International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Weight Optimization & Vibration Analysis of Centrifugal Blower by FEA

Mr. Basavraj S. Chiloba[a] , Prof. K.S.Mangrulkar[b]

[a] *Student,N.B.N. Sinhgad College of Engineering, Solapur 413255, INDIA.*
[b]*Professor,N.B.N. Sinhgad College of Engineering, Solapur 413255, INDIA.*

A B S T R A C T

Centrifugal blower are used extensively for on-board naval application have high noise and vibration levels. This noise produced by rotating component is mainly due to random loading force on blades and periodic iteration of incoming are with the blades of the rotor. The contemporary blades in naval application are made up of aluminium or steel and generated noise that causes disturbance to the people working near the blower. This research paper aims at examining the choice an alternative metal for better vibration control and weight optimization. For the FEA analysis purpose we used modelling software CATAI V5R20, and for analysis purpose we used ANSYS V16.0. We considered three different materials viz. Mild Steel, Aluminium 1060, SS316L with respect to different industrial application. Modal analysis is performed on all the three materials to find out first six natural frequencies.

Keywords: Centrifugal blower, Modal analysis, ANSYS V16.0, FEA.

1. Introduction

Centrifugal blowers are widely used in various industrial applications. Centrifugal blowers are mainly composed of two main parts, the casing and the impeller. The impeller is often considered an integral part of a vacuum motor because its housing and motor are assembled as one unit. The principles involved in the design of fans are almost similar in all respects important to centrifugal pumps, except that the term "centrifugal pump" is often associated with the fluid as the operating fluid.While the fan is said to run on air [1]. The effect of centrifugal force on the rotating air inside the impeller creates suction centre, creating a partial vacuum that helps circulate more air through the wheel, as shown in the figure below.

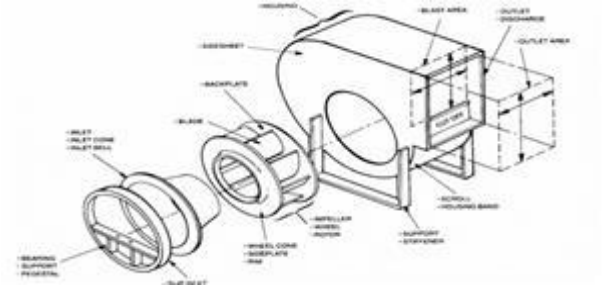

Fig. 1 - Centrifugal Blower

* *Corresponding author.* Tel.: +0-000-000-0000 ; fax: +0-000-000-0000.
E-mail address: author@institute.xxx

Centrifugal blowers are more like centrifugal pumps than fans. The impeller usually gear-driven and rotates at 15,000 rpm. In multi-stage blowers, air is accelerated as it passes through each blade. In single stage blower, there is very less rotation for air and hence it is more efficient. Centrifugal blowers typically operate at a pressures of 0.35 to 0.70 kg/cm2, but higher pressurescan be achieved.

2. Literature Survey

[1] Effect of Impeller Parameters on the Flow inside the Centrifugal Blower using CFD, International Journal of Recent Technology and Engineering (IJRTE)ISSN: 2277-3878, Volume-8 Issue-6, March 2020. In this paper work a numerical analysis is carried out to understand the different impeller configurations of centrifugal blower with the help of GAMBIT 2.4.6 and FLUENT 6.3.26 software.

[2] Optimization of critical parts of centrifugal blower by Modal &CFD Analysis, International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163Volume 1 Issue 12 December 2014. In this research work the optimization of small but critical parts of centrifugal blower is done with the help of ANSYS CFD software. Here food grade metals are used for the analysis purpose.

[3] Static and Dynamic Analysis of a Centrifugal Blower Using FEA, International Journal of Engineering Research & Technology (IJERT) Vol.1 Issue 8, October-2012 ISSN: 2278-0181, in this research work static and dynamic analysis is done to reduce the vibration and impact. The current research work aims to examining the choice of composites as an alternative material for better vibrational control. This research work was done with the help of Hypermesh 10.0 and ANSYS software to perform Modal analysis on Aluminium and composite blower.

