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Performance Analysis of Carbon Steel Axial Fan

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Abstract: Analysis on the axial fans with Carbon steel (SAE1010 /1020) is to find the better performance with low cost manufacturing process and with material cost. Usually they as making these axial fans are made with Aluminium Casted one. It seems more cost inters of quantity is very less in Manufacturing and for based on Shaft size this fans Hub is need to be created new. By this analysis we proved that the cost of fan in terms of manufacturing and material cost reduced in 30%. And the effectiveness of the fan is in terms of stiffness of the blades. Generally these axial fans they were used in high speed machines (2 poles). So it's limited with size of fan seating and outer diameter of fan.

Keywords: Axial fan, Carbon steel (SAE1010/1020), Aluminum

I. Introduction

An axial fan is a type of a compressor that increases the pressure of the air flowing through it. The blades of the axial flow fans force air to move parallel to the shaft about which the blades rotate. In other words, the flow is axially in and axially out, linearly, hence their name. The design priorities in an axial fan revolve around the design of the propeller that creates the pressure difference and hence the suction force that retains the flow across the fan. The main components that need to be studied in the designing of the propeller include the number of blades and the design of each blade.If the propeller is exercising propulsion, then efficiency is the only parameter of interest and other parameters like power required and flow rate are considered of no interest. In case the propeller is used as a fan, the parameters of interest includes power, flowrate, pressure rise andefficiency.

The axial flow fans are conventionally designed with impellers made of aluminum or mild steel. The grey area today is the inconsistency in proper aerofoil selection & dimensional stability of the metallic impellers. This leads to high power consumption & high noise levels with lesser efficiency this axial fans generally used to high speed machines to produce the high volume of air with low velocity. While running the machine in high speed the stiffness of the fan should be the important parameter.Performance analysis on the axial fan with Carbon steel materials, it simply reduces the manufacturing and material cost of Fans. In the piece manufacturing this will be the effective. Without any deviating performance. This analysis is leads to with the carbon steel material we will achieve the same performance of the fan.The leading fan manufacturers in the world have been looking at FRP axial flow fans for higher energy efficiency. The improved design of FRP fan is aimed at higher lift to drag ratio and thereby increasing the overall efficiency. The new & improved aerodynamic fan designing, composite development, structural design combined with latest manufacturing process are also expected to result in consistent quality and higher productivity.
We should analysis the stiffness of fan in the form of deflection of blades. By this way we can approach the static stress analysis with circular co ordinates.

II. Literature Review

Ebrahim Mustafa was et all discussed about to optimize the blade design of an axial-flow fan. Four different chord length and five twisting angle of their blades were studied. The lower chord length of the fan blade has given lower stress in every condition of twisting angle. While the twisting angle of 40o has also shown the lowest stress. The proposed model has successfully developed using 84 mm chord length and distributed twisting angle from 0o , 10o , 20o , 30o and 40o in one blade. The stress analysis of the proposed model has successfully shown that the maximum stress is lower than the other models [1]
G.Chandrashekar was et all discussed about to increase the efficiency of the fan and analysis is to be done on the fan by changing the materials Aluminium, Mild Steel and Carbon Epoxy[2]

M.NagaKiran was et all discussed about an axial flow fan is to be designed and modeled in 3D modeling software Pro/Engineer. Present used axial flow fan in the taken application has 10 blades, in this thesis the number of blades are changed to 12 and 8. Theoretical calculations are done to determine the blade dimensions, % flow change, fan efficiency and axial velocity of fan when number of blades is taken as 10, 12 and 8. The design is to be changed to increase the efficiency of the fan and analysis is to be done on the fan by changing the materials Aluminum Alloy 204, Mild Steel and E Glass. Analysis is done in finite element analysis ANSYS.[3]

Young-Kyun Kim was et. al Three dimensional flow characteristic was present by a revision of an impeller of an axial turbo fan for improving the air flow rate and the static pressure. To consider an incompressible steady three dimensional flow equations are used as the governing equation and the standard turbulence model is chosen

Mahajan Vandana N was et. al The CFD based investigation has been reported in order to study the effect of change in speed of fan on velocity, pressure, and mass flow rate of axial flow fan. It has been observed that there is a significant change in mass flow rate, velocity of rotor and guide or stator vanes as the speed of the fan is varied. As the performance of the fan is directly dependent on mass flow output. So there should be a moderate velocity and pressure[4]

S. Faqruddina& P. HariSankar was et all discussed about axial flow fan with 10 blades, 9 and 11 blades are designed using theoretical calculations. Unigraphics is used for 3D modeling of the fans. Static, dynamic and CFD analysis is done on the 3 models using the materials steel, S2 Glass Epoxy and Kevlar. By observing the static analysis results, the stress values are less than the respective yield stress values of composite materials, using S2 Glass epoxy and Kevlar yields better results.[6]

By review various studies show that performance analysis of axial fan by carbon steel material is not studied yet.so the aim of present work performance analysis axial fan. The present work involved improvisation of fan design by selecting the most appropriate aerodynamic blade shape to suite specific airflow applications, development of suitable materials and structural design to replace the use of metals such as aluminium& mild steel in the impellers.

