

Stress Analysis of a Centrifugal Supercharger Impeller Blade

Mohammed irafanuddin¹, K. Durga Sushmitha²

¹Mtech student, Nimra College of engineering & technology, Ibrahimpattanam, AP, INDIA,

²Guide (Asst.Professor), Nimra College of engineering & technology, Ibrahimpattanam, AP, INDIA.

Abstract

A supercharger is an air compressor that increases the pressure or density of air supplied to an internal combustion engine. This gives each intake cycle of the engine more oxygen, letting it burn more fuel and do more work, thus increasing power. Power for the supercharger can be provided mechanically by means of a belt, gear, shaft, or chain connected to the engine's crankshaft. Superchargers are a type of forced induction system. They compress the air flowing into the engine. The advantage of compressing the air is that it lets the engine squeeze more air into a cylinder, and more air means that more fuel can be added. Therefore, you get more power from each explosion in each cylinder. Here in this project we are designing the compressor wheel by using Pro-E and doing analysis by using FEA package.

An attempt has been made to investigate the effect of pressure and induced stresses on the blade. By identifying the true design feature, the extended service life and long term stability is assured. A structural analysis has been carried out to investigate the stresses, strains and displacements of the blade. An attempt is also made to suggest the best material for an blade of a turbocharger by comparing the results obtained for different materials. Based on the results best material is recommended for the blade of a turbocharger.

Key words: Air compressor, Ansys, FEA package and supercharger

I. INTRODUCTION

A supercharger is an air compressor that increases the pressure or density of air supplied to an internal combustion engine. This gives each intake cycle of the engine more oxygen, letting it burn more fuel and do more work, thus increasing power. Turbocharger components are classified as turbine housing (volute), turbine (radial and axial flow type), compressor, compressor wheel (blade), diffuser, bearing system, bearing housing, control system, waste gates, inter cooler.

The way to add power is to make a normal-sized engine more efficient. You can accomplish this by forcing more air into the combustion chamber. More air means more fuel can be added, and more fuel means a bigger explosion and greater horsepower. Adding a **supercharger** is a great way to achieve forced air induction. In this article, we'll explain what superchargers are, how they work and how they compare to turbochargers. A supercharger is any device that pressurizes the air intake to above atmospheric pressure. Both superchargers and turbochargers do this. In fact, the term "turbocharger" is a shortened version of "turbo-supercharger," its official name. The difference between the two devices is their source of energy. Turbochargers are powered by the mass-flow of exhaust gases driving a turbine. Superchargers are powered mechanically by belt- or chain-drive from the engine's crankshaft.

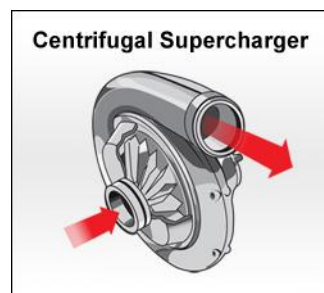


Fig. no 1 Dynamic compressor

The Centrifugal supercharger is used in many applications including, but not limited to, automotive, truck, marine, aircraft, motorcycles and UTV's. Of these applications, they are most commonly utilized for increasing horsepower in street vehicles and race applications. While the first practical centrifugal compressor was designed in 1899, centrifugal superchargers evolved during World War II with their use in aircraft, where they were frequently paired with their exhaust driven counterpart, the turbo supercharger. This term refers to the fact that turbochargers are a specific type of centrifugal supercharger, one that is driven by a turbine.

- Automotive Superchargers
- Aircraft Superchargers

Centrifugal superchargers have become popular in the aftermarket as a bolt-on addition to improve performance. By design, centrifugal superchargers allow for easy integration of air-to-air or air-to-water inter cooling.

Superchargers in aircraft play an important role by providing additional air pressure at higher altitudes. Because air pressure decreases at high altitudes, air compression is necessary in order to keep the airplane's engine running at maximum efficiency.