[4] Numerical Analysis of Internal Flow Field of Multi-Blade Centrifugal Fan for Floor Standing Air- Conditioner, Jia Bing Wang Huazhong University of Science and Technology, here numerical analysis of internal flow field of multi-blade centrifugal fan for floor standing Air- Conditioning system is done to optimize blower discharge. This research examines the effect of splitter vanes corresponding to various geometrical locations on the impeller and diffuser.

[5] A Numerical Study the Acoustic Characteristics of a Centrifugal Impeller with a Splitter, Technical Research Lab, CEDIC Ltd., #1013, Byuksan Digital Valley, Kasan-dong. In this research work, numerical study was done on acoustic characteristics of centrifugal impeller with splitter. These are mainly used in gas turbine engines due to their ability to create high pressure ratio in relatively smaller working area. But this also causes the major problem of high noise and frequency. In the present research work we are going to study on this problem.

[6] Evolution of Static & Dynamic Analysis of a Centrifugal Blower Using FEA, International Journal of Advanced Trends in Computer Science and Engineering (IJATCE), Vol.2, Issue 7, January – 2013. Here static and dynamic analysis of blower is done to reduce its vibration and impact. Centrifugal blowers are used widely in naval applications. The noise level of such blowers increases due to random loading force and periodic iterations. It happens because of conventional material used for fan blades. This research work deals with study of different materials used as blower and to analyse their effect on vibrations and noise. Modeling and analysis work is done in CATIA V5 R19 software and ANSYS software respectively.

3. Scope and Objective

This research work comprises with study of metallic blower used for air conditioning and ventilation purpose in naval applications where high vibration and noise occurs during its operations. Also we are going to study the effect of blower corrosion issue in food industry to avoid its mixing in the food. Weight optimization is also one of the area of study of this research work which can be achieved by using different materials and change in geometry.
Materials which we are going to study for this research work are as follows:

- Mild Steel
- Aluminium 1060
- SS316L (Food Grade Steel)

4. Problem Definition

After study of previous research work presented, we come to notice that the numerical work as well as analytical work is done on the centrifugal blower from the point of view of vibration with mechanical industrial grade materials and very less work is done on consideration of other industries like food industry, Naval applications etc. To overcome this problem, we are going to study for those areas and their respective materials for the work application.

5. Methodology

To achieve our objective of research work, we are going to follow below mentioned methodology of work

- Study of Materials and parameters of present blowers.
- Mathematical Calculations.
- Modeling
- Analysis work
- Result and discussion
- Conclusion

5.1 Study of material and parameters

Industrial use of blowers according to selected materials are given as follows:

- **Mild Steel Blower** – These are widely used blowers in exhaust systems of furnace, boilers, oven etc.
- **Aluminium 1060** – This material gives high stability with good corrosion resistance. It widely used in automobile sector as cooling fan and ventilation purpose where weight is criteria.
- **SS316L** – This material is extensively used in food industry to avoid corrosion level.

Following are the parameters for the present Centrifugal blower:

- Type –Flanged mounted type centrifugal blower
- Flow rate – 12000 cfm (cubic feet meter)
- Operating temperature - 16℃
- Fan RPM – 1440
- Power output – 13.91 HP
- Efficiency – 85%
- Motor Power – 12 HP
- Torque – 6.91 Kg-m
- Noise Level – 88db

Following table gives us brief idea about the materials mechanical properties which we are going to analyse

Table 1 –Material Properties

Properties	Mild Steel	Aluminium 1060	SS316L
Density (Kg/m^3)	7880	2700	8000
Poisson's ratio	0.28	0.33	0.25
Young's Modulus (GPa)	205	71	193
Yield Strength (MPa)	270	117	205

5.2 Mathematical Calculation

We are going to find out the natural frequency of the blower for all the three materials to avoid resonance. We are going to consider impeller as a rotating mass for mathematical calculation purpose.

