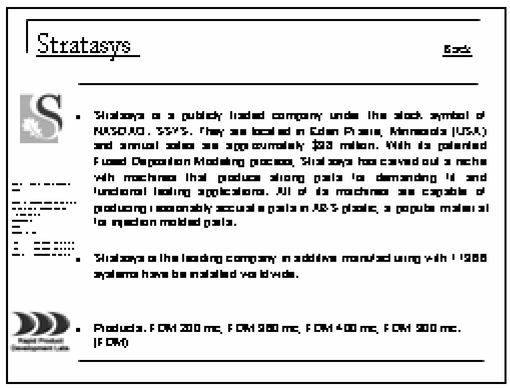
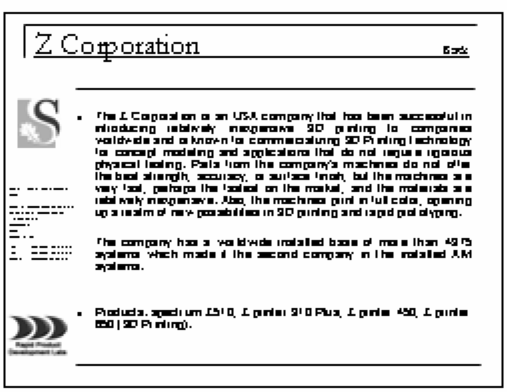

3- Rapid Manufacturing (RM) (Cont.)
The ability of RM to produce complex shapes, without the need for any tooling, is considered a breakthrough in industry. This manufacturing method offers geometrical freedom for designers, they can now combine different pieces into one part, and use combinations of materials to obtain parts with different functionality. It also offers advantages to customers in industry. a customer can design whatever he/she requires, send the drawings to the factory by e-mail (or other communication methods), and receive the finished product within a few hours or days.
Rapid manufacturing is having a significant impact on many industries, including aerospace, military, motor sports, automotive, industrial machinery, medicine, dentistry, consumer products, art and jewellery. It is also affecting games and entertainment, marine products, sporting goods, electronics, forensics, archaeology, construction and even clothing. As RM continually evolves, it will develop and emerge in other industries. As functionality is up-graded and multiple-phase material solutions appear, it will have entirely new and endless applications.
Back

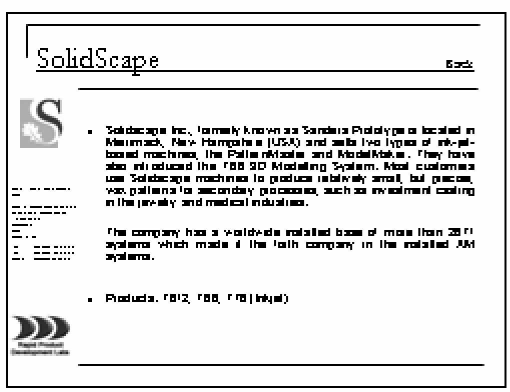

Who is producing AM systems?




3D Systems


Stratasys


Z Corporation


SolidScape

POM

Back

- The Precision Optical Manufacturing (POM) Group is a minority owned and operated business, founded in 1998 and operates its research facility in Auburn Hills, Michigan (USA). The company is currently commercializing Direct Metal Deposition (DMD) systems (the same principle of fused metal deposition). The University of Michigan conducted much of the work for development of the technology under a contract from the U.S. Department of Energy. The process uses a CO_2 laser and powder feed system to produce metal parts from thin layers. The parts are near net shape, so they also require finish machining.

- Products: 1050, 44R, 66R. (DMD)

ProMetal

Back

- The ProMetal (USA) division of Extrude Hone Corporation has been developing 3Dimensional Printing (3DP) process for metal part fabrication for many years. However, it wasn't until the 2001 to 2002 time frame that development and commercialization activity came to life. Currently, several ProMetal initiatives are underway, including a $10.3 million Office of Naval Research project. Its purpose is to integrate ProMetal into the development and repair of weapon systems.

  The process uses print heads to deposit a binder onto the surface of metal powder. Layer by layer, the machine builds metal parts in 316L or 420 stainless steel. A furnace cycle burns out the binder and brings the parts to full density using a bronze infiltrate. The final part consists of about 60% steel and 40% bronze.

- Products: R1. (3D Printing)

Concept

Back

- Concept Laser GmbH (Lichtenfels, Germany) has been producing metal additive machines since 2002. The Hofmann Group, an established German company with interests in tool making, rapid manufacturing, design, and production , owns Concept Laser. Second-generation additive machines have been available since 2005 and new models were introduced in 2006.

  The machines from Concept are being used for the production of dental and medical implants, functional parts for use in aerospace, prototypes for the automotive industry, and tool making. The process is also being applied to diverse areas where reasonable production numbers of complex parts are required.

- Products: M1 Cusing, M2 Cusing, M3 Linear (Laser Cusing)

EOS

Back

- EOS GmbH of Germany offers a family of laser sintering (SLS) machines that compete with 3D Systems' SLS machines. EOS's strategy has been to commercialize a specific machine for each class of material: one for plastics, one for metals, and one for foundry sands. The company has been in the business of manufacturing Additive Manufacturing (AM) machines since 1990 when it began to produce SLS systems. The company stopped SLS machine production in 1997 and began to concentrate entirely on Direct Metal Laser Sintering (DMLS). It is the only European AM machine manufacturer with a significant installed base of customers.

- Products: EOSINT M 270, EOSINT P 390, EOSINT P 700, EOSINT P 730, EOSINT S 750, FORMIGA P 100. (DMLS).

Voxeljet

Back

- Voxeljet Technology GmbH (Augsburg, Germany) has developed and offers a large powder-based system that uses 3D Printing technology originally developed at MIT and commercialized by Z Corp. Voxeljet purchased a nonexclusive patent sublicense from Z Corp. As part of the sublicensing agreement, the Voxeljet equipment is to be used solely for the fabrication of plastic models and prototypes.

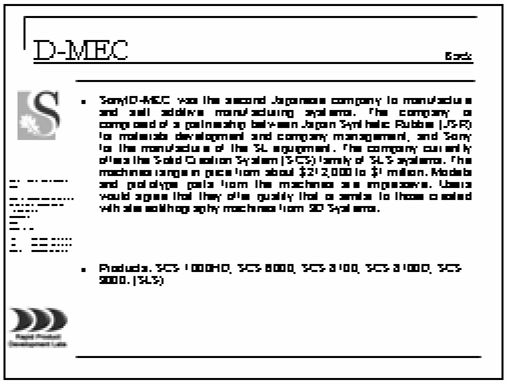
- Products: VX 500, VX 800. (Inkjet)

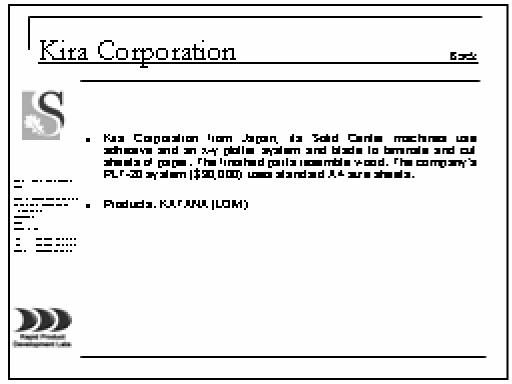
Envisiontec

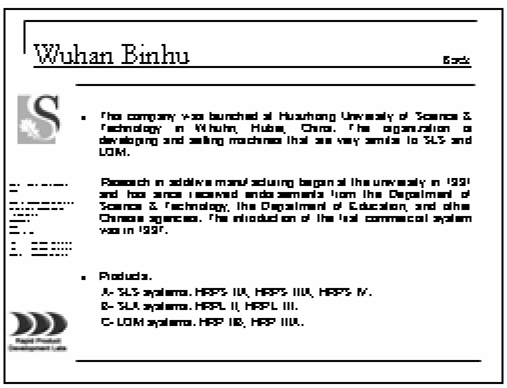
Back

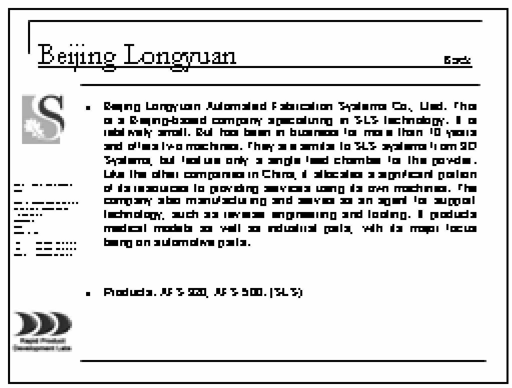
- Envision Technologies, also known as Envisiontec, is a start-up company based in Marl, Germany. The company has two major products. One is their 3D Bioplotter for the medical market. The other is a rapid prototyping system name Perfactory. The system uses acrylate photopolymers and Digital Light Processing (DLP) technology from Texas Instruments. Visible light is projected from underneath through a glass plate onto the bottom side of a thin layer of photopolymer. The systems images and solidifies an entire layer at once, so it offers potential speed advantages over SL technology. The company began to sell systems in Europe in late 2001 and early 2002.

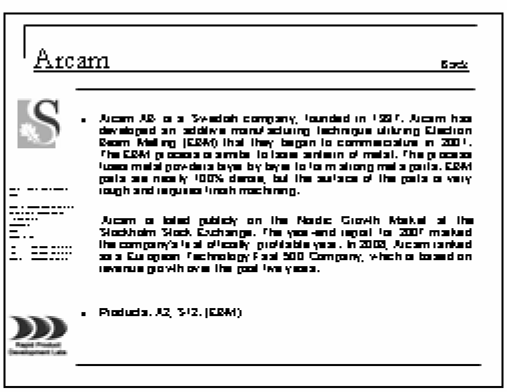
- Products: Perfactory 3D-Bioplotter, Perfactory SXGA standard UV with integrated ERM, Perfactory SXGA standard Zoom with integrated ERM, Perfactory SXGA WIERM Multi Lens, Perfactory Xede, Perfactory Aureus. (Digital light processing)

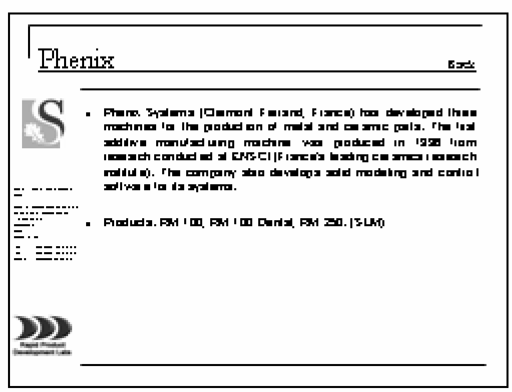

D-MEC
Back
Sony/D-MEC was the second Japanese company to manufacture and sell additive manufacturing systems. The company is composed of a partnership between Japan Synthetic Rubber (JSR) for materials development and company management, and Sony for the manufacture of the SL equipment. The company currently offers the Solid Creation System (SCS) family of SLS systems. The machines range in price from about $212,000 to $1 million. Models and prototype parts from the machines are impressive. Users would agree that they offer quality that is similar to those created with stereolithography machines from 3D Systems.
Products: SCS 1000HD, SCS 8000, SCS 8100, SCS 8100D, SCS 9000. (SLS)

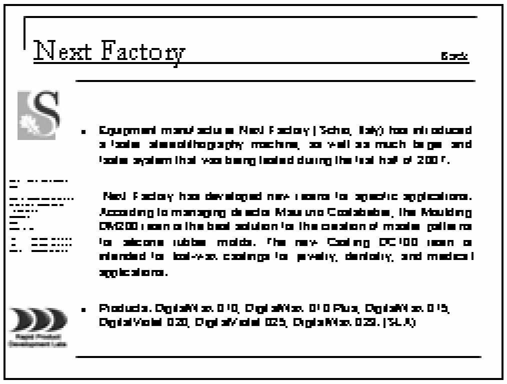

Kira Corporation
Back
Kira Corporation from Japan, its Solid Center machines use adhesive and an x-y plotter system and blade to laminate and cut sheets of paper. The finished parts resemble wood. The company's PLT-20 system ($90,000) uses standard A4 size sheets.
Products: KATANA (LOM)

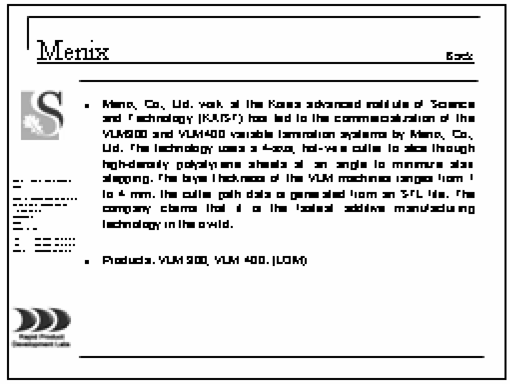

Wuhan Binhu
Back
This company was launched at Huazhong University of Science & Technology in Wuhan, Hubei, China. The organization is developing and selling machines that are very similar to SLS and LOM.
Research in additive manufacturing began at the university in 1991 and has since received endorsements from the Department of Science & Technology, the Department of Education, and other Chinese agencies. The introduction of the first commercial system was in 1997.
Products:
A- SLS systems: HRPS IIA, HRPS IIIA, HRPS IV.
B- SLA systems: HRPL II, HRPL III.
C- LOM systems: HRP IIB, HRP IIIA.

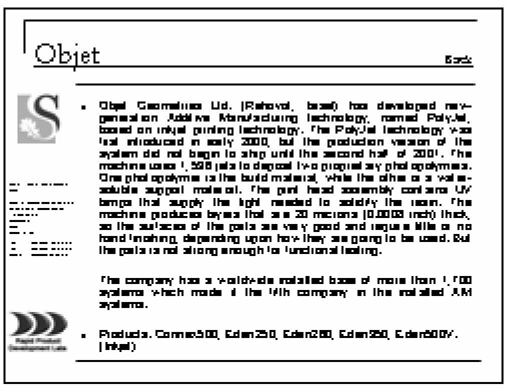

Beijing Longyuan
Back
Beijing Longyuan Automated Fabrication Systems Co., Ltd. This is a Beijing-based company specializing in SLS technology. It is relatively small, but has been in business for more than 10 years and offers two machines. They are similar to SLS systems from 3D Systems, but feature only a single feed chamber for the powder. Like the other companies in China, it allocates a significant portion of its resources to providing services using its own machines. The company also manufacturing and serves as an agent for support technology, such as reverse engineering and tooling. It produces medical models as well as industrial parts, with its major focus being on automotive parts.
Products: AFS 320, AFS 500. (SLS)

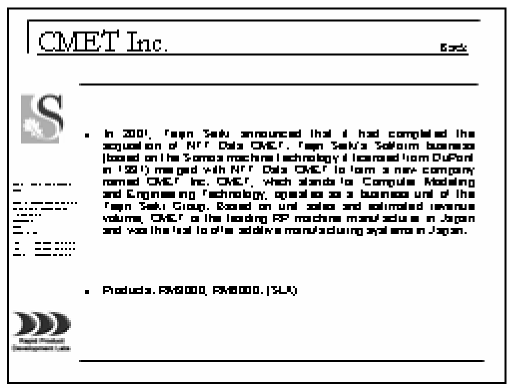

Arcam
Back
Arcam AB is a Swedish company, founded in 1997. Arcam has developed an additive manufacturing technique utilizing Electron Beam Melting (EBM) that they began to commercialize in 2001. The EBM process is similar to laser sintering of metal. The process fuses metal powders layer by layer to form strong metal parts. EBM parts are nearly 100% dense, but the surface of the parts is very rough and requires finish machining.
Arcam is listed publicly on the Nordic Growth Market at the Stockholm Stock Exchange. The year-end report for 2007 marked the company's first officially profitable year. In 2008, Arcam ranked as a European Technology Fast 500 Company, which is based on revenue growth over the past five years.
Products: A2, S12. (EBM)

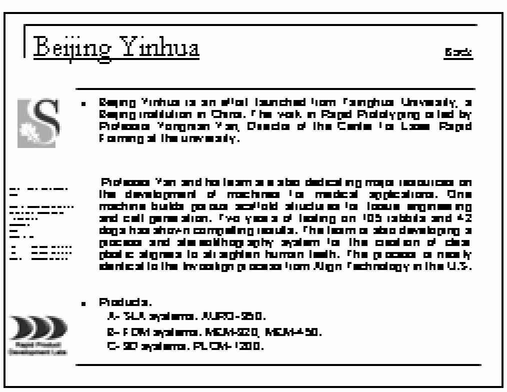

Phenix
Back
Phenix Systems (Clermont Ferrand, France) has developed three machines for the production of metal and ceramic parts. The first additive manufacturing machine was produced in 1998 from research conducted at ENSCI (France's leading ceramics research institute). The company also develops solid modeling and control software for its systems.
Products: PM 100, PM 100 Dental, PM 250. (SLM)

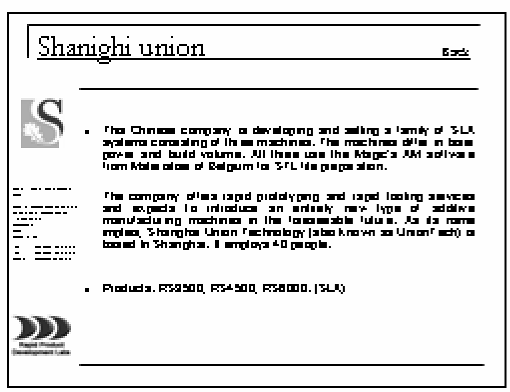

Next Factory
Back
Equipment manufacturer Next Factory (Schio, Italy) has introduced a faster stereolithography machine, as well as much larger and faster system that was being tested during the last half of 2001.
Next Factory has developed new resins for specific applications. According to managing director Massimo Costabeber, the Moulding DM200 resin is the best solution for the creation of master patterns for silicone rubber molds. The new Casting DC100 resin is intended for lost-wax castings for jewelry, dentistry, and medical applications.
Products. DigitalWax 010, DigitalWax 010 Plus, DigitalWax 015, DigitalWax 020, DigitalWax 025, DigitalWax 029. (SLA)

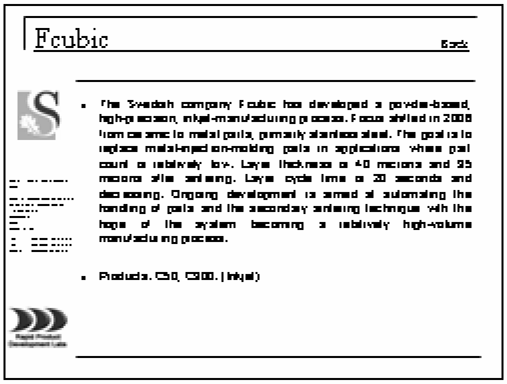

Menix
Back
Menix, Co., Ltd. work at the Korea advanced institute of Science and Technology (KAIST) has led to the commercialization of the VLM300 and VLM400 variable lamination systems by Menix, Co., Ltd. The technology uses a 4-axis, hot-wire cutter to slice through high-density polystyrene sheets at an angle to minimize stair stepping. The layer thickness of the VLM machines ranges from 1 to 4 mm. the cutter path data is generated from an STL file. The company claims that it is the fastest additive manufacturing technology in the world.
Products. VLM 300, VLM 400. (LOM)

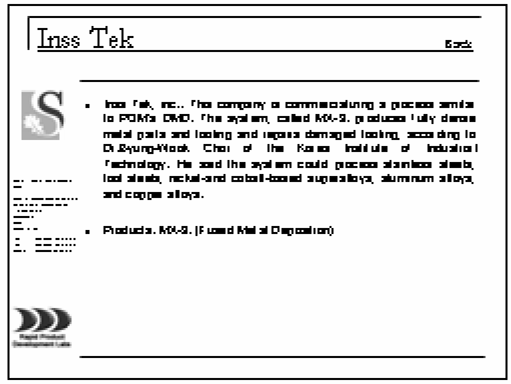

Objet
Back
Objet Geometries Ltd. (Rehovot, Israel) has developed new-generation Additive Manufacturing technology, named PolyJet, based on inkjet printing technology. The PolyJet technology was first introduced in early 2000, but the production version of the system did not begin to ship until the second half of 2001. The machine uses 1,536 jets to deposit two proprietary photopolymers. One photopolymer is the build material, while the other is a water-soluble support material. The print head assembly contains UV lamps that supply the light needed to solidify the resin. The machine produces layers that are 20 microns (0.0008 inch) thick, so the surfaces of the parts are very good and require little or no hand finishing, depending upon how they are going to be used. But the parts is not strong enough for functional testing.
The company has a worldwide installed base of more than 1,700 systems which made it the 4th company in the installed AM systems.
Products. Connex500, Eden250, Eden260, Eden350, Eden500V. (Inkjet)

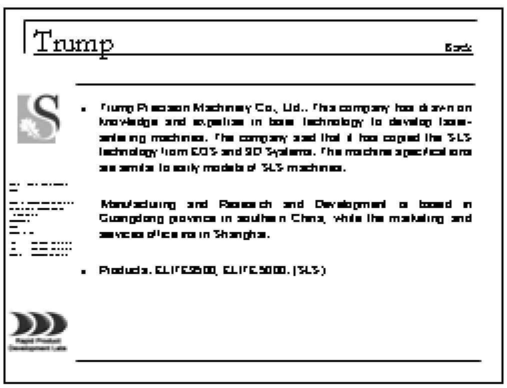

CMET Inc.
Back
In 2001, Teijin Seiki announced that it had completed the acquisition of NTT Data CMET. Teijin Seiki's Soliform business (based on the Somos machine technology it licensed from DuPont in 1997) merged with NTT Data CMET to form a new company named CMET Inc. CMET, which stands for Computer Modeling and Engineering Technology, operates as a business unit of the Teijin Seiki Group. Based on unit sales and estimated revenue volume, CMET is the leading RP machine manufacturer in Japan and was the first to offer additive manufacturing systems in Japan.
Products. RM3000, RM6000. (SLA)

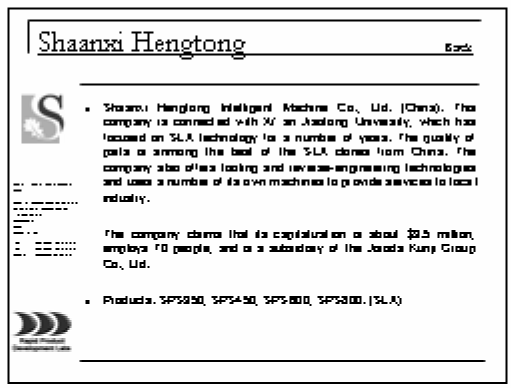

Beijing Yinhua
Back
Beijing Yinhua is an effort launched from Tsinghua University, a Beijing institution in China. The work in Rapid Prototyping is led by Professor Yongnian Yan, Director of the Center for Laser Rapid Forming at the university.
Professor Yan and his team are also dedicating major resources on the development of machines for medical applications. One machine builds porous scaffold structures for tissue engineering and cell generation. Two years of testing on 105 rabbits and 42 dogs has shown compelling results. The team is also developing a process and stereolithography system for the creation of clear plastic aligners to straighten human teeth. The process is nearly identical to the Invisalign process from Align Technology in the U.S.
Products.
A- SLA systems. AURO-350.
B- FDM systems. MEM-320, MEM-450.
C- 3D systems. PLCM-1200.

