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A RESEARCH REPORT ON DESIGN, ANALYSIS AND PROTOTYPING OF AUTOMOBILE INLET MANIFOLD

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ABSTRACT

The research objective is to discuss the development of innovative product development production phase, resulting in a functional prototype with a rapid prototyping method. This project analyzes the advantages of using rapid prototyping technologies for product development process. It compares various fast rapid prototyping systems that are being used, categorizing them by the type of raw material used. It consists of both the theoretical and experimental part. This project goes through a development of the product from idea to functional prototype, making 3D model, analysis of the components the model contains, prototyping, and post-treatment.

This research also deals with the application of rapid manufacturing techniques to save the time as well as cost of manufacturing of few critical components of automobiles. A case study of Inlet manifold of engine is taken here to demonstrate the method. While working on this objective the aim will be to reduce the lead time required for tooling required for the conventional block-type investment casting process. There are strong incentives to reduce costs while increasing speed and accuracy in the current market. RP is an ideal method when the components are complex in shape because it substantially compresses the time for developing prototypes, patterns and tooling. This method is even more promising on cost and time front. The capabilities to fabricate freeform surfaces, inbuilt cores, projections and supports are the unbeatable strengths of RP processes. The use of benefits in terms costs have proved that the adoption of RP technology is techno-economically justifiable for the Indian manufacturing industries. Rapid Prototyping have proved to be a cost-effective and time

efficient approach for development of pattern making, thereby ensuring possibility for technology transfer in Indian manufacturing industries.

In this research a problem of manufacturing of new products is described. It requires making a prototype with conventional or advanced technologies. Prototype can be fabricated with use of rapid prototyping techniques. This technique can have great impact on the preparation of manufacturing process. An example of design and fabrication of a prototype with FDM techniques is presented.

Keywords: Automobile, Prototyping, Inlet Manifold.

INTRODUCTION

For many company Designing and development of new product is prerequisite. A successful product often results from thinking along new lines, free from conventional approaches and traditional choices of materials and designs. Here the word product we will be using in the sense of a mechanical product (automobile and automotive). The full production of any product includes a wide range of activities. In this segment we are going to describe the impact of RP technologies on the entire spectrum of product development and process realization. The activities required for full production in a conventional model compared to the RP model depending on the size of production can save on time and cost ranging from 50% up to 90%.

In today's competitive environment, the manufacturing industries are striving for development of next generation products due to increasing competition among the products and continuously changing customer needs. Among the challenging tasks the manufacturers are facing include, increasing product complexity. This has emerged the concept of rapid physical realization of products well before its manufacturing.

Rapid Prototyping (RP) techniques are fast becoming standard tools in the product design and manufacturing industry. The zero tool costs reduced lead times and considerable gains in terms of freedom in product design and production schedules are the appreciable facts regarding RP. The parts those were previously impossible or extremely costly and time consuming to fabricate can be built with ease with RP. The RP techniques are limited neither by geometry nor by the complexity of parts to be fabricated. Today rapid prototyping has developed to a level where it takes place in wide range of applications for making models like:

• Concept models;

• Functional prototypes;

• End use parts;

• Manufacturing tools.

In metal casting processes, conventionally the development of patterns greatly influence cost and dimensional quality of the product. Comparing the lead-times required for fabrication of sacrificial pattern and patterns produced with RP, allows significant amount (89%) of time-saving. It has been claimed that RP can cut new product costs by up to 70% and the time to market by 90%. To stay a head in competition, the updated technology demands development of fast and accurate products of high standards. Therefore, the time and cost effective advantage of Rapid Prototyping philosophy can be utilized for development of rapid tooling by transferring the technology in investment casting industries. Following are the significant reasons that create a need for technology transfer in the conventional industries.

1. Rapid Prototyping is an automated fabrication process. Hence, it requires minimal human intervention.
2. It can build arbitrarily complex 3D geometries directly from CAD data.
3. It drastically reduces product development cycle time, because the product is directly fabricated from CAD data and process planning is almost eliminated.
4. It uses a generic fabrication machine, i.e., it does not require part-specific fixture or tooling.
5. The process planning is automatic, based on the CAD model.
6. It is most suitable for production of customized or single product.
7. There is no need of assemblage of the components. All the components in assembly are fabricated simultaneously; a layer-by-layer a support material is used to fill-up the cavities.

