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Review Article

A Survey of Performance based Advanced Rapid Prototyping Techniques

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Abstract: Rapid prototyping is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing technology. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a much wider range of applications and are even used to manufacture production-quality parts in relatively small numbers. Some sculptors use the technology to produce exhibitions. Rapid application development (RAD) is a software development methodology that uses minimal planning in favor of rapid prototyping. The "planning" of software developed using RAD is interleaved with writing the software itself. The lack of extensive pre-planning generally allows software to be written much faster, and makes it easier to change requirements. In this paper we discussed a survey of performance based advanced rapid prototyping techniques. The performance based techniques are categorized based upon different approaches. We also analysis the major improvement in recent methods advanced rapid prototyping techniques.
Keywords: Computer-Aided Design, Rapid Prototyping, Performance Analysis

INTRODUCTION

Rapid Prototyping (RP) by layer-by-layer material deposition started during early 1980s with the enormous growth in Computer Aided Design and Manufacturing (CAD/CAM) technologies when almost unambiguous solid models with knitted information of edges and surfaces could define a product and also manufacture it by Computer Numerical Control (CNC) machining. RP process belong to the generative (or additive) production processes unlike subtractive or forming processes such as lathing, milling, grinding or coining etc. in which form is shaped by material removal or plastic deformation. In all commercial RP processes, the part is fabricated by deposition of layers contoured in a (x-y) plane two dimensionally. The third dimension (z) results from single layers being stacked up on top of each other, but not as a continuous z-coordinate. Therefore, the prototypes are very exact on the x-y plane but have stair-stepping effect in z-direction. If model is deposited with very fine layers, i.e., smaller z-stepping, model looks like original. RP can be classified into two fundamental process steps namely generation of mathematical layer information and generation of physical layer model. Rapid prototyping is starting to change the way companies design and build products. On the horizon, though, are several developments that will help to revolutionize manufacturing as we know it. One such improvement is increased speed. "Rapid" prototyping machines are still slow by some standards. By using faster computers, more complex control systems, and improved materials, RP manufacturers are dramatically reducing build time. Another future development is improved accuracy and surface finish. Today's commercially available machines are accurate to ~0.08 millimeters in the x-y plane, but less in the z (vertical) direction. Improvements in laser optics and motor control should increase accuracy in all three directions. The introduction of non-polymeric materials, including metals, ceramics, and composites, represents another much anticipated development. These materials would allow RP users to produce functional parts. Today's plastic prototypes work well for visualization and fit tests, but they are often too weak for function testing. More rugged materials would yield prototypes that could be subjected to actual service conditions [1-2] and [5]. In this paper we represents a review of performance based advanced rapid prototyping techniques.

RAPID PROTYPING TECNIQUES AND APPLICATIONS

Rapid Prototyping

The term rapid prototyping (RP) refers to a class of technologies that can automatically construct physical models from Computer-Aided Design (CAD) data. These "three dimensional printers" allow designers to quickly create tangible prototypes of their designs, rather than just two-dimensional pictures. Such models have numerous uses. They make excellent visual aids for communicating ideas with co-workers or customers. In addition, prototypes can be used for design testing. For example, an aerospace engineer might mount a model airfoil in a wind tunnel to measure lift and drag forces. Designers have always utilized prototypes; RP allows them to be made faster and less expensively. In addition to prototypes, RP techniques can also be used to make tooling (referred to as rapid tooling) and even production-quality parts (rapid manufacturing). For small production runs and complicated objects, rapid prototyping is often the best manufacturing process available. Of course, "rapid" is a relative term. Most prototypes require from three to seventy-two hours to build, depending on the size and complexity of the object. This may seem slow, but it is much faster than the weeks or months required to make a prototype by traditional means such as machining. These dramatic time savings allow manufacturers to bring products to market faster and more cheaply. In 1994, Pratt & Whitney achieved "an order of magnitude reduction and time savings of 70 to 90 percent" by incorporating rapid prototyping into their investment casting process. At least six different rapid prototyping techniques are commercially available, each with unique strengths. Because RP technologies are being increasingly used in non-prototyping applications, the techniques are often collectively referred to as solid free-form fabrication; computer automated manufacturing, or layered manufacturing. The latter term is particularly descriptive of the manufacturing process used by all commercial techniques. A software package "slices" the CAD model into a number of thin (~0.1 mm) layers, which are then built up one atop another. Rapid prototyping is an "additive" process, combining layers of paper, wax, or plastic to create a solid object. In contrast, most machining processes (milling, drilling, grinding, etc.) are "subtractive" processes that remove material from a solid block. RP's additive nature allows it to create objects with complicated internal features that cannot be manufactured by other means. Of course, rapid prototyping is not perfect. Part volume is generally limited to 0.125 cubic meters or less, depending on the RP machine. Metal prototypes are difficult to make, though this should change in the near future. For metal parts, large production runs, or simple objects, conventional manufacturing techniques are usually more economical. These limitations aside, rapid prototyping is a remarkable technology that is revolutionizing the manufacturing process [1] and [3].