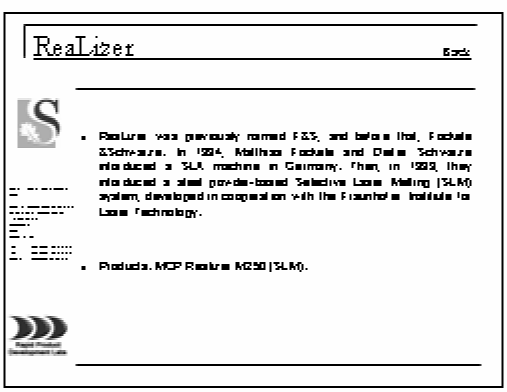

Shanighi union
Back
This Chinese company is developing and selling a family of SLA systems consisting of three machines. The machines differ in laser power and build volume. All three use the Magic's AM software from Materialise of Belgium for STL file preparation.
The company offers rapid prototyping and rapid tooling services and expects to introduce an entirely new type of additive manufacturing machines in the foreseeable future. As its name implies, Shanghai Union Technology (also known as UnionTech) is based in Shanghai. It employs 40 people.
Products. RS3500, RS4500, RS6000. (SLA)

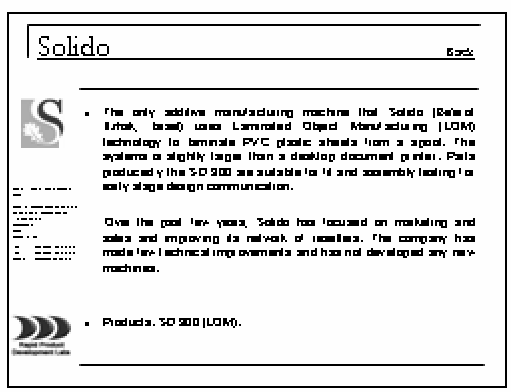

Fcubic
Back
The Swedish company Fcubic has developed a powder-based, high-precision, inkjet-manufacturing process. Focus shifted in 2006 from ceramic to metal parts, primarily stainless steel. The goal is to replace metal-injection-molding parts in applications where part count is relatively low. Layer thickness is 40 microns and 35 microns after sintering. Layer cycle time is 20 seconds and decreasing. Ongoing development is aimed at automating the handling of parts and the secondary sintering technique with the hope of the system becoming a relatively high-volume manufacturing process.
Products: C50, C300. (Inkjet)

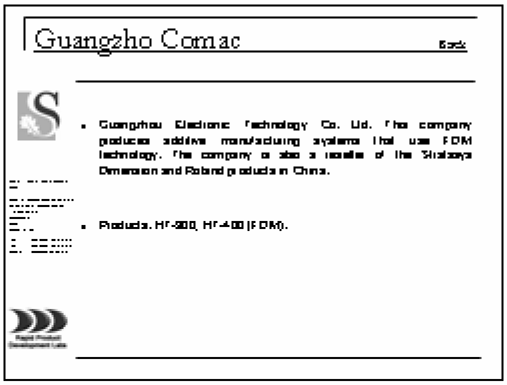

Inss Tek
Back
Insstek, Inc.: This company is commercializing a process similar to POM's DMD. The system, called MX-3, produces fully dense metal parts and tooling and repairs damaged tooling, according to Dr. Kyung-Hook Choi of the Korea Institute of Industrial Technology. He said the system could process stainless steels, tool steels, nickel-and cobalt-based superalloys, aluminum alloys, and copper alloys.
Products: MX-3. (Fused Metal Deposition)

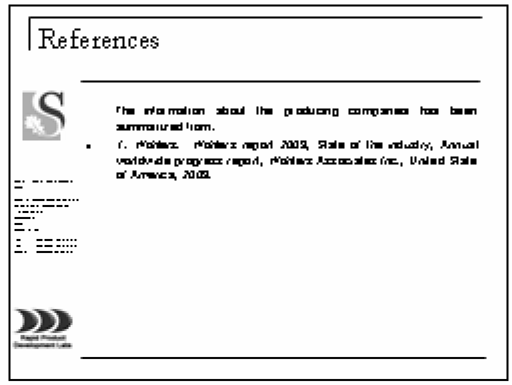

Trump
Back
Trump Precision Machinery Co., Ltd.: This company has drawn on knowledge and expertise in laser technology to develop laser-sintering machines. The company said that it has copied the SLS technology from EOS and 3D Systems. The machine specifications are similar to early models of SLS machines.
Manufacturing and Research and Development is based in Guangdong province in southern China, while the marketing and services offices are in Shanghai.
Products: ELITE2500, ELITE5000. (SLS)


Shaanxi Hengtong
Back
Shaanxi Hengtong Intelligent Machine Co., Ltd. (China): The company is connected with Xi' an Jiaotong University, which has focused on SLA technology for a number of years. The quality of parts is among the best of the SLA clones from China. The company also offers tooling and reverse-engineering technologies and uses a number of its own machines to provide services to local industry.
The company claims that its capitalization is about $3.5 million, employs 70 people, and is a subsidiary of the Jiaoda Kunji Group Co., Ltd.
Products: SPS350, SPS450, SPS600, SPS800. (SLA)


ReaLizer
Back
Realizer was previously named F&S, and before that, Fockele &Schwarze. In 1994, Matthias Fockele and Dieter Schwarze introduced a SLA machine in Germany. Then, in 1999, they introduced a steel powder-based Selective Laser Melting (SLM) system, developed in cooperation with the Fraunhofer Institute for Laser Technology.
Products: MCP Realizer M250 (SLM).


Solido
Back
The only additive manufacturing machine that Solido (Rehovot, Israel) uses Laminated Object Manufacturing (LOM) technology to laminate PVC plastic sheets from a spool. The system is slightly larger than a desktop document printer. Parts produced by the SD 300 are suitable for fit and assembly testing for early stage design communication.
Over the past few years, Solido has focused on marketing and sales and improving its network of resellers. The company has made few technical improvements and has not developed any new machines.
Products: SD 300 (LOM).


Guangzho Comac
Back
Guangzhou Electronic Technology Co. Ltd. The company produces additive manufacturing systems that use FDM technology. The company is also a reseller of the Stratasys Dimension and Roland products in China.


References
The information about the producing companies has been summarised from.
T. Wohlers, Wohlers report 2009, State of the industry, Annual worldwide progress report, Wohlers Associates Inc., United State of America, 2009.

Next

Is CNC better than Additive Manufacturing?

Prepared by: Hossam Shaarka

Study leader: Prof. Dimitri Dimitrov

Stellenbosch University

Rapid Product Development Lab

Is CNC better than AM?

Both of CNC and AM technologies has their own merits. Although CNC is a mature and familiar technology to the industry because it has been invented and developed since almost 40 years ago, AM technologies showed a dramatic development during the last 20 years and confirmed its ability to compete with CNC. Now days it's an important task to compare between these two technologies especially in the case of already using one of them. To select the right tool for the right job, knowledge of both technologies need to be gained. The next table contains a comparison between the two technologies.

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Is CNC better than AM? (cont.)

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	AM	CNC
Materials	Limited.	Unlimited.
Maximum part size	Relatively small.	Large.
Part complexity	Unlimited.	Limited.
Accuracy	Less accurate.	More accurate.
Repeatability	Low.	High.
Surface finish	Low.	High.
Staffing	Minimal.	Significant.
Skilled labor	Minimal.	Relatively high.
Leading time	Short.	Moderate.

Is CNC better than AM? (cont.)

From the previous table it is clear that the main advantages of AM technologies are the design freedom, the leading time, the number of the staff and the needed experience for the staff. AM technologies still developing dramaticly which mean that all its disadvantages might be overcome during the next 10 or 20 years. In the same time, the main advantages of CNC are: the variety of the raw material, the maximum part size, the accuracy of the product, the repeatability and the surface finish. In the practical life, there are other different factors affecting this comparison: machine availability, a specific quality requirement and the available time to do the job. The previous factors are very important and can control the comparison operation. So, as any industrial engineering project, time, cost and quality needed to be balanced in the specific case depending on knowledge and experience to select the proper technology to be used for the critical job.

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References

1. T. Grimm, User's guide to rapid prototyping, United State of America, 2004.

2. T. Wohlers, Wohlers report 2008, State of the industry, Annual worldwide progress report, Wohlers Associates Inc., United State of America, 2008.

Next

The Future of Additive Manufacturing

Prepared by: Hassan Shaanika

Study leader: Prof. Dimitri Dimitrov

Stellenbosch University
Rapid Product Development Labs

The future of Additive Manufacturing

The growing use of AM technologies in manufacturing has been anticipated to drive many changes in the future.

- Specialized AM systems. Once a durable market for a specific type of AM manufactured product has been established, it will make sense to develop specialized AM systems capable of quickly creating high – quality parts of that type. Such systems will then be an obvious choice for also prototyping that type of product. As a result, prototyping will become a function of the contract manufacturer rather than a prototyping service provider.
- Banks of AM systems. We will see plants with banks of AM systems used for production. This will occur when large business opportunities are created from being able to make single parts economically.

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The future of Additive Manufacturing (Cont.)

- Bridge manufacturing. AM systems will be used increasingly to create initial production parts as tooling is being completed. Even though the parts from AM systems may be more expensive than conventionally manufactured parts, the cost will be justified because it will allow the customer to receive products weeks or months sooner.
- Hands-off manufacturing. As the quality of parts built on AM systems improves, the labor content of AM parts will drop dramatically, enabling manufacturers in higher labor cost regions to compete more effectively with manufacturers in countries with lower wages. Competitive pricing, combined with the faster delivery made possible by avoiding international shipping, will give local suppliers and advantage over foreign competitors in those markets.

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The future of Additive Manufacturing (Cont.)

- Distributed manufacturing. As the speed of AM systems increases, the longest lead time item in delivering products will become the time required to ship the product. To further reduce lead times, companies that use AM technologies will build regional and local production facilities close to their customers that will be capable of next day delivery. The ability to receive a product so quickly will enable true just-in-time manufacturing processes and allow customers to minimize inventories. In many cases – especially for limited edition products – inventories will be stored on computer's disk drive.
- Custom manufacturing aids. AM systems are an excellent and inexpensive way to create custom jigs, fixtures, alignment guides, drill guides, and other manufacturing and assembly tools. The market for such items is expected to grow significantly over the next few years. The limitations in materials that prevent greater AM use in the production parts are not nearly so significant for these applications.

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The future of Additive Manufacturing (Cont.)

- Metal parts. Metal-based AM processes will be used increasingly for parts that would otherwise be machined or cast. The most practical application in the foreseeable future is the production of small parts that are highly complex. As the cost of metal systems declines and the speed improves, larger and less complex parts will become viable candidates.
- The need for speed. As applications that use additive manufacturing increase, and the number of parts increase, current AM systems will become unacceptably slow. Already, some AM systems manufacturers have begun to respond to this need.

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References

The text has been summarised from the next reference.

- T. Wohlers. Wohlers report 2009, State of the industry, Annual worldwide progress report, Wohlers Associates Inc., United State of America, 2009.

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Is it economic to use AM technologies?

Stellenbosch University
Rapid Product Development Lab

Economic overview

- Industry growth.
- Revenue growth and forecasts.
- Comparing the costs of rapid manufacture with injection moulding.

Industry growth

With the continuing improvements of additive manufacturing systems capabilities, their sales volumes is growing and their prices is dropping further. Some companies like Solido already produced 10,000$ with LOM technology.

The use of systems for rapid manufacturing is continually gaining momentum. The challenge of making end-use parts is more complex then making prototypes, so rapid manufacturing will require time to develop. Nevertheless, rapid manufacturing is expected to become the largest application of additive technology in the future.

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Revenue growth and forecasts

The market for additive manufacturing in 2008, consisting of all products and services worldwide, grew [illegible]% to $1.[illegible] billion, up from $1.41 billion generated in 2007. Growth was 15% in 2007 and 21.7% in 2006.

The $1.[illegible] billion estimate is composed of revenues generated in the primary AM market. This market consist of all products and services directly associated with additive processes worldwide. Products include additive systems, system upgrades, materials, and aftermarket products, such as third-party software and lasers. Services include revenues generated from parts produced on AM systems by service providers, system maintenance contracts, training , seminars. Conferences, expositions, advertising, publications, contract research, and consulting (See the coming figure).

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Revenue growth and forecasts (Cont.)

The revenues created by these products and services are considerable, but not large compared to many other industries, or even single companies. However, it is important to also consider the overall economic impact that the technology is having on countless design and manufacturing organizations worldwide. For example, Graco Children's Products is producing 7,000-10,000 parts per year-all with four AM systems and one person. A large manufacturer of toys is producing a staggering 12,000 models per year with two people.

It is clear that the economic impact of AM technologies is significant. If one could calculate this impact by the thousands of other companies that also benefit from the technology, the impact would be in the billions of dollars annually.

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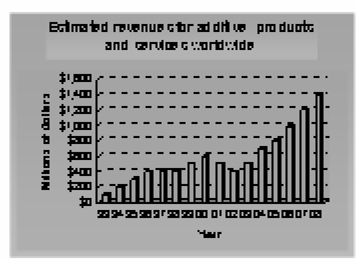
Revenue growth and forecasts (Cont.)



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Comparing the costs of rapid manufacture with injection moulding

There are several studies that focused on comparing the costs of rapid manufacturing and injection moulding. All that studies assumed that the produced rapid manufacturing end-use parts had suitable properties like the injection moulding products. This can be true for some not all cases, but for comparing costs purposes it's applicable.

These studies shows that using rapid manufacturing systems is cheaper when it comes of low volume production (like few thousands) because of the very high moulding tooling cost. But when it comes to high volume production (like hundred thousands) the injection moulding will clearly be the cheapest regarding to the ability of payback for the moulding tooling.

Cut-off volume which is referring to the case when rapid manufacturing production volume becomes more expensive than injection moulding is the target for a lot of recent studies. Such studies like these will allow injection moulding companies to get the benefits of rapid manufacturing industry. The following figure is showing an example of one of these studies.

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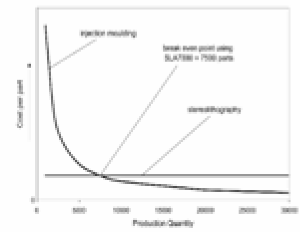
Comparison between the cost of rapid manufacturing and injection moulding (Cont)



Study that compares plastic injection moulding with SLA technology

Back

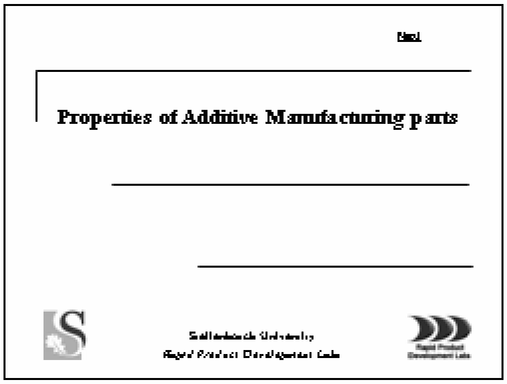
References

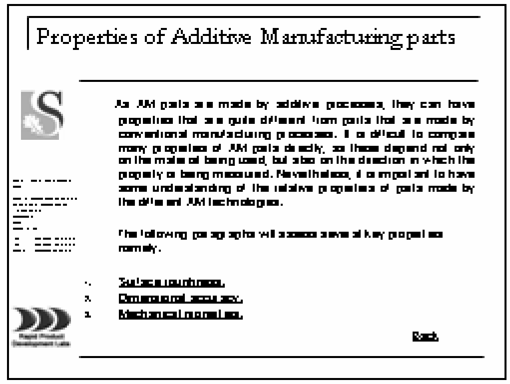
The text of (industry growth) and (revenue growth and forecasts) has been summarized from the next reference.

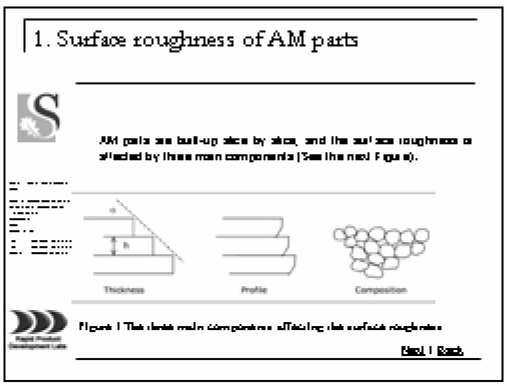
- T. Wohlers, Wohlers report 2009, State of the industry, Annual worldwide progress report, Wohlers Associates Inc., United State of America, 2009.

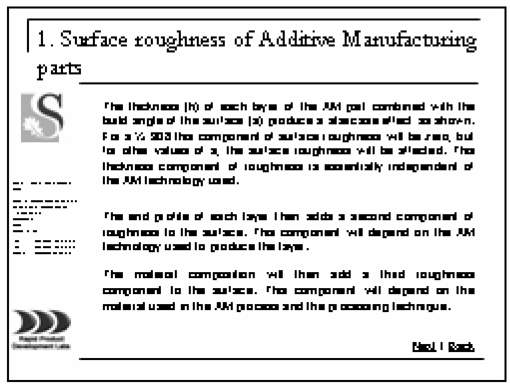
The text of comparing the costs of rapid manufacturing and injection molding has been summarized from the next reference.

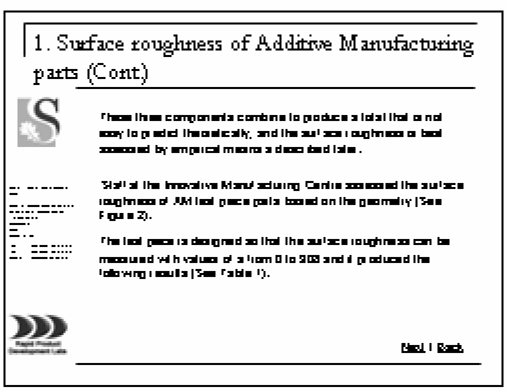
- N. Hopkinson, R.J.M. Hague, P.M. Dickens. Rapid manufacturing – an industrial revolution for the digital age. Wiley, Sussex. WILEY, 2006.

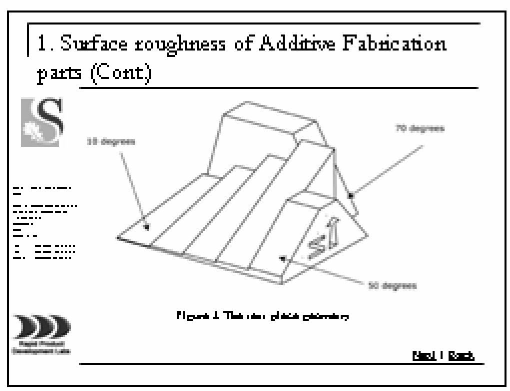

Next
Properties of Additive Manufacturing parts
Stellenbosch University
Rapid Product Development Labs


Properties of Additive Manufacturing parts
Back


1. Surface roughness of AM parts
Thickness
Profile
Composition
Next | Back


1. Surface roughness of Additive Manufacturing parts
Next | Back


1. Surface roughness of Additive Manufacturing parts (Cont)
Next | Back


1. Surface roughness of Additive Fabrication parts (Cont)
10 degrees
70 degrees
50 degrees
Next | Back

1. Surface roughness of Additive Fabrication parts (Cont)

It can be seen that there is a considerable variation in surface roughness depending on the technology, layer thickness and material used, and depending on the build angle of the surface. The build angle is particularly important and the AM user must specify which surface of a AM component should have the best surface finish to ensure that the part can be built in the correct orientation to achieve the desired result.

