International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.5 Issue: Special 2, pp: 392-394 11-12 Feb. 2016

Assessment of Rapid Prototyping Techniques for Metal Casting and its Applications

Regula Sri Nidhi Hrushi Kesav,Y.Shivraj Narayan
Department of Mechanical Engineering,VNR VJIET, Hyderabad,India
Corresponding email: sriregula91@gmail.com

Abstract: Rapid Prototyping is one of the most emerging fields of modern industry. It is one of the most time saving methods for production of physical parts or prototypes according to the required scale. Metal Casting is one of the most widely used methods for production of components. Casting in addition with the rapid prototyping process reduces the time taken to produce a component or part along with an increase in the quality of the component. This paper assesses the current trends in rapid prototyping for metal casting and its various applications.

Keywords-Rapid Prototyping, Metal Casting, 3D Printing, Applications.

I. INTRODUCTION

Rapid prototyping is the process of making components using computer aided design and computer aided manufacturing to build scale model of the component swiftly.

Rapid prototyping meaning can be understood as fast and prototype can be etymologically referred as *prototupos (Greek)* meaning of first model or form for which to base others upon.

The six RP techniques available are as follows [1]

- Stereolithography (SLA).
- Laminated Object Manufacture (LOM).
- Selective Laser Sintering (SLS).
- Fused deposition Modelling (FDM).
- Solid Ground Cuing (SGC).
- 3D Ink Jet Printing

Stereolithography (SLA): This process uses the principle of polymerization of polymers when exposed to ultraviolet light.

Laminated Object Manufacture (LOM): It uses the principle of forming the prototype of attaching the material sheets layer by layer using adhesive.

Selective Laser Sintering (SLS): This Technique uses a powerful laser to melt the materials like polymers or metals and fuses them on a layer.

*i.*PranjalJain and A.M. Kuthe performed afeasibility study with the objective of mass production based on the requirements of customer rather than conventional mass production. Authors presented a case study of middle disc of oldham coupling. Component was first designed using general design software making it suitable for sand casting method. AUTOCAST-X software was used to check for simulation as well as for optimization of the component along with the shape and dimensions required in order to get the hotspots, riser and gating system. The component was then printed using a 3D printer.The

Fused deposition Moulding (FDM): In FDM the component is formed by heating the filament and deposition of the material layer by layer to form the component.

Solid Ground Curing (SGC): This method is similar to that of Stereo Lithography where as the difference is the entire layer is cured at once.

Prof. DeepaYagnik[2] mentioned that there is less chance that the product design functionality is correct in initial phases which are unforeseen. RP helps when there is need for verification of testing operations before the launch of product giving a prototype in early development stages.

Casting is the process of forming a component by using molten material to be poured into the mould cavity. When the molten material is solidified, the obtained part is called casting. It consists of metal and non-metal castings.

Metal casting is one of the oldest manufacturing operations to prepare shapes of the metallic components. It is also known as liquid metal working.

Metal casting is of many varieties, few of which majorly used are sand casting, die casting, investment casting etc. It is generally categorized into expendable mould and permanent mould depending on the reusability of the mould cavity material.

Casting is one of the most widely used manufacturing processes used today for its quality, diversity of components and its ability to make intricate components among its many features.

II. RAPID PROTOTYPING FOR METAL CASTING

Recent research shows that rapid prototyping, along with metal casting, has created few options in manufacturing industry. Based on this, anassessment of such recent studies is done and presented below:

3D printed component was placed along with green sand along with a layer of granite paste to form the mould cavity.The liquid metal was poured into the cavity to form the shape of the middle disc of oldham coupling as shown in the Figure 1.It was concluded that, in the case of investment casting, the component has to be made in one go itself. RP is used when the component has to be made with no errors or faults and for manufacturing intricate components.

