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DEVELOPMENT OF CENTRIFUGAL IMPELLER PROTOTYPE BY 3D PRINTING

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Abstract - Our main aim is to develop a Centrifugal Impeller Prototype through 3D Printing, we may observe design parameters like Dimensions and Global variables. Whereas Speed, Scale, Weight, Time, and number of layers etc. in 3D Printing. We are going to model the material in Solidworks and then print it in Flashforge CreaterPro 3D Printer with ABS plastic as material. We will choose FDM in 3D Printing based on its special features like relatively fast, easy, and affordable method. Through this thesis, the manufacturing process of Impellers will advance to achieve high precision, complexity, less time consuming and low cost-effective. This method can be used in Jewellery making, Toys Industries, and customizable Gift Industries etc.

***Key Words*:** Prototype, Impeller, 3d Printing and FDM

1. INTRODUCTION

1.1 Background of Study

Centrifugal impellers play a significant role in the manufacturing of machinery for several purposes in the present era of for different applications. They also play an important role in domestic products such as bore pumps, refrigeration units, and air conditioners etc. Manufacturing of Impellers is done by metallurgy techniques like sand casting, investments casting, die casting, CNC machining, etc. The major drawback of the centrifugal 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.

1.2 Problem Identification

Manufacturing of impellers by conventional methods is time consuming. This may decrease the production rate and not be a cost-effective method.

1.3 Significant of Project

In the future, this could be a benchmark for further research on the manufacturing of impellers by 3D printing with the data we have established in this project. Companies as well as universities can use this research to update the design and uncertainty used when dealing with impellers and 3D printing.

1.4 Objective

The main objective of this project is to develop the Impeller model by using 3D printing.

1.5 Scope of the Study

The scope of the study will be on the modelling of Centrifugal Impeller through 3D printing. The work initially is to create a model of impeller by using modelling software. Then exporting to STL file format and there after choosing the required parameters for designing and preparing G-Code to move further. Finally, print the model for completion of the experiment.

1.6 Relevancy of the Project

- Giving the general knowledge of manufacturing through 3D printing.
- To spread awareness that an advanced technology like prototyping can minimise the drawbacks of Traditional approach in designing and Modelling.
- As a guideline to gain knowledge on development of Impeller through 3d printing.

1.7 Feasibility of Project

The project is feasible as it makes notoriously expensive, the creation of parts products cheaper and more accessible. As it results less wastage and no human errors with efficiently as well as the economically beneficial. The project is done by Fused Deposition Modelling method, which is low in cost, fast and brings huge benefits for the future. The time frame for the project is about.

2.LITERATURE REVIEW

Ramesh S. [1]

By the reference of this Book (Rapid Prototyping), we have presented an overview of rapid prototyping technology. Part introduction and types of rapid prototyping. By the module we have got detailed information of 3D printing. All basic knowledge of Fused Deposition Modelling is pulled from this module.

Robert R. Ross, Val S. Lobanoff [2]

This book has valuable information on the elements of pump design, specific speed and modelling laws, and impeller design. Discussions focus on Impellers, classification of impeller, materials used, design parameters and design suggestions.

Milos Teodor [3]

By taking the reference of this paper we have concluded that computerized pump design has become a standard practice in industry, and it is widely used for both new designs as well as for old pumps retrofit. Such a complex design code has been developed over the past decade by the author. However, any design method must accept a set of hypotheses that neglect in the first design iteration the three-dimensional effects induced by the blade loading, as well as the viscous effects. As a result, an improved design can be achieved only by performing a full 3D flow analysis in the pump impeller, followed by a suitable correction of the blade geometry and/or the meridian geometry.

Farah Elida SELAMAT [4]

This paper revolves around the idea of design and analysis of centrifugal Impeller for performance enhancement within the pump specifications. it can be observed that as the rotation speed of the impeller increases, the pressure within the impeller increases. The pressure increases gradually from impeller inlet to impeller outlet. It can also be observed that the efficiency of the impeller increases as the rotation speed increases. As a result, the performance of the impeller increases as the

efficiency increases. Performance of the impellers was compared based on inlet and outlet power, impeller efficiency, pressure distribution, and static head pressure produced.