Table 1 The surface roughness of the test piece

		Build angle, a/degrees				
Technology – material	Layer thickness	10	30	50	70	90
SLA – Epoxy (ACES style)	0.15	39.9	28.8	21.5	16.7	6.1
SLS – Polystyrene	0.20	65.2	35.6	32.6	24.7	20.6
SLS – Nylon	0.10	28.5	36.9	36.5	39.2	11.0
LOM – Paper	0.10	29.2	27.7	25.3	23.3	16.9
FDM – ABS	0.25	56.6	38.6	26.4	22.7	17.9

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2. Dimensional accuracy of AM parts

The same test pieces were also measured to establish the accuracy of linear dimensions for the different AM technologies, when compared to the intended dimensions in the CAD model of the test piece. The results are shown in Table 2.

Table 2 The accuracy of the test piece

	Intended dimensions from CAD model (mm)						
Technology – material	34.50	50.35	52.50	56.00	60.00	71.00	75.00
	Actual dimensions of test parts (mm)						
SLA – Epoxy (ACES)	34.83	50.57	52.77	55.85	59.97	70.97	74.94
SLS – Polystyrene	34.43	50.45	52.62	56.48	60.14	71.31	75.12
SLS – Nylon	34.77	50.37	52.59	55.99	60.39	70.65	74.99
LOM – Paper	34.67	50.61	53.20	55.98	59.92	71.05	74.86
FDM – ABS	34.38	50.07	53.45	55.46	60.09	70.42	75.08

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2. Dimensional accuracy of AM parts (cont)

As can be seen, the accuracy varies considerably depending on the AM technology used and also on which dimension is being measured. Using the raw data, the average (un-weighted) linear dimensional accuracy for the different technologies is detailed in Table 3.

Table 3 The average accuracy of the test piece

Technology – material	Average accuracy over seven dimensions (unweighted) (per cent)
SLA – Epoxy (ACES)	97.7
SLS – Polystyrene	97.7
SLS – Nylon	97.8
LOM – Paper	97.2
FDM – ABS	95.3

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2. Dimensional accuracy of AM parts (Cont)

It can be seen that none of the AM technologies considered are more accurate than 97.8 per cent. Although not considered further here, it should also be borne in mind that AM models can also suffer from warpage. The AM user must take the linear dimensional inaccuracy and warpage of AM models into account when considering possible applications for the AM parts.

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3. Mechanical properties of AM parts

It is difficult to measure and compare the mechanical properties of AF parts for a number of reasons. The materials and processes used to make the parts are continually improving therefore the mechanical strength and other properties of the parts are also improving. The mechanical properties are also significantly anisotropic, and depend strongly on the direction in which they are tested. Finally, equipment manufacturers are often loath to supply material data for such comparisons and when they do, it is rarely directly comparable with that supplied by other manufacturers. For example, some manufacturers supply data obtained from test parts made on their AM machines, while others supply only data from tests on bulk samples of the source material.

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3. Mechanical properties of AM parts (cont)

Despite these reservations, it is useful to obtain some feel for the relative order of magnitude of the mechanical properties of the materials used in different AM processes. Table 4 presents data supplied by the material suppliers or equipment manufacturers themselves.

Table 4 data supplied by the material suppliers

Technology	Material	Tensile strength (MPa)	Elastic modulus (MPa)	Hardness (shore D-scale)
SLA	Epoxy	55-65	2,150-2,600	80-85
	Acrylate	35	1,100-1,200	78
LOM	Paper	26-66	2,524-6,087	55-70
	Polyester	85	3,435	N/A
FDM	ABS	35	2,495	105 Rockwell
	Wax	3.5	277	33
SLS	Fine nylon	36	1,400	N/A
	Acrylic polymer	10	1,100	N/A
	Nylon/50 per cent glass	49	2,828	N/A

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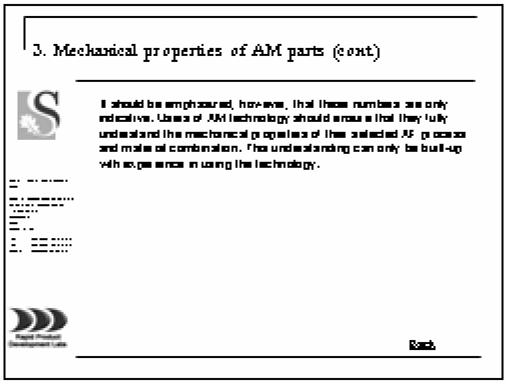
3. Mechanical properties of AM parts (cont)
It should be emphasised, however, that these numbers are only indicative. Users of AM technology should ensure that they fully understand the mechanical properties of their selected AF process and material combination. This understanding can only be built-up with experience in using the technology.
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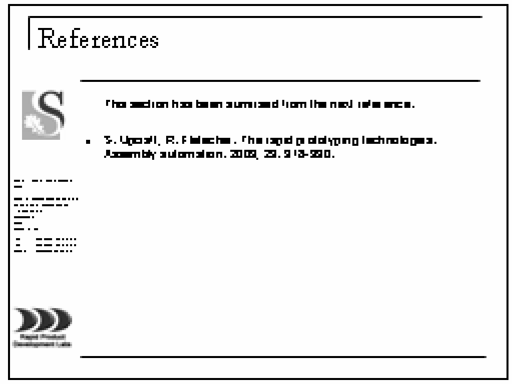
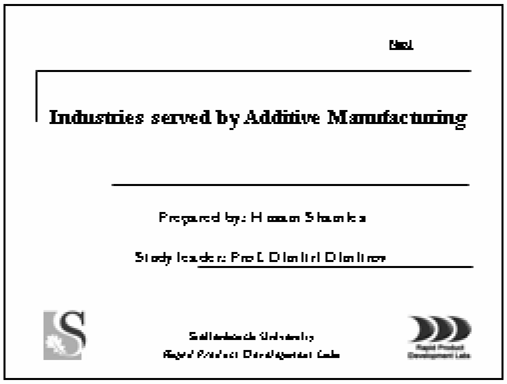
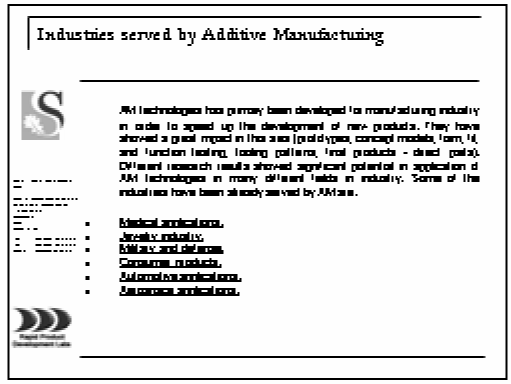
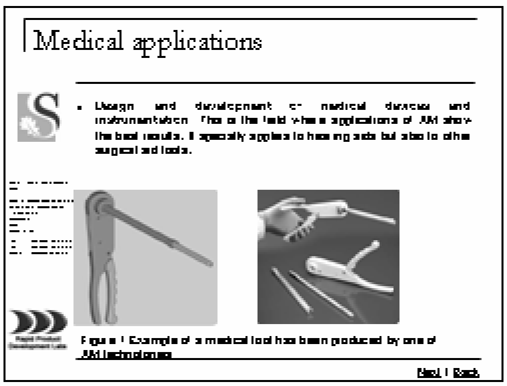

References
This section has been summized from the next reference.
S. Upcraft, R. Fletcher. The rapid prototyping technologies. Assembly automation. 2003, 23: 318-330.


Next
Industries served by Additive Manufacturing
Prepared by: Hassan Shaaban
Study leader: Prof. Dimitri Dimitrov
Stellenbosch University
Rapid Product Development Labs


Industries served by Additive Manufacturing
AM technologies has primary been developed for manufacturing industry in order to speed up the development of new products. They have showed a great impact in this area (prototypes, concept models, form, fit, and function testing, tooling patterns, final products - direct parts). Different research results showed significant potential in application of AM technologies in many different fields in industry. Some of the industries have been already served by AM are.
Medical applications.
Jewelry industry.
Military and defense.
Consumer products.
Automotive applications.
Aerospace applications.


Medical applications
Design and development of medical devices and instrumentation. This is the field where applications of AM show the best results. It specially applies to hearing aids but also to other surgical aid tools.
Figure 1 Example of a medical tool has been produced by one of AM technologies
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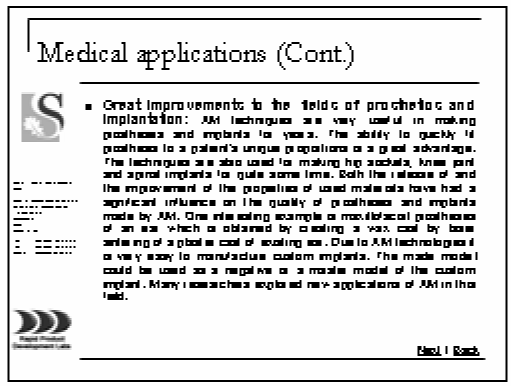
Medical applications (Cont.)
Great improvements to the fields of prosthetics and implantation: AM techniques are very useful in making prostheses and implants for years. The ability to quickly fit prostheses to a patient's unique proportions is a great advantage. The techniques are also used for making hip sockets, knee joint and spinal implants for quite some time. Both the release of and the improvement of the properties of used materials have had a significant influence on the quality of prostheses and implants made by AM. One interesting example is maxillofacial prostheses of an ear which is obtained by creating a wax cast by bone sintering of a plastic cast of existing ear. Due to AM technologies it is very easy to manufacture custom implants. The made model could be used as a negative or a master model of the custom implant. Many researches explored new applications of AM in this field.
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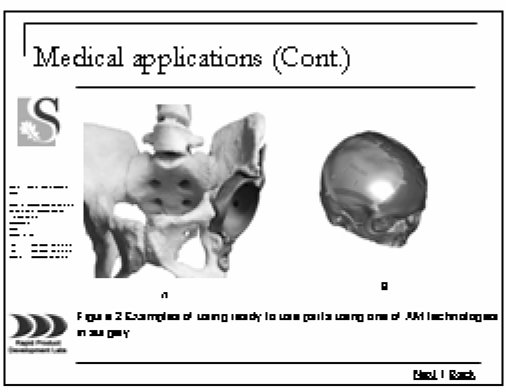
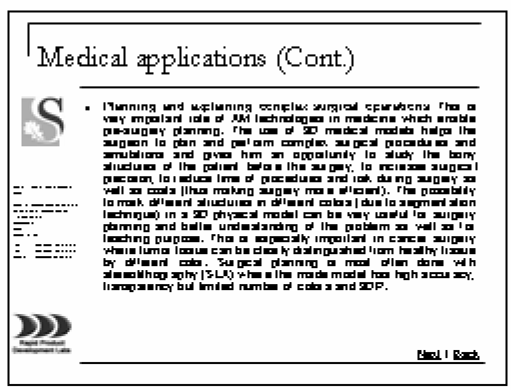

Medical applications (Cont.)
Next | Back


Medical applications (Cont.)
Planning and explaining complex surgical operations: This is very important role of AM technologies in medicine which enable pre-surgery planning. The use of 3D medical models helps the surgeon to plan and perform complex surgical procedures and simulations and gives him an opportunity to study the bony structures of the patient before the surgery, to increase surgical precision, to reduce time of procedures and risk during surgery as well as costs (thus making surgery more efficient). The possibility to mark different structures in different colors (due to segmentation technique) in a 3D physical model can be very useful for surgery planning and better understanding of the problem as well as for teaching purposes. This is especially important in cancer surgery where tumor tissue can be clearly distinguished from healthy tissue by different color. Surgical planning is most often done with stereolithography (SLA) where the made model has high accuracy, transparency but limited number of colors and 3DP.
Next | Back

Medical applications (Cont.)

- Design and manufacturing biocompatible and bioactive implants and tissue engineering. AM technologies gave significant contribution in the field of tissue engineering through the use of biomaterials including the direct manufacture of bioactive implants. Tissue engineering is a combination of living cells and a support structure called scaffolds. AM systems like fused deposition modeling (FDM), 3D printing (3-DP) and selective laser sintering (SLS) have been proved to be convenient for making porous structures for use in tissue engineering. In this field it is essential to be able to fabricate three-dimensional scaffolds of various geometric shapes, in order to repair defects caused by accidents, surgery, or birth. FDM, SLS and 3DP can be used to fabricate a functional scaffold directly but AM systems can also be used for manufacturing a sacrificial mould to fabricate tissue-engineering scaffolds.

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Medical applications (Cont.)

- Teaching purposes: AM models can be used as teaching aids for students in the classroom as well as for researchers. These models can be made in many colors and provide a better illustration of anatomy, allow viewing of internal structures and much better understanding of some problems or procedures which should be taken in concrete case. They are also used as teaching simulators.

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AM medical materials

There are varieties of materials which can be used for medical applications of AM. Which material should be selected depends on the purpose of made model (planning procedures, implants, prostheses, surgical tools, tissue scaffold ...), demanded properties of material for concrete application and the possibilities of the chosen AM technique. Materials must show biological compatibility.

- Photosensitive resins for medical application (STL).
- Metals (stainless steel, titanium alloys, Cobalt Chromium alloys, other).
- Advanced bioceramic materials (Alumina, Zirconia, Calcium phosphate-based bioceramics, porous ceramics) for LOM.
- Polycaprolactone (PCL) scaffolds, polymer-ceramic composite scaffold made of polypropylene-tricalcium phosphate (PP-TCP), PCL and PCL-hydroxyapatite (HA) for FDM, PLGA, starch-based polymer for 3DP, polyetheretherketone-hydroxyapatite (PEEK-HA), PCL scaffolds in tissue engineering for (SLS).

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AM medical materials (Cont.)

- Bone cement, new calcium phosphate powder binders (mixture of tetracalcium phosphate (TTCP) and beta – tricalcium phosphate (TCP)), Polymethyl methacrylate (PMMA) material, other polymer calcium phosphate cement composites for bone substitutes and implants.
- Many other biocompatible materials.

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Jewelry industry

Approximately 40 years ago, the jewelry industry underwent a revolutionary change in production from producing unique items only to mass production as a result of the introduction of a new casting technology based on the lost-wax technique. The traditional jewelry manufacturing process using the lost-wax technique is as follows.

1. Drawing.
2. Prototype is produced by the craftsman.
3. Building a silicon mold.
4. Building the wax with the wax injector.
5. Casting with the lost-wax technique.
6. Finishing.

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Jewelry industry (Cont.)

It is clear from the traditional jewelry manufacturing process that AM can help in producing the prototype instead of the craftsman which saves money and time with better quality. Or, AM can produce the wax part which means cutting the process into just half to just become from point 2 to 5. In conclusion, AM technologies are already saving money and time and bring unique features to the jewelry industry worldwide.

The Solidscape master model shows the intricacy and precision that are not possible with other technologies.

Figure 5

Made from the Solidscape master model (previous image), this ring features a large center stone.

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Jewelry industry (Cont.)

Advantages of using AM technologies with Jewelry industry

- Openwork design that is very difficult to be made by hand.
- Shapes that cannot be made out of rubber cutting.
- New shapes that have to be produced a couple of times to be tried on to get the feel.
- Repetitive patterns made out of expansion and contraction of the same shape that fully take advantage of CAD's unique features.
- Pipes with graduated shapes that are difficult to be made by machine processing.
- Designs that intentionally take advantage of the gaps made unique to production by AM.

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Jewelry industry (Cont.)

Figure 4: Examples of unique jewelries that can not be produced using any other technologies rather than AM technologies.

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Military and defense

The impact of additive manufacturing technologies to the production and maintenance of weapon systems is profound and includes both financial, technical, and logistical advantages as described below.

- Cost saving: AM offers a tremendous opportunity to lower the cost of designing, developing, producing, and maintaining weapon systems and their related components. Specific opportunities for cost reduction include, reduced cost of inventories, lower manufacturing process costs, especially for hard to machine materials, and the ability to repair versus replace high value parts. Cost savings can be achieved for producing parts with AM that are independent of lot size. In many cases, reductions in cost and cycle time can be greater than 50%.

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Military and defense (Cont.)

- Reduced lead time: AM technologies can reduce production lead time from months to days and is especially suited for low rate production, hard to obtain parts, design prototypes, and castings and forgings requiring long lead tooling and molds.
- Improved sustainment: Legacy systems, including both weapon platforms and logistic support systems, are expected to be in-service by as much as 25 years or more beyond the design life and in some cases, 50 or more years. Production base consolidation, transformation, changes in prioritization, and solvency have generated instability in part supplies. Limited availability of technical data packages requires the use of reverse engineering that is facilitated by AM technologies.

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Military and defense (Cont.)

- Increased combat readiness: Potentially, mobile manufacturing platforms provide the capability to enhance field level maintenance. Confidence in part delivery is increased and vulnerability is reduced through distributed, local manufacturing. The digital exchange of data accelerates the maintenance process and establishes chronology of repair. There is also the potential for supporting Allied hardware in the field.
- Personnel reduction: Unattended operation, the ability to provide a fully integrated digital manufacturing solution, and a reduced number of conventional manufacturing processes are achievable through AM.

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Military and defense (Cont.)

- Improved quality: AM improves manufacturing quality through fewer manual processes and localized heating during repair limits part damage.
- New capability: Sensor integration, graded structures, electronics, new alloys, and heterogeneous structures are some of the potential benefits of AM.

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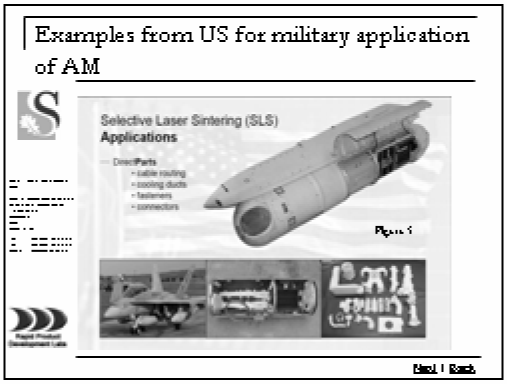
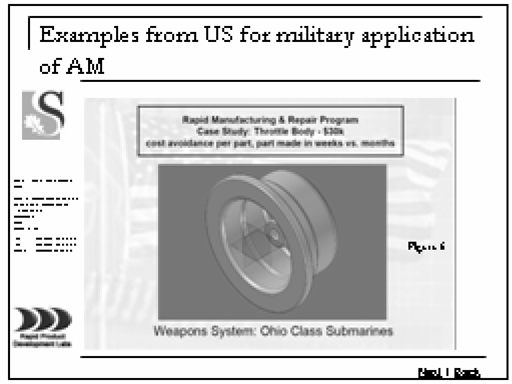
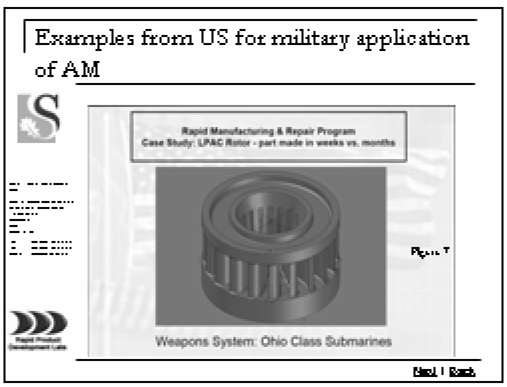

Examples from US for military application of AM
Selective Laser Sintering (SLS)
Applications
Direct Parts
- cable routing
- cooling ducts
- fasteners
- connectors
Next | Back


Examples from US for military application of AM
Rapid Manufacturing & Repair Program
Case Study: Throttle Body - $30k
cost avoidance per part, part made in weeks vs. months
Weapons System: Ohio Class Submarines
Next | Back


