

Design and Additive Manufacturing of Pump Impeller using 3D Printing Technology

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ABSTRACT

Pump impellers play a significant role in the manufacturing of machinery for several purpose at present era of for different applications. They also play an important role in the domestic products such as bore pumps, refrigeration units, and air conditioners etc. Great advancements took place in the manufacturing of the pump impellers such as 3D printing and metallurgy techniques like sand casting, investments casting, die casting, CNC machining, etc. The major drawback of the pump impellers manufactured using traditional methods known as metallurgical techniques is that they consume much time and need more workforce for production which is not a cost-effective technique. To provide a cost-effective production and replacement technique and to reduce the maintenance of the pump impellers, this project aims at developing a pump impeller using CAD software. The pump impeller so designed is printed using additive manufacturing or rapid prototyping techniques. These are quick fabrication techniques and less expensive. The design of pump impeller is carried out in Solidworks Part Design. The designed pump impeller is manufactured using inkjet desktop 3D Printer from MakerBot company 3D printers and printer model MakerBot Replicator 2.

Keywords : 3D Printable, Additive Manufacturing, Inkjet Printer, Rapid Prototyping (RP), Pump Impeller

I. INTRODUCTION

In the past 5 years researchers concentrated on producing prototypes at low cost and with high quality in quick marketing. They used fuzzy logic approach to select the best Rapid Prototyping (RP) technology with the highest overall efficiency. The fuzzy set theory was used to diminish the bias prejudice of subjective evaluation. Fuzzy logic can deal with both qualitative and quantitative data. From the results of the studies conducted by the researchers, they zeroed in on investment casting among technical prototyping, sand casting, “plastic molding and investment casting.”¹ Further, they also highlighted the effectiveness of the fuzzy set theory

in identifying the best Rapid Prototyping (RP) technology with the highest overall efficiency.

From 2013 researchers and industries employed a rule-based expert system for selecting an appropriate Rapid Prototyping (RP) technology. The user was allowed to choose one of the options namely quick selection, build technology and machine style for system selection. Based on the past advancements and developments this paper aims at comparing various specifications and applications of different Rapid Prototyping (RP) system in making a fuzzy selection and through a comprehensive tool for system comparison and selection of a Rapid Prototyping (RP) system based on quantitative analysis by producing the impeller through 3D Printing technology.

II. GOVERNING PROPOSITION

General Design Procedure

The general design tools for parametric modeling (3D CAD) can be explained as follows:

Sketch Entities: For creating sketches in a plane Sketch entities are used. The major tools in sketch entities are lines commands, rectangles commands, circles commands, ellipse commands, and arcs commands. These tools are objected to creating sketches.

Sketch relations: Geometric relations are created using the tools known as Sketch relations. To capture the design intent these relations are used. Vertical, horizontal, dashed line, parallel, perpendicular, coincident and tangent are the sketch relations.

Cut and Boss features: Boss and cut tools are utilized for creating basic features to the design. Revolves tools, extrudes tools, loft tools, sweeps tools, are the tools of the cut and boss tools. These tools are objected to creating extrude revolve features, features, loft features and sweep feature to the model.

Dimensions: The design dimensions are defined by using tools known as dimensions. The two tools, smart dimensions, and standard dimensions are utilized for editing and applying dimensions to the sketch of the model.

By using these tools, the sketch of the model can be created and the basic sketch can be converted to the geometry of the desired model.

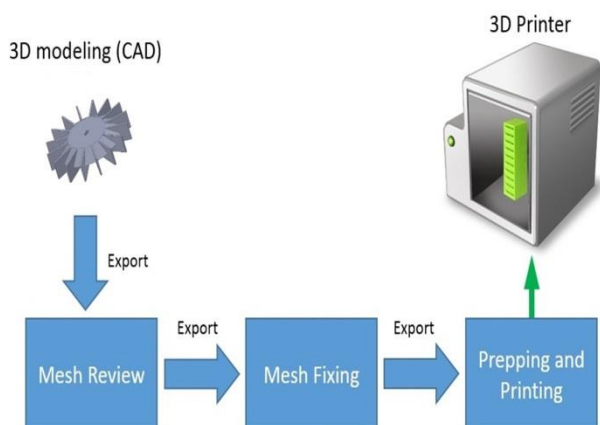


Figure 1. General steps involved in the 3D Printing.

Basic 3D Printing Procedure:

The Additive manufacturing technique or the 3D printing technique is used in the manufacturing of the 3D printed Pump Impeller. The Pump Impeller is manufactured on the desktop 3D Printers. The steps involved in the 3D Printing are stated below.