III. Experimental Work

A) Exiating Fan Design Tubler Axial Fan

The simplest form of axial flow fans comprising an axial type impeller mounted in a basic cylindrical housing. The impeller is usually mounted directly on the motor shaft and the motor, in turn, is mounted on a folded metal base within the housing. In some cases the fans are belt driven with the motor mounted on a bracket outside the housing. Tube axial fans have no provision for recovering the residual tangential component of velocity leaving the impeller and are less efficient than other types but this is offset by simplicity and low cost. They have a wide range of application in ventilation and cooling in industrial and commercial buildings, are used in both fixed locations and as portable units. A special case is the jet fan used in vehicular tunnels. In that application, the fans must be certified to continue operation for a limited time in event of a fire where they are exposed to high temperatures.[5]

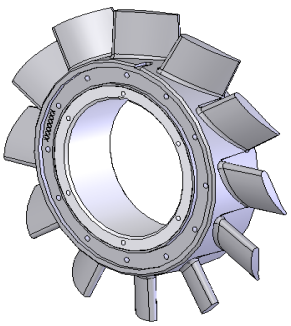


Fig 1 Axial fan

B) Problem identification

The basic principle of a performance analysis is increase the stiffness of the blades by the effective design and the of fan hub and blade welding positions.

By this way we are switch the fan material from aluminum to carbon steel material. This will reduce the manufacturing process and total cost of the fan. Then this is suitable for single piece manufacturing. The main objective of the work is to without deviating the performance as compared with the casted fans. With the comparatively less in cost. And also making standardizing of the fan in terms of performance vs weight is easy

C) Objective of the Work

- This analysis to reduce the cost of the fan by 25-30 %
- This is easy to reduced lot in manufacturing.
- This provides the better performance in same speed.
- Highly reliable in the efficiency of the fan.

D) Material selection

In this work we can selected material is carbon steel such that SAE1010 /1020.In this study, a blade of SAE1010 airfoil is analyzed for the Von Mises stress distribution and how it performance on various speed. The axial fan is made of carbon steel. Carbon steel, or plain-carbon steel, is a metal alloy. It is a combination of two elements, iron and carbon. The only other elements allowed in plain-carbon steel are: manganese (1.65% max), silicon (0.60%max),and copper (0.60%max). Steel with a low carbon content has the same properties as iron, soft but easily formed. As carbon content rises the metal becomes harder and stronger but less ductile and more difficult to weld. Higher carbon content lowers steel's melting point and its temperature resistance in general.so we can observe the performance analysis of carbon steel axial fan carried out and compare the existing Al axial fan.

E) Design and Analysis of Axial flow fan

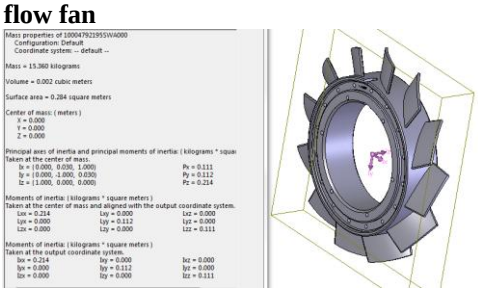


Fig 2 Aluminium casted fan:

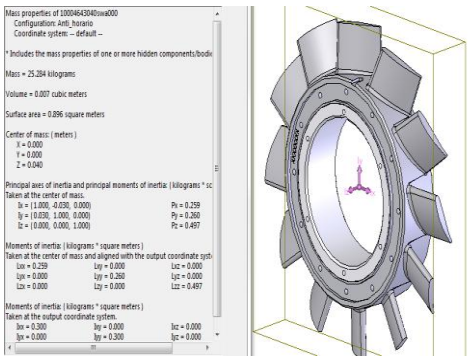


Fig 3 Carbon steel casted fan:

In this thesis, an axial flow fan is to be designed and modeled in 3D modeling software Solid works Present used axial flow fan in the taken application has 12 blades, and material taken as carbon steel material such that SAE1010 or 1020in this work. Theoretical calculations are done to determine the blade dimensions, % flow change, fan efficiency and axial velocity of fan when numbers of blades are taken as 12. Figure4.1shows the dimensions of fan diameter, hub diameter, blade length, blade spacing Fan diameter = 600mm Hub diameter (rh) = 150mm

1) Tip radius (rt) = 120mm
2) Hub radius/tip radius r = (rh / rt) = 75/120 r = 5/8 r = 0.625
3) Number of blades (nb) = 6r/(1-r)
4) Where r = 5/8 nb = 10
5) 4) Blades spacing (xp) = 2πR/ nb (or) πR(1-r)/3r R = fan radius = 300mm xp = 188.4mm

Dimensions as per heat transfer calculations, the flow rate of the fan define in the axial fans are based on the chord and pitch of the fan blades.[3]

The design is to be changed to increase the efficiency of the fan and analysis is to be done on the fan by changing the materials Aluminum alloy, Carbon Steel. Analysis is done in finite element analysis ANSYS.

