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Flow Analysis Of An Axial Compressor

SHAKTI KIRAN V
M.Tech, Thermal Engineering
D.J.R College of engineering and technology,
Vijayawada, A.P, India

M VENKATA SWAMY
Assistant Professor,Dept of Mechanical
D.J.R College of Engineering and technology
Vijayawada, A.P , India

Abstract: **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. Their applications include propellers in aircraft, helicopters, hovercrafts, ships and hydrofoils. They are also used in wind tunnels and cooling towers.**

The materials used for axial flow fan impellers are aluminum or mild steel. The main disadvantages of using metallic impellers are high power consumption & high noise levels with lesser efficiency. To reduce these problems, fans are fabricated by using composite materials

In this thesis, axial flow fans 3 models with 8, 9 and 10 blades are designed in 3D modeling software solid works by using Static and CFD analysis is done on the 3 models using the materials Stainless steel, S2 Glass Epoxy and Kevlar.

By observing the results from ANSYS, 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.

The strength of the composite material S2 Glass epoxy is more than that of other 2 materials Stainless Steel, Kevlar. By observing the analysis results, the displacement and stress values are less when 9 blades are used. Composite material S2 Glass epoxy with 9 blades is better than other two materials.

I. INTRODUCTION

Axial flow fans are particularly versatile, being used in a wide range of applications in industry and in Mining and Tunnel ventilation. Their main attribute compared with centrif solid worksal fans is that they are capable of efficiently delivering very large flow volumes at low pressures (high specific speed). At the other end of the spectrum they are able to deliver sufficiently high pressures for boiler draft applications and as high speed multi-stage compressors in gas turbines they produce high compression ratios.

II. STRUCTURAL ANALYSIS

8 blades analysis using STAINLESS STEEL material

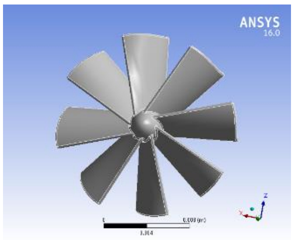

Fig. Imported models from solid works for 8 blades

Element type: 20 node 186
Material properties:
Youngs modulus: 203 Gpa
Poissons ratio: 0.33
Density: 0.0000078 kg/mm^3

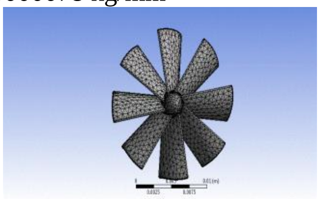

Fig. Meshed Model in ANSYS for 8 blades

Loads

Pressure applied: 83.944 pa
Force applied: 5.578 N
Area: 66454.74 mm^2
Solution
Solution – Solve – Current LS – ok
Post Processor
General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Displacement Vector Sum

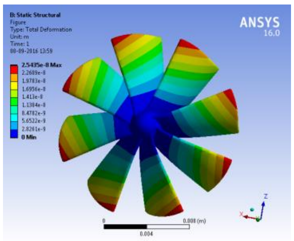

Fig. Displacement model for 8 blades using stainless steel

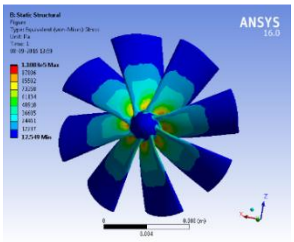

Fig. stress model for 8 blades using stainless steel

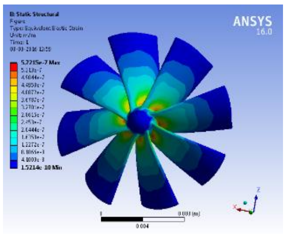

Fig. Strain model for 8 blades using stainless steel

8 blades analysis using S2 GLASS EPOXY material

Material properties:
Youngs modulus: 86.9 gpa
Poissons ratio: 0.23
Density: 0.00000246 kg/ mm^3
Pressure applied: 83.944 pa
Force applied: 5.578 n
Area: 66454.74 mm^2
Element type: 20 node 186

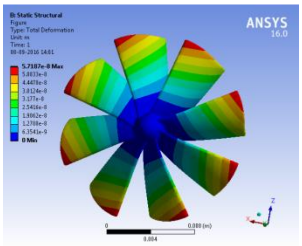

Fig. Displacement model for 8 blades using S2 glass epoxy

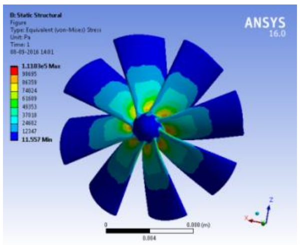

Fig. Stress model for 8 blades using S2 glass epoxy

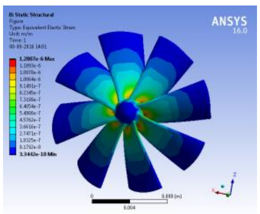

Fig. Strain model for 8 blades using S2 glass epoxy

8 blades analysis using KEVLAR material

Material properties:
Youngs modulus: 827.6 Gpa
Poissons ratio: 0.20
Density: 0.00000150 kg/ mm^3
Pressure applied: 83.944 pa
Force applied: 5.578 n
Area: 66454.74 mm^2
Element type: 20 node 186

