Using Rapid Prototyping Technology In Mechanical Scale Models

Dheeraj Nimawat , Mahaveer Meghvanshi ,
Assistant Professor, Government Engineering College Jhalawar

1.Abstract: -
The aim of this paper is to spread the use of Rapid prototyping technology (RP) into mechanical engineering. In the development of a new product it is invariably necessary to produce a single prototype of a designed product or system before the allocation of large amount of money to new production facilities or assembly lines. The cost is very high and production tooling takes considerable time to prepare. The technology which considerably speeds the interactive product development process is the concept and practice of Rapid Prototyping (RP) also called Solid Freeform Fabrication (SFF).

Rapid Prototyping is being used since its origin by designers in different field as product design, automobile industry, medical applications, arts, and it has been proved that it is an essential tool in any design process. The designer has the possibility of building the scale model in very few hours directly from the CAD system. A methodology of work has been defined, in which has been described the use of three dimension CAD software in the design stage. As case study, some models have been built to illustrate the effectiveness of this technology in the creation of scale models with complex surfaces of mechanical parts.

2. Introduction: -
Rapid Prototyping (RP) has become one of the fastest growing new technologies since its introduction in 1986. By means of this technology it is possible build prototypes and touches them in just a few hours, from a CAD file in which the geometry of the model is defined in 3D. These prototypes are used to visualize those complex shapes not easily seen or understood on conventional drawings. It gives to the designer the possibility of verifying the shapes of the product, validate if it fits into the assembly or if it complies with the desired functions. It cuts down the required time to design a product.

This technology was covered an industrial applications to speed up the design and manufacturing process. But having a 3D touchable model of what you want to or even wish to build is something that can be useful in lots of fields. It has been used in medical application, arts (jewelry etc.), architecture and it is a potential tool for the mechanical field.

In this paper, the design process methodology is described. It tries to be a guide of the logical procedure to introduce RP into a mechanical engineering design process and take the maximum benefit from it.

Finally, the case studies illustrate the benefits of this technology applied to the mechanical field.

3. Rapid Prototyping Technologies: -
Advances in computer and communication technologies have led to globalization and increased competition. This in turn has fuelled interest in new methodologies and technologies to improve and accelerate product development. The most promising of these is Rapid Manufacturing, a combination of Rapid Prototyping and Rapid Tooling technologies.

Rapid Prototyping (RP) involves automated fabrication of intricate shapes from CAD data using a layer-by-layer principle. These “three dimensional printers” allow designers to quickly create tangible prototypes of their designs, rather than just two dimensional pictures. Such models make excellent visual aids for communicating ideas with co-workers or customers and can also be used for testing purposes. For example, an aerospace engineer might mount a model airfoil in a wind tunnel to measure lift and drag forces. While designers have always utilized prototypes, RP is now allowing them to be made faster and less expensively.

At least six different rapid prototyping techniques are commercially available, each with unique capabilities. These are: Stereolithography (SLA), Fused Deposition Modeling (FDM), Laminated object Manufacturing (LOM), Selective Laser Sintering (SLS), Solid Ground Curing (SGC) and Ink-Jet Printing (IJP). A software ‘slices’ the CAD model into a number of thin layers (~0.1 mm), 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. Major limitations of RP include part volume (less than 0.125 m3), and part materials (mainly polymers). Most prototypes require from three to seventy-two hours to build, depending on the size and complexity of the object.

Initial investment is very high. For simple shaped metals parts required in large quantity, conventional manufacturing techniques are usually more economical.

4. Design Process Methodology:-

The aim of this section is to show the design process, from the thinking of the idea of a model to its materialization in a touchable solid model.

Figure 1 shows the process where researches can differentiate perfectly the necessary steps to obtain the model. The process is divided in four stages:-

First stage: - it is based on designer's idea. As we know that any project begins with an idea, a sketch made by the designer by hand or by means of a design software, or with a scale model made by hand of any material.

The two important aspects of this stage are the idea (which is in the designer's mind) and the initial given information for the accomplishment of the project, as main dimensions, surrounding constraints or others.

Second stage: - It is based on modeling in the computer. It is the logical step, to work with the computer, by means of bidimensional CAD software; researches will make the necessary section, sketches and all details for the correct understanding of the original idea. It is not really necessary to start always with a 2D model, but it is quite helpful in making 3D CAD models during the creation of the solid model.

