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Design and Rapid prototyping of Novel Ventricular Assist device

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Abstract—According to statistics coronary heart disease is one of the most common causes of death in the world. Heart failure patients with these diseases are the most common one. External assisted Pumps help ventricular thrust can treat this condition. Novel designed pump were developed in this research due to the expensive production techniques prices by using rapid prototyping stereo-lithography .This device were fabricated and experimental flow parameters were tested by artificial blood .The obtained experimental results were compared with software results . Significant collaboration were obtained and the minor discrepancies in the results were indicated because of the lack of impeller surface finishing defects in stereo lithography. Future research could be conducted to evaluate the parameters with other rapid prototyping techniques such as Selective laser sintering.

Keywords- ventricular assist device, Pump, Rapid prototyping, Automatic

I. INTRODUCTION

According to statistics released by coronary heart disease and one of the most common causes of death in the world.[1] Congestive heart failure is one of the most common diseases with Sander recent decades due to the great need for these patients to a heart transplant and a shortage of hearts for transplantation, doctors and engineers together have tried using mechanical pumps; devices help ventricular for this disease and produce. [2,3] . Different pumps for ventricular assist thrust were developed in several researches and several fabrication methods were presented.[4,5,6]

These pumps were divided into different categories, one of the divisions based on fluid flow through the pump into two general types Axial and Centrifugal.[7] Axial pumps have more advantages in comparison to the pumps. Axial flow blood pumps due to the fluid flow during pumping will not redirect any the fluid were pumped in the direction of the axis ;it resulted that these blood pumps has with less damage than others.[8,9] Axial pumps are consist of four important part of the building is (Inducer, Impeller, diffuser, split Straightener) as it illustrated in figure 1. It is an important principle in the design of pumps blood to be pumped with less noise and turbulence Because of turbulence in fluids such as blood can damage blood components that cause clotting of red blood cells in the blood.[10]

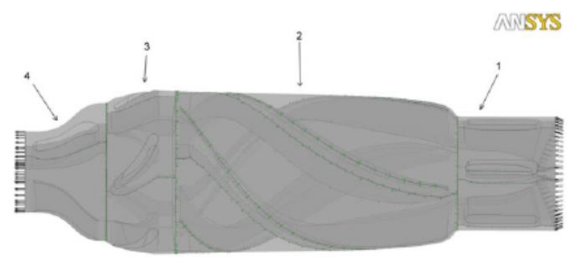

Figure 1: Main components of axial pumps.

Recently, by rapid development of CAD technology in detailed design s, modification forms data in 3D through tranquil. As a result of this data in programming CNC and RP(rapid prototyping), by CAD / CAM, automatic tangible progress is remarkable. Increase the number of common parts and advanced design makes increasing use of CAD design is more complex levels. To reduce the time and costs involved as well as new developments in industrial production, rapid prototyping is known as a great way to prototyping.[11] The purpose of this paper is to present a method of rapid prototyping (RP) used in the development of a of ventricular assist pump. stereo lithography technology was used to create complex impeller blade profiles for testing as part of a this device to optimization fluid convection process.

II. METHODOLOGY

Design and Construction of Vane Pump

The Ventricular Assist pump and the environment by using software were designed. As mentioned, the pump is composed of four blades, each blade of the specific task they are doing at the pump. The four blades, three blades and other moving Impeller are fixed In order to reduce the time to design and simulate blades of any part of the blade is a blade design and simulation The output of the simulation and analysis for a complete blade. So when output from any part of a pre-existing

ANSYS. The output file that can be acceptable for CATIA software for design and ANSYS for analytical analyzed experiments and the final output file is in IGS format. The output files are in the software CATIA as a shell First it should be map the output and then turned to the other parts and details should be added. Which these output would be used with ANSYS for experimental result simulation. (Figure 2)

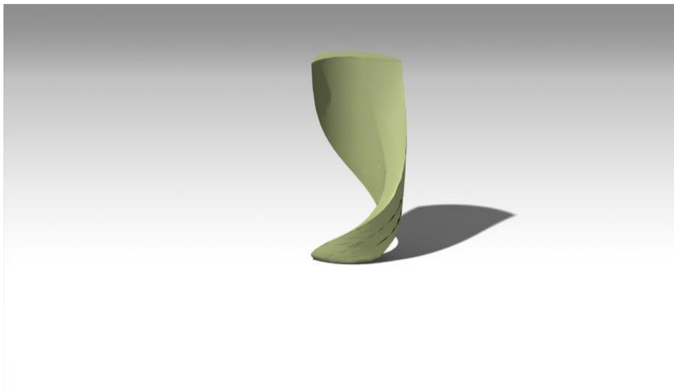

Figure 2: a blade of Impeller

IGS file output from part design were converted using ANSYS software from CATIA environment module, by using the multimedia section. The volume created for the following blade with 4 blades creates. Thus, we repeat the above steps for the other Vane Pump.(Figure 3)