II. MODELLING OF COMPRESSOR BLADE

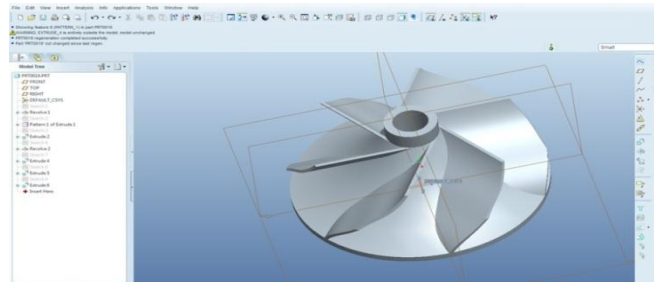


Fig. no 2 Solid model of compressor

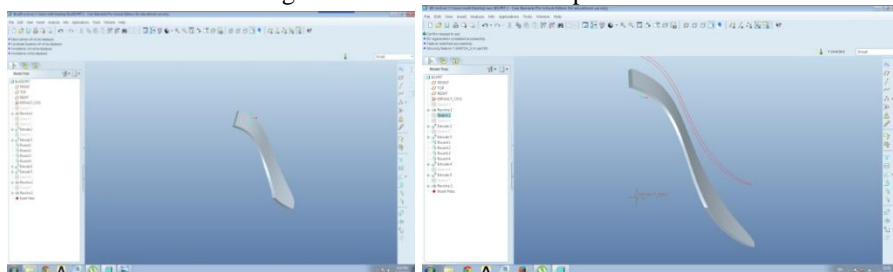


Fig. no 3 actual blade model with thickness = t Fig. no 4 modified blade model with thickness = $t - 0.5$ mm

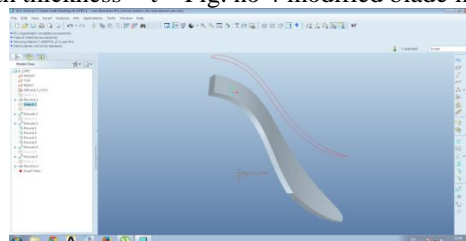


Fig. no 5 modified blade model with thickness = $t + 0.5$ mm

III. ANALYSIS OF COMPRESSOR BLADE

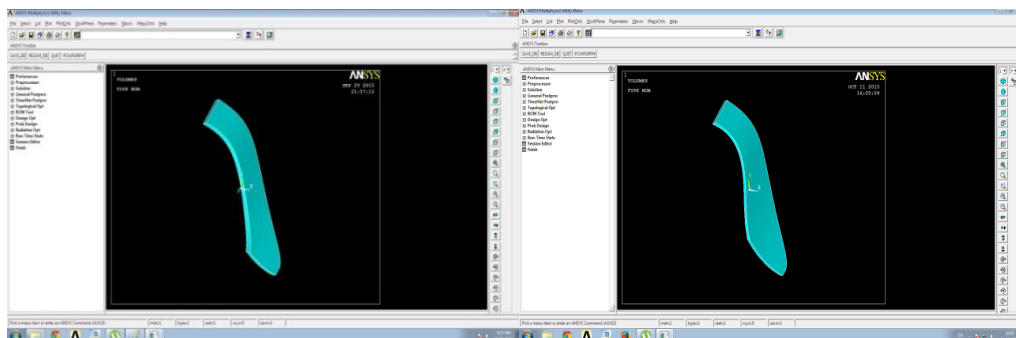


Fig. no 6 Imported model of actual blade with thickness = t Fig. no 7 Imported model of modified blade with thickness = $t - 0.5$ mm