Rapid Prototyping Techniques

Most commercially available rapid prototyping machines use one of six techniques. At present, trade restrictions severely limit the import/export of rapid prototyping machines.

→***Stereo-lithography***
→***Laminated Object Manufacturing***
→***Selective Laser Sintering***
→***Fused Deposition Modeling***
→***Solid Ground Curing***
→***3-D Ink-Jet Printing***

Stereo-lithography

Patented in 1986, stereo-lithography started the rapid prototyping revolution. The technique builds three-dimensional models from liquid photosensitive polymers that solidify when exposed to ultraviolet light. The model is built upon a platform situated just below the surface in a vat of liquid epoxy or acrylate resin. A low-power highly focused UV laser traces out the first layer, solidifying the model's cross section while leaving excess areas liquid. Next, an elevator incrementally lowers the platform into the liquid polymer. A sweeper re-coats the solidified layer with liquid, and the laser traces the second layer atop the first. This process is repeated until the prototype is complete. Afterwards, the solid part is removed from the vat and rinsed clean of excess liquid. Supports are broken off and the model is then placed in an ultraviolet oven for complete curing. Stereo-lithography Apparatus (SLA) machines have been made since 1988 by 3D Systems of Valencia, CA. To this day, 3D Systems is the industry leader, selling more RP machines than any other company. Because it was the first technique, stereo-lithography is regarded as a benchmark by which other technologies are judged. Early stereo-lithography prototypes were fairly brittle and prone to curing-induced warpage and distortion, but recent modifications have largely corrected these problems.

Laminated Object Manufacturing

In this technique, developed by Helisys of Torrance, CA, layers of adhesive-coated sheet material are bonded together to form a prototype. The original material consists of paper laminated with heat-activated glue and rolled up on spools. A feeder/collector mechanism advances the sheet over the build platform, where a base has been constructed from paper and double-sided foam tape. Next, a heated roller applies pressure to bond the paper to the base. A focused laser cuts the outline of the first layer into the paper and then cross-hatches the excess area (the negative space in the prototype). Cross-hatching breaks up the extra material, making it easier to remove during post-processing. During the build, the excess material provides excellent support for overhangs and thin-walled sections. After the first layer is cut, the platform lowers out of the way and fresh material is advanced. The platform rises to slightly below the previous height, the roller bonds the second layer to the first, and the laser cuts the second layer. This process is repeated as needed to build the part, which will have a wood-like texture. Because the models are made of paper, they must be sealed and finished with paint or varnish to prevent moisture damage.

Helisys developed several new sheet materials, including plastic, water-repellent paper, and ceramic and metal powder tapes. The powder tapes produce a "green" part that must be sintered for maximum strength.

Selective Laser Sintering

Developed by Carl Deckard for his master's thesis at the University of Texas, selective laser sintering was patented in 1989. It uses a laser beam to selectively fuse powdered materials, such as nylon, elastomer, and metal, into a solid object. Parts are built upon a platform which sits just below the surface in a bin of the heat-fusable powder. A laser traces the pattern of the first layer, sintering it together. The platform is lowered by the height of the next layer and powder is reapplied. This process continues until the part is complete. Excess powder in each layer helps to support the part during the build. SLS machines are produced by DTM of Austin, TX [6-7].

Fused Deposition Modeling

In this technique, filaments of heated thermoplastic are extruded from a tip that moves in the x-y plane. Like a baker decorating a cake, the controlled extrusion head deposits very thin beads of material onto the build platform to form the first layer. The platform is maintained at a lower temperature, so that the thermoplastic quickly hardens. After the platform lowers, the extrusion head deposits a second layer upon the first. Supports are built along the way, fastened to the part either with a second, weaker material or with a perforated junction.