Figure 1.Casting made using investment casting rapid prototyping approach

ii. Vinay Pramodet al. [1]investigated the feasibility of 3D printed patterns in casting processes experimentally.Initially the geometric model was designed using CAD software and exported as a .STL file. An open source printer called Woodmax i3 was used to print the 3D component pattern using PLA (Poly-Lactic Acid) material. Another pattern was made of wood using conventional method for relative comparison between both the patterns. These patterns were used to obtain the mould cavity. Cast parts made of bronze were prepared using 3D printed pattern made mould cavity and other using wood pattern made mould cavity. Both the parts were compared under a SEM microscope which showed differences in surface uniformity. It was found that the casting using 3D printed pattern was better and had lesser scales as compared to the cast made using wooden pattern. Authors concluded that the casted part using 3D printed pattern had a better surface finish. Figure 2 and Figure 3 shows the SEM images of 3D printed pattern casting and wooden pattern based casting at 1000X respectively.

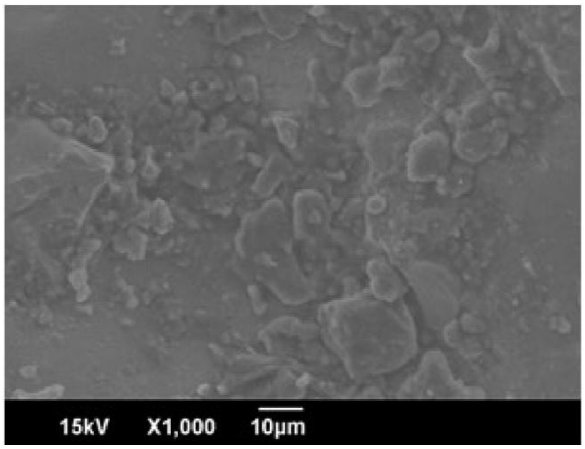

Figure 2. 3D Printed pattern based casting.

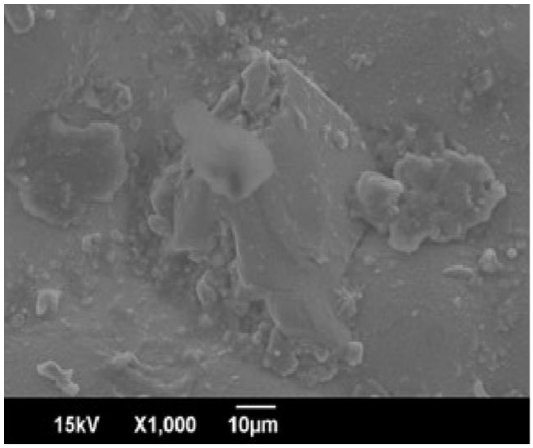

Figure 3. Wooden pattern based casting.

iii. SivadasanMet al. [5] assessed the suitability of the fused deposition modelling (FDM) process for creating sacrificial investment casting patterns by studying FDM fabricated part thermal response at various temperatures.

Initially the patterns were modelled using CATIA software, then converted to .STL file and finally patterns printed using FDM Vantage SE machine with ABS (Acrylonitrile Butadiene Styrene) as the build material.

Different experiments were performed to test the worthiness of the 3D printed component as a pattern and are listed below.

1. Test for ABS compatibility with moulding medium.
2. Test for type of ash & burn out.
3. Test for the thermal decomposition.
4. Test for replicas of precision patterns.
5. Test castings through IC route.

The following observations were made upon the completion of tests.

In the first experiment, there was no damage to the mould cavity after firing the mould. Little amount of ash was observed in the second experiment which could be easily removed. In the third experiment, multiple stages of material decompositions that may occur to ABS practically within the temperature range of 100^{o} to1050^{o}C and where the result is optimal for the process upon viewing the amount of residual ash were studied. Capability of ABS replicas for precision patterns was found to be good in the fourth experiment. Also mould cavities were observed as clean with minimal amount of residue. In the fifth experiment, the moulds with the ABS were filled with molten plain carbon steel to make the component with less residual ash that could be easily removed and documented. It was noted that the ash residue caused by burning the ABS patterns could be removed easily and for the process to be commercially feasible further research need to be conducted in order to establish scale factor and post finishing operations.

