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Design & Performance Analysis Of Exhaust Fan Blade

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ABSTRACT

The exhaust fans are commonly used in the various industrial equipment and processes to provide the necessary airflow for heat & mass transfer operations. These include cooling towers for air-conditioning & ventilation, humidifiers in textile mills, air heat exchangers for various chemical processes, ventilation & exhaust as in the mining industry, etc. Industrial fan blades are generally made from cast or imported aluminum, manufactured steel or stainless steel, or rare metals such as nickel alloys.

In our project, exhaust fan blade designs, creating a blade design using Creo 4.0 parametric software. The structural and thermal analysis predicts the deformation, stress, and temperature in different fiber material. Furthermore, to evaluate the varying airflow rate of temperature and velocity difference using computational fluid dynamics in ANSYS 15 software. The obtained data is expected as a result, which can be crucial for designing future fans.

I. INTRODUCTION

An exhaust fan is a device that uses undesirable odors, particulates, dust, moisture, and other pollutants that may be present in the air to control the indoor environment. Exhaust fans can also be integrated into a heating and cooling system. Popular venues for exhaust fans include kitchens & bathrooms, and these fans are typically very easy to install, so they can also be installed in many other locations. Users need a few tools for installation, and they have to work easily with electricity to wire the fan in place.

Fig. 1.1 Exhaust Fan

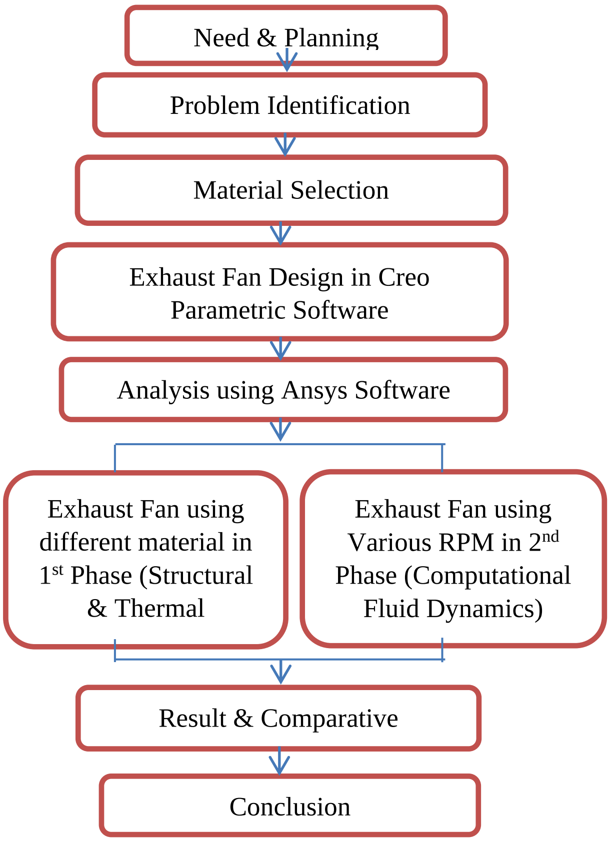
Such fans could also be useful for ventilating the space in garages and workshops. Since these environments can sometimes produce strong smells, and people can work in them with potentially hazardous materials, exhaust fans can be used for comfort and safety. An exhaust fan is particularly important when people work with things like solvents that are not safe or pleasant to inhale.

II. LITERATURE REVIEW

Umamaheswararao& Mohammed Ashif (April 2016), For the case performed, the three parameters static strain, static output, fan-consumed power obtained from the experimental and CFD analysis are successfully correlated. Therefore it can be inferred that CFD volute casing optimization helps to improve performance. There is a 9-10% deviation in the static pressure, 23-24% deviation in the shaft power and 12-13% deviation in the Efficiency. Increasing the outlet region thickness of volute casing by 10-15 percent from contrast gives the increase in performance. **ParasaramSarath Chandra *et al.* (2016),** Efficiency has been increased compared with the existing machine from 52% to 63% of the total to total Efficiency. The new design's performance was verified with commercial CFD software, ANSYS CFX, which is in good agreement.Analysis of aerofoils gave a good experience for processing and analysis while constructing blades of turbomachinery.It can be concluded from the analysis that the design meets the requirement and true with the case that could be implemented forpractical and functional cases.**SatyaNarayana&SudharsanRao (September 2017),** Theoretical calculations are performed to determine blade dimensions, flow change percentage, fan efficiency, and fan axial velocity when the number of blades is 10 12 and 8. By observing the theoretical calculations, axial velocity and flow change is more when 8 blades are used—the fan's weight when 12 blades are increased, thereby reducing its Efficiency. The presently used material for the fan is Mild Steel, which has more weight. By replacing it with Aluminum alloy 7050-T7651 and Carbon epoxy, the weight is reduced, thereby increasing its Efficiency.