Examples from US for military application of AM
Rapid Manufacturing & Repair Program
Case Study: LPAC Rotor - part made in weeks vs. months
Weapons System: Ohio Class Submarines
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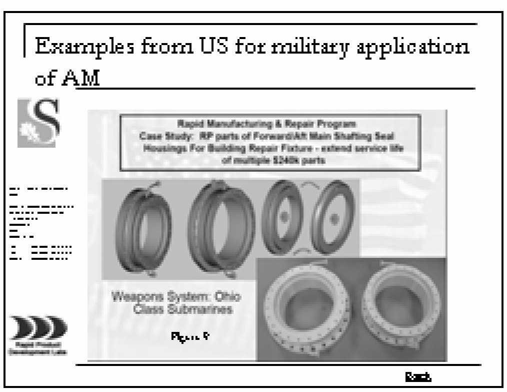
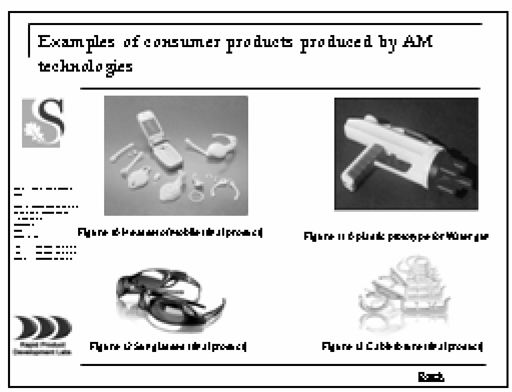
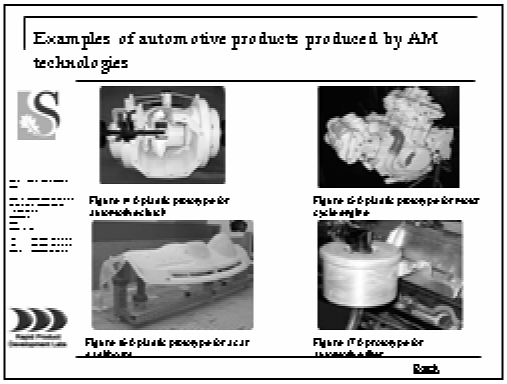
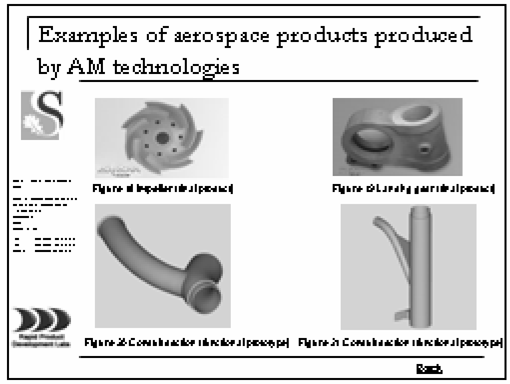
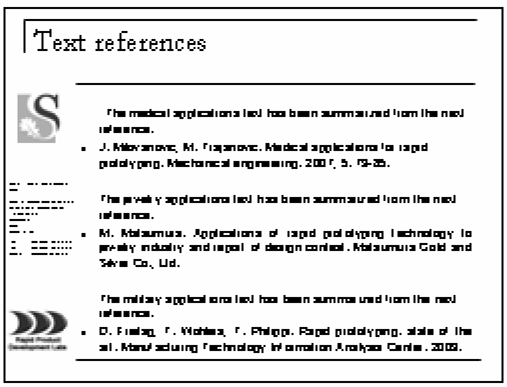
Examples from US for military application of AM
Rapid Manufacturing & Repair Program
Case Study: Mock-up Tool, Standard Canopy Cutting Machine (SCCM)
cost avoidance $42.5k per ship, tool made in weeks vs. months
Weapons system – Virginia Class Submarines
Next | Back


Examples from US for military application of AM
Rapid Manufacturing & Repair Program
Case Study: RP parts of Forward/Aft Main Shafting Seal
Housings For Building Repair Fixture - extend service life
of multiple $240k parts
Weapons System: Ohio Class Submarines
Back


Examples of consumer products produced by AM technologies
Back


Examples of automotive products produced by AM technologies
Back


Examples of aerospace products produced by AM technologies
Back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M. Matsumura. Applications of rapid prototyping technology to jewelry industry and report of design contest. Matsumura Gold and Silver Co., Ltd.
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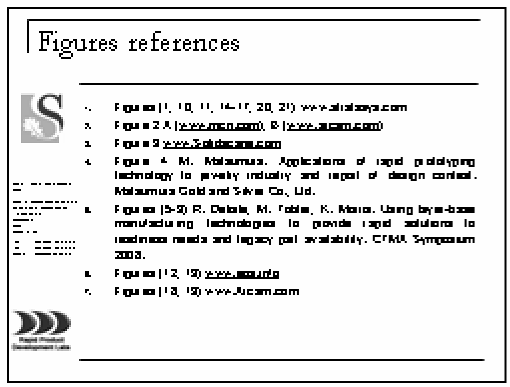
Figures references
1. Figures (1, 10, 11, 14-17, 20, 21) www.stratasys.com
2. Figure 2 A (www.msn.com), B (www.arcam.com)
3. Figure 3 www.3dsystems.com
4. Figure 4 M. Matsumura. Applications of rapid prototyping technology to jewelry industry and report of design contest. Matsumura Gold and Silver Co., Ltd.
5. Figures (5-9) R. Dehoff, M. Tobler, K. Morris. Using layer-base manufacturing technologies to provide rapid solutions to readiness needs and legacy part availability. CTMA Symposium 2008.
6. Figures (12, 13) www.eos.info
7. Figures (18, 19) www.Arcam.com

