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Optimization of Industrial Blower

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Abstract: Blowers are one of the types of turbo machinery which are used to move air continuously with in slight increase in static pressure. Blowers are widely used in industrial and commercial applications from shop ventilation to material handling, boiler applications to some of the vehicle cooling systems. The performance of the fan system may range from free air to several cfm (cubic feet per min.). Selection of fan system depends on various conditions such as airflow rates, temperature of air, pressures, airstream properties, etc. Although, the fan is usually selected for nontechnical reasons like price, delivery, availability of space, packaging etc. The blower is always analyzed by its performance curves which are defined as the plot of developed pressure and power required over a range of fan generated air flow. Also these fan characteristic curves can be used to data like fan bhp for selection of the motor being used. As per the discussion with concern person of the company Foodosavy solutions, Chinchwad, Pune, Maharashtra. It is one of the leading companies in the field of fruit juice. They are facing many problems regarding centrifugal blower. They are using centrifugal blower for air conditioning and ventilation purpose, also they are using blower to maintain the temperature of food storages (Pulp storage).The present centrifugal blower is made up of from M.S. material here corrosion is a major problem. The ingredients of the same are mixing with fruit pulps, which is harmful, also weight of the present blower is high and vibrations produced by the given centrifugal blower is more, discharge of the present blower is 10.84 m3/s, which is somehow less as per the pulp area of the industry considered. This paper gives the solution to above some problems which are facing the industry i.e. Foodosavy solutions, Chinchwad, Pune.

I. INTRODUCTION

The present work aims at examining the choice of material as an alternative for better vibration control. SS316L is well known for their superior damping characteristics are more promising in vibration reduction compared to metals. The modeling of the blower was done by using solid modeling software, CATIA V5 R20. The blower is meshed with a three dimensional hex8 mesh is done using HYPERMESH 10 and analysis using ANSYS14.5. Centrifugal blowers are used extensively for food industrial applications have high corrosion levels. The corrosion produced by a continues contact with water and air. The contemporary blades in naval applications are made up of aluminum or steel and generate noise that causes disturbance to the people working near the blower. Blowers are one of the types of turbo machinery which are used to move air continuously with in slight increase in static pressure. Blowers are widely used in industrial and commercial applications from shop ventilation to material handling, boiler applications to some of the vehicle cooling systems.

The performance of the fan system may range from free air to several cfm (cubic feet per min.). Selection of fan system depends on various conditions such as airflow rates, temperature of air, pressures, airstream properties, etc. Although, the fan is usually selected for nontechnical reasons like price, delivery, availability of space, packaging etc. The blower is always analyzed by its performance curves which are defined as the plot of developed pressure and power required over a range of fan generated air flow. Also these fan characteristic curves can be used to data like fan bhp for selection of the motor being used. The centrifugal fans with impellers having blades of Airfoil section are considered as the high efficiency impellers among the six types Airfoil blades, Backward Inclined single thickness blades, Backward curved blades, forward curved blades, radial tip blades and radial blades. The present study gives the design methodology for these high efficiency impellers which include the numerical design procedure and the CFD analysis of it. The CFD part is used for improvement the results of Static Pressure generated at the entry to the impeller, static efficiency. The CFD optimization also helped to improve the flow pattern through the centrifugal fan system. Centrifugal turbo machines are commonly used in many air-moving devices due to their ability to achieve relatively high-pressure ratios in a compact configuration compared with axial fans.

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They are often found in gas turbine engines, heating ventilation and air conditioning systems, and hydraulic pumps. Because of their widespread use, the noise generated by these machines often causes serious environmental issues. The turbo machinery noise is often dominated by tones at blade passage frequency and its higher harmonics. This is mainly due to strong interactions between the flow discharged from the impeller and the cutoff of the casing. In addition to discrete tones, the broadband noise is also generated due to the separation, turbulence mixing, and the vortex interaction process. The idea of using splitter vanes in the blade passage of both impeller and diffuser is not new. Several works mostly experimental have been carried out to assess the suitability of the method. It is found that a numerical approach using a design analysis tool like CFD is of recent origin and the whole field flow analysis of the complex flow in a centrifugal fan has been the state of the art in the domain.