Saravanakumar*et al.* (November 2017),The strength of the carbon steel material same for aluminum alloy material. As per the performance analysis on this axial fan, the fan's cost was reduced by 25 to 30 % without deviating performance.So we can conclude that using Carbon steel 12 blades is better.**MaimumSiddiqi*et al.* (November 2018),** the LG outward Exhaust Fan of 25° curvature angle is taken, and the curvature angle is increased and decreased by 1 degree for comparison that which is the best and these fan wings are designed on CATIA software then after these are analyzed by using Ansys software. This report has discussed that Exhaust Fan Wings with a 24° curvature angle is the best suited for high airflow and high velocity of air flow than the Exhaust Fan Wings with 25 26-degrees curvature angle.

III.WORKING METHODOLOGY



IV. PROBLEM IDENTIFICATION

We had found that the repeated damage to exhaust fan blade material due to the high stress and temperature on the blades, an investigation shows that the blades require the implementation of new material.

We have suggested a new material based on fiber material and various RPM used in the exhaust fan to predict the temperature & velocity based on CFD in Ansys software.

V. MATERIAL SELECTION

Table 1 Overall Material Property

Material	**Units**	**Steel**	**Aluminum**	**Carbon Fiber**	**Kevlar Fiber**
Density	kg/m^3	7850	2770	2000	1440
Young's Modulus	Gpa	200	71	181	130
Poisson ratio	-	0.3	0.33	0.28	0.44
Thermal Conductivity	W/mk	60.5	165	2.98	4.97

VI. DESIGN & ANALYSIS OF EXHAUST FAN

Computer-aided design (CAD) requires the development of geometrically constructed computer models. Such models typically appear as a three-dimensional representation of a component or a group of parts on a computer monitor, easily changed by modifying the appropriate parameters.CAD systems allow designers to display objects in various representations and evaluate them by simulating conditions in the real world.

ANSYS is preferred-purpose FEA software. FEA is a mathematical method of discretizing a complicated design into very small pieces (of user-specific length) known as factors. The software Implements equations that govern these factors' performance and solves all of them, growing a comprehensive clarification of how the device acts as an entire. Those consequences can be supplied in tabulated or graphical forms.

Analysis of Structural & Thermal Result

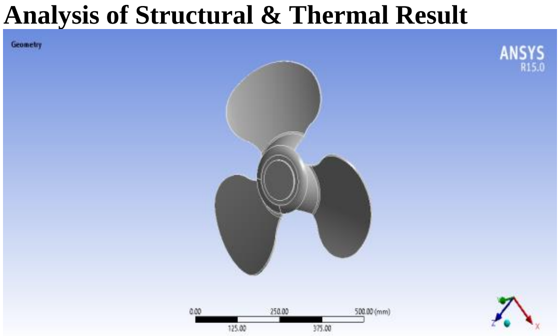


Fig. 6.1 Exhaust Fan Model in Ansys

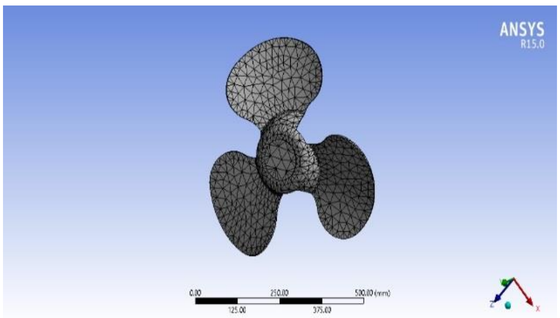


Fig. 6.2 Exhaust Fan Meshing

The domain is needed to be divided into separate cells (meshed) fine mesh creating; it's useful to the Efficiency & Accuracy. The exhaust fan model and mesh are graphically represented in the Fig. 6.1 & 6.2.

Table 2 Comparative of different material

Materials	Deformation	Stress	Temperature	Heat flux
Units	**mm**	**Mpa**	**°C**	**W/mm^2**
Steel	0.12022	10.22	41.31	0.017776
Aluminium	0.32535	10.195	56.431	0.032192
Carbon fiber	0.12886	10.236	31.727	0.006926
Kevlar fiber	0.17817	10.204	33.691	0.009594

The Exhaust fan blade design using the modeling software and evaluation of different material analyses in structural & thermal analysis, the above Table 2 result-based concluded that the carbon fiber is best material in exhaust fan blade, so its reason for high temperature withstand is compared other material.