1. The CAD model designed in the parametric modeling (3D CAD) software is converted to .STL format and is exported into the 3D Printer workbench.
2. Meshing is done on the imported CAD model in the respective 3D printer workbench.
3. The mesh created on the 3D CAD model is checked against errors and is exported to next step.
4. In the Prepping and Printing step, the model is converted to the very small finite printing parts which are printed like layers to form a 3D printed model.

These are the basic steps involved in 3D printing or Additive manufacturing process.

III. METHODOLOGY

Modeling of Pump Impeller

The geometric design of the pump impeller is done in Solidworks Part Design. The design of geometry has the following steps:

1. Open Solidworks and choose the command File > New > Part.
2. Select the system of units as MMGS and choose the sketch plane.
3. Select the top plane from the Sketch tab and then select the line command and centerline tool and draw a center line passing through the origin.
4. Now select the top plane from the Sketch tab and then select the rectangle command and center rectangle tool and draw a rectangle with dimensions 50 mm X 5 mm (l x b) on the center line passing through the origin.
5. Now move the rectangle 90 mm away from the origin.

6. Now select the Circular Sketch Pattern tool and select the corners of the rectangle and give 16 instances and click tick mark.
7. Now exit the sketch. This results in sketch1 in tree bar diagram. Figure 2 shows sketch1 with dimensions in mm.

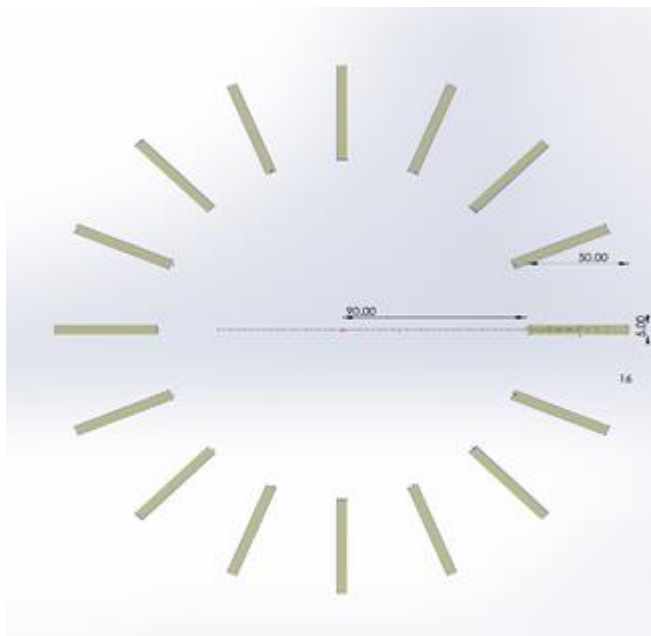


Figure 2. Sketch1 with Dimensions in mm

8. Select the sketch1 and select Features tab and select Extrude Boss/Base tool and extrude blindly through 50 mm. This is Boss- Extrude1 in tree bar diagram.
9. Thus the blades on the impeller are formed.
10. Now select 3D Sketch on the Plane tool and select top plane and draw a circle of diameter 230 mm with the origin as the center point.
11. This will be 3DSketch1 in tree bar diagram. Figure 3 shows 3DSketch1 with dimensions in mm.

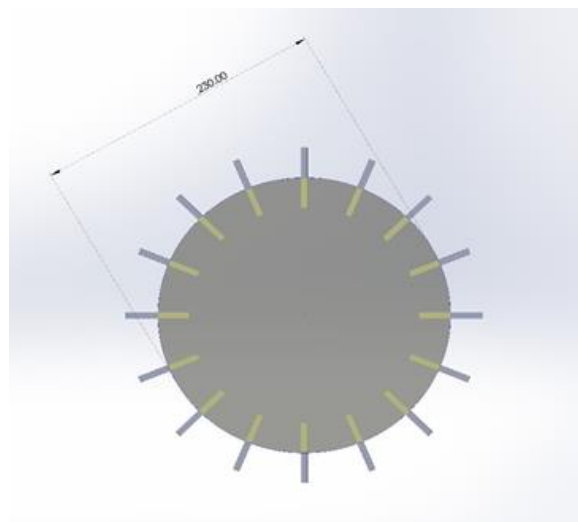


Figure 3. 3D Sketch1 with Dimensions in mm

12. Now select 3DSketch1 and select Extrude Boss/Base tool and select extrude up to surface and select the surface of Boss – Extrude1 facing away from the origin. This is Boss- Extrude3 in tree bar diagram.
13. Now select Chamfer tool in the Features tab and select all the circular edges as the Items to Chamfer and give chamfer parameters as 50 mm distance and 30° angles and use Tangent propagation and press tick mark.
14. Thus chmfer2 and chamfer3 features are formed.
15. Now draw a hole on the impeller using the 3DSketch tool and Cut Extrude feature on the features tab. The hole on the impeller is shown in Figure 4.