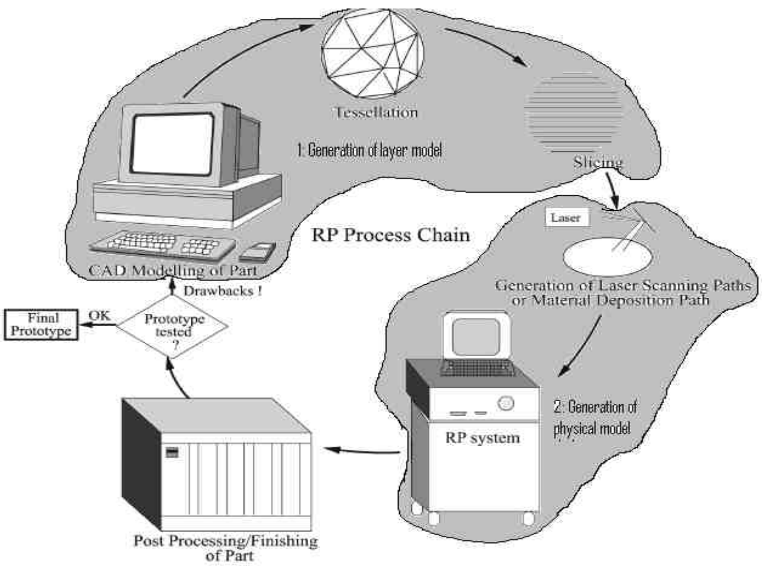


Fig 1. Rapid Prototyping Process Chain

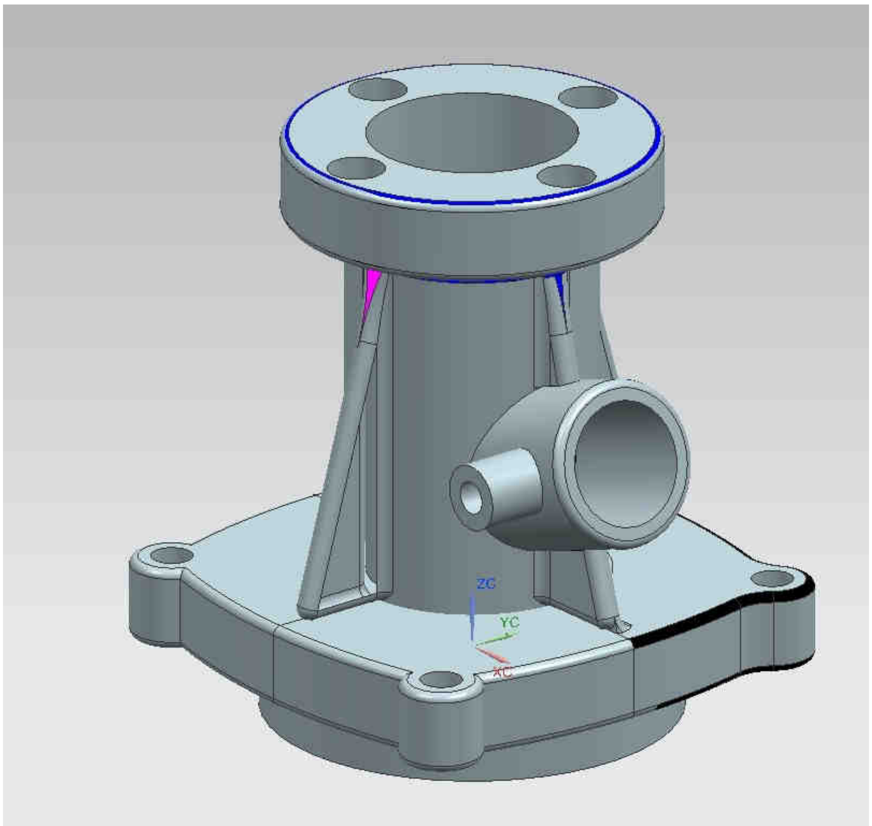
COST ANALYSIS BETWEEN RAPID PROTOTYPING AND CONVENTIONAL MANUFACTURING.

To carry out the cost analysis, following costs elements are considered:

1. Direct materials
2. Direct labour
3. Direct expenses
4. Overhead

COMPONENT TAKEN FOR ANALYSIS.

INLET MANIFOLD.



DETERMINATION OF PART BUILD COST IN FDM

In order to determine the total cost of part preparation in FDM rapid prototyping process, the influencing parameters are considered. The material cost is computed on the basis of volume of model and support material required to build the part and unit price of material.

The FDM process employs external support structure to the part being built. The total build material consists of model a material and the support material. The costs associated with other dominant parameters include, base plate cost (Cpa), electricity cost (Cel), battery depreciation cost (Cbd), machine depreciation cost (Cmd), and the annual maintenance cost

(Cam). The pre or post processing in RP does not differ considerably for different types of parts.

