Centrifugal Compressor

Submitted by Group - 2

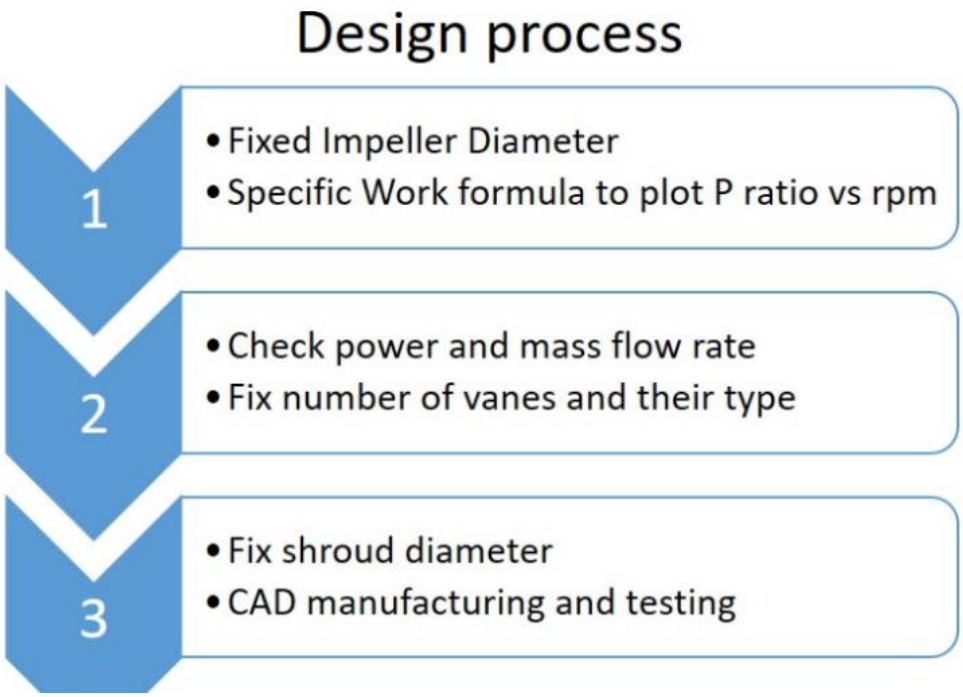
A small centrifugal compressor is to be designed for the Turbomachines course project.

The components needed to be designed:

- Impeller
- Diffuser
- Outer casing

Impeller is the heart of the centrifugal compressor. It is the main component to be designed.

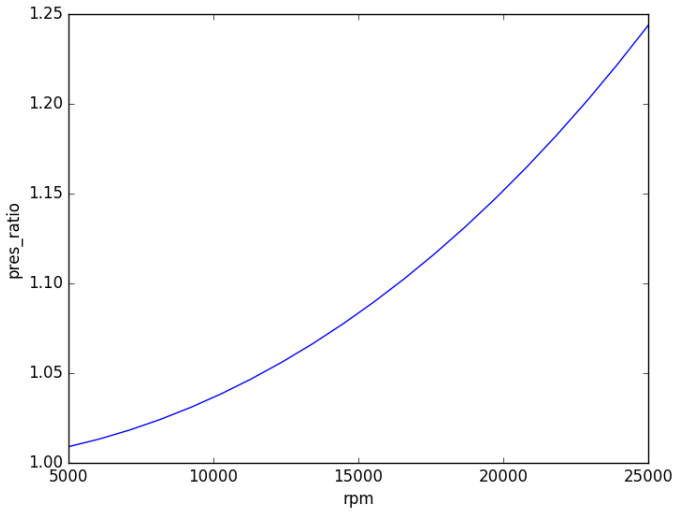
The design steps followed are shown below:



- An approximate impeller diameter is fixed based on cost and manufacturing constraints.
- The concept of specific work by thermodynamics and impeller physics is used to plot a relation between pressure ratio and rpm. The relations are given as:

$$W = \psi \rho U^2_2 = C_p \ (T_{02} - T_{01})$$

The power factor is calculated from the empirical relations given in design notes. Its chosen as 1.03. The pressure ratio is obtained by isentropic relations between total temperature and pressure. The plot between pressure ratio and rpm is shown below.