The maximum deformation of carbon fiber is 0.12886 mm. The maximum stress obtained in the carbon fiber is 10.236 MPa

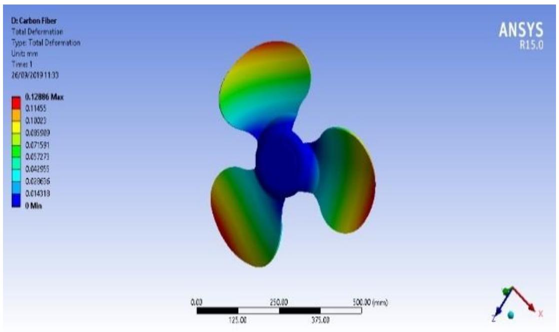


Fig. 6.3 Total Deformation

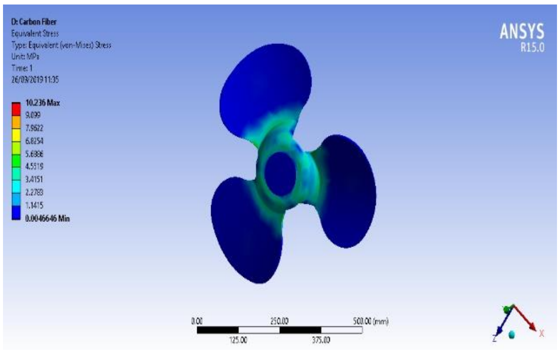


Fig. 6.4 Equivalent Von Misses Stress

The maximum temperature distribution in carbon fiber is 31.727 °C. The maximum heat flux obtained in the carbon fiber is 0.017776 W/mm^2

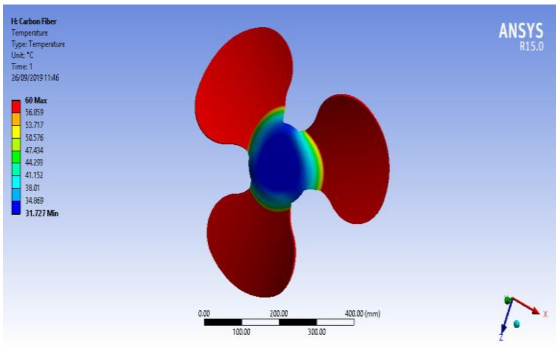


Fig. 6.5 Temperature

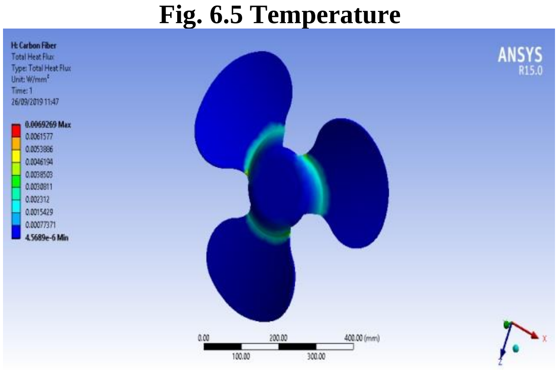


Fig. 6.6 Heat Flux

A. Computational Fluid Dynamics

CFD is a mathematical study of fluid flow, heat transfer, & associated phenomena. CFD solvers contain a complex set of algorithms used to model and simulate fluid, gas, heat, and mechanical flow. Without CFD, it would not be possible to achieve most technological advances in automobiles, aeronautics & space.

Performing a CFD Analysis

This takes place in three stages: pre-processing, processing, and post-processing. It involves problem-solving, meshing, and creating a computational model in the pre-processing stage, all the activities before the numerical solution process. Processing involves the use of a computer to solve fluid flow mathematical equations.

This is a very intensive process, and usually, it requires the computer to solve many thousands of equations. In each case, the equations are integrated, and boundary conditions are applied to it. This software is used to evaluate the data generated by the CFD analysis in the post-processing stage. The findings can be evaluated numerically as well as graphically when the model has been resolved.

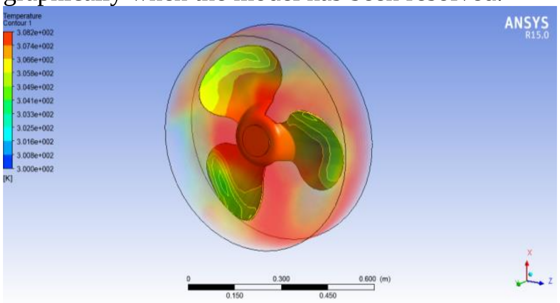


Fig. 6.7 Temperature Difference in 2500 RPM

The Exhaust Fan to predict the temperature and velocity difference based on computational fluid dynamics in Ansys software. It's to check the various RPM rotating speed in the exhaust fan (Carbon material).

Table 3 Comparative Various RPM in Exhaust Fan

Speed (RPM)	**Temperature Inlet (℃)**	**Temperature Outlet (℃)**	**Velocity Inlet (m/s)**	**Velocity Outlet (m/s)**
1500	35	33.27	0.5	1.314
2000	35	32.84	0.5	1.458
2500	35	31.83	0.5	1.519

VII. CONCLUSION

Our project is an Exhaust fan performance analysis based on structural, thermal & computational fluid dynamics analysis in Ansys software. To predict the different materials used in an exhaust fan to the above analysis, choose the suitable material for carbon fiber material.

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