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# Design of Impeller for Centrifugal Compressor

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Abstract: This study deals with the flow analysis of centrifugal compressor impeller. The impeller design based on parameters flow analysis using air as the working fluid shows that a 0.162m diameter centrifugal compressor with a blade outlet width of 0.0021m gives a static pressure ratio of 4:1. In this design, the impeller blade have exit angle 65º with inlet blade angle 37.74º. So, this compressor is backward-curved blades. The number of blades having 19 equally spaced vanes with the profile is used to improve compressor efficiency. This is the single stage compressor. Theme of centrifugal compressor is to atomize diesel. So, it can more ignite in combustion chamber.

**Keywords**: Centrifugal compressor, Impeller, velocity, Diameter, width.

## 1. INTRODUCTION

Compressor are used in many industrial application. A compressor is a piece of machinery that compresses a fluid, a liquid of a gas that flows in the compressor into greater pressure. Compressors are widely used in construction, power plants, process industry, assembly plant, refineries, air conditioning, and refrigeration, to mention some of the applications. It is a power conversion machines, like pumps and electric motors. Centrifugal compressors are second only to reciprocating compressor in services. However, the centrifugal compressor established its hold on the market in an era of cheap energy when power cost was rarely evaluated. This compressor has been around for quite a long time. Originally, it was used in process applications at relatively low-pressure, high-volume services.

Centrifugal compressor used in small gas turbines. These compressors are the driven units in most gas turbine compressor trains. The function of a compressor is to admit vapor from a low pressure region, compress it and deliver it to high pressure region.

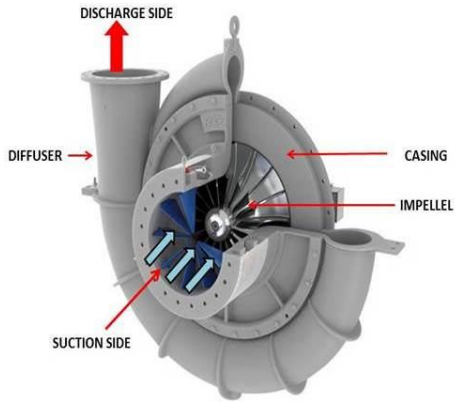


Figure.1 centrifugal compressor

Centrifugal compressor consists of a stationary casing containing an impeller that imparts a high velocity to the air and a number of diverging passages, in which air is decelerated with a consequent rise in static pressure. The centrifugal compressor is designed for the most demanding applications where a reliable air supply is required. It is perfect for automotive, commercial and industrial applications. The maximized operating pressure, increased air flow, and extended duty cycle are required.

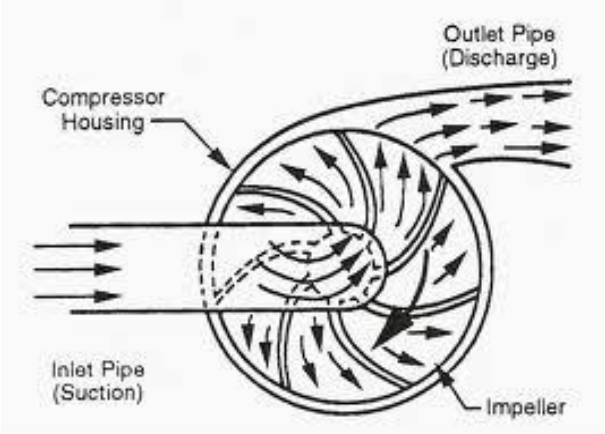


Figure.2 Working Principle of centrifugal compressor

Advantages of the Centrifugal compressor are that it is longer service life than other rotaries and it can often increase the pressure enough for efficient combustion with only one stage. But higher initial cost and air flow is sensitive to change in ambient conditions. However, the airflow for a Centrifugal compressor is much lower than for an axial, and its pressure ratio is generally lower than axial compressor and it is much less effective for creating thrust and less fuel efficient. Hence, it is more often seen in small engines. Centrifugal compressors have two functions: single and multistage.

