Numerical Analysis of Centrifugal Blower Using CFD

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Abstract

Centrifugal blowers, which are designed for high rotating frequencies, generate high levels of noise. Thus noise reduction is a key parameter in the design of centrifugal blowers. The objective the present study is to estimate the aerodynamic and aeroaccoustic parameters like pressure, velocity and noise of centrifugal blower with three different types of impellers namely forward, backward and radial by numerical analysis. Reverse engineering method is used to get the dimensions of centrifugal blower. The modelling of the blower is performed by using Solid modelling software 2010 and blower is meshed with a three dimensional tetra mesh by using HYPERMESH 9.0. Numerical analysis is performed using CFD-Fluent software package for the three types of impellers.

Keywords: *Centrifugal blower, Impeller, Hyper mesh, Aero-dynamic, Aeroaccoustic.etc.*

1. Introduction

A centrifugal blower is a roto-dynamic blower that uses a rotating impeller to increase the pressure of a fluid. With the growing importance of blowers in industries, several researches have focused their work on subject. Different problems associated with the blower like noise and vibration reduction have been received due to concern. Son et al. [1] presented the effects of bell mouth geometries on the flow rate of centrifugal blowers were numerically simulated using a commercial Computational Fluid Dynamics (CFD) code, Fluent. Ramesh kumar et al. [2] observed that mechanical malfunctions such as, rotor unbalance and shaft misalignment are the most common causes of vibration in rotating machineries. Chen-kang and Hsieh [3] explained the performance analysis and optimized design of backward-curved airfoil centrifugal blower. CFD package FLUENT is used to simulate four backward curved air foil centrifugal blowers. Kolla et al. [4] proposed to carry out a study to evaluate the effectiveness of composites in reducing noise levels of the casing. Jianfeng et al. [5] conducted experimental study to reduce the noise of the centrifugal fan, whose impeller has equidistant forward-swept blades. Two new impellers with different blade spacing were designed for noise reduction. Moreland et al. [6] explained the housing effect of centrifugal blower. The sound power spectrum for a centrifugal blower operating at free delivery is characterized by enhancement at various frequencies owing to acoustical resonances in the blower housing.

Noise generated by a centrifugal blower can be divided according to its origin, into aerodynamically induced noise and vibration-induced noise. The contribution of the individual noise source to the total emitted noise is hard to determine, but it is crucial for the design of noise reduction measures. In order to reduce the noise of the centrifugal blower in a broad range of operating conditions, an identification of noise sources needs to be performed. The present blower is of 5 HP capacity with 12 blades is rotating at constant speed of 2550 rpm. The present work is aimed to determine the aerodynamic and aero acoustic analysis of centrifugal blower with numerical analysis by using FW-H equation coupled with LES computer code based on cell-centered finite volume method (FVM) on unstructured meshes for viscous flow field around blower.

2. NUMERICAL ANALYSIS

The Numerical solution have been carried out with a finite volume code method using viscous model as it is used because it needs time dependent solution for aeroaccoustic solution and it is highly dependent to geometrical conditions. . For unsteady-state simulations, the Multiple Reference Frames (MRF) model is used. Surfaces that rotate relatively are defined as “moving wall”. Moreover, as they are dependent on the fluid around them and as they rotate, they are defined as “relative to adjacent cell zone” and “rotational motion”. Cylinder walls are defined as “stationary wall” and the inlet Fluent.the turbulent flow is incorporated through LES. LES is chosen as and defined as pressure inlet and outlet. Fluid Zone in the inner volume is defined as “MRF” and rotates with 2550 r.p.m in X-direction.the pressure and velocity distrubution of backward impeller obtained from fluent software.

2.1 Modelling and Meshing of Centrifugal Blower

Reverse engineering method is used to obtain the dimensions of the centrifugal blower with forward, radial, and backward curved impeller blades and modelled using Solid works 2010. In order to model the centrifugal blower it is necessary to model the parts of the blower which are spiral casing, impellers, pulley, shaft, hub, suction arrangement, supporting structure then it was assembled to forward, radial, and backward curved impeller blades positioned in housing between two housing faces that are spaced apart along the impeller axis. A bell mouth shaped inlet is attached to the one of the facing and the housing is substantially closed with exception of the inlet and outlet. The impeller is attached to the hub which is keyed to the shaft. The solid model is imported as surface set to HYPERMESH 9.0 in ANSYS environment. The solid model is repaired by toggle section option the gaps are stitched. After repairing, the closed surface set was converted into solid. Each component was loaded in the separate component collector. The model was tetra meshed in volume tetra mesh by considering various values like element size, featured angles of the elements and by selecting gradual mesh. After convergence total 439506, 441314 and 435689 elements are for entire blower with backward radial and forward impellers respectively. Fig. 1 and Fig. 2 shows the solid model and meshed model of backward impeller.