Appendix B The Visual Basic code of the program

The Visual Basic code of the program:

```
Private Sub Command1_Click()
DoCmd.OpenForm "General"
End Sub

Private Sub Command2_Click()
DoCmd.OpenForm "Manufacturing"
End Sub

Private Sub Command3_Click()
DoCmd.OpenForm "Prototyping"

End Sub

Private Sub Command3_DblClick(Cancel As Integer)

End Sub

Private Sub Command4_Click()
DoCmd.OpenForm "Tooling"

End SubPrivate Sub Combo3DTCMS_Change()
If Combo3DTCMS = "740x810x1090" Then
Combo3DTCSP.Value = "20.000"
Combo3DTCPMS.Value = "203x254x203"
Combo3DTCSP.Enabled = False
Combo3DTCPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCMS = "1220x790x1400" Then
Combo3DTCSP.Value = "40.000"
Combo3DTCPMS.Value = "203x254x203"
Combo3DTCSP.Enabled = False
Combo3DTCPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCMS = "1070x790x1270" Then
Combo3DTCSP.Value = "50.000"
Combo3DTCPMS.Value = "254x356x203"
Combo3DTCSP.Enabled = False
Combo3DTCPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCMS = "1880x740x1450" Then
Combo3DTCSP.Value = "80.000"
Combo3DTCPMS.Value = "254x381x203"
Combo3DTCSP.Enabled = False
Combo3DTCPMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If Combo3DTCMS = "None" Then
Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCSP.Enabled = True
Combo3DTCPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub Combo3DTCMS1_Change()
If Combo3DTCMS1 = "740x810x1090" Then
Combo3DTCPMS.Enabled = False
Combo3DTSandPMS.Enabled = False
Combo3DTCSP1.Value = "20.000"
Combo3DTCSP1.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCMS1 = "1220x790x1400" Then
Combo3DTCPMS.Enabled = False
Combo3DTSandPMS.Enabled = False
Combo3DTCSP1.Value = "40.000"
Combo3DTCSP1.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCMS1 = "None" Then
Combo3DTCPMS.Enabled = True
Combo3DTCSP1.Value = "None"
Combo3DTSandPMS.Enabled = True
Combo3DTCSP1.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub Combo3DTCPMS_Change()
If Combo3DTCPMS = "203x254x203" Then
Combo3DTCSP1.Visible = True
Combo3DTCMS1.Visible = True
Combo3DTCSP1.Enabled = True
Combo3DTCMS1.Enabled = True
Combo3DTCSP1.Value = ""
Combo3DTCMS1.Value = ""
Combo3DTCSP.Visible = False
Combo3DTCMS.Visible = False
End If

If Combo3DTCPMS = "254x356x203" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCMS.Visible = True
Combo3DTCSP.Value = "50.000"
Combo3DTCMS.Value = "1070x790x1270"
```

```
Combo3DTCSP.Enabled = False
Combo3DTCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCPMS = "254x381x203" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCMS.Visible = True
Combo3DTCSP.Value = "80.000"
Combo3DTCMS.Value = "1880x740x1450"
Combo3DTCSP.Enabled = False
Combo3DTCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCPMS = "None" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTCSP.Value = "None"
Combo3DTCMS.Value = "None"
Combo3DTCSP.Enabled = True
Combo3DTCMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub Combo3DTCSP_Change()
If Combo3DTCSP = "20.000" Then
Combo3DTCPMS.Value = "203x254x203"
Combo3DTCMS.Value = "740x810x1090"
Combo3DTCPMS.Enabled = False
Combo3DTCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCSP = "40.000" Then
Combo3DTCPMS.Value = "203x254x203"
Combo3DTCMS.Value = "1220x790x1400"
Combo3DTCPMS.Enabled = False
Combo3DTCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCSP = "50.000" Then
Combo3DTCPMS.Value = "254x356x203"
Combo3DTCMS.Value = "1070x790x1270"
Combo3DTCPMS.Enabled = False
Combo3DTCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCSP = "80.000" Then
Combo3DTCPMS.Value = "254x381x203"
```

```
Combo3DTCMS.Value = "1880x740x1450"
Combo3DTCPMS.Enabled = False
Combo3DTCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If Combo3DTCSP = "None" Then
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTCPMS.Enabled = True
Combo3DTCMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub Combo3DTCSP1_Change()
If Combo3DTCSP1 = "20.000" Then
Combo3DTCPMS.Enabled = False
Combo3DTSandPMS.Enabled = False
Combo3DTCMS1.Value = "740x810x1090"
Combo3DTCMS1.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTCSP1 = "40.000" Then
Combo3DTCPMS.Enabled = False
Combo3DTSandPMS.Enabled = False
Combo3DTCMS1.Value = "1220x790x1400"
Combo3DTCMS1.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTCSP1 = "None" Then
Combo3DTSandPMS.Enabled = True
Combo3DTCPMS.Enabled = True
Combo3DTCMS1.Value = "None"
Combo3DTCMS1.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub Combo3DTSandMS_Change()
If Combo3DTSandMS = "740x810x1090" Then
Combo3DTSandSP.Value = "20.000"
Combo3DTSandPMS.Value = "203x254x203"
Combo3DTSandSP.Enabled = False
Combo3DTSandPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandMS = "1220x790x1400" Then
Combo3DTSandSP.Value = "40.000"
Combo3DTSandPMS.Value = "203x254x203"
Combo3DTSandSP.Enabled = False
Combo3DTSandPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandMS = "1070x790x1270" Then
```

```
Combo3DTSandSP.Value = "50.000"
Combo3DTSandPMS.Value = "254x356x203"
Combo3DTSandSP.Enabled = False
Combo3DTSandPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandMS = "2100x1150x1650" Then
Combo3DTSandSP.Value = "70.000"
Combo3DTSandPMS.Value = "1200x900x600"
Combo3DTSandSP.Enabled = False
Combo3DTSandPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandMS = "1880x740x1450" Then
Combo3DTSandSP.Value = "80.000"
Combo3DTSandPMS.Value = "254x381x203"
Combo3DTSandSP.Enabled = False
Combo3DTSandPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandMS = "None" Then
Combo3DTSandSP.Value = ""
Combo3DTSandPMS.Value = ""
Combo3DTSandSP.Enabled = True
Combo3DTSandPMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub Combo3DTSandPMS_Change()
If Combo3DTSandPMS = "203x254x203" Then
Combo3DTCSP1.Visible = True
Combo3DTCMS1.Visible = True
Combo3DTCSP1.Enabled = True
Combo3DTCMS1.Enabled = True
Combo3DTSandSP.Visible = False
Combo3DTSandMS.Visible = False
End If
If Combo3DTSandPMS = "254x356x203" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTSandSP.Value = "50.000"
Combo3DTSandMS.Value = "1070x790x1270"
Combo3DTSandSP.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandPMS = "1200x900x600" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTSandSP.Value = "70.000"
Combo3DTSandMS.Value = "2100x1150x1650"
Combo3DTSandSP.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If Combo3DTSandPMS = "254x381x203" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTSandSP.Value = "80.000"
Combo3DTSandMS.Value = "1880x740x1450"
Combo3DTSandSP.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandPMS = "None" Then
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTSandSP.Value = ""
Combo3DTSandMS.Value = ""
Combo3DTSandSP.Enabled = True
Combo3DTSandMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub Combo3DTSandSP_Change()
If Combo3DTSandSP = "20.000" Then
Combo3DTSandPMS.Value = "203x254x203"
Combo3DTSandMS.Value = "740x810x1090"
Combo3DTSandPMS.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandSP = "40.000" Then
Combo3DTSandPMS.Value = "203x254x203"
Combo3DTSandMS.Value = "1220x790x1400"
Combo3DTSandPMS.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandSP = "50.000" Then
Combo3DTSandPMS.Value = "254x356x203"
Combo3DTSandMS.Value = "1070x790x1270"
Combo3DTSandPMS.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandSP = "80.000" Then
Combo3DTSandPMS.Value = "254x381x203"
Combo3DTSandMS.Value = "1880x740x1450"
Combo3DTSandPMS.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
If Combo3DTSandSP = "70.000" Then
Combo3DTSandPMS.Value = "1200x900x600"
Combo3DTSandMS.Value = "2100x1150x1650"
Combo3DTSandPMS.Enabled = False
Combo3DTSandMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If Combo3DTSandSP = "None" Then
Combo3DTSandPMS.Value = ""
Combo3DTSandMS.Value = ""
Combo3DTSandPMS.Enabled = True
Combo3DTSandMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboCeramicFTMS_Change()
If ComboCeramicFTMS = "1450x1250x1900" Then
ComboCeramicFTSP.Value = "283.800 "
ComboCeramicFTPMS.Value = "100(high)x100(Dim)"
ComboCeramicFTSP.Enabled = False
ComboCeramicFTPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboCeramicFTMS = "3250x1300x 2400" Then
ComboCeramicFTSP.Value = "513.480 "
ComboCeramicFTPMS.Value = "250(high)x300(Dim)"
ComboCeramicFTSP.Enabled = False
ComboCeramicFTPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboCeramicFTMS = "None" Then
ComboCeramicFTSP.Value = ""
ComboCeramicFTPMS.Value = ""
ComboCeramicFTSP.Enabled = True
ComboCeramicFTPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboCeramicFTPMS_Change()
If ComboCeramicFTPMS.Value = "100(high)x100(Dim)" Then
ComboCeramicFTMS.Value = "1450x1250x1900"
ComboCeramicFTSP.Value = "283.800 "
ComboCeramicFTMS.Enabled = False
ComboCeramicFTSP.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboCeramicFTPMS.Value = "250(high)x300(Dim)" Then
ComboCeramicFTMS.Value = "3250x1300x 2400"
ComboCeramicFTSP.Value = "513.480 "
ComboCeramicFTMS.Enabled = False
ComboCeramicFTSP.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboCeramicFTPMS.Value = "None" Then
ComboCeramicFTMS.Value = ""
ComboCeramicFTSP.Value = ""
ComboCeramicFTMS.Enabled = True
ComboCeramicFTSP.Enabled = True
CommandRecommend.Enabled = False
End If
```

```
End Sub

Private Sub ComboCeramicFTSP_Change()
If ComboCeramicFTSP.Value = "513.480" Then
ComboCeramicFTMS.Value = "3250x1300x 2400"
ComboCeramicFTPMS.Value = "250(high)x300(Dim)"
ComboCeramicFTMS.Enabled = False
ComboCeramicFTPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboCeramicFTSP.Value = "283.800" Then
ComboCeramicFTMS.Value = "1450x1250x1900"
ComboCeramicFTPMS.Value = "100(high)x100(Dim)"
ComboCeramicFTMS.Enabled = False
ComboCeramicFTPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboCeramicFTSP.Value = "None" Then
ComboCeramicFTMS.Value = ""
ComboCeramicFTPMS.Value = ""
ComboCeramicFTMS.Enabled = True
ComboCeramicFTPMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboConcept_BeforeUpdate(Cancel As Integer)

End Sub

Private Sub ComboConcept_Change()
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = False
ComboVisualT.Visible = False
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTCSP1.Enabled = True
Combo3DTCMS1.Enabled = True
Combo3DTCSP.Enabled = True
Combo3DTCPMS.Enabled = True
Combo3DTCMS.Enabled = True
Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTSandSP.Enabled = True
Combo3DTSandPMS.Enabled = True
Combo3DTSandMS.Enabled = True

If ComboConcept = "Starch" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
```

```
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTCSP.Enabled = True
Combo3DTCPMS.Enabled = True
Combo3DTCMS.Enabled = True
Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboConcept = "Sand" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = True
Combo3DTSandPMS.Visible = True
Combo3DTSandMS.Visible = True
Combo3DTSandSP.Value = ""
Combo3DTSandPMS.Value = ""
Combo3DTSandMS.Value = ""
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
```

```
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboConcept = "Plaster" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTCSP.Enabled = True
Combo3DTCPMS.Enabled = True
Combo3DTCMS.Enabled = True
Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCT.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
```

```
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If


If ComboConcept = "Ceramic" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTCSP.Enabled = True
Combo3DTCPMS.Enabled = True
Combo3DTCMS.Enabled = True
Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboConcept = "Wax" Then
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = True
```

```
ComboPlasticCT.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboConcept = "Paper" Then
Label3DT.Visible = False
LabelPaperT.Visible = True
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
```

```
ComboPaperCTLOMSP.Visible = True
ComboPaperCTLOMPMS.Visible = True
ComboPaperCTLOMMS.Visible = True
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboConcept = "Plastic" Then
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = True
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboConcept = "Metal" Then
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Label3DT.Visible = True
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
```

```
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = True
LabelMetalCT3DPMS.Visible = True
LabelMetalCT3DMS.Visible = True
CommandRecommend.Enabled = True
End If

If ComboConcept = "None" Then
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
```

```
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboForm_Change()
LabelPaperT.Visible = False
ComboWaxT.Visible = False
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = False
ComboVisualT.Visible = False
If ComboForm = "Ceramic" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboForm = "Paper" Then
Label3DT.Visible = False
LabelPaperT.Visible = True
ComboWaxT.Visible = False
```

```
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = True
ComboPaperCTLOMPMS.Visible = True
ComboPaperCTLOMMS.Visible = True
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboForm = "Plastic" Then
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = True
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
```

```
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

If ComboForm = "Metal" Then
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Label3DT.Visible = True
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = True
LabelMetalCT3DPMS.Visible = True
LabelMetalCT3DMS.Visible = True
CommandRecommend.Enabled = True
End If

If ComboForm = "None" Then
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
```

```
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboFunction_Change()
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCT.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
```

```
ComboPlasticCTFDMMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
ComboCeramicFTSP.Visible = False
ComboCeramicFTPMS.Visible = False
ComboCeramicFTMS.Visible = False
ComboPlasticFTSLSSP.Visible = False
ComboPlasticFTSLSPMS.Visible = False
ComboPlasticFTSLSMS.Visible = False
If ComboFunction = "Ceramic" Then
LabelFunctionCeramicT.Visible = True
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = False
ComboCeramicFTSP.Visible = True
ComboCeramicFTPMS.Visible = True
ComboCeramicFTMS.Visible = True
End If

If ComboFunction = "Metal" Then
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = True
ComboFunctionPlasticT.Visible = False
ComboCeramicFTSP.Visible = False
ComboCeramicFTPMS.Visible = False
ComboCeramicFTMS.Visible = False
End If

If ComboFunction = "Plastic" Then
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = True
```

```
ComboCeramicFTSP.Visible = False
ComboCeramicFTPMS.Visible = False
ComboCeramicFTMS.Visible = False
End If

If ComboFunction = "None" Then
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = False
ComboCeramicFTSP.Visible = False
ComboCeramicFTPMS.Visible = False
ComboCeramicFTMS.Visible = False
End If
End Sub

Private Sub ComboJapanChina_Change()

End Sub

Private Sub ComboFunctionMetalT_Change()
If ComboFunctionMetalT = "DMLS" Then
ComboMetalFTDMLSSP.Visible = True
ComboMetalFTDMLSPMS.Visible = True
ComboMetalFTDMLSMS.Visible = True
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
End If

If ComboFunctionMetalT = "SLS" Then
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = True
ComboMetalFTSLSPMS.Visible = True
ComboMetalFTSLSMS.Visible = True
End If
```

```
If ComboFunctionMetalT = "LC" Then
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = True
ComboMetalFTLCPMS.Visible = True
ComboMetalFTLCMS.Visible = True
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
End If
If ComboFunctionMetalT = "EBM" Then
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = True
ComboMetalFTEBMPMS.Visible = True
LabelMetalFTEBMMS.Visible = True
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
End If

If ComboFunctionMetalT = "Fused metal deposition" Then
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = True
ComboMetalFTFPMS.Visible = True
ComboMetalFTFMS.Visible = True
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
End If

If ComboFunctionMetalT = "None" Then
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
```

```
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
End If

End Sub

Private Sub ComboFunctionPlasticT_Change()
If ComboFunctionPlasticT = "SLS" Then
End If
If ComboFunctionPlasticT = "FDM" Then
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = True
ComboPlasticCTFDMPMS.Visible = True
ComboPlasticCTFDMMS.Visible = True
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticFTSLSSP.Visible = False
ComboPlasticFTSLSPMS.Visible = False
ComboPlasticFTSLSMS.Visible = False
End If
```

```
If ComboFunctionPlasticT = "SLS" Then
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticFTSLSSP.Visible = True
ComboPlasticFTSLSPMS.Visible = True
ComboPlasticFTSLSMS.Visible = True
End If

If ComboFunctionPlasticT = "None" Then
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
```

```
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticFTSLSSP.Visible = False
ComboPlasticFTSLSPMS.Visible = False
ComboPlasticFTSLSMS.Visible = False
End If

End Sub

Private Sub ComboMetalFTDMLSMS_Change()
If ComboMetalFTDMLSMS = "1320x1067x2204" Then
ComboMetalFTDMLSSP.Value = "225.000"
ComboMetalFTDMLSPMS.Value = "200x250x330"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSMS = "2000x1050x1940" Then
ComboMetalFTDMLSSP.Value = "570.000"
ComboMetalFTDMLSPMS.Value = "250x250x215"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSMS = "1840x1175x2100" Then
ComboMetalFTDMLSSP.Value = "470.000"
ComboMetalFTDMLSPMS.Value = "340x340x620"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSMS = "1420x1400x2150" Then
ComboMetalFTDMLSSP.Value = "950.000"
ComboMetalFTDMLSPMS.Value = "720x380x380"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSMS = "None" Then
ComboMetalFTDMLSSP.Value = ""
ComboMetalFTDMLSPMS.Value = ""
ComboMetalFTDMLSSP.Enabled = True
ComboMetalFTDMLSPMS.Enabled = True
```

```
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTDMLSPMS_Change()
If ComboMetalFTDMLSPMS = "200x250x330" Then
ComboMetalFTDMLSSP.Value = "225.000"
ComboMetalFTDMLSMS.Value = "1320x1067x2204"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSPMS = "570.000" Then
ComboMetalFTDMLSSP.Value = "250x250x215"
ComboMetalFTDMLSMS.Value = "2000x1050x1940"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSPMS = "340x340x620" Then
ComboMetalFTDMLSSP.Value = "470.000"
ComboMetalFTDMLSMS.Value = "1840x1175x2100"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSPMS = "720x380x380" Then
ComboMetalFTDMLSSP.Value = "950.000"
ComboMetalFTDMLSMS.Value = "1420x1400x2150"
ComboMetalFTDMLSSP.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSPMS = "None" Then
ComboMetalFTDMLSSP.Value = ""
ComboMetalFTDMLSMS.Value = ""
ComboMetalFTDMLSSP.Enabled = True
ComboMetalFTDMLSMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboMetalFTDMLSSP_Change()
If ComboMetalFTDMLSSP = "225.000" Then
ComboMetalFTDMLSPMS.Value = "200x250x330"
ComboMetalFTDMLSMS.Value = "1320x1067x2204"
ComboMetalFTDMLSPMS.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboMetalFTDMLSSP = "570.000" Then
ComboMetalFTDMLSPMS.Value = "250x250x215"
ComboMetalFTDMLSMS.Value = "2000x1050x1940"
ComboMetalFTDMLSPMS.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSSP = "470.000" Then
ComboMetalFTDMLSPMS.Value = "340x340x620"
ComboMetalFTDMLSMS.Value = "1840x1175x2100"
ComboMetalFTDMLSPMS.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSSP = "990.000" Then
ComboMetalFTDMLSPMS.Value = "700x380x580"
ComboMetalFTDMLSMS.Value = "2250x1550x2100"
ComboMetalFTDMLSPMS.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSSP = "1.030.000" Then
ComboMetalFTDMLSPMS.Value = "700x380x580"
ComboMetalFTDMLSMS.Value = "2250x1550x2100"
ComboMetalFTDMLSPMS.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSSP = "950.000" Then
ComboMetalFTDMLSPMS.Value = "720x380x380"
ComboMetalFTDMLSMS.Value = "1420x1400x2150"
ComboMetalFTDMLSPMS.Enabled = False
ComboMetalFTDMLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTDMLSSP = "None" Then
ComboMetalFTDMLSPMS.Value = ""
ComboMetalFTDMLSMS.Value = ""
ComboMetalFTDMLSPMS.Enabled = True
ComboMetalFTDMLSMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTEBMPMS_Change()
If ComboMetalFTEBMPMS = "200x200x350" Then
ComboMetalFTEBMSP.Value = "875.000"
ComboMetalFTEBMSP.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboMetalFTEBMPMS = "200x200x180" Then
ComboMetalFTEBMSP.Value = "725.000"
ComboMetalFTEBMSP.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTEBMPMS = "None" Then
ComboMetalFTEBMSP.Value = ""
ComboMetalFTEBMSP.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTEBMSP_Change()
If ComboMetalFTEBMSP = "875.000" Then
ComboMetalFTEBMPMS.Value = "200x200x350"
ComboMetalFTEBMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTEBMSP = "725.000" Then
ComboMetalFTEBMPMS.Value = "200x200x180"
ComboMetalFTEBMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTEBMSP = "None" Then
ComboMetalFTEBMPMS.Value = ""
ComboMetalFTEBMPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTFMS_Change()
If ComboMetalFTFMS = "3835x2286x3048" Then
ComboMetalFTFSP.Value = "800.000"
ComboMetalFTFPMS.Value = "750x500x400"
ComboMetalFTFSP.Enabled = False
ComboMetalFTFPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFMS = "6096x5500x2450" Then
ComboMetalFTFSP.Value = "1.400.000"
ComboMetalFTFPMS.Value = "Robot arm"
ComboMetalFTFSP.Enabled = False
ComboMetalFTFPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFMS = "7400x6646x4166" Then
ComboMetalFTFSP.Value = "1.500.000"
ComboMetalFTFPMS.Value = "Robot arm"
```

```
ComboMetalFTFSP.Enabled = False
ComboMetalFTFPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFMS = "4500x1200x2200" Then
ComboMetalFTFSP.Value = "980.000"
ComboMetalFTFPMS.Value = "1200x800x450"
ComboMetalFTFSP.Enabled = False
ComboMetalFTFPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFMS = "None" Then
ComboMetalFTFSP.Value = ""
ComboMetalFTFPMS.Value = ""
ComboMetalFTFSP.Enabled = True
ComboMetalFTFPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTFPMS_Change()
If ComboMetalFTFPMS = "750x500x400" Then
ComboMetalFTFSP.Value = "800.000"
ComboMetalFTFMS.Value = "3835x2286x3048"
ComboMetalFTFSP.Enabled = False
ComboMetalFTFMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFPMS = "1200x800x450" Then
ComboMetalFTFSP.Value = "980.000"
ComboMetalFTFMS.Value = "4500x1200x2200"
ComboMetalFTFSP.Enabled = False
ComboMetalFTFMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFPMS = "None" Then
ComboMetalFTFSP.Value = ""
ComboMetalFTFMS.Value = ""
ComboMetalFTFSP.Enabled = True
ComboMetalFTFMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTFSP_Change()
If ComboMetalFTFSP = "800.000" Then
ComboMetalFTFPMS.Value = "750x500x400"
ComboMetalFTFMS.Value = "3835x2286x3048"
ComboMetalFTFPMS.Enabled = False
ComboMetalFTFMS.Enabled = False
```

```
CommandRecommend.Enabled = True
End If

If ComboMetalFTFSP = "1.400.000" Then
ComboMetalFTFPMS.Value = "Robot arm"
ComboMetalFTFMS.Value = "6096x5500x2450"
ComboMetalFTFPMS.Enabled = False
ComboMetalFTFMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboMetalFTFSP = "1.500.000" Then
ComboMetalFTFPMS.Value = "Robot arm"
ComboMetalFTFMS.Value = "7400x6646x4166"
ComboMetalFTFPMS.Enabled = False
ComboMetalFTFMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFSP = "980.000" Then
ComboMetalFTFPMS.Value = "1200x800x450"
ComboMetalFTFMS.Value = "4500x1200x2200"
ComboMetalFTFPMS.Enabled = False
ComboMetalFTFMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTFSP = "None" Then
ComboMetalFTFPMS.Value = ""
ComboMetalFTFMS.Value = ""
ComboMetalFTFPMS.Enabled = True
ComboMetalFTFMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTLCMS_Change()
If ComboMetalFTLCMS = "2450x1490x1775" Then
ComboMetalFTLCSP.Value = "448.800"
ComboMetalFTLCPMS.Value = "150x150x200"
ComboMetalFTLCSP.Enabled = False
ComboMetalFTLCPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCMS = "2440x1630x1992" Then
ComboMetalFTLCSP.Value = "765.000"
ComboMetalFTLCPMS.Value = "250x250x280"
ComboMetalFTLCSP.Enabled = False
ComboMetalFTLCPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCMS = "2670x1990x2180" Then
ComboMetalFTLCSP.Value = "726.000"
ComboMetalFTLCPMS.Value = "300x350x300"
```

```
ComboMetalFTLCSP.Enabled = False
ComboMetalFTLCPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCMS = "None" Then
ComboMetalFTLCSP.Value = ""
ComboMetalFTLCPMS.Value = ""
ComboMetalFTLCSP.Enabled = True
ComboMetalFTLCPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTLCPMS_Change()
If ComboMetalFTLCPMS = "150x150x200" Then
ComboMetalFTLCSP.Value = "448.800"
ComboMetalFTLCMS.Value = "2450x1490x1775"
ComboMetalFTLCSP.Enabled = False
ComboMetalFTLCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCPMS = "250x250x280" Then
ComboMetalFTLCSP.Value = "765.000"
ComboMetalFTLCMS.Value = "2440x1630x1992"
ComboMetalFTLCSP.Enabled = False
ComboMetalFTLCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCPMS = "300x350x300" Then
ComboMetalFTLCSP.Value = "726.000"
ComboMetalFTLCMS.Value = "2670x1990x2180"
ComboMetalFTLCSP.Enabled = False
ComboMetalFTLCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCPMS = "None" Then
ComboMetalFTLCSP.Value = ""
ComboMetalFTLCMS.Value = ""
ComboMetalFTLCSP.Enabled = True
ComboMetalFTLCMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTLCSP_Change()
If ComboMetalFTLCSP = "448.800" Then
ComboMetalFTLCPMS.Value = "150x150x200"
ComboMetalFTLCMS.Value = "2450x1490x1775"
ComboMetalFTLCPMS.Enabled = False
ComboMetalFTLCMS.Enabled = False
```

```
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCSP = "765.000" Then
ComboMetalFTLCPMS.Value = "250x250x280"
ComboMetalFTLCMS.Value = "2440x1630x1992"
ComboMetalFTLCPMS.Enabled = False
ComboMetalFTLCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCSP = "726.000" Then
ComboMetalFTLCPMS.Value = "300x350x300"
ComboMetalFTLCMS.Value = "2670x1990x2180"
ComboMetalFTLCPMS.Enabled = False
ComboMetalFTLCMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTLCSP = "None" Then
ComboMetalFTLCPMS.Value = ""
ComboMetalFTLCMS.Value = ""
ComboMetalFTLCPMS.Enabled = True
ComboMetalFTLCMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTSLSMS_Change()
If ComboMetalFTSLSMS = "900x800x2500" Then
ComboMetalFTSLSSP.Value = "700.000"
ComboMetalFTSLSPMS.Value = "80(high)x125(Dim)"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSMS = "1900x1400x2500" Then
ComboMetalFTSLSSP.Value = "800.000"
ComboMetalFTSLSPMS.Value = "250x250x220"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSMS = "1900x2600x2500" Then
ComboMetalFTSLSSP.Value = "85.000"
ComboMetalFTSLSPMS.Value = "250x250x240"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSMS = "1450x1250x1900" Then
ComboMetalFTSLSSP.Value = "283.800"
```

```
ComboMetalFTSLSPMS.Value = "100(high)x100(Dim)"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSMS = "3250x1300x 2400 " Then
ComboMetalFTSLSSP.Value = "513.480"
ComboMetalFTSLSPMS.Value = "250(high)x300(Dim)"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSMS = "None" Then
ComboMetalFTSLSSP.Value = ""
ComboMetalFTSLSPMS.Value = ""
ComboMetalFTSLSSP.Enabled = True
ComboMetalFTSLSPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTSLSPMS_Change()
If ComboMetalFTSLSPMS = "80(high)x125(Dim)" Then
ComboMetalFTSLSSP.Value = "700.000"
ComboMetalFTSLSMS.Value = "900x800x2500"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSPMS = "250x250x220" Then
ComboMetalFTSLSSP.Value = "800.000"
ComboMetalFTSLSMS.Value = "1900x1400x2500"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSPMS = "500x500x460" Then
ComboMetalFTSLSSP.Value = "710.000"
ComboMetalFTSLSMS.Value = "2120x1580x2010"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSPMS = "500x500x750" Then
ComboMetalFTSLSSP.Value = "800.000"
ComboMetalFTSLSMS.Value = "2120x1580x2010"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboMetalFTSLSPMS = "250x250x240" Then
ComboMetalFTSLSSP.Value = "85.000"
ComboMetalFTSLSMS.Value = "1900x2600x2500"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSPMS = "100(high)x100(Dim)" Then
ComboMetalFTSLSSP.Value = "283.800"
ComboMetalFTSLSMS.Value = "1450x1250x1900"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSPMS = "250(high)x300(Dim)" Then
ComboMetalFTSLSSP.Value = "513.480"
ComboMetalFTSLSMS.Value = "3250x1300x 2400"
ComboMetalFTSLSSP.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSPMS = "None" Then
ComboMetalFTSLSSP.Value = ""
ComboMetalFTSLSMS.Value = ""
ComboMetalFTSLSSP.Enabled = True
ComboMetalFTSLSMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboMetalFTSLSSP_Change()
If ComboMetalFTSLSSP = "1.100.000" Then
ComboMetalFTSLSPMS.Value = "381x330x457"
ComboMetalFTSLSMS.Value = "1680x1020x2120"
ComboMetalFTSLSPMS.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "700.000" Then
ComboMetalFTSLSPMS.Value = "80(high)x125(Dim)"
ComboMetalFTSLSMS.Value = "900x800x2500"
ComboMetalFTSLSPMS.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "710.000" Then
ComboMetalFTSLSPMS.Value = "500x500x460"
ComboMetalFTSLSMS.Value = "2120x1580x2010"
ComboMetalFTSLSPMS.Enabled = False
```

```
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "1.300.000" Then
ComboMetalFTSLSPMS.Value = "381x330x457"
ComboMetalFTSLSMS.Value = "1680x1020x2120"
ComboMetalFTSLSPMS.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "85.000" Then
ComboMetalFTSLSPMS.Value = "250x250x240"
ComboMetalFTSLSMS.Value = "1900x2600x2500"
ComboMetalFTSLSPMS.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "283.800" Then
ComboMetalFTSLSPMS.Value = "100(high)x100(Dim)"
ComboMetalFTSLSMS.Value = "1450x1250x1900"
ComboMetalFTSLSPMS.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "513.480" Then
ComboMetalFTSLSPMS.Value = "250(high)x300(Dim)"
ComboMetalFTSLSMS.Value = "3250x1300x 2400 "
ComboMetalFTSLSPMS.Enabled = False
ComboMetalFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboMetalFTSLSSP = "None" Then
ComboMetalFTSLSPMS.Value = ""
ComboMetalFTSLSMS.Value = ""
ComboMetalFTSLSPMS.Enabled = True
ComboMetalFTSLSMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPaperCTLOMMS_Change()
If ComboPaperCTLOMMS = "860x660x1330" Then
ComboPaperCTLOMSP.Value = "30.000"
ComboPaperCTLOMPMS.Value = "180x280x150"
ComboPaperCTLOMSP.Enabled = False
ComboPaperCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMMS = "1750x980x1500" Then
```

```
ComboPaperCTLOMSP.Value = "33.000"
ComboPaperCTLOMPMS.Value = "450x350x350"
ComboPaperCTLOMSP.Enabled = False
ComboPaperCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMMS = "1860x1100x1700" Then
ComboPaperCTLOMSP.Value = "73.000"
ComboPaperCTLOMPMS.Value = "600x400x500"
ComboPaperCTLOMSP.Enabled = False
ComboPaperCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMMS = "None" Then
ComboPaperCTLOMSP.Value = ""
ComboPaperCTLOMPMS.Value = ""
ComboPaperCTLOMSP.Enabled = True
ComboPaperCTLOMPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPaperCTLOMPMS_Change()
If ComboPaperCTLOMPMS = "180x280x150" Then
ComboPaperCTLOMSP.Value = "30.000"
ComboPaperCTLOMMS.Value = "860x660x1330"