Stratasys, of Eden Prairie, MN makes a variety of FDM machines ranging from fast concept modelers to slower, high-precision machines. Materials include ABS (standard and medical grade), elastomer (96 durometer), polycarbonate, polyphenolsulfone, and investment casting wax.

Solid Ground Curing

Developed by Cubital, solid ground curing (SGC) is somewhat similar to stereolithography (SLA) in that both use ultraviolet light to selectively harden photosensitive polymers. Unlike SLA, SGC cures an entire layer at a time. The solid ground curing, this is also known as the solider process. First, photosensitive resin is sprayed on the build platform. Next, the machine develops a photo-mask (like a stencil) of the layer to be built. This photo-mask is printed on a glass plate above the build platform using an electrostatic process similar to that found in photocopiers. The mask is then exposed to UV light, which only passes through the transparent portions of the mask to selectively harden the shape of the current layer.

After the layer is cured, the machine vacuums up the excess liquid resin and sprays wax in its place to support the model during the build. The top surface is milled flat, and then the process repeats to build the next layer. When the part is complete, it must be de-waxed by immersing it in a solvent bath. SGC machines are distributed in the U.S. by Cubital America Inc. of Troy, MI. The machines are quite big and can produce large models [3] and [6].

3-D Ink-Jet Printing

Ink-Jet Printing refers to an entire class of machines that employ ink-jet technology. The first was 3D Printing (3DP), developed at MIT and licensed to Soligen Corporation, Extrude Hone, and others. The ZCorp 3D printer, produced by Z Corporation of Burlington, MA is an example of this technology. The parts are built upon a platform situated in a bin full of powder material. An ink-jet printing head selectively deposits or "prints" a binder fluid to fuse the powder together in the desired areas. Unbound powder remains to support the part. The platform is lowered, more powder added and leveled, and the process repeated. When finished, the green part is then removed from the unbound powder, and excess unbound powder is blown off. Finished parts can be infiltrated with wax, CA glue, or other sealants to improve durability and surface finish. Typical layer thicknesses are on the order of 0.1 mm. This process is very fast, and produces parts with a slightly grainy surface. ZCorp uses two different materials, a starch based powder (not as strong, but can be burned out, for investment casting applications) and a ceramic powder. Machines with 4 color printing capability are available. 3D Systems' version of the ink-jet based system is called the Thermo-Jet or Multi-Jet Printer. It uses a linear array of print heads to rapidly produce thermoplastic models. If the part is narrow enough, the print head can deposit an entire layer in one pass. Otherwise, the head makes several passes.

Sanders Prototype of Wilton, NH uses a different ink-jet technique in its Model Maker line of concept modelers. The machines use two ink-jets. One dispenses low-melt thermoplastic to make the model, while the other prints wax to form supports. After each layer, a cutting tool mills the top surface to uniform height. This yields extremely good accuracy, allowing the machines to be used in the jewelry industry [1-4] and [7-8].

Applications of Rapid Prototyping

Rapid prototyping is widely used in the automotive, aerospace, medical, and consumer products industries. Although the possible applications are virtually limitless, nearly all fall into one of the following categories: prototyping, rapid tooling, or rapid manufacturing.

Prototyping

As its name suggests, the primary use of rapid prototyping is to quickly make prototypes for communication and testing purposes. Prototypes dramatically improve communication because most people, including engineers, find three-dimensional objects easier to understand than two-dimensional drawings. Such improved understanding leads to substantial cost and time savings. Effective communications is especially important in this era of concurrent engineering. By exchanging prototypes early in the design stage, manufacturing can start tooling up for production while the art division starts planning the packaging, all before the design is finalized.

Prototypes are also useful for testing a design, to see if it performs as desired or needs improvement. Engineers have always tested prototypes, but RP expands their capabilities. First, it is now easy to perform iterative testing: build a prototype, test it, redesign, build and test, etc. Such an approach would be far too time-consuming using traditional prototyping techniques, but it is easy using RP.

In addition to being fast, RP models can do a few things metal prototypes cannot. For example, Porsche used a transparent stereo-lithography model of the 911 GTI transmission housing to visually study oil flow. Snecma, a French turbomachinery producer, performed photoelastic stress analysis on a SLA model of a fan wheel to determine stresses in the blades.