Ogawa and Gopalakrishnan , Bhargava and Gopalakrishnan , Fabri performed computations on splittered centrifugal rotors based upon potential flow models. Millour examined the same configuration using a 3-D Euler analysis with simplified viscous forces. They observed that the primary effect of the splitters was to decrease the loading on the main blades, as well as to reduce the jet/wake effect at the rotor exit. Fradin performed an extensive set of experiments on the flow fields of two centrifugal rotors: one with splitters, and one without. In both cases the flow field was transonic.

II. LITERATURE SERVEY

Static and Dynamic Analysis of a Centrifugal Blower Using Fea Veeranjaneyulu Itha1, T.B.S.Rao2, International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October - 2012 ISSN: 2278-0181, pp. 1-11.-In this project work this paperis used to study static and dynamic analysis of blower so as to reduce vibrations & impact.

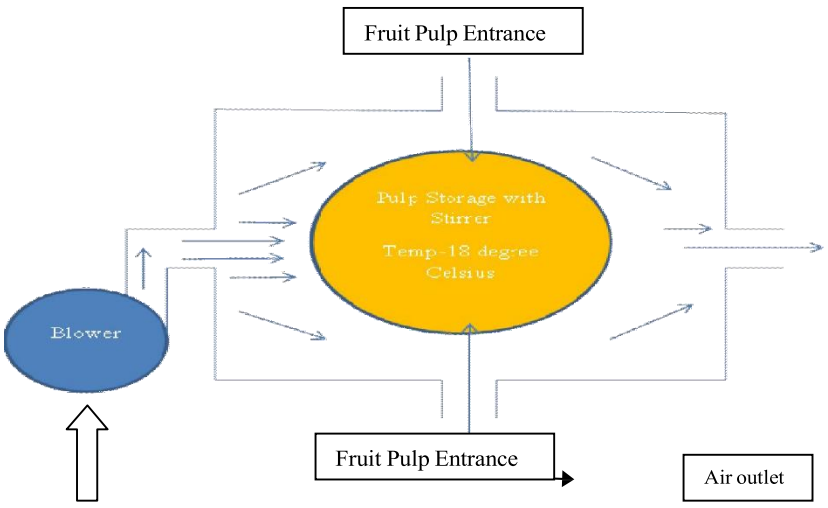
Numerical Design and Parametric Optimization of Centrifugal Fans with Airfoil Blade Impellers Atre Pranav C. and Thundil Karuppa Raj R. School of Mechanical and Building Sciences, VIT University, Vellore-632014, Tamilnadu, INDIA.- In this project work this paper is used to know how Numerical Design and Parametric Optimization of Centrifugal Fans with Airfoil Blade impellers help to improve the efficiency of blades & optimize the weight.

A numerical Study on the Acoustic Characteristics of a Centrifugal Impeller with a Splitter Wan-Ho Jeon1 1 Technical Research Lab., CEDIC Ltd., #1013, Byuksan Digital Valley II, Kasan- dong.-This paper is used to know Acoustic Characteristics of a Centrifugal Impeller with a Splitter.

Evaluation of Static & Dynamic Analysis of a Centrifugal Blower Using Fea Mohd Jubair Nizami, Ramavath Sunman, M.Guru Bramhananda Reddy, International Journal Of Advanced Trends in Computer Science and Engineering, Vol.2, Issue 7, January-2013, pp. - 316-321. -To study static and dynamic analysis of blower so as to reduce vibrations & impact.

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.-In this project work this paper is used to Numerical Analysis of Internal Flow Field of Multi- Blade Centrifugal Fan for Floor Standing Air- Conditioner so as to improve discharge of the blower i.e. this paper is used to study the CFD analysis of the blower.

PROBLEM IDENTIFICATION AND PROBLEM DEFINITION:



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Above fig (1) shows the plant layout of industry where the juice is produced. In this plant centrifugal blower is used for the ventilation purpose. As per the discussion with concern person of the company Foodosavy solutions, Chinchwad, Pune, it isfound that it is one of the leading company in Maharashtra and they are producing different types of juice. They are facing manyproblems regarding centrifugal blower. They are using centrifugal blower for ventilation purpose, also they are using blower to maintain the temperature of food storages (Pulp storage).The present centrifugal blower is made up of from M.S. material here corrosion is a major problem. The ingredients of the same are mixing with food, which is harmful, also weight of the present blower is high and vibrations produced by the given centrifugal blower is more, discharge of the present blower is 10.84 m^3/s, which is somehow less as per the pulp area of the industry considered.