ComboPaperCTLOMSP.Enabled = False
ComboPaperCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMPMS = "450x350x350" Then
ComboPaperCTLOMSP.Value = "33.000"
ComboPaperCTLOMMS.Value = "1750x980x1500"
ComboPaperCTLOMSP.Enabled = False
ComboPaperCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMPMS = "600x400x500" Then
ComboPaperCTLOMSP.Value = "73.000"
ComboPaperCTLOMMS.Value = "1860x1100x1700"
ComboPaperCTLOMSP.Enabled = False
ComboPaperCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMPMS = "None" Then
ComboPaperCTLOMSP.Value = ""
ComboPaperCTLOMMS.Value = ""
ComboPaperCTLOMSP.Enabled = True
ComboPaperCTLOMMS.Enabled = True
CommandRecommend.Enabled = False
```

```
End If

End Sub

Private Sub ComboPaperCTLOMSP_Change()
If ComboPaperCTLOMSP = "30.000" Then
ComboPaperCTLOMPMS.Value = "180x280x150"
ComboPaperCTLOMMS.Value = "860x660x1330"
ComboPaperCTLOMPMS.Enabled = False
ComboPaperCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMSP = "33.000" Then
ComboPaperCTLOMPMS.Value = "450x350x350"
ComboPaperCTLOMMS.Value = "1750x980x1500"
ComboPaperCTLOMPMS.Enabled = False
ComboPaperCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMSP = "73.000" Then
ComboPaperCTLOMPMS.Value = "600x400x500"
ComboPaperCTLOMMS.Value = "1860x1100x1700"
ComboPaperCTLOMPMS.Enabled = False
ComboPaperCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPaperCTLOMSP = "None" Then
ComboPaperCTLOMPMS.Value = ""
ComboPaperCTLOMMS.Value = ""
ComboPaperCTLOMPMS.Enabled = True
ComboPaperCTLOMMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCT_Change()
If ComboPlasticCT = "SLA" Then
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAPMS.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
```

```
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
End If

If ComboPlasticCT = "Jetting Systems" Then
ComboPlasticCTJSP.Visible = True
ComboPlasticCTJPMS.Visible = True
ComboPlasticCTJMS.Visible = True
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
End If

If ComboPlasticCT = "FDM" Then
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTFDMSP.Visible = True
ComboPlasticCTFDMPMS.Visible = True
```

```
ComboPlasticCTFDMMS.Visible = True
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
End If


If ComboPlasticCT = "LOM" Then
ComboPlasticCTLOMSP.Visible = True
ComboPlasticCTLOMPMS.Visible = True
ComboPlasticCTLOMMS.Visible = True
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
End If

If ComboPlasticCT = "3D Printing" Then
ComboPlasticCT3DSP.Visible = True
ComboPlasticCT3DPMS.Visible = True
ComboPlasticCT3DMS.Visible = True
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
```

```
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If

End Sub

Private Sub ComboPlasticCT3DMS_Change()
If ComboPlasticCT3DMS = "500x500x635" Then
ComboPlasticCT3DSP.Value = "5.000"
ComboPlasticCT3DPMS.Value = "125x125x125"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DMS = "1070x790x1270" Then
ComboPlasticCT3DSP.Value = "50.000"
ComboPlasticCT3DPMS.Value = "254x356x203"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DMS = "740x810x1090" Then
ComboPlasticCT3DSP.Value = "20.000"
ComboPlasticCT3DPMS.Value = "203x254x203"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DMS = "1220x790x1400" Then
ComboPlasticCT3DSP.Value = "40.000"
ComboPlasticCT3DPMS.Value = "203x254x203"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DMS = "1880x740x1450" Then
ComboPlasticCT3DSP.Value = "80.000"
ComboPlasticCT3DPMS.Value = "254x381x203"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DMS = "None" Then
ComboPlasticCT3DSP.Value = ""
ComboPlasticCT3DPMS.Value = ""
ComboPlasticCT3DSP.Enabled = True
ComboPlasticCT3DPMS.Enabled = True
```

```
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCT3DPMS_Change()
If ComboPlasticCT3DPMS = "125x125x125" Then
ComboPlasticCT3DSP.Value = "5.000"
ComboPlasticCT3DMS.Value = "500x500x635"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DPMS = "254x356x203" Then
ComboPlasticCT3DSP.Value = "50.000"
ComboPlasticCT3DMS.Value = "1070x790x1270"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If



If ComboPlasticCT3DPMS = "254x381x203" Then
ComboPlasticCT3DSP.Value = "80.000"
ComboPlasticCT3DMS.Value = "1880x740x1450"
ComboPlasticCT3DSP.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DPMS = "None" Then
ComboPlasticCT3DSP.Value = ""
ComboPlasticCT3DMS.Value = ""
ComboPlasticCT3DSP.Enabled = True
ComboPlasticCT3DMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCT3DSP_Change()
If ComboPlasticCT3DSP = "5.000" Then
ComboPlasticCT3DPMS.Value = "125x125x125"
ComboPlasticCT3DMS.Value = "500x500x635"
ComboPlasticCT3DPMS.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DSP = "50.000" Then
ComboPlasticCT3DPMS.Value = "254x356x203"
ComboPlasticCT3DMS.Value = "1070x790x1270"
ComboPlasticCT3DPMS.Enabled = False
ComboPlasticCT3DMS.Enabled = False
```

```
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DSP = "20.000" Then
ComboPlasticCT3DPMS.Value = "203x254x203"
ComboPlasticCT3DMS.Value = "740x810x1090"
ComboPlasticCT3DPMS.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DSP = "40.000" Then
ComboPlasticCT3DPMS.Value = "203x254x203"
ComboPlasticCT3DMS.Value = "1220x790x1400"
ComboPlasticCT3DPMS.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DSP = "80.000" Then
ComboPlasticCT3DPMS.Value = "254x381x203"
ComboPlasticCT3DMS.Value = "1880x740x1450"
ComboPlasticCT3DPMS.Enabled = False
ComboPlasticCT3DMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCT3DSP = "None" Then
ComboPlasticCT3DPMS.Value = ""
ComboPlasticCT3DMS.Value = ""
ComboPlasticCT3DPMS.Enabled = True
ComboPlasticCT3DMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTFDMMS_Change()
If ComboPlasticCTFDMMS = "865x685x1040" Then
ComboPlasticCTFDMSP.Value = "55.000"
ComboPlasticCTFDMPMS.Value = "203x203x305"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMMS = "2235x1120x1980" Then
ComboPlasticCTFDMSP.Value = "250.000"
ComboPlasticCTFDMPMS.Value = "914x610x914"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMMS = "1500x930x2200" Then
ComboPlasticCTFDMSP.Value = "58.000"
```

```
ComboPlasticCTFDMPMS.Value = "400x400x450"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMMS = "1300x730x2200" Then
ComboPlasticCTFDMSP.Value = "47.000"
ComboPlasticCTFDMPMS.Value = "320x320x350"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMMS = "950×820×900" Then
ComboPlasticCTFDMSP.Value = "70.000"
ComboPlasticCTFDMPMS.Value = "280x250x300"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMMS = "950×820×1050" Then
ComboPlasticCTFDMSP.Value = "90.000"
ComboPlasticCTFDMPMS.Value = "360x320x400"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMMS = "None" Then
ComboPlasticCTFDMSP.Value = ""
ComboPlasticCTFDMPMS.Value = ""
ComboPlasticCTFDMSP.Enabled = True
ComboPlasticCTFDMPMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboPlasticCTFDMPMS_Change()
If ComboPlasticCTFDMPMS = "203x203x305" Then
ComboPlasticCTFDMSP.Value = "55.000"
ComboPlasticCTFDMMS.Value = "865x685x1040"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMPMS = "914x610x914" Then
ComboPlasticCTFDMSP.Value = "250.000"
ComboPlasticCTFDMMS.Value = "2235x1120x1980"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboPlasticCTFDMPMS = "400x400x450" Then
ComboPlasticCTFDMSP.Value = "58.000"
ComboPlasticCTFDMMS.Value = "1500x930x2200"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMPMS = "320x320x350" Then
ComboPlasticCTFDMSP.Value = "47.000"
ComboPlasticCTFDMMS.Value = "1300x730x2200"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMPMS = "280x250x300" Then
ComboPlasticCTFDMSP.Value = "70.000"
ComboPlasticCTFDMMS.Value = "950×820×900"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMPMS = "360x320x400" Then
ComboPlasticCTFDMSP.Value = "90.000"
ComboPlasticCTFDMMS.Value = "950×820×1050"
ComboPlasticCTFDMSP.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMPMS = "None" Then
ComboPlasticCTFDMSP.Value = ""
ComboPlasticCTFDMMS.Value = ""
ComboPlasticCTFDMSP.Enabled = True
ComboPlasticCTFDMMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTFDMSP_Change()
If ComboPlasticCTFDMSP = "55.000" Then
ComboPlasticCTFDMPMS.Value = "203x203x305"
ComboPlasticCTFDMMS.Value = "865x685x1040"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "150.000" Then
ComboPlasticCTFDMPMS.Value = "406x355x406"
ComboPlasticCTFDMMS.Value = "1275x874x1950"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
```

```
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "190.000" Then
ComboPlasticCTFDMPMS.Value = "406x355x406"
ComboPlasticCTFDMMS.Value = "1275x874x1950"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "250.000" Then
ComboPlasticCTFDMPMS.Value = "914x610x914"
ComboPlasticCTFDMMS.Value = "2235x1120x1980"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "58.000" Then
ComboPlasticCTFDMPMS.Value = "400x400x450"
ComboPlasticCTFDMMS.Value = "1500x930x2200"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "47.000" Then
ComboPlasticCTFDMPMS.Value = "320x320x350"
ComboPlasticCTFDMMS.Value = "1300x730x2200"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "70.000" Then
ComboPlasticCTFDMPMS.Value = "280x250x300"
ComboPlasticCTFDMMS.Value = "950×820×900"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "90.000" Then
ComboPlasticCTFDMPMS.Value = "360x320x400"
ComboPlasticCTFDMMS.Value = "950×820×1050"
ComboPlasticCTFDMPMS.Enabled = False
ComboPlasticCTFDMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTFDMSP = "None" Then
ComboPlasticCTFDMPMS.Value = ""
ComboPlasticCTFDMMS.Value = ""
ComboPlasticCTFDMPMS.Enabled = True
ComboPlasticCTFDMMS.Enabled = True
```

```
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTJMS_Change()
If ComboPlasticCTJMS = "711.2x495.3x495.3" Then
ComboPlasticCTJSP.Value = "50.000"
ComboPlasticCTJPMS.Value = "304.8x152.4x152.4"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "1790x1852x1660" Then
ComboPlasticCTJSP.Value = "700.000"
ComboPlasticCTJPMS.Value = "850x450x500"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "2600x23500x2300" Then
ComboPlasticCTJSP.Value = "600.000"
ComboPlasticCTJPMS.Value = "500x400x300"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "600x700x400" Then
ComboPlasticCTJSP.Value = "138.000"
ComboPlasticCTJPMS.Value = "300x300x130"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "1200x750x1500" Then
ComboPlasticCTJSP.Value = "220.000"
ComboPlasticCTJPMS.Value = "50x50x150"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "1800x950x1500" Then
ComboPlasticCTJSP.Value = "260.000"
ComboPlasticCTJPMS.Value = "300x300x150"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "1420x1120x1130" Then
ComboPlasticCTJSP.Value = "107.000"
```

```
ComboPlasticCTJPMS.Value = "490x390x200"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJMS = "None" Then
ComboPlasticCTJSP.Value = ""
ComboPlasticCTJPMS.Value = ""
ComboPlasticCTJSP.Enabled = True
ComboPlasticCTJPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTJPMS_Change()
If ComboPlasticCTJPMS = "304.8x152.4x152.4" Then
ComboPlasticCTJSP.Value = "50.000"
ComboPlasticCTJMS.Value = "711.2x495.3x495.3"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "850x450x500" Then
ComboPlasticCTJSP.Value = "700.000"
ComboPlasticCTJMS.Value = "1790x1852x1660"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "500x400x300" Then
ComboPlasticCTJSP.Value = "600.000"
ComboPlasticCTJMS.Value = "2600x23500x2300"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "300x300x130" Then
ComboPlasticCTJSP.Value = "138.000"
ComboPlasticCTJMS.Value = "600x700x400"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "175x131x230" Then
ComboPlasticCTJSP.Value = "100.000"
ComboPlasticCTJMS.Value = "730x480x1350"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboPlasticCTJPMS = "190x142x230" Then
ComboPlasticCTJSP.Value = "95.000"
ComboPlasticCTJMS.Value = "730x480x1350"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If


If ComboPlasticCTJPMS = "90x67.5x230" Then
ComboPlasticCTJSP.Value = "75.000"
ComboPlasticCTJMS.Value = "730x480x1350"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "50x50x150" Then
ComboPlasticCTJSP.Value = "220.000"
ComboPlasticCTJMS.Value = "1200x750x1500"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "300x300x150" Then
ComboPlasticCTJSP.Value = "260.000"
ComboPlasticCTJMS.Value = "1800x950x1500"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "260x260x200" Then
ComboPlasticCTJSP.Value = "60.000"
ComboPlasticCTJMS.Value = "870x735x1200"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "250x250x200" Then
ComboPlasticCTJSP.Value = "80.000"
ComboPlasticCTJMS.Value = "870x735x1200"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "340x340x200" Then
ComboPlasticCTJSP.Value = "128.000"
ComboPlasticCTJMS.Value = "1320x990x1200"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
```

```
End If

If ComboPlasticCTJPMS = "340x340x200" Then
ComboPlasticCTJSP.Value = "128.000"
ComboPlasticCTJMS.Value = "1320x990x1200"
ComboPlasticCTJSP.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJPMS = "None" Then
ComboPlasticCTJSP.Value = ""
ComboPlasticCTJMS.Value = ""
ComboPlasticCTJSP.Enabled = True
ComboPlasticCTJMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTJSP_Change()
If ComboPlasticCTJSP = "35.000" Then
ComboPlasticCTJPMS.Value = "152.4x152.4x101.6"
ComboPlasticCTJMS.Value = "548.6x489.2x407.7"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "50.000" Then
ComboPlasticCTJPMS.Value = "304.8x152.4x152.4"
ComboPlasticCTJMS.Value = "711.2x495.3x495.3"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "40.000" Then
ComboPlasticCTJPMS.Value = "152.4x152.4x101.6"
ComboPlasticCTJMS.Value = "548.6x489.2x407.7"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTJSP = "700.000" Then
ComboPlasticCTJPMS.Value = "850x450x500"
ComboPlasticCTJMS.Value = "1790x1852x1660"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "600.000" Then
ComboPlasticCTJPMS.Value = "500x400x300"
ComboPlasticCTJMS.Value = "2600x23500x2300"
ComboPlasticCTJPMS.Enabled = False
```

```
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "138.000" Then
ComboPlasticCTJPMS.Value = "300x300x130"
ComboPlasticCTJMS.Value = "600x700x400"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "100.000" Then
ComboPlasticCTJPMS.Value = "175x131x230"
ComboPlasticCTJMS.Value = "730x480x1350"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "95.000" Then
ComboPlasticCTJPMS.Value = "190x142x230"
ComboPlasticCTJMS.Value = "730x480x1350"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "75.000" Then
ComboPlasticCTJPMS.Value = "90x67.5x230"
ComboPlasticCTJMS.Value = "730x480x1350"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "220.000" Then
ComboPlasticCTJPMS.Value = "50x50x150"
ComboPlasticCTJMS.Value = "1200x750x1500"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "260.000" Then
ComboPlasticCTJPMS.Value = "300x300x150"
ComboPlasticCTJMS.Value = "1800x950x1500"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "107.000" Then
ComboPlasticCTJPMS.Value = "490x390x200"
ComboPlasticCTJMS.Value = "1420x1120x1130"
ComboPlasticCTJPMS.Enabled = False
```

```
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "60.000" Then
ComboPlasticCTJPMS.Value = "260x260x200"
ComboPlasticCTJMS.Value = "870x735x1200"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "80.000" Then
ComboPlasticCTJPMS.Value = "250x250x200"
ComboPlasticCTJMS.Value = "870x735x1200"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "128.000" Then
ComboPlasticCTJPMS.Value = "340x340x200"
ComboPlasticCTJMS.Value = "1320x990x1200"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "164.000" Then
ComboPlasticCTJPMS.Value = "490x390x200"
ComboPlasticCTJMS.Value = "1320x990x1200"
ComboPlasticCTJPMS.Enabled = False
ComboPlasticCTJMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTJSP = "None" Then
ComboPlasticCTJPMS.Value = ""
ComboPlasticCTJMS.Value = ""
ComboPlasticCTJPMS.Enabled = True
ComboPlasticCTJMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTLOMMS_Change()
If ComboPlasticCTLOMMS = "450x725x415" Then
ComboPlasticCTLOMSP.Value = "15.000"
ComboPlasticCTLOMPMS.Value = "170x220x145"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMMS = "860 x660x1330" Then
```

```
ComboPlasticCTLOMSP.Value = "30.000"
ComboPlasticCTLOMPMS.Value = "180x280x150"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMMS = "1750x980x1500" Then
ComboPlasticCTLOMSP.Value = "33.000"
ComboPlasticCTLOMPMS.Value = "450x350x350"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMMS = "1860x1100x1700" Then
ComboPlasticCTLOMSP.Value = "73.000"
ComboPlasticCTLOMPMS.Value = "600x400x500"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMMS = "1100x900x40" Then
ComboPlasticCTLOMSP.Value = "25.000"
ComboPlasticCTLOMPMS.Value = "200x180xUnlimited"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMMS = "760x1190x1090" Then
ComboPlasticCTLOMSP.Value = "35.000"
ComboPlasticCTLOMPMS.Value = "320x250xUnlimited"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTLOMMS = "None" Then
ComboPlasticCTLOMSP.Value = ""
ComboPlasticCTLOMPMS.Value = ""
ComboPlasticCTLOMSP.Enabled = True
ComboPlasticCTLOMPMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTLOMPMS_Change()
If ComboPlasticCTLOMPMS = "170x220x145" Then
ComboPlasticCTLOMSP.Value = "15.000"
ComboPlasticCTLOMMS.Value = "450x725x415"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboPlasticCTLOMPMS = "180x280x150" Then
ComboPlasticCTLOMSP.Value = "30.000"
ComboPlasticCTLOMMS.Value = "860x660x1330"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMPMS = "450x350x350" Then
ComboPlasticCTLOMSP.Value = "33.000"
ComboPlasticCTLOMMS.Value = "1750x980x1500"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMPMS = "600x400x500" Then
ComboPlasticCTLOMSP.Value = "73.000"
ComboPlasticCTLOMMS.Value = "1860x1100x1700"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMPMS = "200x180xUnlimited" Then
ComboPlasticCTLOMSP.Value = "25.000"
ComboPlasticCTLOMMS.Value = "1100x900x40"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMPMS = "320x250xUnlimited" Then
ComboPlasticCTLOMSP.Value = "35.000"
ComboPlasticCTLOMMS.Value = "760x1190x1090"
ComboPlasticCTLOMSP.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMPMS = "None" Then
ComboPlasticCTLOMSP.Value = ""
ComboPlasticCTLOMMS.Value = ""
ComboPlasticCTLOMSP.Enabled = True
ComboPlasticCTLOMMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTLOMSP_Change()
If ComboPlasticCTLOMSP = "15.000" Then
ComboPlasticCTLOMPMS.Value = "170x220x145"
ComboPlasticCTLOMMS.Value = "450x725x415"
ComboPlasticCTLOMPMS.Enabled = False
```

```
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMSP = "30.000" Then
ComboPlasticCTLOMPMS.Value = "180x280x150"
ComboPlasticCTLOMMS.Value = "860x660x1330"
ComboPlasticCTLOMPMS.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMSP = "33.000" Then
ComboPlasticCTLOMPMS.Value = "450x350x350"
ComboPlasticCTLOMMS.Value = "1750x980x1500"
ComboPlasticCTLOMPMS.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMSP = "73.000" Then
ComboPlasticCTLOMPMS.Value = "600x400x500"
ComboPlasticCTLOMMS.Value = "1860x1100x1700"
ComboPlasticCTLOMPMS.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMSP = "25.000" Then
ComboPlasticCTLOMPMS.Value = "200x180xUnlimited"
ComboPlasticCTLOMMS.Value = "1100x900x40"
ComboPlasticCTLOMPMS.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMSP = "35.000" Then
ComboPlasticCTLOMPMS.Value = "320x250xUnlimited"
ComboPlasticCTLOMMS.Value = "760x1190x1090"
ComboPlasticCTLOMPMS.Enabled = False
ComboPlasticCTLOMMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTLOMSP = "None" Then
ComboPlasticCTLOMPMS.Value = ""
ComboPlasticCTLOMMS.Value = ""
ComboPlasticCTLOMPMS.Enabled = True
ComboPlasticCTLOMMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTSLAMS_Change()
If ComboPlasticCTSLAMS = "600x610x504" Then
```

```
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "33.000"
ComboPlasticCTSLAPMS.Value = "200x200x60"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTSLAMS = "600x610x504" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "40.000"
ComboPlasticCTSLAPMS.Value = "200x200x60"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTSLAMS = "600x605x487" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "60.000"
ComboPlasticCTSLAPMS.Value = "200x200x60"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTSLAMS = "630x606x662" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "46.000"
ComboPlasticCTSLAPMS.Value = "200x200x200"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If

If ComboPlasticCTSLAMS = "630x606x662" Then
```

```
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "66.000"
ComboPlasticCTSLAPMS.Value = "200x200x200"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "770x545x1350" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "70.000"
ComboPlasticCTSLAPMS.Value = "110x110x60"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1750x980x1500" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "110.000"
ComboPlasticCTSLAPMS.Value = "300x300x300"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1860x1100x1700" Then
ComboSLASP21.Visible = True
ComboSLAPMS21.Visible = True
ComboSLASP21.Enabled = True
ComboSLAPMS21.Enabled = True
ComboSLASP21.Value = ""
ComboSLAPMS21.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
End If
If ComboPlasticCTSLAMS = "1800x930x2200" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
```

```
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "22.000"
ComboPlasticCTSLAPMS.Value = "350x350x350"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1650x8960x2000" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "158.000"
ComboPlasticCTSLAPMS.Value = "450x450x350"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "17000x8150x2000" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "210.000"
ComboPlasticCTSLAPMS.Value = "600x600x400"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1550x850x2000" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "130.000"
ComboPlasticCTSLAPMS.Value = "350x350x300"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "2065x1245x2220" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "340.000"
```

```
ComboPlasticCTSLAPMS.Value = "800x600x400"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1665x1095x1930" Then
ComboSLASP22.Visible = True
ComboSLAPMS22.Visible = True
ComboSLASP22.Enabled = True
ComboSLAPMS22.Enabled = True
ComboSLASP22.Value = ""
ComboSLAPMS22.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
End If
If ComboPlasticCTSLAMS = "1560x990x1930 " Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "250.000"
ComboPlasticCTSLAPMS.Value = "350x350x350"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1430x1045x1575" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "300.000"
ComboPlasticCTSLAPMS.Value = "300x300x250"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "1020x2045x2050" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "555.555"
ComboPlasticCTSLAPMS.Value = "610x610x500"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
```

```
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "2120x1580x2210" Then
ComboSLASP23.Visible = True
ComboSLAPMS23.Visible = True
ComboSLASP23.Enabled = True
ComboSLAPMS23.Enabled = True
ComboSLASP23.Value = ""
ComboSLAPMS23.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
End If
If ComboPlasticCTSLAMS = "1340x860x1780" Then
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
ComboPlasticCTSLASP.Value = "185.000"
ComboPlasticCTSLAPMS.Value = "250x250x250"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAMS = "None" Then
ComboPlasticCTSLASP.Value = ""
ComboPlasticCTSLAPMS.Value = ""
ComboPlasticCTSLASP.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLASP21.Visible = False
ComboSLAPMS21.Visible = False
ComboSLASP22.Visible = False
ComboSLAPMS22.Visible = False
ComboSLASP23.Visible = False
ComboSLAPMS23.Visible = False
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTSLAPMS_Change()
If ComboPlasticCTSLAPMS = "110x110x60" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
```

```
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "70.000"
ComboPlasticCTSLAMS.Value = "770x545x1350"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "350x350x300" Then
ComboSLASP1.Visible = True
ComboSLAMS1.Visible = True
ComboSLASP1.Enabled = True
ComboSLAMS1.Enabled = True
ComboSLASP1.Value = ""
ComboSLAMS1.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
End If
If ComboPlasticCTSLAPMS = "300x300x300" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "110.000"
ComboPlasticCTSLAMS.Value = "1750x980x1500"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "600x600x500" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "230.000"
ComboPlasticCTSLAMS.Value = "1860x1100x1700"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
```

```
End If
If ComboPlasticCTSLAPMS = "350x350x350" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboSLASP2.Visible = True
ComboSLAMS2.Visible = True
ComboSLASP2.Enabled = True
ComboSLAMS2.Enabled = True
ComboSLASP2.Value = ""
ComboSLAMS2.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAMS.Visible = False
End If
If ComboPlasticCTSLAPMS = "450x450x350" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = True
ComboSLAMS3.Visible = True
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboSLASP3.Enabled = True
ComboSLAMS3.Enabled = True
ComboSLASP3.Value = ""
ComboSLAMS3.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAMS.Visible = False
End If
If ComboPlasticCTSLAPMS = "600x600x400" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = True
ComboSLAMS4.Visible = True
ComboSLASP4.Enabled = True
ComboSLAMS4.Enabled = True
ComboSLASP4.Value = ""
ComboSLAMS4.Value = ""
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAMS.Visible = False
End If
If ComboPlasticCTSLAPMS = "800x600x400" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
```

```
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "340.000"
ComboPlasticCTSLAMS.Value = "2065x1245x2220"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "300x300x250" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "300.000"
ComboPlasticCTSLAMS.Value = "1430x1045x1575"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "610x610x500" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "555.555"
ComboPlasticCTSLAMS.Value = "1020x2045x2050"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "1500x750x500" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "933.000"
```

```
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "650x750x550" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "785.000"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "650x750x275" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "535.000"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "650x350x300" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "450.000"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboPlasticCTSLAPMS = "250x250x250" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = "185.000"
ComboPlasticCTSLAMS.Value = "1340x860x1780"
ComboPlasticCTSLASP.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLAPMS = "None" Then
ComboSLASP1.Visible = False
ComboSLAMS1.Visible = False
ComboSLASP2.Visible = False
ComboSLAMS2.Visible = False
ComboSLASP3.Visible = False
ComboSLAMS3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS4.Visible = False
ComboPlasticCTSLASP.Visible = True
ComboPlasticCTSLAMS.Visible = True
ComboPlasticCTSLASP.Value = ""
ComboPlasticCTSLAMS.Value = ""
ComboPlasticCTSLASP.Enabled = True
ComboPlasticCTSLAMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticCTSLASP_Change()
If ComboPlasticCTSLASP = "22.000" Then
ComboPlasticCTSLAPMS.Value = "350x350x350"
ComboPlasticCTSLAMS.Value = "1800x930x2200"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "33.000" Then
ComboPlasticCTSLAPMS.Value = "200x200x60"
ComboPlasticCTSLAMS.Value = "600x610x504"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "40.000" Then
ComboPlasticCTSLAPMS.Value = "200x200x60"
ComboPlasticCTSLAMS.Value = "600x435x400"
ComboPlasticCTSLAPMS.Enabled = False
```

```
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "60.000" Then
ComboPlasticCTSLAPMS.Value = "200x200x60"
ComboPlasticCTSLAMS.Value = "600x605x487"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "46.000" Then
ComboPlasticCTSLAPMS.Value = "200x200x200"
ComboPlasticCTSLAMS.Value = "630x606x662"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "66.000" Then
ComboPlasticCTSLAPMS.Value = "200x200x200"
ComboPlasticCTSLAMS.Value = "630x606x662"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "70.000" Then
ComboPlasticCTSLAPMS.Value = "110x110x60"
ComboPlasticCTSLAMS.Value = "770x545x1350"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "110.000" Then
ComboPlasticCTSLAPMS.Value = "300x300x300"
ComboPlasticCTSLAMS.Value = "1750x980x1500"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "150.000" Then
ComboPlasticCTSLAPMS.Value = "350x350x300"
ComboPlasticCTSLAMS.Value = "1860x1100x1700"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "230.000" Then
ComboPlasticCTSLAPMS.Value = "600x600x500"
ComboPlasticCTSLAMS.Value = "1860x1100x1700"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "158.000" Then
ComboPlasticCTSLAPMS.Value = "450x450x350"
ComboPlasticCTSLAMS.Value = "1650x8960x2000"
ComboPlasticCTSLAPMS.Enabled = False
```

```
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "210.000" Then
ComboPlasticCTSLAPMS.Value = "600x600x400"
ComboPlasticCTSLAMS.Value = "17000x8150x2000"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "130.000" Then
ComboPlasticCTSLAPMS.Value = "350x350x300"
ComboPlasticCTSLAMS.Value = "1550x850x2000"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "340.000" Then
ComboPlasticCTSLAPMS.Value = "800x600x400"
ComboPlasticCTSLAMS.Value = "2065x1245x2220"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "325.000" Then
ComboPlasticCTSLAPMS.Value = "600x600x400"
ComboPlasticCTSLAMS.Value = "1665x1095x1930"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "280.000" Then
ComboPlasticCTSLAPMS.Value = "450x450x350"
ComboPlasticCTSLAMS.Value = "1665x1095x1930"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "250.000" Then
ComboPlasticCTSLAPMS.Value = "350x350x350"
ComboPlasticCTSLAMS.Value = "1560x990x1930"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "300.000" Then
ComboPlasticCTSLAPMS.Value = "300x300x250"
ComboPlasticCTSLAMS.Value = "1430x1045x1575"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "555.555" Then
ComboPlasticCTSLAPMS.Value = "610x610x500"
ComboPlasticCTSLAMS.Value = "1020x2045x2050"
ComboPlasticCTSLAPMS.Enabled = False
```

```
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "933.000" Then
ComboPlasticCTSLAPMS.Value = "1500x750x500"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "785.000" Then
ComboPlasticCTSLAPMS.Value = "650x750x550"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "535.000" Then
ComboPlasticCTSLAPMS.Value = "650x750x275"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "450.000" Then
ComboPlasticCTSLAPMS.Value = "650x350x300"
ComboPlasticCTSLAMS.Value = "2120x1580x2210"
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "185.000" Then