Rapid Tooling

A much-anticipated application of rapid prototyping is rapid tooling, the automatic fabrication of production quality machine tools. Tooling is one of the slowest and most expensive steps in the manufacturing process, because of the extremely high quality required. Tools often have complex geometries, yet must be dimensionally accurate to within a hundredth of a millimeter. In addition, tools must be hard, wear-resistant, and have very low surface roughness (about 0.5 micrometers root mean square). To meet these requirements, molds and dies are traditionally made by CNC-machining, electro-discharge machining, or by hand. All are expensive and time consuming, so manufacturers would like to incorporate rapid prototyping techniques to speed the process. Peter Hilton, president of Technology Strategy Consulting in Concord, MA, believes that "tooling costs and development times can be reduced by 75 percent or more" by using rapid tooling and related technologies. [16] Rapid tooling can be divided into two categories, indirect and direct.

Rapid Manufacturing

A natural extension of RP is rapid manufacturing (RM), the automated production of salable products directly from CAD data. Currently only a few final products are produced by RP machines, but the number will increase as metals and other materials become more widely available. RM will never completely replace other manufacturing techniques, especially in large production runs where mass-production is more economical.

For short production runs, however, RM is much cheaper, since it does not require tooling. RM is also ideal for producing custom parts tailored to the user's exact specifications. A University of Delaware research project uses a digitized 3-D model of a person's head to construct a custom-fitted helmet. NASA is experimenting with using RP machines to produce spacesuit gloves fitted to each astronaut's hands. From tailored golf club grips to custom dinnerware, the possibilities are endless.

The other major use of RM is for products that simply cannot be made by subtractive (machining, grinding) or compressive (forging, etc.) processes. This includes objects with complex features, internal voids, and layered structures. Specific Surface of Franklin, MA uses RP to manufacture complicated ceramic filters that have eight times the interior surface area of older types. The filters remove particles from the gas emissions of coal-fired power plants. Therics, Inc. of NYC is using RP's layered build style to develop "pills that release measured drug doses at specified times during the day" and other medical products [1-5] and [9-10].

REVIEW OF RAPID PROTYPING TECHNIQUES

Advances in Materials for Power based Rapid Prototyping:

Prashant K. Jain and K. Senthilkumaran and Pulak M. Pandey and P. V. M. Rao et. al. represent the recent developments in materials for powder based layered manufacturing is reviewed and emphasize is given on issues and challenges in developing new materials and methods to meet high standards of part quality. Also recent research and accomplishments in processing bio-materials, heterogeneous materials and direct tools are discussed.

Due to the varied material capabilities, Selective Laser Sintering (SLS) process now stands as an alternative to conventional manufacturing techniques. Because of the time compression between product conceptualization to realization, these technologies are sometimes referred to as Rapid Manufacturing SLS also processes bio-materials for fabricating scaffolds in tissue engineering scaffolds. Layer-by-layer additive fabrication in SLS allows construction of scaffolds with complex internal and external geometries. Moreover, virtually any powdered biomaterial that will fuse but not decompose under a laser beam can be used to fabricate scaffolds. SLS enables fabrication of anatomically shaped scaffolds with varying internal architectures, thereby allowing precise control over pore size, porosity, permeability, and stiffness. Control over these characteristics may enhance cell infiltration and mass transport of nutrients and metabolic waste throughout the scaffold. SLS also allows for the fabrication of biphasic scaffolds that incorporate multiple geometries into a single scaffold, allowing for in growth of multiple tissues into a single scaffold structure.

This paper represents the state of the art in processing of different materials through SLS is presented. Studies involving developing new materials and improving the existing materials were discussed. Although many materials have been developed, there is still a need for research into new materials. It should be noted that the SLS process is still a relatively new process and therefore continued development of the technology and understanding of process fundamentals is needed to carry the technique forward. The addition of a secondary material to modify the mechanical properties of polymers is common practice, to ensure materials meet design requirements and are suitable for a wide range of applications. Addition of rigid particles and clay to polymers can produce a number of desirable effects on the mechanical properties of parts.

The knowledge of existing materials and the nature of complexity in processing them by laser will be helpful in achieving functional requirements of parts for present and future applications [1].