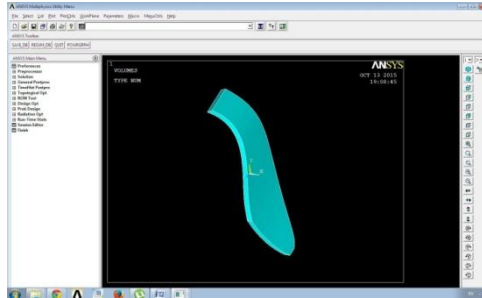


Fig. no 8 Imported model of modified blade with thickness = $t + 0.5$ mm

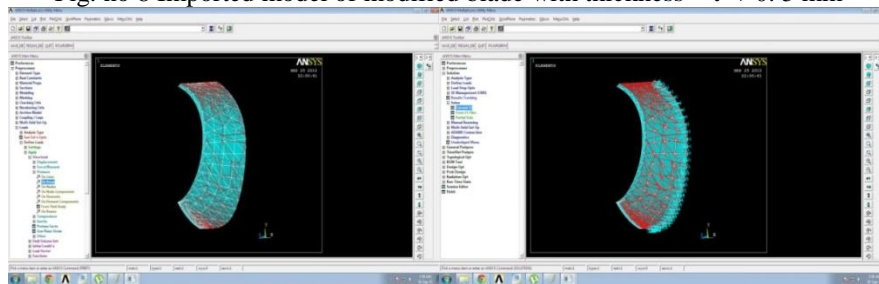


Fig. no 9 Applying load on surface of blade

Fig. no 10 Load distribution on blade

IV. RESULTS AND DISCUSSION

Structural analysis

4.1 ACTUAL MODEL WITH THICKNESS = T

a) ALLOY 706

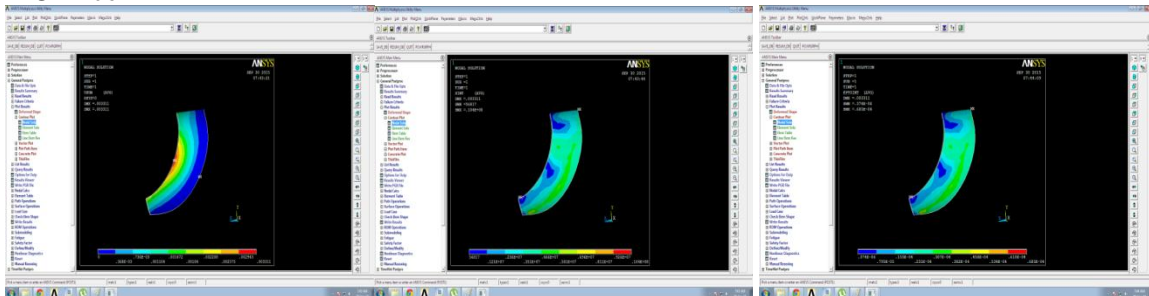


Fig. no 11 Total deformation

Fig. no 12 Stress intensity

Fig. no 13 Strain intensity

b) Composite alloy

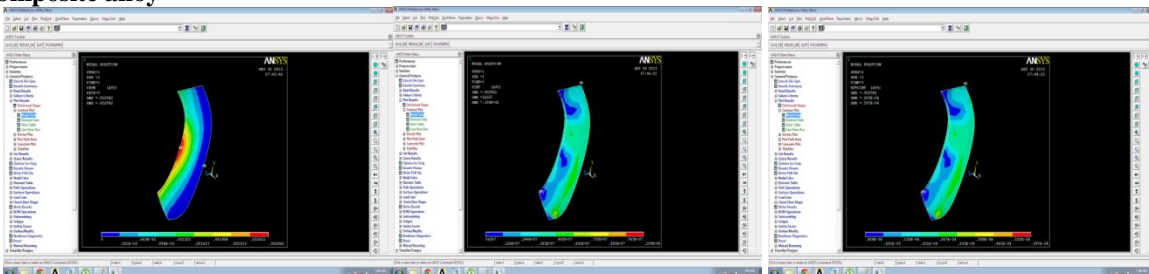


Fig. no 14 Total deformation

Fig. no 15 Stress intensity

Fig. no 16 Strain intensity

c) Steel

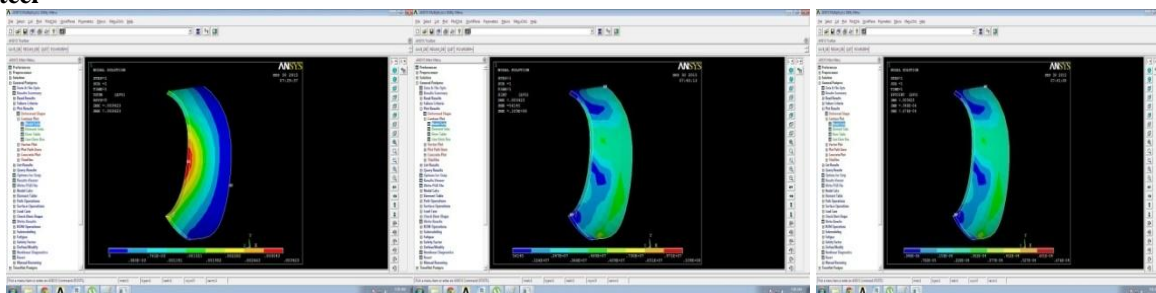


Fig. no 17 Total deformation

Fig. no 17 Stress intensity