For finding natural frequencies we are going to use following formulae

- Torsional Stiffness of shaft –$k\_t = \ (G.J)/l = (G.(\pi/32 \times d\text{^}4\ ))/l$
- Torsional natural frequency – $\omega\_nf = \sqrt{(k\_t/I\_p\ )}$

Where,

k_t = the torsional stiffness of shaft

I_p = the polar mass moment of inertia of the disc

J = the polar second moment of area of the shaft cross-section

l = the length of the shaft

d = the diameter of the shaft

With the help of above formulae we can achieve the calculations for finding resonance frequencies of the required materials. Input values for the above formulae are given in the following table.

Table 2–Input Values

Material	Mass (Kg)	I_p (Kg.m^2)	d (mm)	l (mm)
Mild Steel	36.44	2.256	40	80
Aluminium 1060	12.56	0.778	40	80
SS316L	37.08	2.296	40	80

By using above values as an input values for the given formulae we got the results of the given materials and the natural frequencies are 333.75 Hz, 409.87 Hz and 287.30 Hz respectively.

5.3Modeling and Analysis Work

Modeling of the research work is done with the help of Creo 5.0 software as it have wide range of tools and many other software formats are supported to this software so we can get more transferability of the model into different applications as per the requirement. After completion of the model in the design software, we later transfer this file to the analysis software. Here we are using ANSYS 16.0 as our analysis software because it gives more accurate results for the problems of natural frequencies. To use the model in the ANSYS software we need to convert the existing model file into STEP or IGS format so that it can be viewed in the analysis software. Following figures shows the modeling and analysis software's user interface.

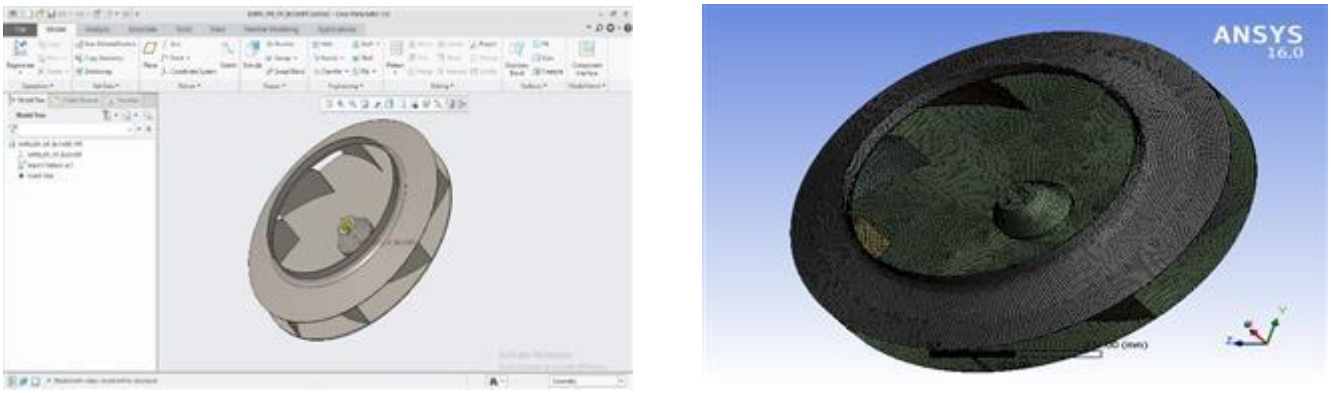

Fig. 2–(a) Creo Model; (b) Mesh Model in ANSYS

5.4Result and Discussion

First 6 natural frequencies and shape modes are found out for all three materials with their respective deformations which can be given as follows

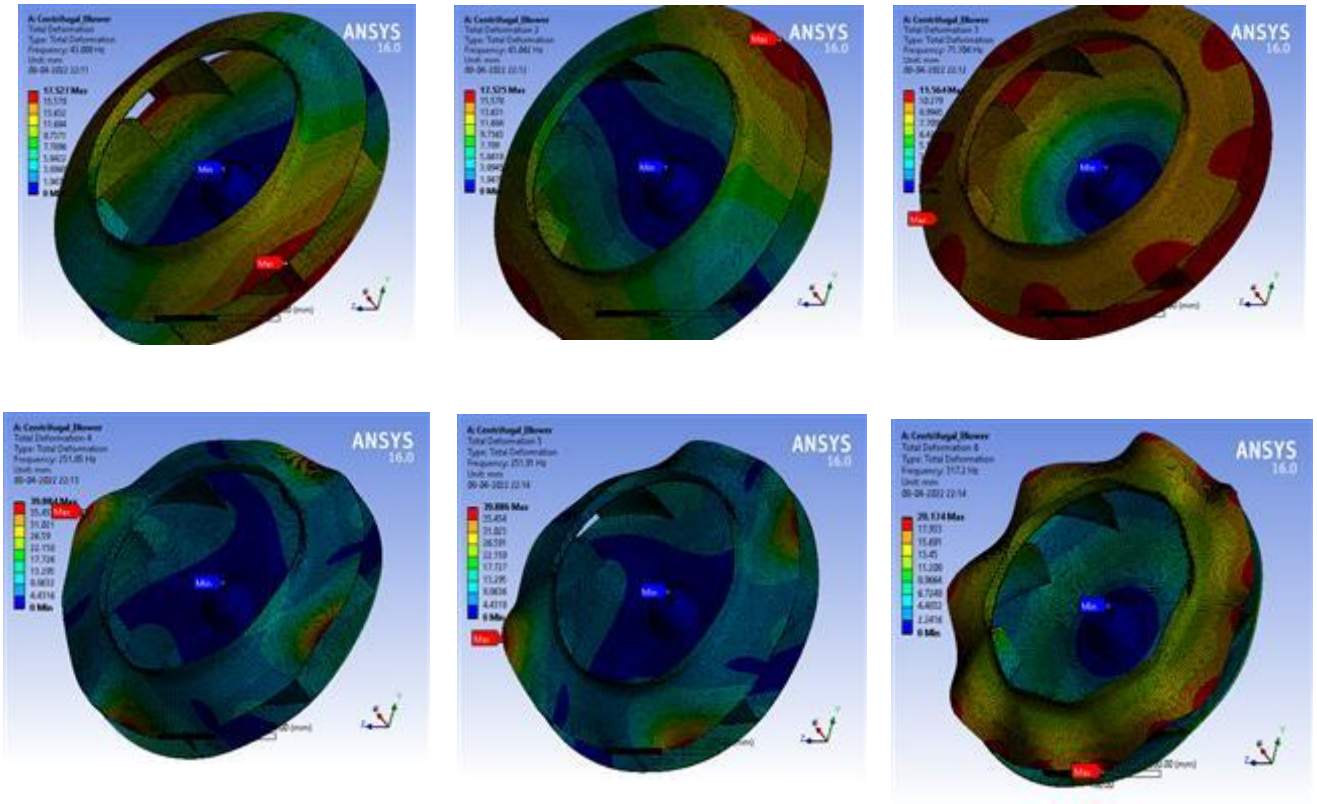

Fig. 3–Mode Shapes and their respective deformation for M.S. Material

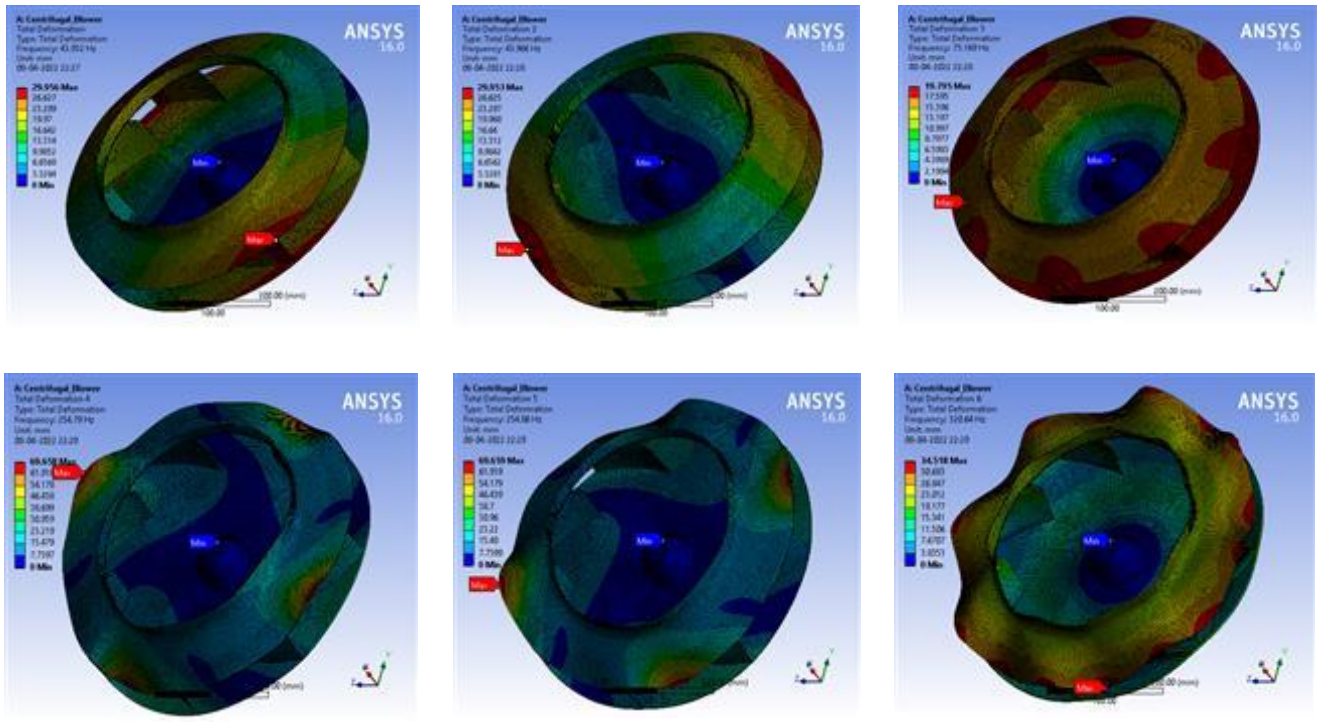

Fig. 4–Mode Shapes and their respective deformation for Aluminium 1060 Material

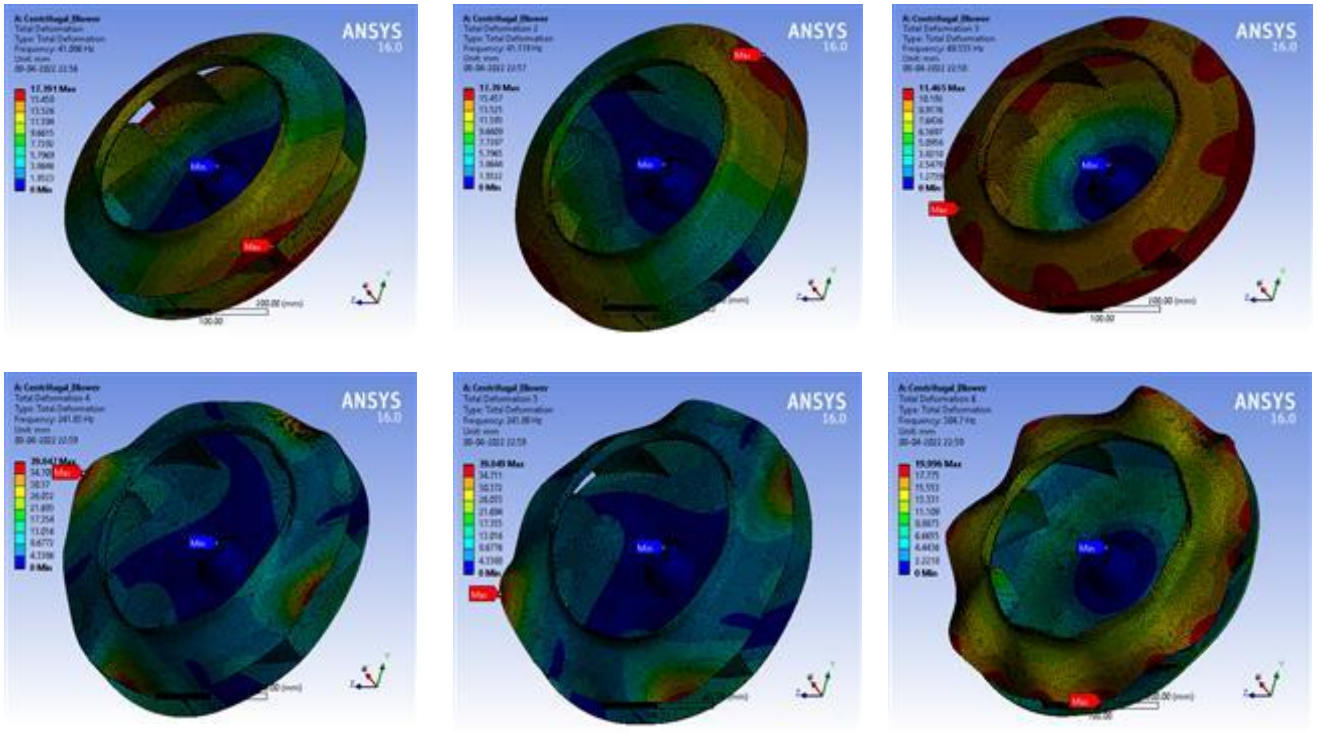

Fig. 5–Mode Shapes and their respective deformation for SS316L Material

Above figures illustrates the shape mode of natural frequencies and their respective deformations. From the obtained result we came to notice that the natural frequencies obtained from the analysis not exceeding the values of the natural frequencies of the mathematical values so we can say that all the materials are safe for the first 5 frequencies to operate so that there will not be any resonance in the centrifugal blower models. Detailed values of shape modes and deformations are tabulated with the graph given below.

Table 3–Result Table

Shape Modes	Natural Frequency (Hz)			Deformation (mm)		
	Mild Steel	Aluminium 1060	SS316L	Mild Steel	Aluminium 1060	SS316L
Mode 1	43.008	43.932	41.086	17.527	29.956	17.319
Mode 2	43.042	43.966	41.119	17.525	29.953	17.390
Mode 3	71.704	73.169	68.533	11.564	19.795	11.465
Mode 4	251.85	254.79	241.83	39.884	69.658	39.047
Mode 5	251.91	254.86	241.89	39.886	69.059	39.049
Mode 6	317.2	320.64	304.7	20.174	34.518	19.996

5.5Conclusion

Modal analysis is done to determine the vibration characteristics of a structure or machine component. From above results of mathematical calculations and analytical approach, following points can be concluded:

- All the blower materials are safe as the impeller speed is 24 Hz which does not matches with the analytical frequency values.
- First critical speed of blower is less than that of mathematical values. If the operating speed frequency of the impeller matches with the natural frequency of the fan then vibration failure will occur with high noise.
- From above result we conclude that, fan is not safe to run at the obtained natural frequencies.

REFERENCES

Yogesh R Pathak, Kailas D Deore, Rohan R Ozarkar, (2020). Effect of Impeller Parameters on the Flow inside the Centrifugal Blower using CFD, International Journal of Recent Technology and Engineering (IJRTE)ISSN: 2277-3878, Volume-8 Issue-6.

Kusekar S.K.,Prof.Lavnis A.K., (2014). Optimization of critical parts of centrifugal blower by Modal &CFD Analysis, International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163Volume 1 Issue 12 (December 2014).

KarthikMatta, KodeSrividya, Inturi Prakash, (2014). Static and Dynamic Response of an Impeller at Varying Effects, IOSR Journal of Mechanical and Civil Engineering (IOSRJM CE) e ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11, Issue 1 Ver. III pp 101-106.

VeeranjaneyuluItha, T.B.S.Rao, (2012). Static and Dynamic Analysis of a Centrifugal Blower Using FEA, International Journal of Engineering Research & Technology (IJERT) Vol.1 Issue 8, ISSN: 2278-0181.

Wan-Ho Jeon, (2019). A Numerical Study the Acoustic Characteristics of a Centrifugal Impeller with a Splitter, Technical Research Lab, CEDIC Ltd., #1013, Byuksan Digital Valley, Kasan-dong.