ComboPlasticCTSLAPMS.Value = "250x250x250"
ComboPlasticCTSLAMS.Value = "1340x860x1780 "
ComboPlasticCTSLAPMS.Enabled = False
ComboPlasticCTSLAMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticCTSLASP = "None" Then
ComboPlasticCTSLAPMS.Value = ""
ComboPlasticCTSLAMS.Value = ""
ComboPlasticCTSLAPMS.Enabled = True
ComboPlasticCTSLAMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboPlasticFTSLSMS_Change()
If ComboPlasticFTSLSMS = "900x800x2500" Then
ComboPlasticFTSLSSP.Value = "700.000"
ComboPlasticFTSLSPMS.Value = "80(high)x125(Dim)"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboPlasticFTSLSMS = "1900x1400x2500" Then
ComboPlasticFTSLSSP.Value = "800.000"
ComboPlasticFTSLSPMS.Value = "250x250x220"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "1425x110x1590" Then
ComboPlasticFTSLSSP.Value = "215.000"
ComboPlasticFTSLSPMS.Value = "300x300x250"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "1425x1115x1610" Then
ComboPlasticFTSLSSP.Value = "555.555"
ComboPlasticFTSLSPMS.Value = "610x610x500"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "2340x1640x2760" Then
ComboPlasticFTSLSSP.Value = "815.000"
ComboPlasticFTSLSPMS.Value = "1000x800x500"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "2060x930x1830" Then
ComboPlasticFTSLSSP.Value = "107.000"
ComboPlasticFTSLSPMS.Value = "360x360x500"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "2860x1210x2180" Then
ComboPlasticFTSLSSP.Value = "177.000"
ComboPlasticFTSLSPMS.Value = "500x500x500"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "1280x1340x2320" Then
ComboPlasticFTSLSSP.Value = "100.000"
ComboPlasticFTSLSPMS.Value = "350x350x600"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "1410x1340x2100" Then
ComboPlasticFTSLSSP.Value = "140.000"
ComboPlasticFTSLSPMS.Value = "480x480x600"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
```

```
If ComboPlasticFTSLSMS = "1860x1100x1700" Then
ComboPlasticFTSLSSP.Value = "90.000"
ComboPlasticFTSLSPMS.Value = "320x320x450"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "2030x1050x2070" Then
ComboPlasticFTSLSSP.Value = "115.000"
ComboPlasticFTSLSPMS.Value = "400x400x450"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "2270x1150x2070" Then
ComboPlasticFTSLSSP.Value = "165.000"
ComboPlasticFTSLSPMS.Value = "500x500x400"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSMS = "None" Then
ComboPlasticFTSLSSP.Value = ""
ComboPlasticFTSLSPMS.Value = ""
ComboPlasticFTSLSSP.Enabled = True
ComboPlasticFTSLSPMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboPlasticFTSLSPMS_Change()
If ComboPlasticFTSLSPMS = "80(high)x125(Dim)" Then
ComboPlasticFTSLSSP.Value = "700.000"
ComboPlasticFTSLSMS.Value = "900x800x2500"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "250x250x220" Then
ComboPlasticFTSLSSP.Value = "800.000"
ComboPlasticFTSLSMS.Value = "1900x1400x2500"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "500x500x460" Then
ComboPlasticFTSLSSP.Value = "710.000"
ComboPlasticFTSLSMS.Value = "2120x1580x2010"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "500x500x750" Then
ComboPlasticFTSLSSP.Value = "800.000"
ComboPlasticFTSLSMS.Value = "2120x1580x2010"
ComboPlasticFTSLSSP.Enabled = False
```

```
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "300x300x250" Then
ComboPlasticFTSLSSP.Value = "2150.000"
ComboPlasticFTSLSMS.Value = "1425x110x1590"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "360x360x500" Then
ComboPlasticFTSLSSP.Value = "107.000"
ComboPlasticFTSLSMS.Value = "2060x930x1830"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "500x500x500" Then
ComboPlasticFTSLSSP.Value = "177.000"
ComboPlasticFTSLSMS.Value = "2860x1210x2180"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "350x350x600" Then
ComboPlasticFTSLSSP.Value = "100.000"
ComboPlasticFTSLSMS.Value = "1280x1340x2320"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "480x480x600" Then
ComboPlasticFTSLSSP.Value = "140.000"
ComboPlasticFTSLSMS.Value = "1410x1340x2100"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "320x320x450" Then
ComboPlasticFTSLSSP.Value = "90.000"
ComboPlasticFTSLSMS.Value = "1860x1100x1700"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "400x400x450" Then
ComboPlasticFTSLSSP.Value = "115.000"
ComboPlasticFTSLSMS.Value = "2030x1050x2070"
ComboPlasticFTSLSSP.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "500x500x400" Then
ComboPlasticFTSLSSP.Value = "165.000"
ComboPlasticFTSLSMS.Value = "2270x1150x2070"
ComboPlasticFTSLSSP.Enabled = False
```

```
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSPMS = "None" Then
ComboPlasticFTSLSSP.Value = ""
ComboPlasticFTSLSMS.Value = ""
ComboPlasticFTSLSSP.Enabled = True
ComboPlasticFTSLSMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboPlasticFTSLSSP_Change()
If ComboPlasticFTSLSSP = "700.000" Then
ComboPlasticFTSLSPMS.Value = "80(high)x125(Dim)"
ComboPlasticFTSLSMS.Value = "900x800x2500"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "215.000" Then
ComboPlasticFTSLSPMS.Value = "300x300x250"
ComboPlasticFTSLSMS.Value = "1425x110x1590"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "1.100.000" Then
ComboPlasticFTSLSPMS.Value = "381x330x457"
ComboPlasticFTSLSMS.Value = "1680x1020x2120"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "1.300.000" Then
ComboPlasticFTSLSPMS.Value = "381x330x457"
ComboPlasticFTSLSMS.Value = "1680x1020x2120"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "710.000" Then
ComboPlasticFTSLSPMS.Value = "500 x500x460"
ComboPlasticFTSLSMS.Value = "2120x1580x2010"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "555.555" Then
ComboPlasticFTSLSPMS.Value = "610x610x500"
ComboPlasticFTSLSMS.Value = "1425x1115x1610"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "725.000" Then
```

```
ComboPlasticFTSLSPMS.Value = "610x610x500"
ComboPlasticFTSLSMS.Value = "1940x1150x1990"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "770.230" Then
ComboPlasticFTSLSPMS.Value = "1000x800x500"
ComboPlasticFTSLSMS.Value = "1940x1150x1990"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "815.000" Then
ComboPlasticFTSLSPMS.Value = "1000 x800x500"
ComboPlasticFTSLSMS.Value = "2340x1640x2760"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "107.000" Then
ComboPlasticFTSLSPMS.Value = "360x360x500"
ComboPlasticFTSLSMS.Value = "2060x930x1830"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "177.000" Then
ComboPlasticFTSLSPMS.Value = "500x500x500"
ComboPlasticFTSLSMS.Value = "2860x1210x2180"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "100.000" Then
ComboPlasticFTSLSPMS.Value = "350x350x600"
ComboPlasticFTSLSMS.Value = "1280x1340x2320"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "140.000" Then
ComboPlasticFTSLSPMS.Value = "480x480x600"
ComboPlasticFTSLSMS.Value = "1410x1340x2100"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "90.000" Then
ComboPlasticFTSLSPMS.Value = "320x320x450"
ComboPlasticFTSLSMS.Value = "1860x1100x1700"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "115.000" Then
```

```
ComboPlasticFTSLSPMS.Value = "400x400x450"
ComboPlasticFTSLSMS.Value = "2030x1050x2070"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "165.000" Then
ComboPlasticFTSLSPMS.Value = "500x500x400"
ComboPlasticFTSLSMS.Value = "2270x1150x2070"
ComboPlasticFTSLSPMS.Enabled = False
ComboPlasticFTSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboPlasticFTSLSSP = "None" Then
ComboPlasticFTSLSPMS.Value = ""
ComboPlasticFTSLSMS.Value = ""
ComboPlasticFTSLSPMS.Enabled = True
ComboPlasticFTSLSMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboRPA_Change()
Label3DT.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = False
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCT.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
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ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
ComboCeramicFTSP.Visible = False
ComboCeramicFTPMS.Visible = False
ComboCeramicFTMS.Visible = False
ComboPlasticFTSLSSP.Visible = False
ComboPlasticFTSLSPMS.Visible = False
ComboPlasticFTSLSMS.Visible = False
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
Combo3DTCSP1.Enabled = True
Combo3DTCMS1.Enabled = True

Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTSandSP.Value = ""
Combo3DTSandPMS.Value = ""
Combo3DTSandMS.Value = ""
ComboWaxSLSSP.Value = ""
ComboWaxSLSPMS.Value = ""
ComboWaxSLSMS.Value = ""
ComboPlasticCTSLASP.Value = ""
ComboPlasticCTSLAPMS.Value = ""
ComboPlasticCTSLAMS.Value = ""
ComboPlasticCTJSP.Value = ""
ComboPlasticCTJPMS.Value = ""
ComboPlasticCTJMS.Value = ""
ComboPlasticCTFDMSP.Value = ""
ComboPlasticCTFDMPMS.Value = ""
ComboPlasticCTFDMMS.Value = ""
ComboPlasticCTLOMSP.Value = ""
ComboPlasticCTLOMPMS.Value = ""
ComboPlasticCTLOMMS.Value = ""
ComboPlasticCT3DSP.Value = ""
ComboPlasticCT3DPMS.Value = ""
ComboPlasticCT3DMS.Value = ""
```

```
ComboPaperCTLOMSP.Value = ""
ComboPaperCTLOMPMS.Value = ""
ComboPaperCTLOMMS.Value = ""
ComboMetalFTDMLSSP.Value = ""
ComboMetalFTDMLSPMS.Value = ""
ComboMetalFTDMLSMS.Value = ""
ComboMetalFTLCSP.Value = ""
ComboMetalFTLCPMS.Value = ""
ComboMetalFTLCMS.Value = ""
ComboMetalFTFSP.Value = ""
ComboMetalFTFPMS.Value = ""
ComboMetalFTFMS.Value = ""
ComboMetalFTEBMSP.Value = ""
ComboMetalFTEBMPMS.Value = ""
ComboMetalFTSLSSP.Value = ""
ComboMetalFTSLSPMS.Value = ""
ComboMetalFTSLSMS.Value = ""
ComboCeramicFTSP.Value = ""
ComboCeramicFTPMS.Value = ""
ComboCeramicFTMS.Value = ""
ComboPlasticFTSLSSP.Value = ""
ComboPlasticFTSLSPMS.Value = ""
ComboPlasticFTSLSMS.Value = ""


If ComboRPA = "Concept models" Then
ComboConcept.Value = ""
Combo1.Visible = False
ComboConcept.Visible = True
ComboForm.Visible = False
ComboFunction.Visible = False
ComboVisual.Visible = False
CommandRecommend.Enabled = False
End If
If ComboRPA = "Form fit and checking" Then
ComboForm.Value = ""
Combo1.Visible = False
ComboConcept.Visible = False
ComboForm.Visible = True
ComboFunction.Visible = False
ComboVisual.Visible = False
CommandRecommend.Enabled = False
End If
If ComboRPA = "Function models" Then
ComboFunction.Value = ""
Combo1.Visible = False
ComboConcept.Visible = False
ComboForm.Visible = False
ComboFunction.Visible = True
ComboVisual.Visible = False
CommandRecommend.Enabled = False
End If
If ComboRPA = "Visual prototypes" Then
ComboVisual.Value = ""
Combo1.Visible = False
ComboConcept.Visible = False
```

```
ComboForm.Visible = False
ComboFunction.Visible = False
ComboVisual.Visible = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboUSAChinaFrance_Change()


End Sub

Private Sub ComboSLAMS1_Change()
If ComboSLAMS1 = "1860x1100x1700" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP1.Value = "150.000"
ComboSLASP1.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS1 = "1550x850x2000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP1.Value = "130.000"
ComboSLASP1.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS1 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLASP1.Value = ""
ComboSLASP1.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboSLAMS2_Change()
If ComboSLAMS2 = "1800x930x2200" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP2.Value = "22.000"
ComboSLASP2.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS2 = "1560x990x1930" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP2.Value = "250.000"
ComboSLASP2.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS2 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
```

```
ComboSLASP2.Value = ""
ComboSLASP2.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboSLAMS3_Change()
If ComboSLAMS3 = "1650x8960x2000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP3.Value = "158.000"
ComboSLASP3.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS3 = "1665x1095x1930" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP3.Value = "280.000"
ComboSLASP3.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS3 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLASP3.Value = ""
ComboSLASP3.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboSLAMS4_Change()
If ComboSLAMS4 = "1665x1095x1930" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP4.Value = "325.000"
ComboSLASP4.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS4 = "17000x8150x2000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLASP4.Value = "210.000"
ComboSLASP4.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLAMS4 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLASP4.Value = ""
ComboSLASP4.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub
```

```
Private Sub ComboSLASP1_Change()
If ComboSLASP1 = "150.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS1.Value = "1860x1100x1700"
ComboSLAMS1.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP1 = "130.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS1.Value = "1550x850x2000"
ComboSLAMS1.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP1 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLAMS1.Value = ""
ComboSLAMS1.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboSLASP2_Change()
If ComboSLASP2 = "22.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS2.Value = "1800x930x2200"
ComboSLAMS2.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP2 = "250.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS2.Value = "1560x990x1930"
ComboSLAMS2.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP2 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLAMS2.Value = ""
ComboSLAMS2.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboSLASP3_Change()
If ComboSLASP3 = "158.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS3.Value = "1650x8960x2000"
```

```
ComboSLAMS3.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP3 = "280.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS3.Value = "1665x1095x1930"
ComboSLAMS3.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP3 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLAMS3.Value = ""
ComboSLAMS3.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboSLASP4_Change()
If ComboSLASP4 = "210.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS4.Value = "17000x8150x2000"
ComboSLAMS4.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP4 = "325.000" Then
Combo3DTCPMS.Enabled = False
ComboPlasticCTSLAPMS.Enabled = False
ComboSLAMS4.Value = "1665x1095x1930"
ComboSLAMS4.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboSLASP4 = "None" Then
Combo3DTCPMS.Enabled = True
ComboPlasticCTSLAPMS.Enabled = True
ComboSLAMS4.Value = ""
ComboSLAMS4.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboVisual_Change()
LabelPaperT.Visible = False
ComboWaxT.Visible = False
ComboPlasticCT.Visible = False
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
If ComboVisual = "Starch" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Combo3DTCSP.Visible = True
```

```
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If
If ComboVisual = "Plaster" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
```

```
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If
If ComboVisual = "Wax" Then
Label3DT.Visible = True
ComboVisualT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If
If ComboVisual = "Ceramic" Then
Label3DT.Visible = True
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboVisualT.Visible = False
```

```
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If
If ComboVisual = "Plastic" Then
Label3DT.Visible = False
ComboVisualT.Visible = True
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
```

```
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If
If ComboVisual = "None" Then
Label3DT.Visible = False
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If


End Sub

Private Sub ComboVisualT_Change()
If ComboVisualT = "3D Printing" Then
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
```

```
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = True
ComboPlasticCT3DPMS.Visible = True
ComboPlasticCT3DMS.Visible = True
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
End If
If ComboVisualT = "FDM" Then
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPlasticCTFDMSP.Visible = True
ComboPlasticCTFDMPMS.Visible = True
ComboPlasticCTFDMMS.Visible = True
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
End If


End Sub

Private Sub ComboVisualT_DblClick(Cancel As Integer)
```

```
End Sub

Private Sub ComboWaxSLSMS_Change()
If ComboWaxSLSMS = "2060x930x1830" Then
ComboWaxSLSSP.Value = "107.000"
ComboWaxSLSPMS.Value = "360x360x500"
ComboWaxSLSSP.Enabled = False
ComboWaxSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboWaxSLSMS = "2860x1210x2180" Then
ComboWaxSLSSP.Value = "177.000"
ComboWaxSLSPMS.Value = "500x500x500"
ComboWaxSLSSP.Enabled = False
ComboWaxSLSPMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboWaxSLSMS = "None" Then
ComboWaxSLSSP.Value = ""
ComboWaxSLSPMS.Value = ""
ComboWaxSLSSP.Enabled = True
ComboWaxSLSPMS.Enabled = True
CommandRecommend.Enabled = False
End If
End Sub

Private Sub ComboWaxSLSPMS_Change()
If ComboWaxSLSPMS = "360x360x500" Then
ComboWaxSLSSP.Value = "107.000"
ComboWaxSLSMS.Value = "2060x930x1830"
ComboWaxSLSSP.Enabled = False
ComboWaxSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboWaxSLSPMS = "500x500x500" Then
ComboWaxSLSSP.Value = "177.000"
ComboWaxSLSMS.Value = "2860x1210x2180"
ComboWaxSLSSP.Enabled = False
ComboWaxSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboWaxSLSPMS = "None" Then
ComboWaxSLSSP.Value = ""
ComboWaxSLSMS.Value = ""
ComboWaxSLSSP.Enabled = True
ComboWaxSLSMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboWaxSLSSP_Change()
If ComboWaxSLSSP = "107.000" Then
ComboWaxSLSPMS.Value = "360x360x500"
ComboWaxSLSMS.Value = "2060x930x1830"
ComboWaxSLSPMS.Enabled = False
```

```
ComboWaxSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboWaxSLSSP = "177.000" Then
ComboWaxSLSPMS.Value = "500x500x500"
ComboWaxSLSMS.Value = "2860x1210x2180"
ComboWaxSLSPMS.Enabled = False
ComboWaxSLSMS.Enabled = False
CommandRecommend.Enabled = True
End If
If ComboWaxSLSSP = "None" Then
ComboWaxSLSPMS.Value = ""
ComboWaxSLSMS.Value = ""
ComboWaxSLSPMS.Enabled = True
ComboWaxSLSMS.Enabled = True
CommandRecommend.Enabled = False
End If

End Sub

Private Sub ComboWaxT_Change()
If ComboWaxT = "SLS" Then
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = True
ComboWaxSLSPMS.Visible = True
ComboWaxSLSMS.Visible = True
ComboWaxSLSSP.Value = ""
ComboWaxSLSPMS.Value = ""
ComboWaxSLSMS.Value = ""
ComboWaxSLSSP.Enabled = True
ComboWaxSLSPMS.Enabled = True
ComboWaxSLSMS.Enabled = True
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
End If
If ComboWaxT = "3D Printing" Then
ComboVisualT.Visible = False
Combo3DTCSP.Visible = True
Combo3DTCPMS.Visible = True
Combo3DTCMS.Visible = True
Combo3DTCSP.Value = ""
Combo3DTCPMS.Value = ""
Combo3DTCMS.Value = ""
Combo3DTCSP.Enabled = True
Combo3DTCPMS.Enabled = True
Combo3DTCMS.Enabled = True
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
```

```
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
End If
If ComboWaxT = "None" Then
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
End If

End Sub

Private Sub ComboWaxT_DblClick(Cancel As Integer)
End Sub

Private Sub CommandRecommend_Click()
If Combo3DTCSP = "50.000" And Combo3DTCPMS = "254x356x203" And Combo3DTCMS =
"1070x790x1270" Then
DoCmd.OpenForm "Spectrum Z 510"
End If
If Combo3DTCSP = "80.000" And Combo3DTCPMS = "254x381x203" And Combo3DTCMS =
"1880x740x1450" Then
DoCmd.OpenForm "Z Printer 650"
End If
If Combo3DTCSP1 = "20.000" And Combo3DTCMS1 = "740x810x1090" Then
DoCmd.OpenForm "Z printer 310 Plus "
End If
If Combo3DTCSP1 = "40.000" And Combo3DTCMS1 = "1220x790x1400" Then
DoCmd.OpenForm "Z printer 450"
End If


If Combo3DTSandSP = "70.000" And Combo3DTSandPMS = "1200x900x600" And
Combo3DTSandMS = "2100x1150x1650" Then
DoCmd.OpenForm "PLCM-1200"
End If
If Combo3DTSandSP = "50.000" And Combo3DTSandPMS = "254x356x203" And
Combo3DTSandMS = "1070x790x1270" Then
DoCmd.OpenForm "Spectrum Z 510"
End If
If Combo3DTSandSP = "80.000" And Combo3DTSandPMS = "254x381x203" And
Combo3DTSandMS = "1880x740x1450" Then
DoCmd.OpenForm "Z Printer 650"
End If


If ComboWaxSLSSP = "107.000" And ComboWaxSLSPMS = "360x360x500" And
ComboWaxSLSMS = "2060x930x1830" Then
```

```
DoCmd.OpenForm "AFS 320"
End If
If ComboWaxSLSSP = "177.000" And ComboWaxSLSPMS = "500x500x500" And ComboWaxSLSMS = "2860x1210x2180" Then
DoCmd.OpenForm "AFS 500"
End If


If ComboPlasticCTSLASP = "70.000" And ComboPlasticCTSLAPMS = "110x110x60" And ComboPlasticCTSLAMS = "770x545x1350" Then
DoCmd.OpenForm "DWX029"
End If
If ComboPlasticCTSLASP = "110.000" And ComboPlasticCTSLAPMS = "300x300x300" And ComboPlasticCTSLAMS = "1750x980x1500" Then
DoCmd.OpenForm "HRPL - I"
End If
If ComboPlasticCTSLASP = "340.000" And ComboPlasticCTSLAPMS = "800x600x400" And ComboPlasticCTSLAMS = "2065x1245x2220" Then
DoCmd.OpenForm "SPS800"
End If
If ComboPlasticCTSLASP = "300.000" And ComboPlasticCTSLAPMS = "300x300x250" And ComboPlasticCTSLAMS = "1430x1045x1575" Then
DoCmd.OpenForm "RM3000"
End If
If ComboPlasticCTSLASP = "555.555" And ComboPlasticCTSLAPMS = "610x610x500" And ComboPlasticCTSLAMS = "1020x2045x2050" Then
DoCmd.OpenForm "RM6000"
End If
If ComboPlasticCTSLASP = "185.000" And ComboPlasticCTSLAPMS = "250x250x250" And ComboPlasticCTSLAMS = "1340x860x1780" Then
DoCmd.OpenForm "Viper SLA"
End If


If ComboPlasticCTJSP = "50.000" And ComboPlasticCTJPMS = "304.8x152.4x152.4" And ComboPlasticCTJMS = "711.2x495.3x495.3" Then
DoCmd.OpenForm "T612"
End If
If ComboPlasticCTJSP = "700.000" And ComboPlasticCTJPMS = "850x450x500" And ComboPlasticCTJMS = "1790x1852x1660" Then
DoCmd.OpenForm "VX500"
End If
If ComboPlasticCTJSP = "600.000" And ComboPlasticCTJPMS = "500x400x300" And ComboPlasticCTJMS = "2600x23500x2300" Then
DoCmd.OpenForm "VX800"
End If
If ComboPlasticCTJSP = "138.000" And ComboPlasticCTJPMS = "300x300x130" And ComboPlasticCTJMS = "600x700x400" Then
DoCmd.OpenForm "Perfactory 3D-Bioplotter"
End If
If ComboPlasticCTJSP = "220.000" And ComboPlasticCTJPMS = "50x50x150" And ComboPlasticCTJMS = "1200x750x1500" Then
DoCmd.OpenForm "c50"
End If
If ComboPlasticCTJSP = "260.000" And ComboPlasticCTJPMS = "300x300x150" And ComboPlasticCTJMS = "1800x950x1500" Then
```

```
DoCmd.OpenForm "c300"
End If


If ComboPlasticCTFDMSP = "55.000" And ComboPlasticCTFDMPMS = "203x203x305" And
ComboPlasticCTFDMMS = "865x685x1040" Then
DoCmd.OpenForm "FDM 200 mc"
End If
If ComboPlasticCTFDMSP = "250.000" And ComboPlasticCTFDMPMS = "914x610x914" And
ComboPlasticCTFDMMS = "2235x1120x1980" Then
DoCmd.OpenForm "FDM 900 mc"
End If
If ComboPlasticCTFDMSP = "58.000" And ComboPlasticCTFDMPMS = "400x400x450" And
ComboPlasticCTFDMMS = "1500x930x2200" Then
DoCmd.OpenForm "MEM-450"
End If
If ComboPlasticCTFDMSP = "47.000" And ComboPlasticCTFDMPMS = "320x320x350" And
ComboPlasticCTFDMMS = "1300x730x2200" Then
DoCmd.OpenForm "MEM-320"
End If
If ComboPlasticCTFDMSP = "70.000" And ComboPlasticCTFDMPMS = "280x250x300" And
ComboPlasticCTFDMMS = "950×820×900" Then
DoCmd.OpenForm "HT-300"
End If
If ComboPlasticCTFDMSP = "90.000" And ComboPlasticCTFDMPMS = "360x320x400" And
ComboPlasticCTFDMMS = "950×820×1050" Then
DoCmd.OpenForm "HT-400"
End If


If ComboPlasticCTLOMSP = "15.000" And ComboPlasticCTLOMPMS = "170x220x145" And
ComboPlasticCTLOMMS = "450x725x415" Then
DoCmd.OpenForm "SD 300"
End If
If ComboPlasticCTLOMSP = "25.000" And ComboPlasticCTLOMPMS = "200x180xUnlimited"
And ComboPlasticCTLOMMS = "1100x900x40" Then
DoCmd.OpenForm "VLM300"
End If
If ComboPlasticCTLOMSP = "35.000" And ComboPlasticCTLOMPMS = "320x250xUnlimited"
And ComboPlasticCTLOMMS = "760x1190x1090" Then
DoCmd.OpenForm "VLM400"
End If


If ComboPlasticCT3DSP = "50.000" And ComboPlasticCT3DPMS = "254x356x203" And
ComboPlasticCT3DMS = "1070x790x1270" Then
DoCmd.OpenForm "Spectrum Z 510"
End If
If ComboPlasticCT3DSP = "80.000" And ComboPlasticCT3DPMS = "254x381x203" And
ComboPlasticCT3DMS = "1880x740x1450" Then
DoCmd.OpenForm "Z Printer 650"
End If
If ComboPlasticCT3DSP = "5.000" And ComboPlasticCT3DPMS = "125x125x125" And
ComboPlasticCT3DMS = "500x500x635" Then
DoCmd.OpenForm "125ci"
End If
```

```
If ComboPaperCTLOMSP = "30.000" And ComboPaperCTLOMPMS = "180x280x150" And
ComboPaperCTLOMMS = "860x660x1330" Then
DoCmd.OpenForm "KATANA"
End If
If ComboPaperCTLOMSP = "33.000" And ComboPaperCTLOMPMS = "450x350x350" And
ComboPaperCTLOMMS = "1750x980x1500" Then
DoCmd.OpenForm "HRP - IIB"
End If
If ComboPaperCTLOMSP = "73.000" And ComboPaperCTLOMPMS = "600x400x500" And
ComboPaperCTLOMMS = "1860x1100x1700" Then
DoCmd.OpenForm "HRP - IIIA"
End If


If ComboCeramicFTSP = "283.800" And ComboCeramicFTPMS = "100(high)x100(Dim)" And
ComboCeramicFTMS = "1450x1250x1900" Then
DoCmd.OpenForm "RM100"
End If
If ComboCeramicFTSP = "513.480" And ComboCeramicFTPMS = "250(high)x300(Dim)" And
ComboCeramicFTMS = "3250x1300x 2400" Then
DoCmd.OpenForm "RM250"
End If


If LabelMetalCT3DSP.Visible = True And LabelMetalCT3DPMS.Visible = True And
LabelMetalCT3DMS.Visible = True Then
DoCmd.OpenForm "R1"
End If


If ComboPlasticFTSLSSP = "700.000" And ComboPlasticFTSLSPMS = "80(high)x125(Dim)" And
ComboPlasticFTSLSMS = "900x800x2500" Then
DoCmd.OpenForm "DM 100"
End If
If ComboPlasticFTSLSSP = "215.000" And ComboPlasticFTSLSPMS = "300x300x250" And
ComboPlasticFTSLSMS = "1425x110x1590" Then
DoCmd.OpenForm "SCS-1000HD"
End If
If ComboPlasticFTSLSSP = "107.000" And ComboPlasticFTSLSPMS = "360x360x500" And
ComboPlasticFTSLSMS = "2060x930x1830" Then
DoCmd.OpenForm "AFS 320"
End If
If ComboPlasticFTSLSSP = "177.000" And ComboPlasticFTSLSPMS = "500x500x500" And
ComboPlasticFTSLSMS = "2860x1210x2180" Then
DoCmd.OpenForm "AFS 500"
End If
If ComboPlasticFTSLSSP = "100.000" And ComboPlasticFTSLSPMS = "350x350x600" And
ComboPlasticFTSLSMS = "1280x1340x2320" Then
DoCmd.OpenForm "ELITE3500"
End If
If ComboPlasticFTSLSSP = "140.000" And ComboPlasticFTSLSPMS = "480x480x600" And
ComboPlasticFTSLSMS = "1410x1340x2100" Then
DoCmd.OpenForm "ELITE5000"
End If
```

```
If ComboPlasticFTSLSSP = "90.000" And ComboPlasticFTSLSPMS = "320x320x450" And
ComboPlasticFTSLSMS = "1860x1100x1700" Then
DoCmd.OpenForm "HRPS - IIA"
End If
If ComboPlasticFTSLSSP = "115.000" And ComboPlasticFTSLSPMS = "400x400x450" And
ComboPlasticFTSLSMS = "2030x1050x2070" Then
DoCmd.OpenForm "HRPS - IIIA"
End If
If ComboPlasticFTSLSSP = "165.000" And ComboPlasticFTSLSPMS = "500x500x400" And
ComboPlasticFTSLSMS = "2270x1150x2070" Then
DoCmd.OpenForm "HRPS - IV"
End If


If ComboMetalFTSLSSP = "700.000" And ComboMetalFTSLSPMS = "80(high)x125(Dim)" And
ComboMetalFTSLSMS = "900x800x2500" Then
DoCmd.OpenForm "DM 100"
End If
If ComboMetalFTSLSSP = "85.000" And ComboMetalFTSLSPMS = "250x250x240" And
ComboMetalFTSLSMS = "1900x2600x2500" Then
DoCmd.OpenForm "MCP Realizer SLM 250"
End If
If ComboMetalFTSLSSP = "283.800" And ComboMetalFTSLSPMS = "100(high)x100(Dim)" And
ComboMetalFTSLSMS = "1450x1250x1900" Then
DoCmd.OpenForm "RM100"
End If
If ComboMetalFTSLSSP = "513.480" And ComboMetalFTSLSPMS = "250(high)x300(Dim)" And
ComboMetalFTSLSMS = "3250x1300x 2400" Then
DoCmd.OpenForm "RM 250"
End If


If ComboMetalFTDMLSSP = "225.000" And ComboMetalFTDMLSPMS = "200x250x330" And
ComboMetalFTDMLSMS = "1320x1067x2204" Then
DoCmd.OpenForm "FORMIGA P 100"
End If
If ComboMetalFTDMLSSP = "570.000" And ComboMetalFTDMLSPMS = "250x250x215" And
ComboMetalFTDMLSMS = "2000x1050x1940" Then
DoCmd.OpenForm "EOSINT M 270"
End If
If ComboMetalFTDMLSSP = "470.000" And ComboMetalFTDMLSPMS = "340x340x620" And
ComboMetalFTDMLSMS = "1840x1175x2100" Then
DoCmd.OpenForm "EOSINT P 390"
End If
If ComboMetalFTDMLSSP = "950.500" And ComboMetalFTDMLSPMS = "720x380x380" And
ComboMetalFTDMLSMS = "1420x1400x2150" Then
DoCmd.OpenForm "EOSINT S 750"
End If


If ComboMetalFTLCSP = "448.800" And ComboMetalFTLCPMS = "150x150x200" And
ComboMetalFTLCMS = "2450x1490x1775" Then
DoCmd.OpenForm "M1 Cusing"
End If
If ComboMetalFTLCSP = "765.000" And ComboMetalFTLCPMS = "250x250x280" And
ComboMetalFTLCMS = "2440x1630x1992" Then
```

```
DoCmd.OpenForm "M2 Cusing"
End If
If ComboMetalFTLCSP = "726.000" And ComboMetalFTLCPMS = "300x350x300" And ComboMetalFTLCMS = "2670x1990x2180" Then
DoCmd.OpenForm "M3 Linear"
End If


If ComboMetalFTFSP = "800.000" And ComboMetalFTFPMS = "750x500x400" And ComboMetalFTFMS = "3835x2286x3048" Then
DoCmd.OpenForm "105D"
End If
If ComboMetalFTFSP = "980.000" And ComboMetalFTFPMS = "1200x800x450" And ComboMetalFTFMS = "4500x1200x2200" Then
DoCmd.OpenForm "MX - 3"
End If


If ComboMetalFTEBMSP = "875.000" And ComboMetalFTEBMPMS = "200x200x350" Then
DoCmd.OpenForm "ARCAM A2"
End If
If ComboMetalFTEBMSP = "725.000" And ComboMetalFTEBMPMS = "200x200x180" Then
DoCmd.OpenForm "ARCAM EBM S12"
End If


End Sub

Private Sub Form_Current()
Combo1.Enabled = False
Combo2.Enabled = False
Combo3.Enabled = False
Combo4.Enabled = False
Combo5.Enabled = False
Combo1.Visible = True
Combo2.Visible = True
Combo3.Visible = True
Combo4.Visible = True
Combo5.Visible = True
ComboConcept.Visible = False
ComboForm.Visible = False
ComboFunction.Visible = False
ComboVisual.Visible = False
LabelPaperT.Visible = False
ComboWaxT.Visible = False
Label3DT.Visible = False
LabelFunctionCeramicT.Visible = False
ComboFunctionMetalT.Visible = False
ComboFunctionPlasticT.Visible = False
ComboVisualT.Visible = False
Combo3DTCSP.Visible = False
Combo3DTCPMS.Visible = False
Combo3DTCMS.Visible = False
Combo3DTSandSP.Visible = False
Combo3DTSandPMS.Visible = False
Combo3DTSandMS.Visible = False
```

```
ComboWaxSLSSP.Visible = False
ComboWaxSLSPMS.Visible = False
ComboWaxSLSMS.Visible = False
ComboPlasticCT.Visible = False
ComboPlasticCTSLASP.Visible = False
ComboPlasticCTSLAPMS.Visible = False
ComboPlasticCTSLAMS.Visible = False
ComboPlasticCTJSP.Visible = False
ComboPlasticCTJPMS.Visible = False
ComboPlasticCTJMS.Visible = False
ComboPlasticCTFDMSP.Visible = False
ComboPlasticCTFDMPMS.Visible = False
ComboPlasticCTFDMMS.Visible = False
ComboPlasticCTLOMSP.Visible = False
ComboPlasticCTLOMPMS.Visible = False
ComboPlasticCTLOMMS.Visible = False
ComboPlasticCT3DSP.Visible = False
ComboPlasticCT3DPMS.Visible = False
ComboPlasticCT3DMS.Visible = False
ComboPaperCTLOMSP.Visible = False
ComboPaperCTLOMPMS.Visible = False
ComboPaperCTLOMMS.Visible = False
LabelMetalCT3DSP.Visible = False
LabelMetalCT3DPMS.Visible = False
LabelMetalCT3DMS.Visible = False
ComboMetalFTDMLSSP.Visible = False
ComboMetalFTDMLSPMS.Visible = False
ComboMetalFTDMLSMS.Visible = False
ComboMetalFTLCSP.Visible = False
ComboMetalFTLCPMS.Visible = False
ComboMetalFTLCMS.Visible = False
ComboMetalFTFSP.Visible = False
ComboMetalFTFPMS.Visible = False
ComboMetalFTFMS.Visible = False
ComboMetalFTEBMSP.Visible = False
ComboMetalFTEBMPMS.Visible = False
LabelMetalFTEBMMS.Visible = False
ComboMetalFTSLSSP.Visible = False
ComboMetalFTSLSPMS.Visible = False
ComboMetalFTSLSMS.Visible = False
ComboCeramicFTSP.Visible = False
ComboCeramicFTPMS.Visible = False
ComboCeramicFTMS.Visible = False
ComboPlasticFTSLSSP.Visible = False
ComboPlasticFTSLSPMS.Visible = False
ComboPlasticFTSLSMS.Visible = False
Combo3DTCSP1.Visible = False
Combo3DTCMS1.Visible = False
ComboSLASP1.Visible = False
ComboSLASP2.Visible = False
ComboSLASP3.Visible = False
ComboSLASP4.Visible = False
ComboSLAMS1.Visible = False
ComboSLAMS2.Visible = False
ComboSLAMS3.Visible = False
End Sub
```