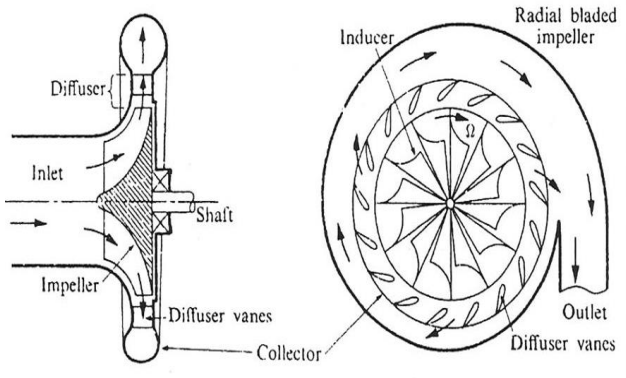


Figure.3 Component of centrifugal compressor

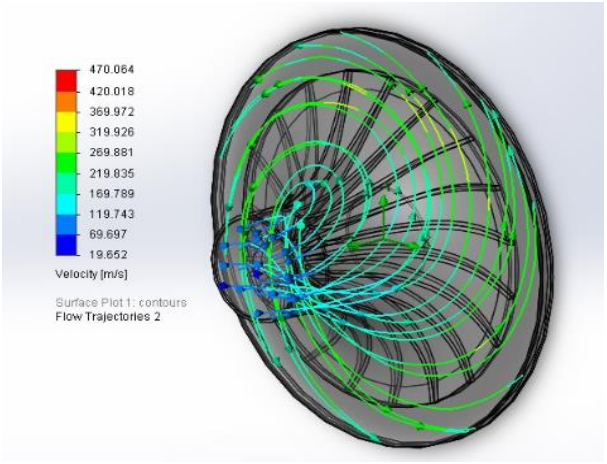


Figure.4 Velocity distribution of centrifugal compressor impeller (flow trajectories)

## 2. SPECIFICATION DATA

| | | |
|---|---|---|
| Inlet pressure , $P_1$ | | = 1030.766 kPa |
| Inlet temperature , $T_1$ | | = 380 K |
| Rated speed , N | | = 45561 rpm |
| Outlet pressure , $P_2$ | | = 1799.6 kPa |
| Outlet temperature , $T_2$ | | = 448 K |
| Capacity , Q | | = 0.1275 $m^3/s$ |
| Air mass flow rate , $\dot{m}$ | | = 1.5907 kg/s |
| Shaft diameter, | $D_s$ | = 0.0254 m |
| Hub diameter , | $D_h$ | = 0.028m |
| Eye diameter , | $D_o$ | = 0.053m |
| Inlet diameter , | $D_1$ | = 0.054 m |
| Outlet diameter , | $D_2$ | = 0.17m |
| Inlet width , | $b_1$ | = 0.0098m |
| Outlet width , | $b_2$ | = 0.0025 m |
| Number of vanes , | z | =19 |

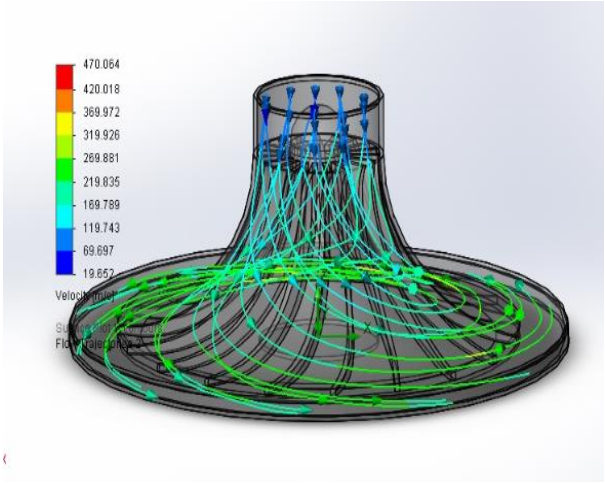


Figure.4 Velocity distribution of centrifugal compressor impeller (flow trajectories- side view)