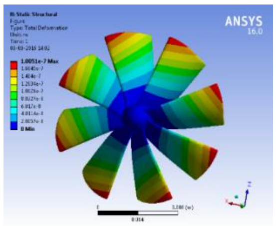

Fig. Displacement model for 8 blades using KEVLAR material

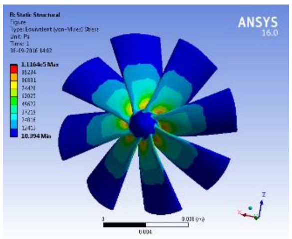

Fig. Stress model for 8 blades using KEVLAR material

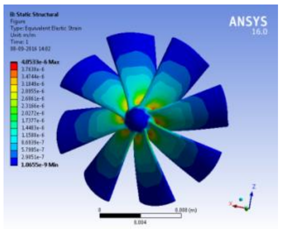

Fig. Strain model for 8 blades using KEVLAR material

10 blades analysis using STAINLESS STEEL material

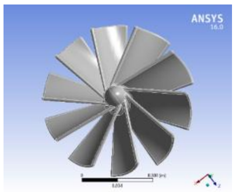

Fig. Imported model from solid works for 10 blades

Element type: 20 node 186
Material properties:
Youngs modulus: 203 Gpa
Poissons ratio: 0.33
Density: 0.0000078 kg/ mm^3

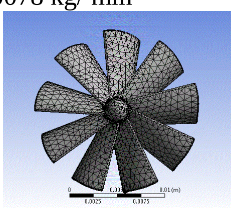

Fig. Meshed model in Ansys for 10 blades

Pressure applied: 83.944 pa
Force applied: 5.578 N
Area: 66454.74 mm^2

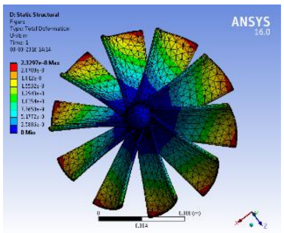

Fig. Displacement model for 10 blades using Stainless Steel

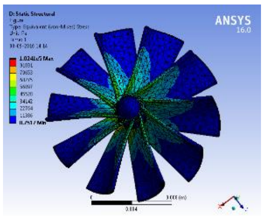

Fig. Stress model for 10 blades using Stainless Steel

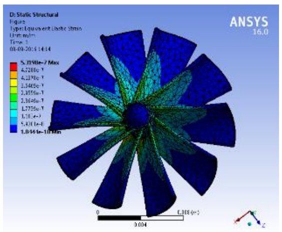

Fig. Strain model for 10 blades using Stainless Steel

10 blades analysis using S2 GLASS EPOXY material

Material properties:
Youngs modulus: 86.9 Gpa
Poissons ratio: 0.23
Density: 0.00000246 kg/ mm^3
Pressure applied: 83.944 pa
Force applied: 5.578 N
Area: 66454.74 mm^2
Element type: 20 node 186

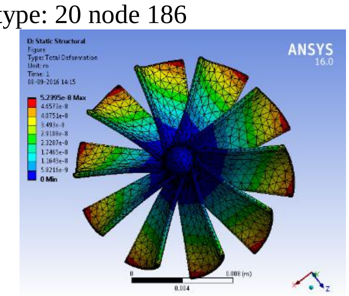

Fig. Displacement model for 10 blades using S2 Glass epoxy

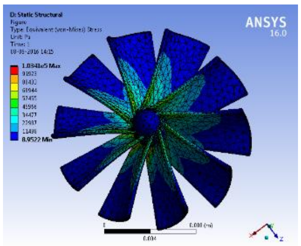

Fig. Stress model for 10 blades using S2 Glass epoxy

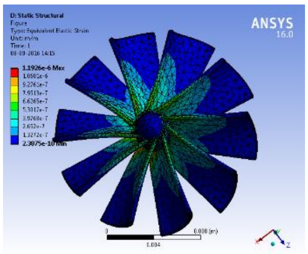

Fig. Strain model for 10 blades using S2 Glass epoxy

10 blades analysis using KEVLAR material

Material properties:
Youngs modulus: 827.6 Gpa
Poissons ratio: 0.20
Density: 0.00000150 kg/ mm^3
Pressure applied: 83.944 pa
Force applied: 5.578 N
Area: 66454.74 mm^2
Element type: 20 node 186