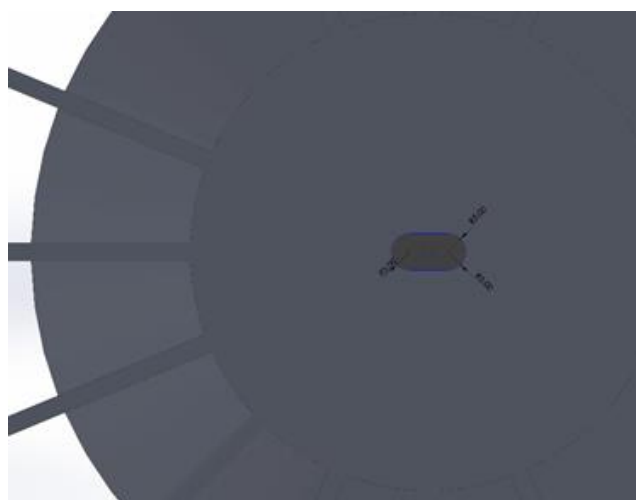


Figure 4. Hole on Impeller with Dimensions in mm

Thus the Pump impeller is modeled in Solidworks Part design. Figure 5 shows the isometric view of the impeller. Figure 6 shows the dimensions of the impeller sketched in ANSI A4 Drawing Sheet format and various views.

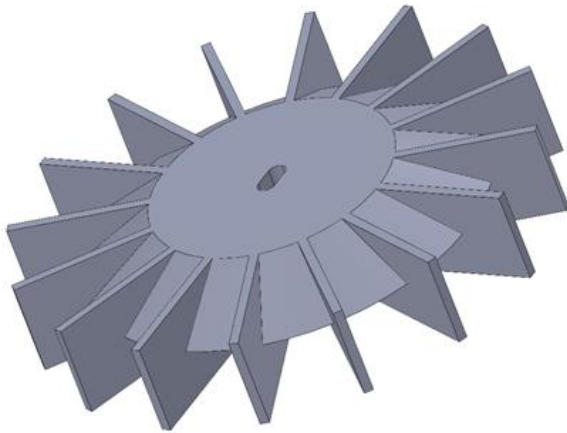


Figure 4. Isometric View of Pump Impeller

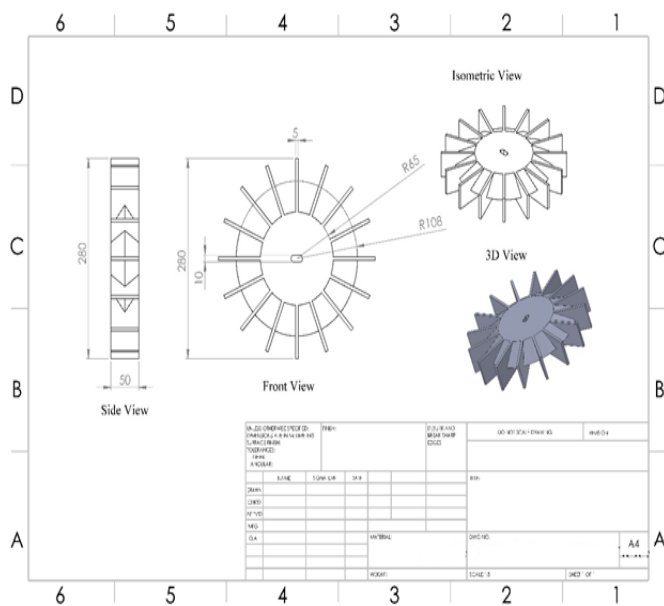


Figure 5. Regenerative Pump Impeller - Views and Dimensions

Pump Impeller 3D Printing Procedure

The pump impeller designed in Solidworks is used to fabricate pump impeller using MakerBot Replicator 2 3D Printer. The process is as follows:

1. The Solidworks file containing Pump Impeller design is converted to .STL format and is exported to MakerBot Replicator 2 workbench.
2. The .STL file is opened in the MakerBot Replicator 2 and resized to a scale 1:2 to fit

within the 3D printing volume of the 3D printer.