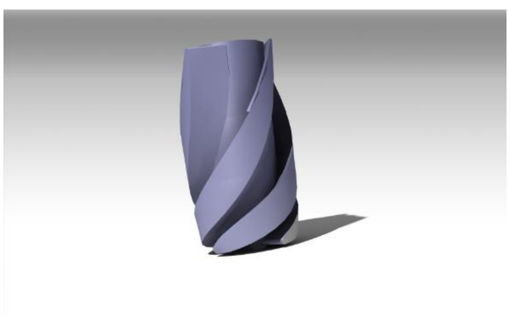

Figure 3: Impeller completed

Design and construction of the pump casing

After the turn of the pump casing is designed blades. Designed pump casing is designed according to the shape of the blades. As already mentioned, only with rotary vane pump is Impeller. The distance (clearance) Impeller the body of each side is 0.2 mm. The following figure Impeller with pre-Impeller body inside it shows.

The body design Impeller a groove at both ends, for male and female for the purpose of making and assembling other parts of the body are embedded. In real examples of the different parts of the fuselage on both the threads and the O-rings are used to seal off these parts. Due to the method of stereo lithography construction on the project it should be designed housing for threaded connections there. The possibility of making the thickness of less than 0.8 mm is not possible for us and because of the thickness and depth of less than 0.8 is threaded on the connection. In this project we have used male and female groove. After Impeller body design, body design Inducer we start. Inducer first blades from the inlet pump. The blades rotate and move not because any Within the body and is fixed for any clearance between the blades there Inducer body fluid passes only through the vane pump. In other words, in addition to covering the body Inducer duty blade holder also holds Inducer. (Figure 4)

In the actual case, the pump inlet in parallel with the axis of the blade and shift into the pumped fluid without any In the prototype system driving the pump electrically and fails Impeller pump rotor and a winding around the exterior Impeller, and by passing an electric current through the coil, rotor, which Impeller be induced and began to spin and causes the fluid motion forward.

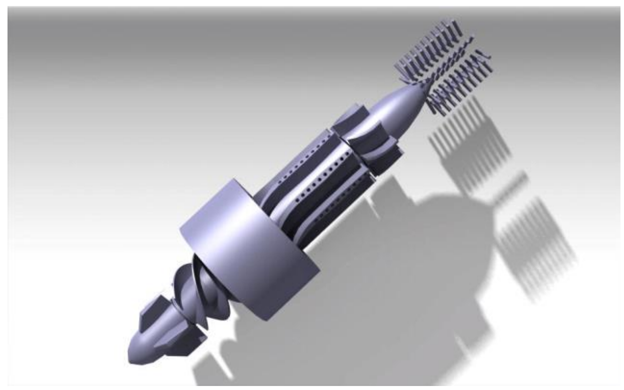

Figure 4: Body Inducer with pre Inducer inside

In these pumps because the steel blades of titanium and titanium as well as magnetism, no holes on the blades Impeller create and sticks very small magnetic inserted up to a coil around it could bars inspire and create spin in Impeller But the project of a power transmission systems outside the pumps have been used. In the following sections we will refer to it because of the design of the pump inlet to discuss the case of 90 degrees. After Inducer body design, body design diffusers have begun. Like Inducer a fixed diffuser blades and chassis in addition to covering the diffuser blades, it also has the duty holder. At the beginning and end of the groove body in order to get on Impeller body and the body is designed Straightener. The last part of the pump body, the body is Straightener. This body should also fully compatible with the external form Straightener blades because the body in addition to covering the blade, blade holder also plays a role. This part of the system, like other parts of the body to the groove of the male and female together. It is located in the pump outlet pipe. Outlet pipe to the inlet pipe diameter is the same.

Transmission

As mentioned in the previous sections due to laboratory use of the pump system for the external drive. This pump were installed with two mm shaft rotor diameter and the hole on the side of Inducer and pre Inducer and pre Impeller had crossed in front, and inside the bearings inside the body of the diffuser of the bearings packed and in the end Inducer body by bearings inside the bearing are sealed. Because the system driving the pump externally and by an axis of rotation of the pump to Impeller transmitted, so unlike real examples pump axial inlet hose pump with the pump shaft angle of 90 degrees to find which in turn caused a slight difference in pump efficiency compared to the simulated data. Compliance is centered inside the Impeller for the referendum. Sliding bearings used in the pump within Inducer body and diffuser are asking for compliance and the final fabrication were illustrated in figure5.