Miniaturized Cylinder Head Production by Rapid Prototyping:

Melo and Monteiro And Martins And Coene And Puga And Barbosa et. al. illustrated the various tasks involved in the design and development stages leading to the production of a running prototype of the cylinder head for this small engine. This work shows the development of the design and manufacturing of a very small engine, namely its head. The engine works under the 4-stroke cycle, therefore having a very complex cylinder head, housing the camshaft, valves and its auxiliaries, spark plug, inlet and exhaust passages and a coolant chamber. The geometries, both inner and outer are highly intricate which makes the production of such a part a very difficult job. In addition, when the engine is very small, as it is the case of this engine, all dimensions are miniaturized therefore making it extremely difficult to design, cast and finish. The cooling chamber, in particular, has a critical inner core removal problem due to reduced accessibility, imposing casting limitations. The cores place also a problem of air and gas removal during metal filling and solidification. Rapid prototyping may be the only solution to build the cores, and may help in the design and manufacturing phases of the casting tools. 3D printing with a plaster based material as a rapid prototyping technique presents itself as a tool to drastically reduce the design-development-casting process effort and time cycle. This technique enables the designer to obtain new moulds for castings on the shortest time possible, following redesign and new casting simulations.

The head was decided to be produced by casting, as its intricate design rendered it impossible to be produced by other methods such as machining. The material used for the cores and the moulds is to be produced by rapid prototyping.

There are some restrictions to this process:

→It is impossible to produce very sharp angles.

→ It is impossible to have undercuts, as it would not be possible to open the moulds.

To design the intake three software packages were used:

→ CAD software: Solid Works

→ Meshing software: Gambit

→ Modeling software: Fluent

A special purpose internal combustion engine was designed using CAD techniques. This is one of a kind engine, designed for a specific aim (minimal fuel consumption). The head was designed with intense swirl production by means of specific intake geometry. The geometry was optimized using CFD (FLUENT) modeling. Rapid Prototypes have been produced, allowing early improvements on the design, enabling a fast final design. The use of Rapid Prototyping in the production of the casting moulds and cores made it easier to implement the design changes in the actual manufactured components. Modifications of the design are easily introduced into the actual parts. A metal prototype was obtained by direct pouring molten aluminum into a plaster moulds directly obtained by 3D printing rapid prototyping.

The encountered defects led will need to improve the design better production in future [2].

Slicing Issues in CAD Translation to STL in Rapid Prototyping

Divesh R. Sahatoo and Boppana V. Chowdary and Fahraz F. Ali and Raj Bhatti et. al. showed the effects of slice thickness on the surface finish, layering error, and build time of a prototype, as well as to show how an efficient STL file can be developed. Three objects were modeled and Standard Template Library (STL) files were generated. One STL file for each object was sliced using different slice thicknesses, and the build times were obtained. Screenshots were used to show the slicing effect on layering error and surface finish and to demonstrate the means to a more efficient STL file. From the results, it is clear that the surface finish and build time are important factors that are affected by slice thickness. This study demonstrates the effect of slice thickness on the surface finish, layering error, and build time of a prototyped object. It is also aimed at showing the relationship between tessellation and slicing in the development of a more efficient and effective STL file. For the purpose of investigation, three objects were modeled and used to demonstrate the effect of slice thickness on layering error, surface finish, and build time, as well as the tessellation-slicing relationship. Several screenshots were generated that focused on specific parts of each object to get a better view of the issues. In showing the tessellation-slicing relationship, the triangular facets and slice planes were shown where they lay in relation to each other using different slice thicknesses and tolerances.

Three objects were modeled using the Solid works package for demonstration of the research issues. Three STL files of different tolerances were generated for each object. One of these STLs for each object was used to show the effect of slice thickness on the layering error and surface finish. All of the STLs were used to investigate the tessellation-slicing relationship.

To meet the research objectives, three objects were modeled using the Solid works package. STL files of different tolerances and slice thicknesses were generated to study the effect of slice thickness on surface finish and build time. It has been shown that the layering error increases, and the surface finish quality and build time decreases, with increasing slice thickness. The use of screenshots in this research provides a clear view of how tessellation and slicing are related and how fine-tuning the tolerance and slice thickness values can lead to a more efficient STL representation. It is clear in this study that non-tessellation of flat faces perpendicular to build direction would also contribute to a more efficient STL file representation.

This paper will need more optimal utilization of computer resources and improvement in production time for useful to the industry [3].