Anirudha S. Bhosale, P. N. Gore [5]

In this paper model we have referred to the design parameter, working conditions and maximum efficiency with lowest power consumption. Study indicates that Computational fluid dynamics (CFD) analysis is being increasingly applied in the design of centrifugal pumps. Various parameters affect the pump performance and energy consumption. The impeller material, blade angle and the blade number are the most critical. Therefore, it is necessary for development in the impeller so we can improve the performance of pump.

Syam Prasad, BVVV Lakshmipathi Rao, A Babji, Dr P Kumar Babu [6]

It described the static and dynamic analysis of a centrifugal pump impeller which is made of three different alloy materials (viz., Inconel alloy 740, Nicolay alloy 803, Waspily) to estimate its performance. The investigation has been done by using CATIA and ANSYS13.0 software's. A structural analysis has been carried out to investigate the stresses, strains and displacements of the impeller and modal analysis has been carried out to investigate the frequency and deflection of the impeller. An attempt is also made to suggest the best alloy for an impeller of a centrifugal pump by comparing the results obtained for three different alloys.

Sambhrant Srivastavaa, Apurba Kumar Roy [7]

In this module we have noticed the natural frequency and deformation of mixed flow pump impeller were evaluated considering two different blade positions in the meridional annulus. ANSYS was used for the investigation of natural frequency and deformation. It was observed that the mixed flow pump impeller with inlet inclined blade position in the meridional annulus was more suitable than the trapezoidal one.

Matlakala [8]

Centrifugal pumps contain two main parts: an impeller that imparts Centrifugal forces to the production fluid and diffuser which is the fixed part that guides the flow to the discharge. The shape of the impeller influences the performance of the pump. Thus, the area of the significance to the pump design is the impeller geometric parameters to achieve pump performance. The consumption of energy by the pump is caused by the failure to choose the right pump size for the system, improper installation, and pump operation. Poor pump performance may affect the plant operation such as maintenance cost, downtime, loss of production, increase in operating cost.

Zhang, Yu. [9]

This paper presents the optimization of vibrations of centrifugal pump considering fluid-structure interaction (FSI). A set of centrifugal pumps with various blade shapes were studied using FSI method, to investigate the transient vibration performance. The Kriging model, based on the results of the FSI simulations, was established to approximate the relationship between the geometrical parameters of pump impeller and the root mean square (RMS) values of the displacement response at the pump bearing block.

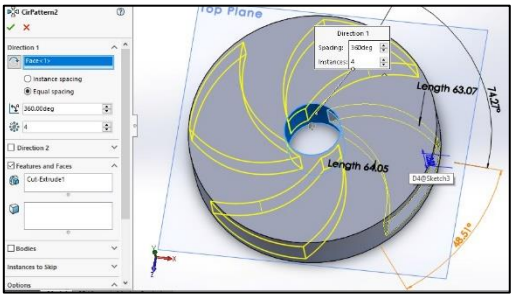
Korakianitis, Theodosios. [10]

Mechanical pumps as heart assist devices impose power and size limitations on the pumping mechanism, and therefore requires careful optimization of pump characteristics. Typically, new pumps are designed by relying on the performance of other previously designed pumps of known performance using concepts of fluid dynamic similarity. Such data are readily available for industrial pumps, which operate in Reynolds numbers region.