SCOPE OF WORK:

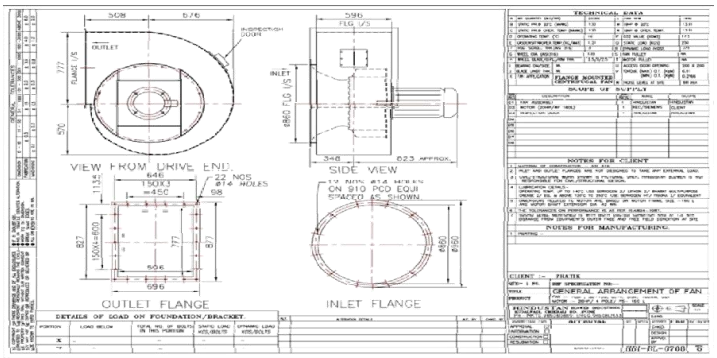
- As per the discussion with concern person of the company Foodosavy solutions, Chinchwad, Pune, it is found thatcurrently they are using Flanged Mounted type Centrifugal Blower (HBI-BL-0768). The specifications of the same are as follows:
- Type of blower: Flanged Mounted type Centrifugal Blower (HBI-BL-0768)
- Volume flow rate: 12000 cfm (cubic feet meter)
- Operating temperature: 16 degree centigrade
- Static pressure at operating temperature: 130 mm of Hg
- Size of blower/Wheel diameter(AISI316): 735 mm
- Fan RPM: 1440
- BHP at operating temperature: 13.91 HP
- Efficiency: 85%
- Motor Power: 12 HP, Torque: 6.91 kg-m
- Gas density at operating temperature: 1.21 kg/m3
- Static Load: 250 kg, Dynamic Load: 375 kg
- Noise Level at Site: 88 db
- The scope of this paper is also mentioned below:
- Study of present design of centrifugal Blower.
- Identification and problem finding.
- Collection of input data from Industry.
- Study of weight-dimensional parameters
- Study of Vibration and impact resistance.
- Study of Keeping of service life at transportation and changes in climate

OBJECTIVES:

- To reduce vibration problem of centrifugal blower by doing modal analysis for the material MS, SS316L (Food GradeSteel) using FEA.
- To determine natural frequency of the MS, SS, SS316L (Food Grade Steel) material.

To check discharge of blower by CFD analysis

III. METHODOLOGY



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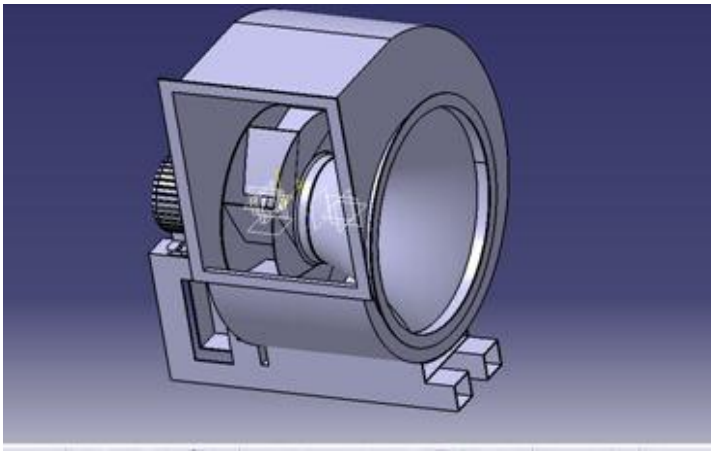
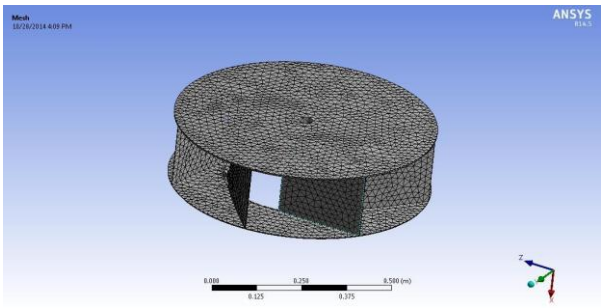


Meshing by using HYPERMESH 11.0: The solid model is imported to HYPERMESH 9.0 and hexahedral mesh is generated for the same. The meshed model is shown in figure 4. The meshing was done by splitting it into different areas and the 2D mapped mesh was done and then it was converted into 3D mesh using the tool linear solid. The number of elements and nodes are 20,837 and 42,177. Quality checks are verified for the meshed model. Jacobian, warpage and aspect ratio are within permissible limits. Then the meshed model is imported into the ANSYS.