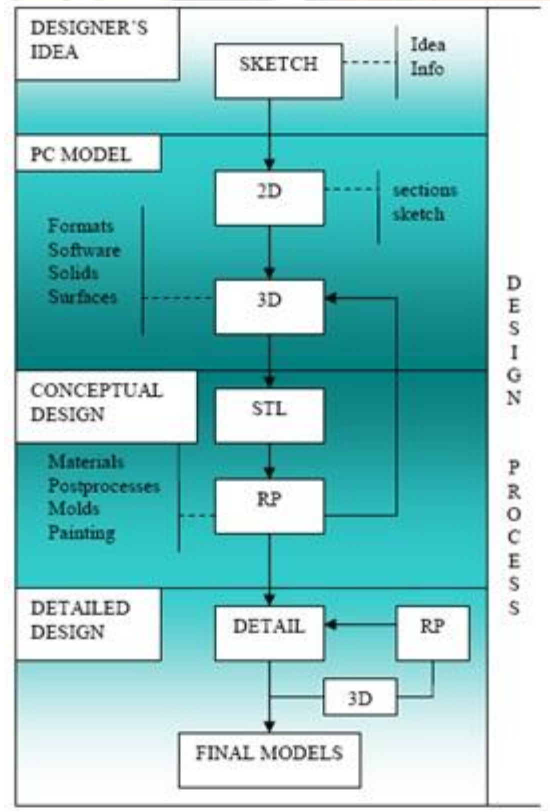

Figure 1: Design Process

Third stage: - It is based on conceptual design. Once the 3D solid model is completed, it should be saved in STL format (means stereolithography format). This file will generate a fact model (the facets can be controlled therefore the final resolution of the model) and finally the model is sent to be built. Most of the software can export the model to this format.

A touchable model on the designer's hand help the designer to see if the model is what he shaped in his mind. If he needed some necessary changes, he can go back to the 3D model, and make necessary changes as he wants, until the desired model is achieved.

Fourth stage: - It is based on detailed design. At this point it is possible to achieve directly the correct 3D model or by successive approaches building intermediate models with rapid prototyping, until designers obtain the desired final model.

5. Case Studies: -

Case Study 1:-

The project is prepared at M/S Stratasys Inc.; Banglore; GTRE, Banglore; BARC, Mumbai.

An mechanical component that is impeller casting development. The pattern (Figure 2.1.1) was reverse engineered using Renishaw Cyclone Laser scanner for getting the Cloud of points (CoPs) (Figure 2.1.2).Firstly, CAD model (Figure 2.1.3) was generated using Imageware surface software.STL format of the CAD data was used for generating FDM pattern with plastic material (Figure 2.1.4).

Figure 2.1.1: Original wooden pattern

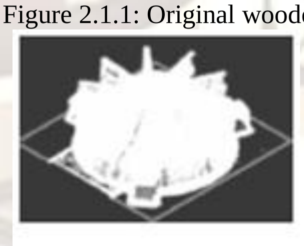

Figure 2.1.2: Laser Scan CoPs Data Using Renishaw Cyclone Scanner

Figure 2.1.3: CAD Model Developed Using Imageware Surfacer Software

Figure 2.1.4: FDM Plastic Pattern

The STL file was sent over Internet to an RP facility with an FDM machine. This FDM pattern was used for Aluminum sand casting (Figure 2.1.5).

Figure 2.1.5: Al Casting Developed Using FDM Pattern

The model was used to fabricate five different patterns with Fused Deposition Modeling (FDM), Stereolithography (STL), Thermojet and Laminated object manufacturing processes, and a Silicon rubber mold using the RP part as master. This investigation for major RP processes will motivate the industry to explore & adopt this new RP technology. This pattern is made by conventional method in large time consuming than RP technology, as the data taken from above organizations.

Case study 2: -

This project has been prepared at Gdansk University of Technology & medium sized industrial company in north Poland. Here Rapid Prototyping technique was applied and tested for a new pomp rotor construction.