The modified impeller blade profiles, relative to the standard radial configuration, were evaluated with the use of computational fluid dynamics (CFD) and experimental testing. Rapid prototype impellers were needed for experimental validation and comparison of results with software (CFD) results.

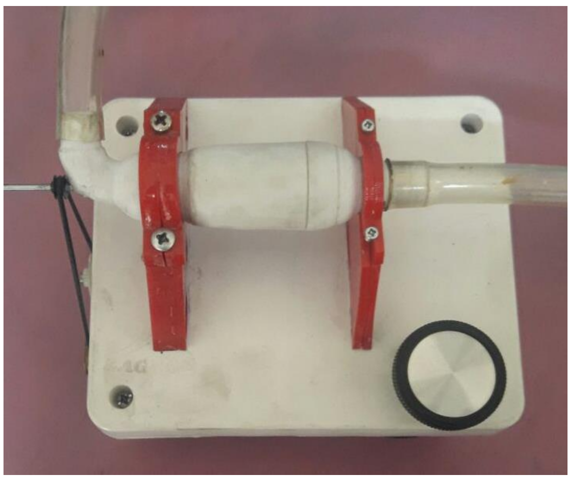

Figure 5: Sample Laboratory pumps

III. Results

We have chosen. Then the pump inlet pipe placed inside the container. In the direction of the inlet pipe to connect a tap water tested. Pump outlet pipe into an empty container with a capacity of 6 liters made. the path is not output, the pumps are turned on In the direction of the outlet pipe pump, a pressure gauge and a pressure relief valve to measure and control the output pressure placed on the inlet port of the pump and the valve at the outlet is also open to any pressure The path is not output, First, we tested the pump with 4000rpm rotational speed, the speed water pump with flow rate of 3L / min and a pressure of 40 mmHg the pump. Next, set the pump on a rotational speed of 6000rpm and we turn it on. The speed of the fluid pump is proceeding with a flow rate of 5 liters per minute and a pressure of 80mmHg pump. (figue.6) During testing the pressure reducing valve is slowly closed until pressure is 100mmHg. The pump discharge pressure to 4.8L / min reduced. In the final stage pump with ideal rotational speed that simulate the speed of 6250 rpm, the test was conducted At this rate observed at 100 ml mercury pressure, pump flow is equal to 7.5 liters per minute.(table1).

Table 1: Results of testing pumps

Experiment	output fluid pressure (mm Hg)	rotational speed (rpm)	(liters per minute)
The first stage	40	4000	3
The second stage	80	6000	5
The third stage	100	6000	4/8
The fourth stage	100	6250	5/7

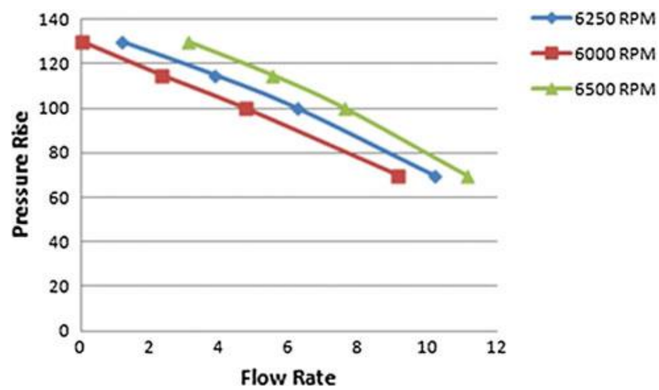

Figure 6: The results of the simulation software

IV. Discussion and Conclusion

In fabrication of such a complex and sensitive products, the product development process should be done gradually. The product is designed, for example, then the simulation is done, then built and tested prototypes of the product were developed gradually. Actual samples of products were fabricated and the processes were repeated to justify test condition environment. After making quality assurance of product were obtained, the product mass-produced and used. The aim of the project is the construction of a ventricular assist pump test. This pump using actual environment was designed and simulated. In order to ensure the results of the simulation, we decided to build a prototype of the pump. All sizes according to the size of the pump is powered by software. After making the prototype pump were manufactured with rapid prototyping and the experiments were conducted to test it by flowing artificial blood .

The significant results were obtained with slight difference with comparison with the results of the simulation. The reasons for this minor difference between the results of the simulation results were analyzed. The ability to manufacture complex blade profiles that are robust enough for testing, in a rapid and cost effective manner is proving essential in the overall design optimization process for this device.

Finally, the main clues were obtained for the rapid prototyping method of making practices such as, low cost and suitability of accuracy of this method to manufacture prototype of the pump. Construction of the pump with other rapid prototyping methods such as FDM ,SLS or SLA would be next phase of this research, which at this stage is a real sample of the product will be produced by selective laser sintering with bio metal material such as tantalum..

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