Development of customized innovative product using Fused Deposition Modeling Technique of Rapid Prototyping and Investment Casting:

Nagnath U. Kakde and Atul S. Tumane et. al. represents the analysis of investment casting using fused deposition modeling (FDM) technique is carried out. FDM is used for getting physical part in Acrylonitrile Butadiene Styrene (ABS) polymer from Computer Aided Design (CAD) data and using it as pattern for investment casting. Feasibility of manufacturing the customized/tailor made part using FDM is the main focus in this paper. The experimentation is carried out to develop mathematical model so as to minimize the defects in casting. Zero defect casting is possible using the mathematical model and simulation software thus setting the parameter to design correctly the gating and riser. Rapid Prototyping reduces production time and increase efficiency and accuracy in developing and manufacturing prototypes compared to traditional prototype manufacture. The research development in Rapid Prototyping (RP) gives the manufacturing industry needed confidence to go on to customized/tailor made Product. Investment casting process is improved by developments in Rapid Prototyping. The process for Lost RP pattern has evolved new research avenues in the Block mold Investment Casting. Investment casting process is quite different process when compared to the sand casting or other similar casting process. ABS part of which mould cavity is to be prepared is placed on surface and around it x-ray film or any other film is placed and fix with packing wax. With the help of simulation software, runner and pouring basin are designed. With FDM patterns, investment casting is practical for casting and low volume production applications. Making investment casting patterns out of ABS materials saves both time and money on low volume production applications as well as tooling in investment casting. With only minor modification to the pattern design and the burnout process, FDM technology eliminates the costly and time-consuming tool making step needed for lost wax casting [4].

Optimizing Scale Factors of the PolyJet™ RP Procedure by Genetic Programming:

T. Brajlih and I. Drstvensek and M. Kovacic and J. Balic et. al. proposed to test the influence of the recommended scale factor values on the dimensional accuracy of the finished parts. Then, the genetic programming was used in optimization of scale factor values regarding to the part's properties. Finally, the optimized values were tested on another test series of parts. The main purpose of the article is to represent results of our research that investigated the implementation of genetic programming methods into optimization process of the scale factor values used in PolyJet™ rapid prototyping procedures. The optimized scale factor values can be used in the RP machine software package in order to achieve higher accuracy of manufactured prototypes. This paper can be used as a guideline in implementation of genetic programming in optimization process of various manufacturing parameters of RP technologies. Additionally, any user of the PolyJet™ RP machine can use optimized scale factor values described.

Genetic programming was used to establish a mathematical relation between nominal measures of the object's CAD model in individual axes, scale factor values and final measures of finished objects. Then this mathematical model was used to determine the optimal scale factor values regarding to the nominal measures of individual objects in each axis. The optimal value of scale factor is calculated in a case of equal nominal and final measure (regarding to the mathematical model). Genetic programming starts with a primal population of thousands of randomly created computer programs. This population of programs is progressively evolved over a series of generations. The evolutionary search uses the Darwinian principle of natural selection (survival of the fittest) and analogs of various naturally occurring operations, including crossover, mutation, gene duplication, gene deletion. In this case, each of this computer programs will represent a mathematical function, which will more or less accurately define the final measure of an object (in individual axis) regarding to the nominal measures and the scale factor value used. The final mathematical model will include the most accurate function (the fittest program) for each axis.

The optimization of the scaling process has definitely improved the accuracy of the PolyJet procedure. The problem of our method is that we are able to optimize scale value of a model based on only one dimension of a model in a particular axis. Because most "real-life" prototypes have many different dimensions in individual axes, choosing the optimal dimension on which to calculate the scale factor can be difficult. However, for the common usage of rapid prototyping the recommended value of scaling enables satisfactory results. The optimization method becomes useful, when they had to manufacture a prototype with one dimension that has very high accuracy demands.

The scale factors calculate will need more the appropriate value for particular dimension and then it will scale the whole prototype correctly orientated in workspace [5].

Rapid Prototyping /Rapid Tooling – A Over View and Its Applications in Orthopedics:

Mr. D. Chandramohan and Dr. K. Marimuthu et. al. proposed a new method of using data obtained from Computer Tomography (CT) images combined with digital CAD and rapid prototyping model for the surgical planning of difficult corrective and this new application enables the surgeon to choose the proper configuration and location of internal fixation of plate on hummers bone in the field of orthopedics. This paper presents the procedure for making model of hummers bone using rapid prototyping technologies [RPT].