1. Model material cost (Cmm): Rs.12.95/ cm^3
2. Support material cost (Csm): Rs.10.85/cm^3
3. Base plate cost (Cpa): Rs.270.5 per plate
4. Annual maintenance cost (Cam): Rs.0.913/min
5. Electricity cost (Cel): Rs.0.013/min
6. Battery depreciation (Cbd): Rs.0.01926/min
7. Machine depreciation (Cmd): Rs.0.078/min

CALCULATION FOR INLET MANIFOLD

Model material (cm^3) =68.78

Support material (cm^3) = 18.88

Cost of base plate (Rs) = Rs.270.5 per plate, one base plate is require for it

Build time (min) =7.41 hours

RP technology derives radical change by removing the price of tooling, jigs and fixtures. It dramatically reduces the cost of process planning. As a major change, the human cost is substantially reduced, since RP requires minimum human skill and attention. Finally, the significant change occurs by materially reducing the cost of scrap, rework and assembly.

The total cost (Ct): After calculating the machine operating cost (C operating), material cost (Cmaterial), operator cost (C operator) and pre-processing cost (C processing) cost components.

In any RP process, deciding the orientation of part before its actual fabrication is very important. RP parts can be built with infinite number of orientations. The build orientations directly affect build time, volume of material required and surface quality. The optimal part build orientation utilizes the optimum resources. In order to determine the optimum part build orientation, it is necessary to identify such orientation that incurs the minimum build cost.After summing up the machine operating cost (Coperating), material cost (Cmaterial), operator cost (C operator) and pre-processing cost (Cprocessing) cost components, the total cost considering the benefit of RP technology. So total computed cost.

$$C_{total} = C_{operating} + C_{material} + C_{Operator} + C_{processing}$$

The minimum total cost of Inlet Manifold (Ct) =Rs 3095

CASTING COST ESTIMATION (CONVENTIONAL METHOD)

Indian casting industry is booming at a rapid pace and looking at the present scenario one concept that has gained its popularity in past couple of years is "Casting Cost Estimation". These days the competition has grown at the phenomenon rate and in order to survive and compete at a global platform, metal casting industry has to meet ever increasing customers' expectations in terms of quality standards and lower pricing.

Casting process planning generally consists of proper choice of suitable casting process and various materials. Now in order to have continuous cost reduction in casting process, it is essential to build up an easy-to-use casting cost estimation methodology. It is also important to note that any comprehensive casting cost estimation methodology must have ability to identify the most important parameters in casting cost. The most important attributes of casting are cost estimation of material and tooling process. The casting cost estimation is carried out for getting benefit of RP in casting industries. The total casting cost is given as the sum of costs corresponding to material, labour, energy, tooling and overheads costs.

$$C_{\text{total casting cost}} = C_{\text{material}} + C_{\text{melting}} + C_{\text{molding}} + C_{\text{core making}} + C_{\text{finishing}}$$

Other costs related to interest rate, fixed cost, delivery, taxes, duties and premium can be added and calculate for casting cost estimation.

DIFFERENT OTHER COST CONSIDERATION FOR INLET MANIFOLD

To carry out cost analysis following cost element are considered:

1. Direct materials
2. Direct labour
3. Direct expenses

After calculation following values for wax pattern total cost required for inlet manifold Wax pattern

1. Raw material cost =Rs 33.76 per kg of steel
2. Freight charges =Rs 2.5 per kg
3. Design cost = Rs 2000
4. Machining cost =Rs 3500
5. Labour cost =Rs 560

Total cost = Rs 6096.

INVESTMENT CASTING TOTAL COST ESTIMATION: With using Material: mild steel, Density of MS =7.85 gm/cm3, Mass of the material required = 1.670 kg, Cost of the raw material per unit = 75 Rs/kg, the following value for the inlet manifold