III.APPLICATIONS OF RAPID PROTOTYPING FOR METAL CASTING

Rapid prototyping has many advantages over conventional methods leading to increased research and development. This in turn has created many current and potential applications. The following applications are based on the literature review.

i. Jauharet al. [6] performed cost benefit analysis for implementation of rapid manufacturing approach using FDM with ABS over conventional wax patterns. The cost of wax patterns made using conventional approach was found to be costlier. In contrast, the RP technology is technically and economically justifiable creating an opportunity for new applications in automotive industry and also reducing the cost of making the components.

ii. MilanHoráčeket al. [7] used RP process to make a component in order to replace the original part. This was compared with the conventional method. It was found that if the mechanical and material properties matched, then the component made using the standard technique could provide advantages in form of cost. This application shows the potential of RP process to make replacement components to the original body part creating better medical applications.

Other applications of RP include aerospace and aeronautical, electronics, tool making and medical applications. It can also be used in making of very intricate component which are either difficult or almost impossible to make using traditional methods.

RajashekarPatil et al.[8] mentioned that by using low cost materials with additive manufacturing processes, the volumes of casting production could change potentially. Rupinder Singh et al. [9] concluded from investigation that ABS based patterns could replace the conventional wax patterns with respect to dimensional accuracy for development of bio-medical implants.

IV. CONCLUSION

Rapid prototyping along with casting process is found to be one of the spreading approaches in manufacturing. Due to this, many researchers are carrying out investigations leading to justify its suitability and applicability. This paper assessed various such studies which substantiated the use of RP process along with casting in manufacturing different types of components. Also, an attempt is made to showcase the applications of this combinatorial process in different sectors justifying that it is economically and technically feasible. Hence RP along with casting process can be used for manufacturing all types of intricate and complex shapes.

V.REFERENCES

i. *Prof. D.V. Mahindru& Prof. PriyankaMahendru, Review of Rapid Prototyping-Technology for the Future, Global Journal of Computer Science and Technology Graphics & Vision, pp.27-37, 2013.*

ii. *Prof.DeepaYagnik, Fused Deposition Modeling – A Rapid Prototyping technique for Product Cycle Time Reduction cost effectively in Aerospace Applications, International Conference on Advances in Engineering & Technology – 2014 (ICAET-2014),pp.62-68,2014.*

iii. *Pranjal Jain, A. M. Kuthe, Feasibility Study of manufacturing using rapid prototyping: FDM Approach , The Manufacturing Engineering Society International Conference, MESIC 2013, Procedia Engineering 63(2013), pp.4-11,2013.*

iv. *VinayPramod, AbhijithBaiju, AkkashBabuji, RijoPlathanam, Aby K Abraham, Feasibility Study on 3D Printed Patterns in Casting, International Journal of Emerging Technology and Advanced Engineering,pp.199-202, June 2015.*

v. *Sivadasan M, Dr. N K Singh, Dr. Anoop Kumar Sood, Use of fused deposition modeling process in investment precision casting – a viable rapid tooling, International Journal of Conceptions on Mechanical and Civil Engineering, pp.46-49,Dec. 2013.*

vi. *Sunil Jauhar, K. M. Asthankar, A.M. Kuthe, Cost benefit analysis of Rapid Manufacturing in Automotive Industries , Advances in Mechanical Engineering and its Applications (AMEA), pp.181-188,2012.*

vii. *Milan Horáček, OndřejCharvát, TomášPavelka, Josef Sedlák, Martin Madaj, JindřichNejedlý, and Jan Dvořáček, Medical implants by using RP and investment casting technologies, 69th World Foundry Congress, Hangzhou China 2010,pp.107-111,Feb. 2011.*

viii. *RajashekarPatil, S. Mohan Kumar, E. Abhilash, Development of Complex Patterns: Scope and Benefits of Rapid Prototyping in Foundries, International Journal of Engineering and Innovative Technology (IJEIT), pp.68-72, April 2012.*

ix. *Rupinder Singh, Sunpreet Singh, Gurpartap Singh, Dimensional Accuracy Comparison of Investment Castings Prepared With Wax and ABS Patterns for Bio-Medical Application, 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014), Procedia Materials Science,pp. 851-858,2014*