## 3. FLOW SIMULATION

In this study, the SolidWorks simulation is used to analyze the pressure and velocity distribution of centrifugal compressor impeller. The first step of simulation is the user would work with a impeller assembly model in SolidWorks, accessing SolidWorks flow simulation via a menu heading in SolidWorks and follow these steps. The Wizard is selected from the SolidWorks flow simulation menu and firstly chooses the configuration for the analysis as well as the unit system requirement. To determine the boundary condition at inlet and outlet of impeller cover, the inlet boundary condition is the inlet mass flow rate and outlet boundary condition is the discharge pressure. Next, choose the working fluid, which in this case is air. The program has a library of commonly used liquids and gases from which to choose. Finally select the resolution of result on a scale from one to eight. The higher the number , the more refined the mesh will be and the more accurate the results.

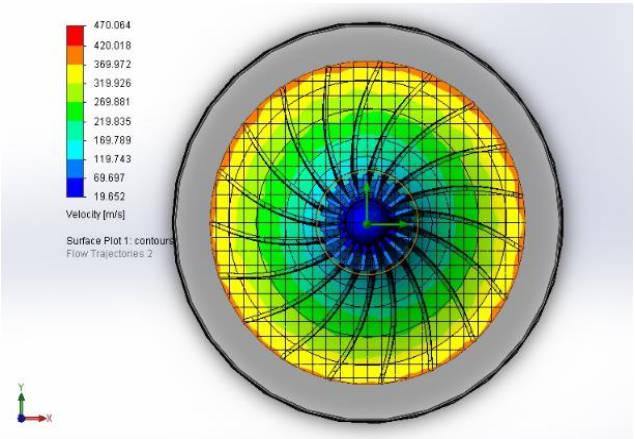


Figure.5 Velocity distribution of centrifugal compressor impeller (surface plots - top view)

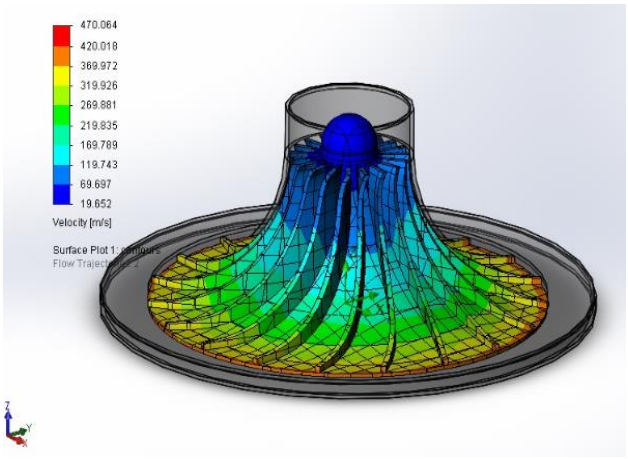


Figure.6 Velocity distribution of centrifugal compressor impeller (surface plots - side view)

Figure 4, 5 and 6 illustrate the velocity distribution of centrifugal compressor impeller by using SolidWorks software. The inlet boundary condition is the inlet mass flow rate. The value of inlet mass flow rate is 1.5907 kg/s. The outlet boundary condition is the outlet pressure. The value of outlet pressure is 1799.595 kPa. The theoretical result of impeller inlet velocity $V_1$ is 117.566 m/s and outlet velocity $V_2$ is 338.664 m/s. The numerical result of inlet velocity rate is 69.697 to 119.743 m/s and outlet velocity rate is 319.926 to 369.972 m/s. So, theoretical result of impeller inlet and outlet velocity are nearly the same with numerical result.

## 4. CONCLUSIONS

Centrifugal compressors are compressible flow machine. Centrifugal compressor used in small gas turbines. This study can also be improved to gain a better understanding of the relationship between velocities and blade shape by using suitable theory. This research can support the production of centrifugal compressor impeller. Moreover, the flow simulation procedure is described in detail. . And this study shows the velocity distribution by using SolidWorks software. The existing value of impeller inlet and outlet flow are nearly equal with numerical research value.

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