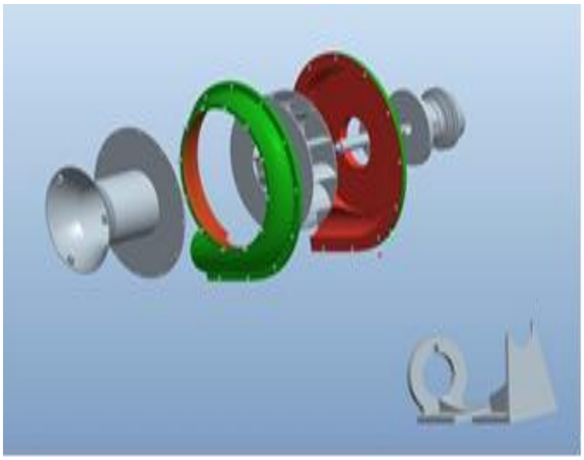

Figure.1 solid model of blower

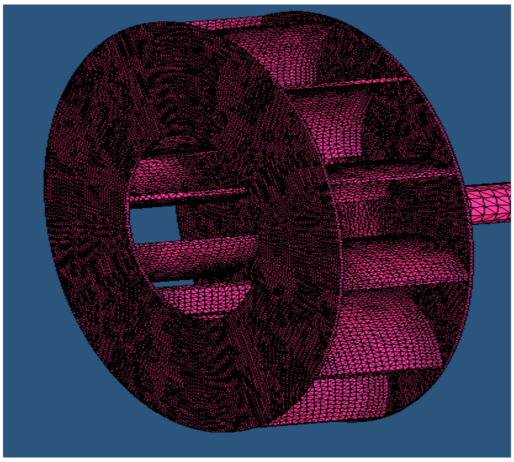

Figure.2 Meshed Model of backward impeller

3. Results and Discussions

The aerodynamic and aeroaccoustic properties of blower with radial, forward and backward impellers are predicted with numerical simulations (CFD-Fluent software).Table.1 shows the aerodynamic and aeroaccoustic results from this table it shows that blower with backward impeller having more velocity and pressure compared with other forward and radial impellers. The results shows that blower with backward impeller was generating less noise (92.2dB) compared with other forward and radial impellers. Fig3.shows the pressure distribution of backward impeller across the blower was observed as 103.8N/m^2 and Fig.4 shows the velocity distribution of the backward impeller across the blower was observed to be 99.4m/s and Fig.5 shows the noise prediction graph at inlet of blower from numerical simulations with Fluent software.

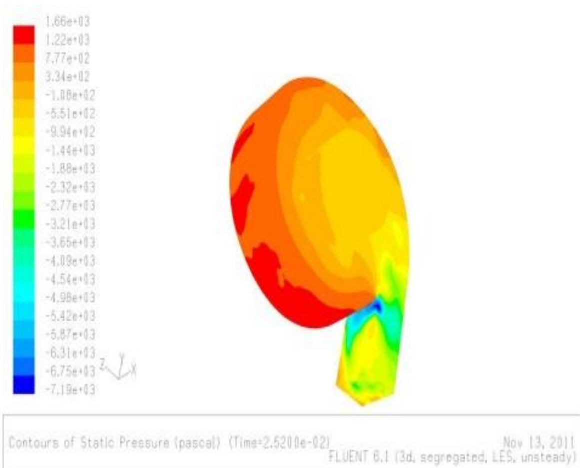

Figure 3. Pressure distribution across backward Impeller

Table 1. Aerodynamic and Aeroaccoustic Results

Vane Type	Aeroaccoustic Results		Aerodynamic Results	
	Inlet (dB)	Outlet (dB)	Pressure (N/m^2)	Velocity (m/s)
Backward	92.2	90.1	103.8	99.4
Forward	101.8	99.4	92.2	90.1
Radial	98.1	96.1	101.5	98.6

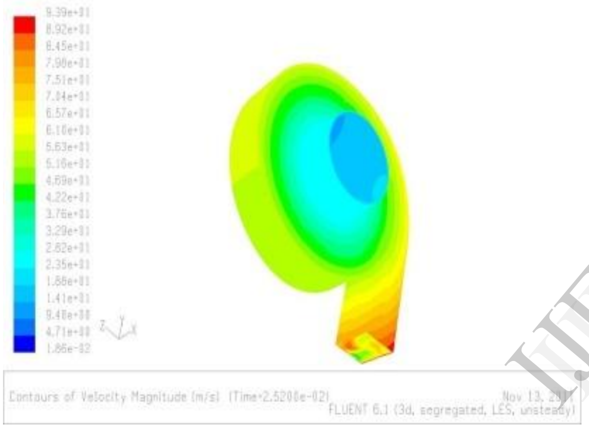

Figure 4. Velocity distribution across backward impeller

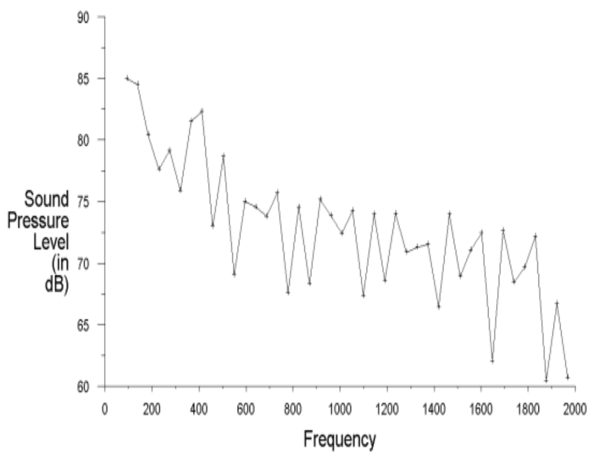

Figure 5. Noise prediction graph at inlet of blower

4. CONCLUSIONS

The aerodynamic and aeroaccoustic parameters of centrifugal blower with forward, backward and radial impellers with are measured and these results are obtained from CFD-Fluent software. From this analysis it is concluded that backward impeller generates less noise and high pressure compared to other forward and radial impellers.

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