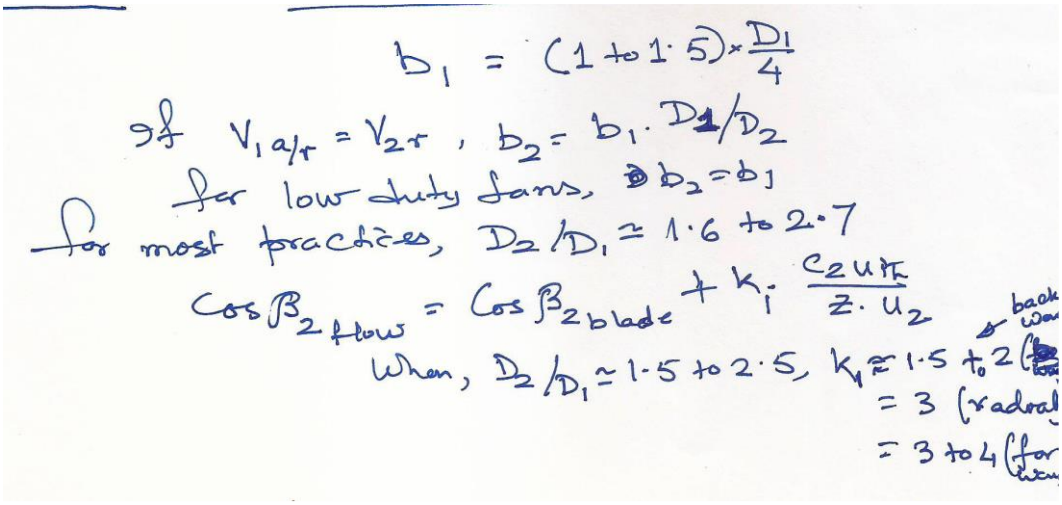


According to the potential motor a working rom of 10000 is chosen with a pressure ratio of 1.03. The power feasibility is checked if its within limits. It is below 230W as expected.

With this an impeller diameter of 11cm is fixed, with a mass flow of 5g/s.

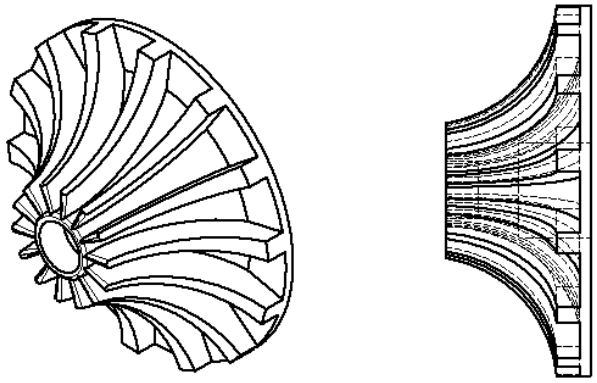
The next step is to fix the impeller vane shape and number of vanes. The vane shape is radial as the pressure rise from backward curved vanes could not computed.

The rest of the impeller parameters are computed from thumb rules in the Centrifugal Fan Design notes. A snippet of those rules is given:

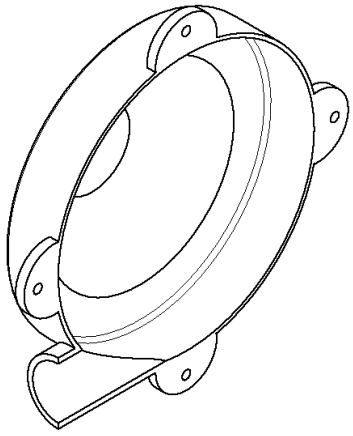


With this we get b1 = 3 cm and b2 = 1.2cm.

The impeller CAD model is made after this. All the thicknesses and other parameters are chosen keeping in mind the strength and manufacturing constraints.



The diffuser is designed after that, but it crosses the cost constraints for the project. Hence a simple small casing is chosen for the design leading to a loss of efficiency. The casing model is shown below:



The parts are manufactured using SLS 3D printer for better accuracy and finish. The assembly is made and the compressor is tested using pitot probes and a hand held manometer. The exit velocity is measured.

A pressure ratio of 1.016 is achieved as opposed to the design value of 1.03. This loss is due to:

- Improper design of diffuser
- Not using backward curved vanes
- Improper design of inlet leading a lot of noise and vibrations.

The overall specifications are summarized as:

- Impeller diameter: 11cm
- Casing diameter: 15 cm
- Pressure Ratio achieved: 1.016
- Exit velocity: 42 m/s
- Vanes: 14 radial vanes
- Impeller Diameter Ratio: 2.5

Testing of Centrifugal Compressor