MODAL ANALYSIS OF CENTRIFUGAL BLOWER FAN:

Procedure for modal analysis in ANSYS:

- Build the FE model explained in chapter 6.
- Define the material properties such as young's modulus and density etc
- Apply boundary conditions
- Enter the ANSYS solution processor in which analysis type is taken as modal analysis, and 'by taking mode extractionmethod, by defining number of modes to be extracted. Solution method is chosen as Block lanczos method.
- Solve the problem using current LS command from the tool bar.

MATERIAL PROPERTIES OF THE BLOWER:

The analysis is performed on (i) MS blower and (ii) SS316L blower

Material properties of MS blower:

- Young's modulus E= 210 MPa
- Poisson's ratio NUXY=0.303
- Mass density =7860 kg/m3
- Damping co-efficient =0.008

Material properties of SS316L (Food Grade Steel) blower:

- Yield stress 0.2 % proof (MPa) minimum- 170
- Elastic modulus- 193 GPa
- Mass density-8000 kg/m3
- Hardness B (HRB) max- 217

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➢ Elongation (%)- 40 minimum

EIGEN VALUE ANALYSIS OF BLOWER:

Eigen value analysis results show that the first critical speed of MS blower is 30.532 Hz and that of SS316L blower is 31.656 Hz the reduction in natural frequency of MS blower is due to the high stiffness of the MS blower as per the equation below. This shows that both MS and SS316L blower are running with in the safe limits. The natural frequencies of the experimental results match with the natural frequency in the table.

$$F = \frac{1}{2\pi}\sqrt{\omega_1}$$

Comparison of first six natural frequencies of MS and SS316L blower

No. of Modes	Natural frequencies of MS blower fan in Hz	Natural frequencies of SS316L blower fan in Hz	Natural frequencies of SS316L with1mm reduced thickness blower fan in Hz
1	30.532	31.656	25.172
2	30.643	31.772	25.348
3	48.683	50.476	43.99
4	144.63	149.96	124.08
5	159.58	186.2	147.68
6	159.64	165.46	148.08

The detail modal analysis which has been done in Ansys 14.5 with its sequential mode shape is as shown in following figures.

Tabular Data

	Mode	Frequency [Hz]
1	1.	30.532
2	2.	30.643
3	3.	48.683
4	4.	144.63
5	5.	159.58
6	6.	159.64

IV. RESULTS

By changing the number of blades on the Blower's impeller. The static and modal analysis is done for MS, SS304 and SS316L (food grade material) materials. The present blower is composed of MS material and has seven blades. When the static and modal analysis is done the five blade impeller made up of SS316L is found better than the presentblower. Hence it is selected. This five-blade centrifugal blower is utilised for CFD analysis,and the findings are compared to the findings of the existing seven-blade centrifugal blower's CFD study. The following are the findings, which are tabulated below.

	Existing 7 Blade Blower	Five Blade Blower
Material	Mild Steel	Stainless Steel SS316L
Weight (Kg)	28.95	27.492
Total Deformation (mm)	0.00041962	0.00038791
Equivalent Stress (MPa)	1.2962	1.264
First Natural Frequency (Hz)	45.032	42.91

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Maximum Velocity in blower (m/sec)	66.91	54.58
Velocity at Outlet (m/sec)	16.41	13.73
Maximum Pressure inblower (×10^3 Pa)	1.499	1.38
Pressure at Outlet (Pa)	48.19	31.38
Volume flow rate (cfm)	12833.36	12250.39

V. CONCLUSION

According to the results of the project, a stainless steel SS316L five blade impeller may beutilized instead of a mild steel seven blade impeller to avoid the corrosion of the blower. When SS316L impeller is compared with the present impeller, the stresses created in the SS316L five blade impeller are lower, as is the deformation. Although the SS316 five blade impeller's first natural frequency is somewhat lower than the previous impeller but it is above the working frequency. Hence this can be neglected. Furthermore, using SS316L five blade instead of MS seven blade impeller leads in a weight savings of about 1.5 kg. From CFD analysis we can say that the pressure and velocity distribution are better with the five-blade blower than with the seven-blade blower. There is also no sign of backflow in the casing. The volume flow rate of a five-blade impeller is somewhat lower than that ofa seven-blade blower presently in operation, according to the CFD research. This can be improved by increasing the motor's rotational speed.

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