Production of prototypes for medical modeling (orthopedics) in general can be classified into two broad categories based on manufacturing process route and type of data available, i.e. designed data and scanned/digitized data. Designed data is data that is created according to a person's idea on computer aided design (CAD) system. For this type of data, the designer has total control to modify, adjust and manipulate his design ideas to serve the functional purpose of his design. Producing models with this type of data is very straightforward and no further data treatment is required. CAD solid model can be directly converted to STL format for use in subsequent rapid prototyping process. For this type of data, the user has limited capability to modify and manipulate the geometry and further processing is required before they can be readily used by rapid prototyping system. The undesired soft tissue data is removed before it is sent to rapid prototyping machine for fabrication. This procedure can be a daunting task for complex structure and one has to repeat the procedure many times until satisfactory result is achieved. There are a number of commercial software's, and Go-build which translate this data to the format required by RP systems.

There are many rapid prototyping systems that can be used for physical modeling. These are a few examples of rapid prototyping with different method of forming three-dimensional objects. However, no single rapid prototyping alone is dominant in medical applications. As model material varies and consequently their strength and properties also vary from one system to another, users will find that one system alone is not always the best choice in every condition:

➔Stereo lithography (SLA)
➔Laminated Object Manufacturing (LOM)
➔Selective Laser Sintering (SLS)
➔Fused Deposition Modeling (FDM)
➔Solid Ground Curing (SGC)
➔ 3D-Printing (3DP)

Tooling is one of the slowest and most expensive steps in the manufacturing process, because of the extremely high quality required. Tools often have complex geometries, yet must be dimensionally accurate to within a hundredth of a millimeter. In addition, tools must be hard, wear resistant, and have very low surface roughness (about 0.5 micrometers root mean square).

To meet these requirements, molds and dies are traditionally made by CNC-machining, electro-discharge machining, or by hand. All are expensive and time consuming, so manufacturers would like to incorporate rapid prototyping techniques to speed the process.

RP technologies are definitely widely spread in different fields of medicine and show a great potential in medical applications. Various uses of RP within surgical planning, simulation, training, production of models of hard tissue, prosthesis and implants, biomechanics, tissue engineering and many other cases open up a new chapter in medicine. Due to RP technologies doctors and especially surgeons are privileged to do some things which previous generations could only have imagined. However this is just a little step ahead. There are many unsolved medical problems and many expectations from RP in this field. Development in speed, cost, accuracy, materials and tight collaboration between surgeons and engineers is necessary and so are constant improvements from RP vendors. This will help RP technologies to give their maximum in such an important field like medicine. This technique helps to analyze the actual bone structure and plate fixation can be done more accurately. Due to RP technologies doctors and especially surgeons are privileged to do some things which previous generations could only have imagined. However this is just a little step ahead. There are many unsolved medical problems and many expectations from RP in this field. Development in speed, cost, accuracy, materials (especially biomaterials) and tight collaboration between surgeons and engineers is necessary and so are constant improvements from RP vendors. This will help RP technologies to give their maximum in such an important field like medicine.

In future new technologies will improve and replace conventional methods; they also offer the chance for new types of products and developing procedures [6].

Table-1: Surveying different techniques on RP and we define the Advantages and Disadvantages of techniques