3.EXPERIMENTATION

3.1 Modelling of Centrifugal Impeller

1. The geometric modelling of the Centrifugal impeller is done in Solid works Part Design. The design of geometry has the following steps:
2. Open Solid works and choose the command File > New > Part.
3. Select the system of units as MMGS and choose the sketch plane.
4. Select the top plane from the Sketch tab and then select the line command and centreline tool and draw a centre line passing through the origin.
5. Now select the top plane from the Sketch tab and then select the rectangle command and centre rectangle tool and draw a rectangle with dimensions >105 mm X >105 mm (l x b) on the centre line passing through the origin.
6. Now move the rectangle 90 mm away from the origin.
7. Now select the Circular Sketch Pattern tool and select the corners of the rectangle and give 16 instances and click tick mark.
8. Now exit the sketch. This results in sketch1 in tree bar diagram. Figure 15 and 16 shows sketch1 and 2 with dimensions in mm.
9. 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.
10. Thus, the blades on the impeller are formed.
11. Now select 3D Sketch on the Plane tool and select top plane and draw a circle of diameter 105 mm with the origin as the centre point.
12. This will be 3DSketch1 in tree bar diagram. Figure 3 shows 3DSketch1 with dimensions in mm.
13. 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.
14. Now select Chamfer tool in the Features tab and select all the circular edges as the Items to Chamfer and give chamfer parameters as 64 mm distance and use Tangent propagation and press tick mark.
15. Thus, chmfer2 and chamfer3 features are formed.
16. Now draw a hole on the impeller using the 3DSketch tool and Cut Extrude feature on the features tab.



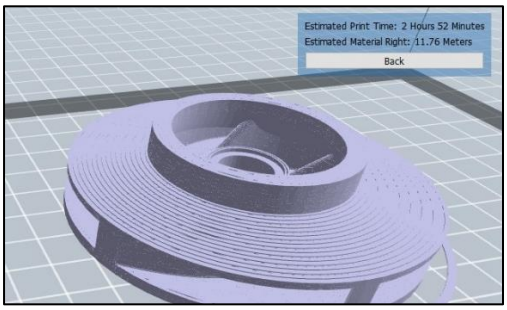
Impeller 3D Printing Procedure

The pump impeller designed in Solid works is used to fabricate pump impeller using Flashforge3D Printer. The process is as follows:

1. The Solid works file containing Pump Impeller design is converted to. STL format and is exported to Flashforge workbench.

The .STL file is opened in the Flashforge and resized to a scale 82.25mm x 82.25mm x 20.83mm to fit within the 3D printing volume of the 3D printer.

2. The model is meshed and prepared for 3D Printing.
3. The Pump Impeller is printed in layers.
4. Figure 22 shows the preview of the 3D print model.



4. RESULTS

Thus, the Centrifugal Impeller is manufactured using Additive Manufacturing technique. The nozzle of the Flashforge Creator Pro 3D Printer moves 144 times along the X axis and Z axis parallel to XZ plane. The time taken to print the scaled model of Pump Impeller is estimated around 3 hours. The material estimated for printing scaled model of Pump Impeller is estimated around 66.86 grams (0.15 lb.).

Observations:

Table1 shows the material properties.

Model Scale	82.25mm x 82.25mm x 20.83mm
Material Estimation	66.86 grams
Print time	2 hours 52 minutes
Material	ABS

This is the Modelling procedure and Additive Manufacturing procedure for designing Centrifugal Impeller using Solid works Software and Flashforge3D Printer.

5.CONCLUSION

This study may result in the transforming the way of manufacturing the Centrifugal 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, Modelling and Additive Manufacturing of Impeller using 3D Printing as follows:

1. The layering procedure of 3D printing considers a greater level of complexity, making it conceivable to print segments with complicated shapes and complex geometry. The pump impeller is fabricated as a single unit with no seam.
2. No need of 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 without the continuous surveillance and inspections.
4. Continuous production made within less span of time sometimes in a matter of hours only.
5. No need of finishing to product through 3D printing procedure.

Therefore, by the study we have concluded that the pump impeller manufactured using the 3D Printing technique can be employed by the industries, by replacing the traditional manufacturing techniques.

6.FUTURE SCOPE

The centrifugal pump impeller modelled using Solid works and printed using Flashforge Creater pro 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 Simulation. 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.

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