Appendix C Examples of educational institutions with AM capabilities

Institutions from the United State of America:

- Altoona College of Pennsylvania State University.
- Clemson University.
- Cleveland Institute.
- Cornell University.
- Drexel University.
- East Tennessee State University.
- Ferris State University.
- Georgia Institute of Technology.
- Iowa State University.
- Kent State University.
- James Madison University.
- Loyola Marymount University.
-
- Milwaukee school of Engineering.
- Missouri University of Science and Technology.
- Moraine Valley Community College.
- Robert Morris University.
- North Carolina State University.
- Saddleback College.
- South Dakota School of Mines and Technology.
- South Dakota State University.
- Southern Methodist University.
- Tennessee Tech University.
- Texas State University.
- University at Buffalo.
- University of central Florida.
- University of Louisville.
- University of Michigan.

- University of Minnesota.
- University of north Carolina.
- University of Texas at Austin.
- University of Texas at EL Paso.
- Utah State University.
- Utah Valley University.
- Washington State University.
- York Technical College.

Institutions from Germany:

- University of Freiburg.
- University of Duisburg-Essen.

Institutions from United Kingdom:

- DeMontfort University.
- Norhtumbria University.
- Lancaster University.
- Loughborough University.
- University of Bath.
- University of Exeter.
- University of Liverpool.
- The University of Manchester.
- University of Nottingham.

Institutions from Spain:

- Technical University of Catolonia,
- Metal Processing Institute.
- University of Navarra.

Institutions from Turkey:

- Middle East Technical University.
- Gebze Institute of Technology.

Institutions from Canada:

- University of Western Ontario.
- University of Waterloo.

Institutions from Australia:

- University of Queensland.
- University Western Australia.

Institutions from South Africa:

- Central University of Technology (CUT).
- Stellenbosch University.
- Cape Peninsula University of Technology (CPUT).
- Nelson Mandela Metropolitan University (NMMU).
- Tshwane University of Technology (TUT).
- Durban University of Technology (DUT).
- Vaal University of Technology (VUT).

Institutions from other countries:

- Central Metallurgical Research and Development Institute (CMRDI), Egypt.
- Delft University of Technology, Netherlands.
- Helsinki University of Technology (HUT), Finland.
- Katholieke University Leuven, Belgium.
- Modena and Reggio Emilia University, Italy.
- National University of Singapore, Singapore.
- Oslo School of Architecture and Design, Norway.
- Polytechnic Institute of Leiria, Portugal.

- Russian Academy of Sciences, Russia.
- University Technology Malaysia, Malaysia.
- University of Maribor, Slovenia.
- University of Patras, Greece.
- Wroclaw University of Technology, Poland.