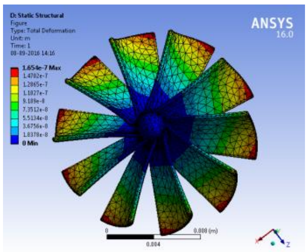

Fig. Displacement model for 10 blades using KEVLAR material

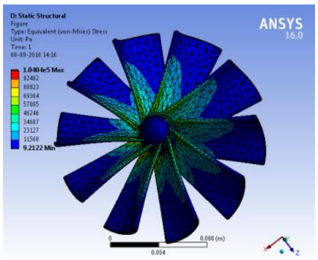

Fig. Stress model for 10 blades using KEVLAR material

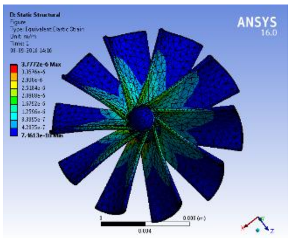

Fig. Strain model for 10 blades using KEVLAR material

10 blades CFD Analysis for Stainless Steel Material

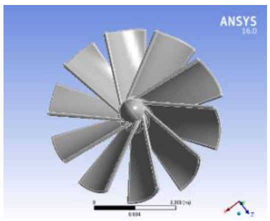

Fig. Imported Model from solidworks

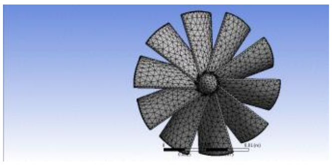

Fig. Meshed Model in CFD

SPECIFYING BOUNDARIES FOR INLET AND OUTLET

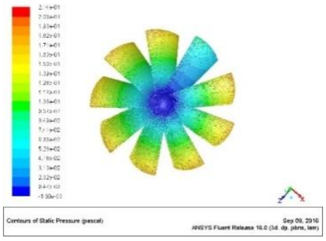

Fig. Static pressure for 10 blades using stainless steel

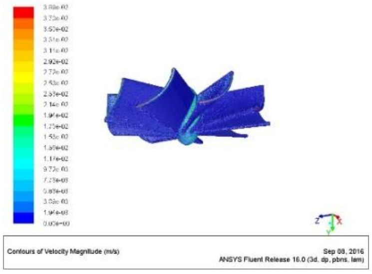

Fig. Velocity for 10 blades using stainless steel

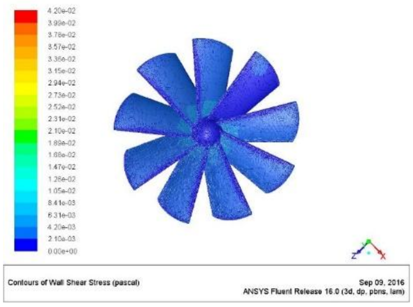

Fig. shear stress for 10 blades using stainless steel

9 blades CFD Analysis for Stainless Steel Material

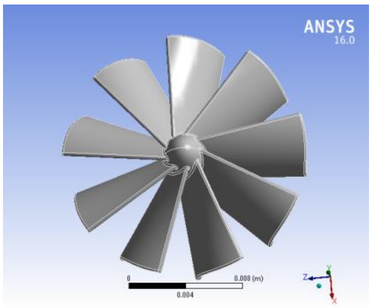

Fig. Imported Model from solid works

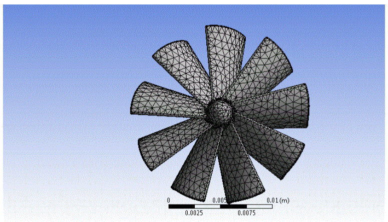

Fig. Meshed Model in CFD

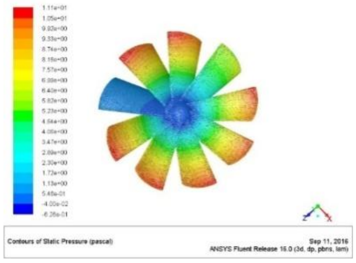

Fig. Static pressure for 9 blades using Stainless steel

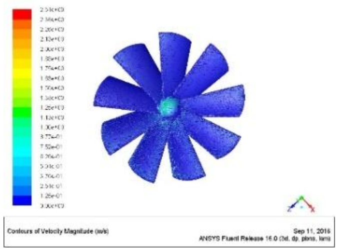

Fig. Velocity for 9 blades using Stainless steel

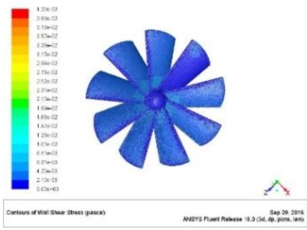

Fig. wall shear for 9 blades using Stainless steel

8 blades CFD Analysis for Stainless Steel Material

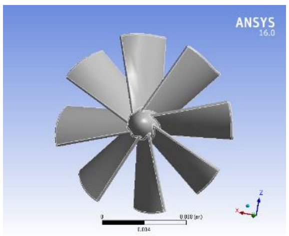

Fig. Imported Model from solid works

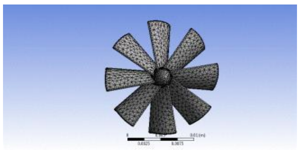

Fig. Meshed Model in CFD

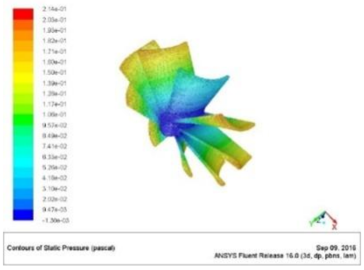

Fig. Static pressure for 8 blades using Stainless steel

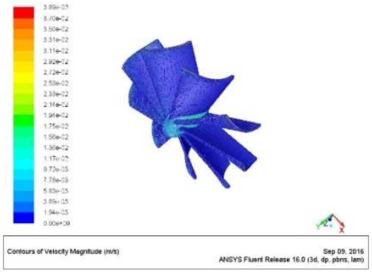

Fig. Velocity for 8 blades using Stainless steel

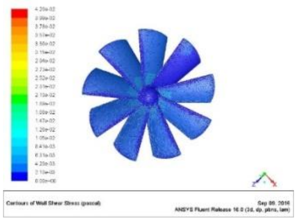

Fig. wall shear stress for 8 blades using Stainless steel

III. RESULTS AND DISCUSSION

Weight of axial flow fan

The weights of axial flow fans for different materials for different number of blades are given in the table 2.

Structural analysis results

The structural analysis results are obtained from ansys software for axial flow fan having the blades 8,9 and 10 for different materials as shown in table 4.

