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Case Study

ANALYSIS AND EVALUATION OF INLET MANIFOLD AUTOMOBILE PROTOTYPE

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Abstract - 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 paper a problem of manufacturing of new products is described. It requires inter alia making a prototype with conventional or advanced technologies. Prototype can be fabricated with use of rapid prototyping techniques.

Key Words:-Inlet manifold, casting process, Prototype.

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

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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.

In this process photosensitive liquid resin which forms a solid polymer when exposed to ultraviolet light is used as a fundamental concept. Due to the absorption and scattering of beam, the reaction only takes place near the surface and voxels of solid polymeric resin are formed. A SL machine consists of a build platform (substrate), which is mounted in a vat of resin and a UV Helium-Cadmium or Argon ion laser. The laser scans the first layer and platform is then lowered equal to one slice thickness and left for short time (dip-delay) so that liquid polymer settles to a flat and even surface and inhibit bubble formation. The new slice is then scanned.

Objective of Work

This paper aims to explore the possibility of a new process that will combine freeze casting and the basic principles of AM based on extrusion methods. This new method will be capable of producing new ceramic products without the cost and restrictions associated with a conventional manufacturing porcelain process that requires tooling.

- Investigate the suitability of conventional made prototype
- Develop and fine tune a prototype that can be successfully cast in minimum time.
- Develop improved processing conditions for the new material.

It is not within the scope of this research to analyses and comment on the full spectrum of contemporary industrial and architectural design; precedents have been selected from a very large pool of talent. Designs that focus on exploiting the capabilities of specific fabrication techniques, performance oriented design: based on "the integral relationship between form generation, material behaviour and capacity, manufacturing and assembly".

Experimental Procedure: Powders that depict low fusion or sintering properties can be laser sintered by adding a low melting temperature binder material (typically a polymer binder) to the basic powder. Shows the wide range of materials SLS can process. The initial materials used in SLS are polymers which are materials made up of long-chain molecules formed primarily by carbon-to-carbon bonds. Mostly, three types of polymers are used in engineering: thermoplastics; thermosetting plastics; and elastomers. Most polymers used in SLS process are thermoplastics. Thermoplastics can be recycled in SLS, thus saving material. Generally, thermoplastic polymers can be classified into two types: amorphous and crystalline. Amorphous material has chain molecules arranged in a random manner like in polycarbonate (PC). Crystalline material has chain molecules arranged in an orderly structure like in nylon. Amorphous polymers are able to produce parts with very good dimensional accuracy, feature resolution and surface finish (depending on the grain size). However, they are only partially dense parts. As a consequence, these parts are only useful for applications that do not require part strength and durability. Typical applications are SLS masters used for manufacturing silicone rubber and cast epoxy moulds. The first sintering model developed for processing of polycarbonate shows the effect of energy density on the sinter ability of polycarbonate powder beds. The densification and accuracy of PC parts are most sensitive to changes in activation energy and heat capacity of the amorphous polymer.

Reinforced and Filled Polymers

Polymer powders can be easily reinforced with other materials in order to further improve their mechanical and thermal properties. Several grades of glass fibre reinforced PA powders are readily available the market. The part fabricated from glass filled polyamide (PA3200 GF) has excellent mechanical properties and high accuracy. Typical applications of these materials are housings and thermally stressed parts. It was experimentally measured that density of glass filled nylon-11 and simulated the effect of varying bed temperature on the density of sintered parts. DTM Corporation (Austin, USA) introduced in mid-1998, copper polyamide, which is a thermally conductive composite of copper and plastic and can be used to create tooling for short runs of production equivalent plastic parts. Copper polyamide is suitable for injection moulded inserts to mould around 100–400 parts in polyethylene (PE), polypropylene (PP), glass filled PP, polystyrene, ABS, PC/ABS, and other common plastics. Lower material strengths are the limitation in application of Copper polyamide moulds.

Selection of Work Piece Material

Fused deposition modelling offers a unique variety of thermoplastic modelling materials for FDM Systems. The mechanical properties of ABS-M30, polycarbonate (PC), PC-ABS and polyphenolsulfone (PPSF) can withstand the forces and stresses induced as the air flow strikes the model's surface. Each FDM material can be used for wind tunnel models. Selection will be based on the strength needed to resist the wind forces in the tunnel. The material options currently include ABS, a high-impact grade of ABSi, investment casting wax, and elastomer. The use of ABS provides the impact resistance, toughness, heat stability, chemical resistance, and the ability to perform functional tests on sample parts. ABS-M30 is up to 25 to 70% stronger than standard

ABS and is an ideal material for conceptual modelling, functional prototyping, manufacturing tools, and endues- parts. ABS-M30 has greater tensile, impact, and flexural strength than standard ABS. Layer bonding is significantly stronger than that of standard ABS, for a more durable part. In this research AM models were constructed using the ABS-M30 materials. ABS-M30 gives real parts that are stronger, smoother, and with better feature detail. Steel (AISI 1045H) was chosen as the material for the machined metal model.

Cost Analysis

To carry out the cost analysis Between Rapid Prototyping and Conventional Manufacturing, following costs elements are considered:

1. Direct materials
2. Direct labour

3. Direct expenses
4. Overhead

Component taken for analysis Inlet manifold.

Fig1 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.13.95/ cm^3
2. Support material cost (Csm): Rs.13.95/cm^3
3. Base plate cost (Cpa): Rs.267.5 per plate
4. Annual maintenance cost (Cam): Rs.0.913/min
5. Electricity cost (Cel): Rs.0.012/min
6. Battery depreciation (Cbd): Rs.0.01826/min
7. Machine depreciation (Cmd): Rs.0.068/min

Calculation for Inlet Manifold

Model material (cm^3) =68.78

Support material (cm^3) = 18.88

Cost of base plate (Rs) = Rs.267.5 per plate, one base plate is require for it

Build time (min) =7.41 hours

Substituting the values, the total costs are

Total part cost (Ct) =Rs 5703

RP technology derives radical change by eliminating the costs in 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 summing up the machine operating cost (Co), material cost (Cm), operator cost (Cl) and pre-processing cost (Cp) 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. This is taking from the literature review. After summing up the machine operating cost (Co), material cost (Cm), operator cost (Cl) and pre-processing cost (Cp) cost components, the total cost considering the benefit of RP technology. So total computed cost.

Ct= Co+Cm+Cl+Cp

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

Casting Cost Estimation

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.

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

1. Raw material cost =Rs 33.76
2. Freight charges =Rs 2.5
3. Design cost = Rs 2000
4. Machining cost =Rs 3500
5. Labour cost =Rs 560
6. 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 3001 Rs 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.

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.

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