Total cost for casting excluding pattern cost

Total cost of material = Rs125

Freight charges = 0.02*125=Rs 2.5

Total labour cost =Rs 380

Core box design cost =Rs 1000

Cost of melting = Rs 695

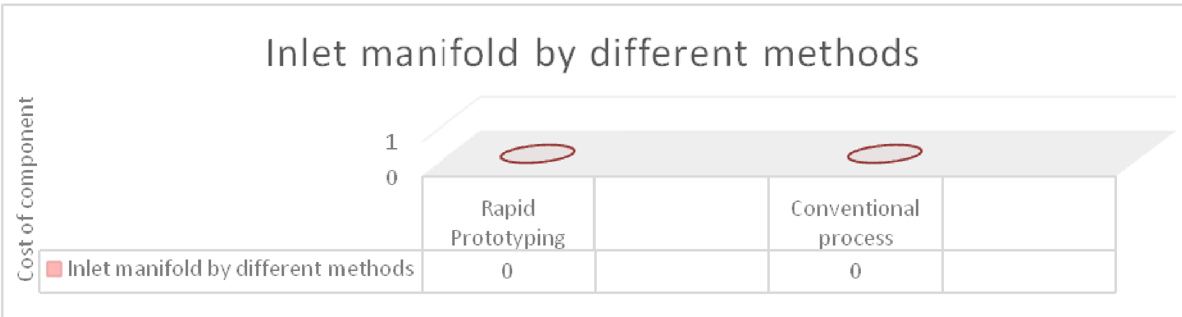
Total machining cost =Rs 200

Total cost = Rs 2402

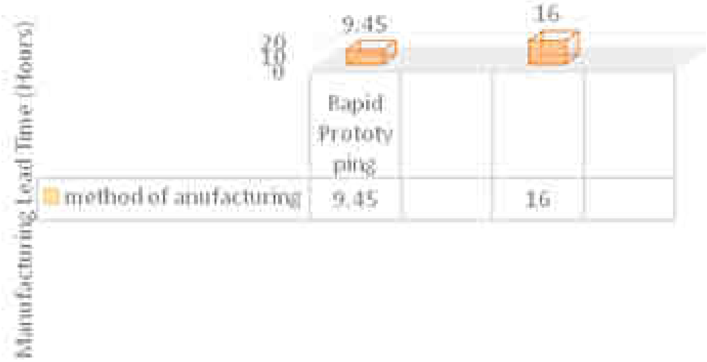
With Including Pattern Cost =6096+2402, Total cost =Rs 8498

With the help of the FDM for pattern making we have save the Rs 5403 for inlet manifold ABS pattern. The cost of WAX pattern making with the use of conventional investment casting method is costlier than the ABS pattern making in FDM.

Cost Comparison of inlet manifold by different method



Comparison of manufacturing lead time



Conclusions

The competition in the market of materials for automotive applications is substantial. This is due to the size and value of the market. In the more recent years the environmental concern has opened the need for lighter vehicle for lower fuel consumption and also for the need of recycling. These recent pressures have opened the door for introduction of new materials to the automotive market such as alternative metals and composites. However there are yet significant barriers in large scale use of these materials mainly due to the cost of the raw materials or the large capital investment need for transformation of the forming processes.

Future Scope

Therefore the need for further research for suitable processes, properties and lower cost materials in this lucrative industry is at its peak. The more traditional materials such as steel producers are trying hard to keep their market by further innovations and improvements in their alloying and their processes in order to offer lighter material and structure option. But at the same time the newer materials such as alternative metals and composites are at the heart of the research and innovation for opening the possibility of the lighter and more environmentally friendly future vehicles.

By the use of rapid prototyping the product cost is minimised and the product lead time is also minimised. Hence in future use of Rapid Prototyping will bring a revolutionary in the field of automobile and automotive industry.The rapid prototyped part must be able to withstand the chemicals in the sand, be abrasion resistant and be able to withstand the ramming forces that are applied to pack the sand, FDM meets these requirements with its ABS material.

References

1. Szatkowski K.: Przygotowanie produkcji. Wydawnictwo Naukowe PWN, Warszawa 2008,
2. Oczoś K.E.: Rosnące znaczenie Rapid Manufacturing w przyrostowym kształtowaniu wyrobów. Mechanik 4/2008,
3. Pham D. T., Gault R. S.: A comparison of rapid prototyping technologies. International Journal of Machine Tools and Manufacture Volume 38, Issues 10–11, October 1998, Pages 1257–1287
4. Stratasys FDM: http://www.stratasys.com/ 18.07.2012
5. 15th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2011, Prague, Czech Republic, 12-18 September 2011.
6. D.S. Ingole., A.M. Kuthe., S.B. Thakare, A.S. Talankar, Rapid prototyping – a technology transfer approach for development of rapid tooling, Journal: rapid prototyping

journal, Volume: 15, (2009) pp: 280 – 290.

7. D.S. Ingole, A.M. Kuthe. T.R. Deshmukh, Rapid prototyping for pattern making, Foundry: A journal of progressive metal casters, Vol: 5, (2009) pp: 53 – 55.

8. P. Duverlie, J. M. Castelain, Cost estimation during design step: parametric method versus case based reasoning method, International Journal of Advanced Manufacturing Technology, 15(12), (1999) 895–906.