Table Structural Analysis results for 8, 9 & 10 Blades Geometry.

	Material	8 Blades	9 Blades	10 Blades
Displacement(m)	Stainless Steel	2.5435 e^{-08}	2.3256 e^{-08}	2.3297 e^{-08}
	S2glass	5.7187 e^{-08}	5.229e $^{-08}$	5.2395 e^{-08}
	Kevlar	1.8051 e^{-07}	1.6506 e^{-07}	1.654e $^{-07}$
Stress (pa)	Stainless Steel	1.1003 e^{5}	1.0487 e^{+5}	1.0241 e^{+5}
	S2glass	1.1103 e^{+5}	1.0518 e^{+5}	1.0341 e^{+5}
	Kevlar	1.1164 e^{+5}	1.055e $^{+5}$	1.0404 e^{+5}
Strain	Stainless Steel	5.7215 e^{-07}	5.4598 e^{-07}	5.3198 e^{-07}
	S2glass	1.2807 e^{-06}	1.2152 e^{-06}	1.926e $^{-06}$
	Kevlar	4.0533 3e $^{-06}$	3.8398 e^{-06}	3.7772 e^{-05}

CFD Results

The CFD results of axial flow fan gives the static pressure, velocity and temperatures for 9, 10 and 11 blades of fan are shown in table 8.

Table CFD results for 8, 9, & 10 Blades Geometry.

	8Blades	9Blades	10 Blades
Pressure (Pa)	3.56 e^{-04}	1.11e^{+01}	2.14 e-$^{-01}$
Velocity (m/s)	2.79 e—02	2.51e^{00}	3.89 e^{-02}
Wall shear stress	3.00 e—02	2.85e^{-02}	4.20 e-$^{-02}$

IV. CONCLUSION AND FUTURE SCOPE

In this thesis, an axial flow fan is designed and modeled in 3D modeling software Solid works . Presently used axial flow fan in the taken application has 10 blades, in this thesis the number of blades are changed to 8 and 9. 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 8, 9 and 10.

Structural analysis is done on the fan by changing the materials Stainless Steel, Kevlar and S2 Glass epoxy. Analysis is done in finite element analysis ANSYS.

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. The strength of the composite material S2 Glass epoxy is more than that of other 2 materials Stainless Steel, Kevlar. By observing the analysis results, the displacement and stress values are less when 9 blades are used.

So we can conclude that using composite material S2 Glass epoxy with 9 blades is better than other two materials

V. FUTURE SCOPE

The work can be extended by changing the number of blades, blade angle, materials, Design of Hub and Dimensions of Hub and also by changing the casing for fans with respect to pressure, power, flow rate & material properties.

VI. REFERENCES

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