Techniques	Advantages/ Merits	Disadvantages /Future Improvement Direction
Rapid Prototyping, Selective Laser Sintering	This paper represents the state of the art in processing of different materials through SLS is presented. Studies involving developing new materials and improving the existing materials were discussed. Although many materials have been developed, there is still a need for research into new materials.	The knowledge of existing materials and the nature of complexity in processing them by laser will be helpful in achieving functional requirements of parts for present and future applications [1].
Engine design; Casting design; Rapid Prototyping	Rapid Prototypes have been produced, allowing early improvements on the design, enabling a fast final design. The use of Rapid Prototyping in the production of the casting moulds and cores made it easier to implement the design changes in the actual manufactured components.	The encountered defects led will need to improve the design better production in future [2].
Rapid Prototyping, STL	The use of screenshots in this research provides a clear view of how tessellation and slicing are related and how fine-tuning the tolerance and slice thickness values can lead to a more efficient STL representation.	This paper will need more optimal utilization of computer resources and improvement in production time for useful to the industry [3].
Customized product, Fused deposition modeling, Zero defect casting, Rapid prototyping	Investment casting process is quite different process when compared to the sand casting or other similar casting process. ABS part of which mould cavity is to be prepared is placed on surface and around it x-ray film or any other film is placed and fix with packing wax. With the help of simulation software, runner and pouring basin are designed. With FDM patterns, investment casting is practical for casting and low volume production applications.	With only minor modification to the pattern design and the burnout process, FDM technology eliminates the costly and time-consuming tool making step needed for lost wax casting [4].
Rapid prototyping; Artificial intelligence methods; Quality assessment	The optimization method becomes useful, when they had to manufacture a prototype with one dimension that has very high accuracy demands.	The scale factors calculate will need more the appropriate value for particular dimension and then it will scale the whole prototype correctly orientated in workspace [5].
Rapid Prototyping (RPT); Rapid tooling (RT); Computer Tomography (CT)	Development in speed, cost, accuracy, materials (especially biomaterials) and tight collaboration between surgeons and engineers is necessary and so are constant improvements from RP vendors. This will help RP technologies to give their maximum in such an important field like medicine.	In future new technologies will improve and replace conventional methods; they also offer the chance for new types of products and developing procedures [6].

CONCLUSION

Despite the recent advancements and successes of rapid prototyping, there are various limitations which still exist. The first and foremost issue is the high cost associated with rapid prototyping. A lack of cost estimating and cost analysis of rapid prototyping technologies has brought about uncertainties for industrial applications. Secondly, rapid prototyping systems are limited by the materials which may be used. Casting is a technique where a metal part is created by pouring molten metal into a mold or a die. Compared to all metal forming processes, casting is one of the most direct processes to acquire a finished product from a component design. Due to the flexibility of the process, castings may virtually be of any shape, size, or weight. In this paper we represents a survey of performance based advanced rapid prototyping techniques. During the survey, we also find some points that can be further explored in the future, such as Rapid Prototyping with Vacuum Casting Methodologies.

REFERENCES

1. Prashant K. Jain K., Senthilkumaran and Pulak M. Pandey P. V. M. Rao, Advances In Materials For Powder Based Rapid Prototyping, International Conference on Recent Anvances in Materials and Processing. PSG-tech. Coimbatore, India, 2006; pp. 1-8.
2. Melo, Monteiro, Martins, Coene, Puga, Barbosa, Miniaturised Cylinder Head Production By Rapid Prototyping, 20th International Congress of Mechanical Engineering. Gramado, RS, Brazil. November 15-20, 2009.
3. Divesh R. Sahatoo and Boppana V. Chowdary and Fahraz F. Ali and Raj Bhatti, Slicing Issues in CAD Translation to STL in Rapid Prototyping, Proceedings of the 2008 IAJC-IJME International Conference, 2008.
4. Nagnath U. Kakde and Atul S. Tumane, “Development of customized innovative product using Fused Deposition Modeling Technique of Rapid Prototyping and Investment Casting”, Proceedings published by International Journal of Computer Applications (IJCA), 2008; pp. 27-30.
5. T. Brajlih and I. Drstvensek and M. Kovacic and J. Balic, “Optimizing Scale Factors of the PolyJet™ RP Procedure by Genetic Programming”, Journal of Achievements in Materials and Manufacturing Engineering, 2006; 16(1-2):101-105.
6. Chandramohan D, Marimuthu K. Rapid Prototyping/Rapid Tooling – A Over View And Its Applications In Orthopaedics, International Journal of Advanced Engineering Technology, 2011; 2(4):435-448.
7. Fodran E, Koch M, Menon U, Mechanical and dimensional characteristics of fused deposition modeling build styles, in: Proceedings of the 1996 Solid Freeform Fabrication Symposium, 1996, pp. 419–442.
8. Bertoldi M, Yardimci MA, Pistor CM, Guceri SI, Sala G. Mechanical characterization of parts processed via fused deposition, in: Proceedings of the 1998 Solid Freeform Fabrication Symposium, 1998, pp. 557– 565.
9. S.H. Ahn SH, Lee CH, Jung WB, Development translucent FDM parts by post-processing, Rapid Prototyping J. 2004;10 (4) :218–224.
10. Sachs E, Haggerty J, Williams P, Cima M, Three-dimensional printing techniques, US patent 5,204,055, 1993.