3. The resized model is shown in Figure 6.

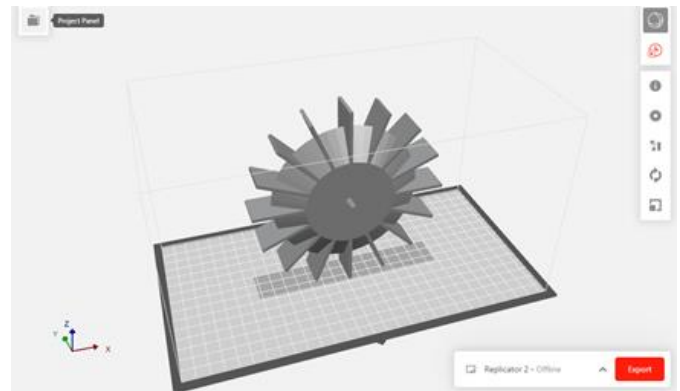


Figure 6. Pump Impeller Scaled Model

4. The model is meshed and prepared for 3D Printing.
5. The Pump Impeller is printed in layers.
6. Figure 7 shows the preview of the 3D print model.

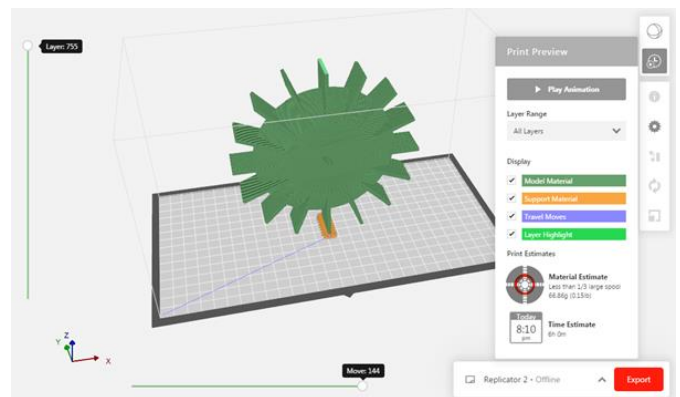


Figure 7. Preview of the 3D print model

Thus the Pump Impeller is manufactured using Additive Manufacturing technique.

The nozzle of the MakerBot Replicator 2 3D Printer moves 144 times along the X axis and Z axis and print 755 layers' parallel to XZ plane. The time taken to print the scaled model of Pump Impeller is estimated around 6 hours 0 minutes. The material estimated for printing scaled model of Pump Impeller is estimated around 66.86 grams (0.15 lb).

Table1 shows the material properties.

Table 1. Print Estimates & Material Properties

Model Scale	1:2
Layers Printed	775
Material Estimate	66.86 grams
Print Time	6 hours
Material	ABS Plastic

This is the design procedure and Additive Manufacturing procedure for designing Pump Impeller using Solidworks Software and 3D Printing Pump Impeller using MakerBot Replicator 2 3D Printer.

IV. CONCLUSION

This study may result in the transforming the way of manufacturing the pump impellers. There are various unique technological benefits of the 3D printing process which make it stand apart from other manufacturing techniques. The main advantages obtained from this study, Design and Additive Manufacturing of Pump Impeller using 3D Printing Technology are as follows:

1. The layering procedure of 3D printing takes into account a more profound level of complexity than traditional metallurgical and other manufacturing processes, making it conceivable to print segments with complicated shapes also, complex geometry. The pump impeller is fabricated as a single unit with no seam.
2. There is no necessity in making patterns or using tools in additive manufacturing of the pump impeller which results in a reduction of the production costs.
3. The model can be printed whenever necessary without the continuous surveillance and inspections.
4. Continuous production can be made within less span of time sometimes in a matter of hours.
5. The manufactured pump impeller using 3D

Printing technique can be accessed immediately since there is no need for finishing the product.

Therefore, the study gives the following conclusions that the pump impeller manufactured using the Additive Manufacturing (AM) technique or 3D Printing technique can be employed by the industries by replacing the traditional manufacturing techniques.

V. FUTURE SCOPE

The pump impeller modeled using Solidworks and printed using MakerBot Replicator 2 3D Printer should be evaluated for its performance either using experimental analysis or the simulation studies. The printed model is a scale model and hence the results obtained during experimental analysis or the simulation studies should also be scaled mathematically considering the principles, theory and the governing equations Dimensional Analysis and Similitude. The material used in this study is ABS Plastic which is quite enough for low discharge low-speed impeller pumps. The material should be changed in case of high discharge high-speed impeller pumps.

VI. REFERENCES

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