IV. Results and Discussion

A) Mass Properties of Axial Fan

By the results of both solid models shows that the total mass of Aluminum alloy axial fan is 25.284kg And the moment of inertia is- 0.497 kg m2 and the total mass of the carbon steel fan is – 15.360 kg And the moment of inertia is- 0.214 kg m2 by conclude the above result taken asthe weight reduction in carbon steel axial fan is: 39.2%

B) Static Analysis

Static analysis of carbon steel is carried out so as to check the performance of axial fan such that stress and deformation calculated.

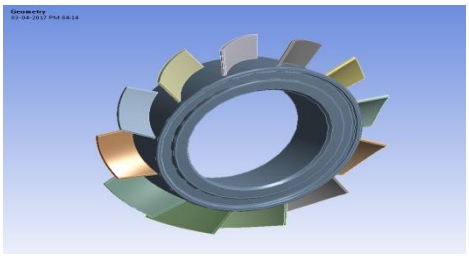


Fig 4 Solid model of Al axial fan

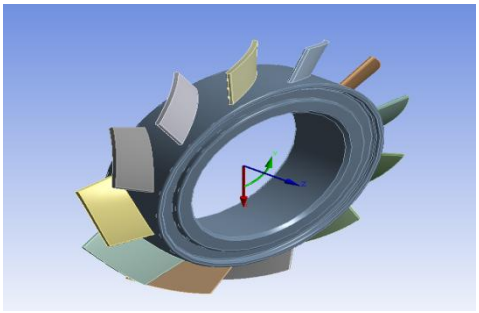


Fig 5 Solid model of Carbon steel axial fan

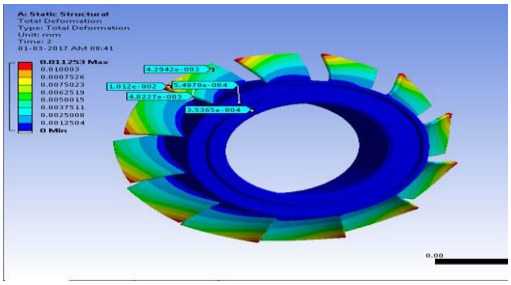
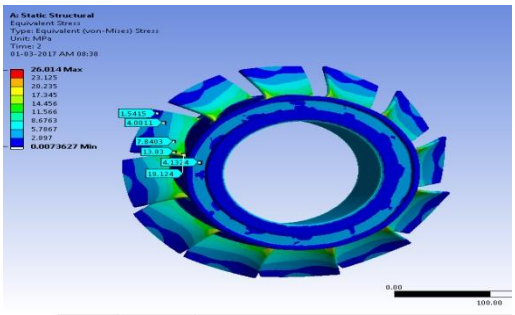


Fig 6 Displacement distribution for Carbon steel axial fan



Figu7 Stress distribution for Carbon steel axial fan

For above analysis results discussed such that The equivalent stress developed in the fan is: 26 MpaBut the material Yield strength is : 250 Mpa.As per the comparison of stress developed on the fan blades is 10.4% onlyBy the deformation The blade affected by the load is:0.011mm

Material	Blade Nos	Stress	strain	displacement
Aluminum alloy	12	25Mpa	4.3942e-003	0.012253
Carbon steel (SAE 1020)	12	26 Mpa	4.2944e-003	0.011253

Table 1. Static Results AL vs Carbon Steel(SAE 1020)

V. Conclusion

In this thesis, an axial flow fan is to be designed and modeled in 3D modeling software called UG. Present available model has 12 no of blades; designed is made. Material optimization is also carried for all the two blades and the conventional material used for the blade is steel and the study is made for carbon steel.By observing the analysis results, for all materials,the analyzed stress values are less than their respective yield stress values, so using all the three materials is safe under given load conditions. By comparing the results the stress and deformation values for both blades are nearly same within the limit. So replacing carbon steel axial fan instead of Aluminum is better as the weight also decreases.The strength of the carbon steel material same for aluminum alloy material as per the performance analysis on this axial fan the without deviating performance the cost of the fan reduced by 25 to 30 %.So we can conclude that using Carbon steel 12 blades is better.

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