Figure 3.2.1: Cycle of the integrated Product Development of the Pomp Rotor with the Utilization of Stereolithography Technology (SLA)

An iterative process of product development in north Poland Company occurs when errors are discovered or more efficient, better design solution are looked for study of an earlier generation prototype of pomp rotors .Traditionally, the main problem involves a series of advanced machining processor utilizing a variety of expansive tooling; it is time consuming & cost consuming. Manufacturing take several months to prepare and the production of a single complicated part, as a pomp rotor, by conventional machining operation can be very difficult.

Those factors were the main reasons to utilize stereolithography technology for pomp rotor manufacturing at Gdansk University of Technology.

Figure 3.2.2: The Pomp Rotor Prototype using Rapid Prototyping Technology

In a competitive market, it is well known products that are introduced before those of their competitors generally are more profitable and take a larger share of the market. Stereolithography as a means of rapid manufacturing of pomp rotors of prototypes has proved its usefulness in product development cycle.

Case Study 3: -

The product of top cover of the natural gas pump is prepared by Renishaw, UK.

The top cover of natural gas pump (Figure 4.3.1) mainly is being fabricated using high pressure aluminum die casting and finished by machining. This technique needs to start by machining a complicated mold because it has many fine details for producing few numbers of this product, the cost of the mold will be very expensive in addition to that the mould will take several weeks to be designed, optimized & manufactured.

Figure 4.3.1: The Original Part: Cover of the Gas Pump

In this part is being re-designed because this part is subjected to high gas pressure from inside the pump several defect such as surface deformation & crakes were observed and reported. According a CAD modal (Figure 4.3.2) was generated for this part using the 3D Digitizing system cyclone 2 Then the modal transferred to Ansys to simulate the non-linear materials behavior under non-linear pressure and fatigue loads ending with new optimized design (Figure 4.3.3).

Figure 4.3.2: CAD Model of the Part was Developed with aid of 3D Digitizing Machine

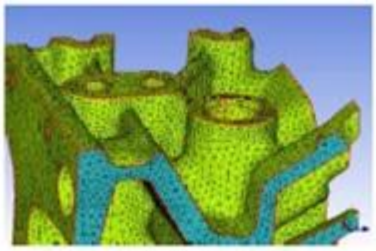

Figure 4.3.3: Finite element model – using Ansys 10 – was used to optimize part wall thickness and dimensions according to the applied pressure inside the pump**.**

Figure 4.3.4: Rapid prototyping model was developed using Invision 3D printer. This model will be used to re-produce the optimized part with the new dimensions and modified details through the Investment casting techniques**.**

Finally a RP physical modal was built using invasion si2 3D printer (Figure 4.3.4) and after validating the shape and dimension of the new product, investment casting process was used to produce the required number of this part.

6. Conclusion: -

The use of Rapid Prototyping technologies is essential in any design fields. Although it was conceived as an medical application, arts, architecture applications, the mechanical field can also take benefit from this technology.

It gives the mechanical engineer, the possibility to visualize those complex shapes not easily seen or understood on connectional drawings, and touch them to verify the shape. It can be used to in early design stages to build a conceptual model or in later stages when details are needed.

Complex shapes can be obtained using surface and solid modeling CAD software, and then build the physical model. In a few hours the model can be built easily, in a similar way as a 2D drawing is plotted.

In a short time, rapid prototyping will become a technology that will be used routinely by many design engineers in conjunction with the traditional existing ways of creating scale models of mechanical parts.

7. References: -

Dickens, P.M., et al., (1995) "Conversion of RP models to investment casting", Rapid Prototyping Journal,4 ,4-11.

Sushila, B., K. Karthik P. Radhakrishanan, " Rapid Tooling for casting – A case study on application of Rapid Prototyping Processes", Indian Foundary Journal, 11,213-216.

Warner, M.C.,(1997), "Metal Rapid Prototyping methods and case studies for metal casting and tooling", Rapid News, 6,1-5.

Wlodzimierz Przybylski, Stefan Dzionk, "Impeller Pump Development Using Rapid Prototyping Methods", Advances in Manufacturing Science and Technology, Vol. 35,No. 1,2011.

Dr. Khalid Abd. Elghany, "Rapid Prototyping and Additive Manufacturing in Egypt", Central Metallurgical Research and Development Institute (CMRDI).

Andreas Gebhardt, "Rapid prototyping", Carl Hanser Verlag, Munich 2003, ISDN 1-56990-281-X, 379 pp.

Chua. C.k., Leong, K.F. (2000), "Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific.