Static and Dynamic Analysis of Centrifugal Blower Impeller using FEA

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Abstract - Centrifugal blower used extensively for boiler applications have high noise levels. The noise produced by a rotating component is mainly due to random loading force on the impeller blades. It is important to recognize that the design of any machine is an interdisciplinary process, involving aerodynamics, thermodynamics, fluid dynamics, stress analysis, vibration analysis, the selection of materials, and the requirements for manufacturing. Though centrifugal fans have been developed as highly efficient machines, design is still based on various empirical and semi empirical rules proposed by fan designers. Further the scope of work was extended towards performance evaluation of unified design along with comparative assessment of centrifugal fans. A multi-disciplinary approach to evaluate existing fan systems design for root causes of overall vibration problems and development of methods to solve them. To optimize impeller which holds the advantage over right now no matter for its process features or mechanical properties. At last, proposing a rationalize design such that, its natural frequency are far away from the basic frequency of the fan. The modeling of the blower and impeller was done by using solid modeling software, CATIA V5 R19. It is proposed to design a blower with Aluminum, analyze its strength and deformation using FEM software.

***Keywords* - Centrifugal Blower, Impeller, Static, Modal and Harmonic Response, CATIA V5 R19, ANSYS 14.5.7**

I. INTRODUCTION

Fans and blowers provide air for ventilation and industrial process requirements. Fans generate a pressure to move air (or gases) against a resistance caused by ducts, dampers, or other components in a fan system. The fan rotor receives energy from a rotating shaft and transmits it to the air. Blowers are one of the important component used regularly in Boiler operation. High efficient fans can increase Boiler efficiency. They are used to supply air for combustion of fuel in boiler furnace using Forced Draught (FD) fan, installed in front side of furnace supplying air either at normal temperature or at elevated temperature, if air is supplied using air-pre heater. The fans must have a pressure capability high enough to overcome the total resistance of inlet silencers, air preheat coils, air ducts, air heaters, wind boxes, burner registers, and any other resistance between the air intake of the fan and the furnace. The flue gases generated after combustion of fuel can be drawn out using Induced Draught (ID) fans. They maintain furnace pressure slightly below atmospheric. Primary Air (PA) fans are used to supply combustion air for atomization of pulverized fuel. Secondary Air (SA) fans are used to convey pulverized fuel through duct conveying system. Generally FD,SA and PA are direct-drive fans whereas ID fan is belt-driven fan. The present work aims at reducing vibration levels below permissible levels.

LOADING CONDITION AND CASE DESCRIPTION

There are three types of loading that actually act on the centrifugal fan impeller. The first one is the centrifugal force because of impeller rotation that resulted in centrifugal acceleration of the impeller body. The second is that resulted from thermal expansion caused by temperature rising. The last one is the aerodynamic force from pressure conversion between the blade and the air.

The impeller considered for case study has OD660mm, ID200mm, Width of blade at leading edge 45mm, Width of blade at trailing edge 30mm, thickness of back plate 4 mm, thickness of blades 4 mm and shroud 3 mm. Number of blades is 12.Speed of impeller is 2900 rpm. The modified impeller considered for case study has same dimensional considerations except, thickness of back plate 6 mm, thickness of blades 5 mm and shroud 4 mm.

II. STEPS IN PROJECT WORK

A. Modeling by Using CATIA V5 R19

Modeling of Impeller is done using 3D software CATIA V5 R19. The material used for impeller manufacturing is Structural Steel. Steel has Density 7850 kg/m3 , Yield Strength 250 MPa, Ultimate Tensile Strength 460 MPa, Poisson's Ratio 0.3 and reference temperature taken is 22^{O} C.

1.
2. B. Analysis Of Centrifugal Blower Using ANSYS14.5.7

The analysis of centrifugal blower has been carried out by using ANSYS 14.5.7 general purpose FEM software. Meshing of the same is been done in ANSYS itself. The total number of Nodes and Elements generated were 345010 and 172137 respectively for existing impeller. The total number of Nodes

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and Elements generated were 298079 and 149669 respectively for modified impeller.

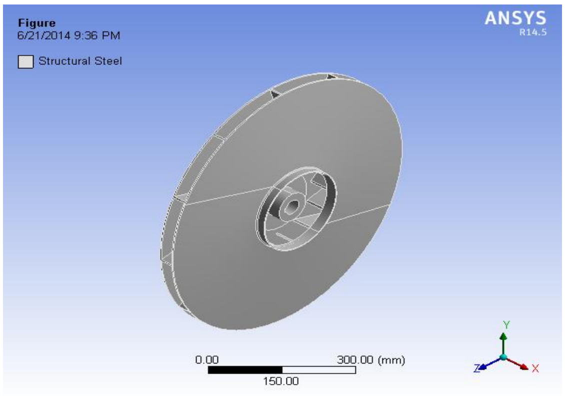

Fig. 1 Modelling of Centrifugal Fan Impeller

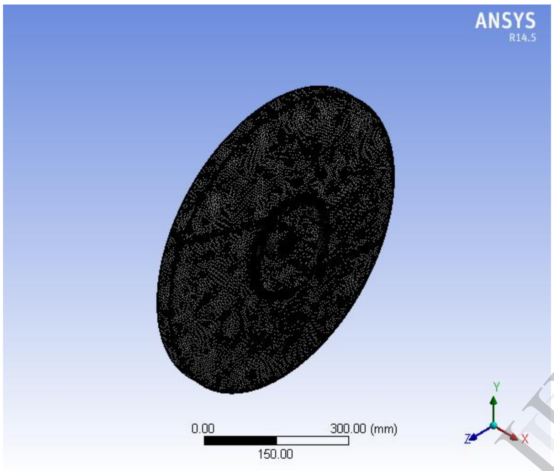

Fig. 2 Meshing of Centrifugal Fan Impellerr

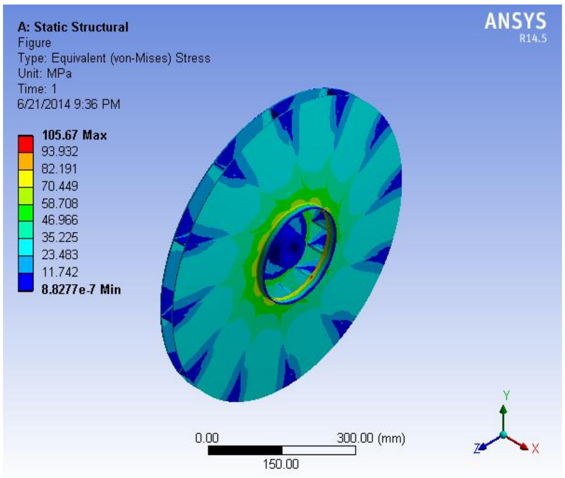

Fig. 3 Equivalent (Von-Mises) Stress of existing Impeller

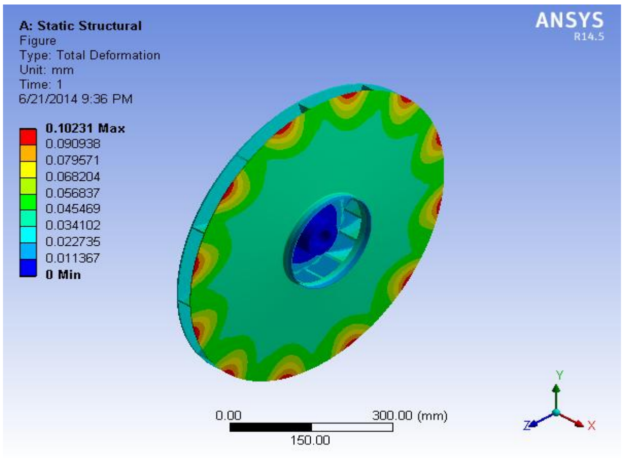

Fig. 4 Total Deformation of existing Impeller

Mode	Frequency [Hz]
1.	99.666
2.	99.769
3.	258.19
4.	376.85
5.	376.95
6.	413.38
7.	593.09

Fig. 5 Pre-Stress Modal Analysis frequency of existing Impeller

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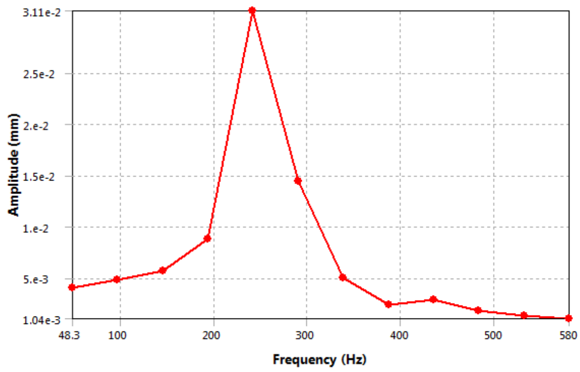

Fig. 6 Deformational Amplitude (x axis) V/s Frequency of existing Impeller

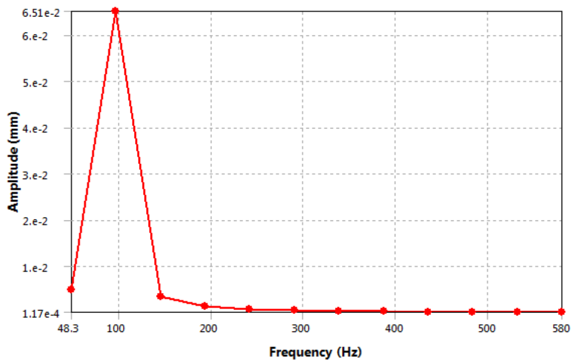

Fig. 7 Deformational Amplitude (y axis) V/s Frequency of existing Impeller

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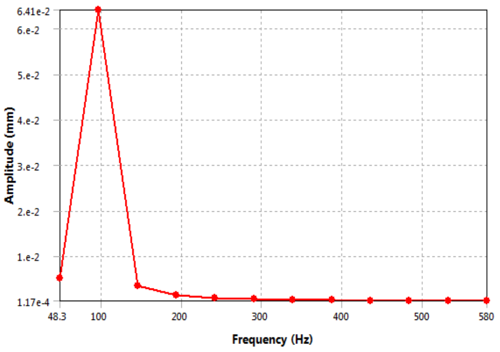

Fig. 8 Deformational Amplitude (y axis) V/s Frequency of existing Impeller

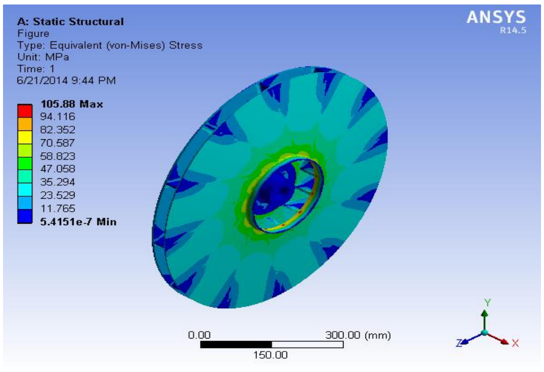

Fig. 9 Equivalent (Von-Mises) Stress of Modified Impeller

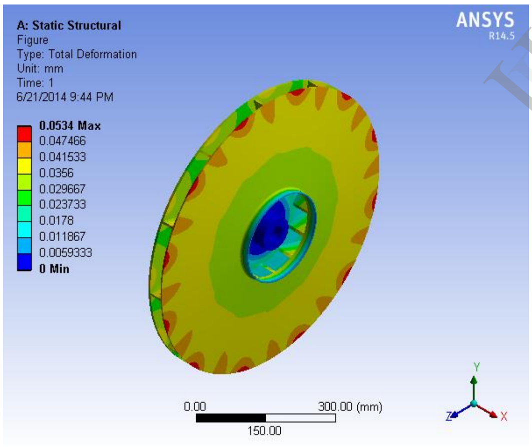

Fig. 10 Total Deformation of Modified Impeller

Mode	Frequency [Hz]
1.	122.33
2.	122.42
3.	315.
4.	403.86
5.	414.44
6.	414.51
7.	695.92

Fig. 11 Pre-Stress Modal Analysis frequency of Modified Impeller

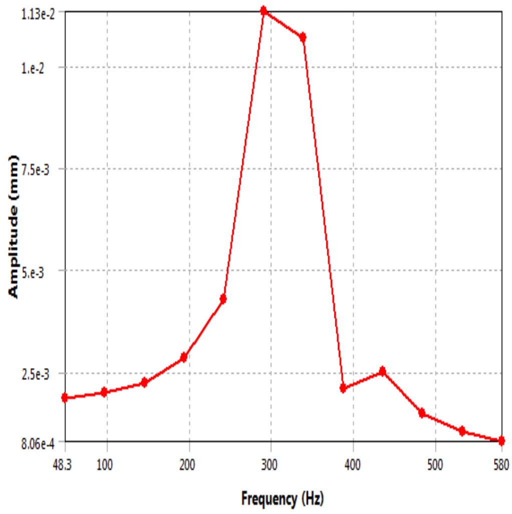

Fig. 12 Deformational Amplitude (x axis) V/s Frequency of Modified Impeller

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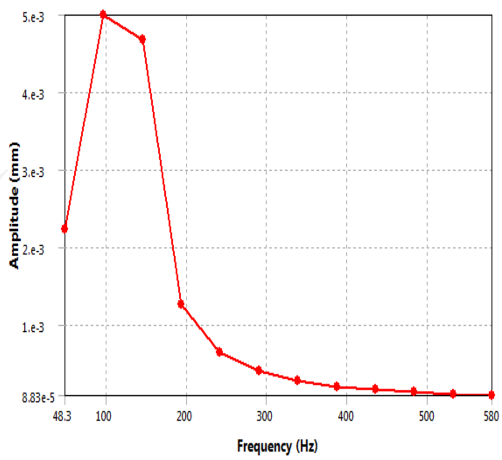

Fig. 13 Deformational Amplitude (y axis) V/s Frequency of modified Impeller

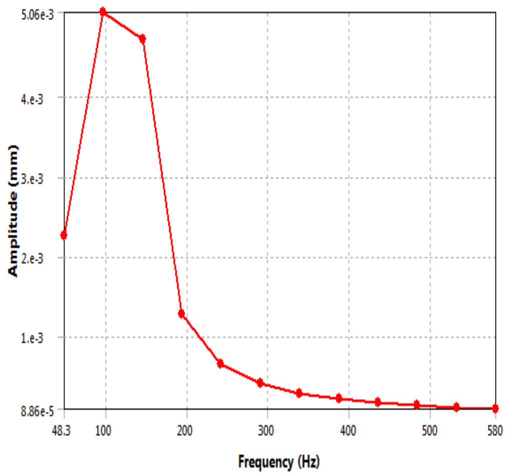

Fig. 12 Deformational Amplitude (z axis) V/s Frequency of Modified Impeller

III. RESULTS AND DISCUSSION

Static and Dynamic analysis was carried out using ANSYS 14.5.7 .There was no significant difference for Equivalent (Von-Mises) stress which was around 105 MPa for both cases. Total deformation of existing and modified impeller was 0.10231 mm and 0.0534 mm respectively . In existing impeller its first modal frequency i.e. 99 Hz is closer to 2X frequency of fan i.e. 96Hz. After modifying the impeller the first modal frequency was shifted to 122 Hz. . Frequency Response of Displacement Amplitude (mm) versus Frequency (Hz) was carried out in x, y and z direction Directional deformation obtained for existing impeller in the form of amplitude in x, y, z is 0.0311 mm, 0.0651 mm and 0.0641 mm respectively. Directional deformation obtained in the form amplitude in x, y, z is 0.0113 mm, 0.005 mm and 0.00506 mm respectively for modified impeller.

TABLE I RESULT FROM ANALYSIS

Impeller / Parameter	Existing	Modified
Equivalent Stress (MPa)	105.67	105.88
Total Deformation (mm)	0.10231	0.0534
x-axis amplitude v/s frequency	0.0311	0.0113
y-axis amplitude v/s frequency	0.0651	0.0050
z-axis amplitude v/s frequency	0.0641	0.00506

IV. CONCLUSION

1. Analysis show that modified impeller is more vibrationally stable than previous one .
2. Maximum Von-Mises stress are induced in Air inlet of shroud.
3. Prestressed first modal frequency was shifted from 99Hz to 122Hz for modified impeller
4. Total Deformation is less in modified impeller as compared to inbuilt impeller
5. Deformational Amplitude in harmonic response analysis is less for modified impeller in all directions.

V. FUTURE SCOPE OF WORK

In future scope for work, the fan can be simultaneously designed by simulation checking for both flow and structural performance. Also now-a- days materials like aluminium and GRPF (materials) are replacing structural steel these can be thought of as alternative unless proving their reliability.

VI. ACKNOWLEDGMENT

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