Fig. no 18 Strain intensity

4.2 MODIFIED MODEL WITH THICKNESS = T - 0.5 mm

a. Composite alloy

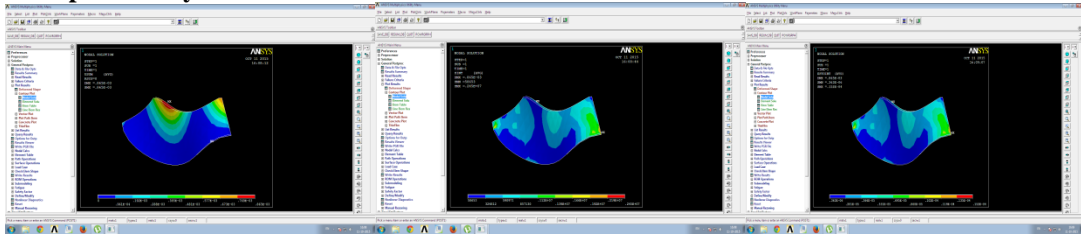


Fig. no 19 Total deformation Fig. no 20 Stress intensity Fig. no 21 Strain intensity

b. Alloy 706

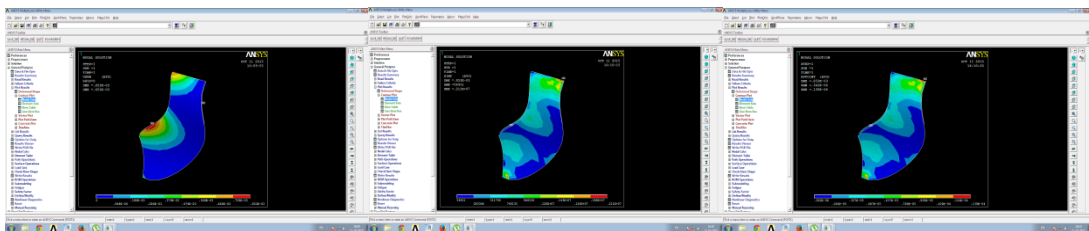


Fig. no 22 Total deformation Fig. no23 Stress intensity Fig. no24 Strain intensity

d) Steel

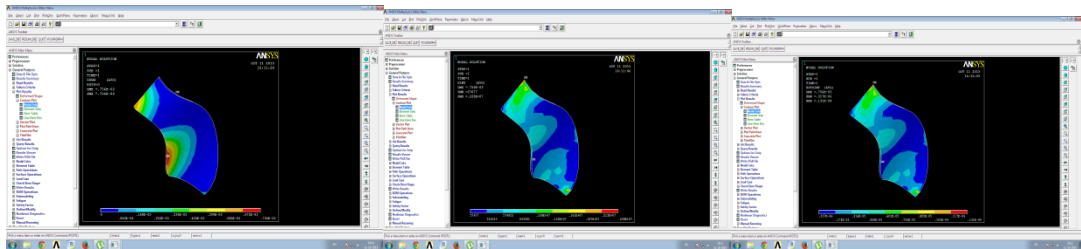


Fig. no25 Total deformation Fig. no 26 Stress intensity Fig. no 27 Strain intensity

4.3 MODIFIED MODEL WITH THICKNESS = T + 0.5 mm

a. Composite alloy

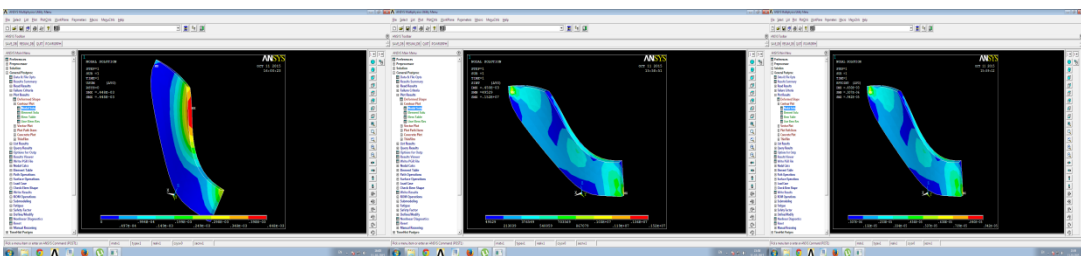


Fig. no 28 Total deformation Fig. no 29 Stress intensity Fig. no 30 Strain intensity

b. Alloy 706

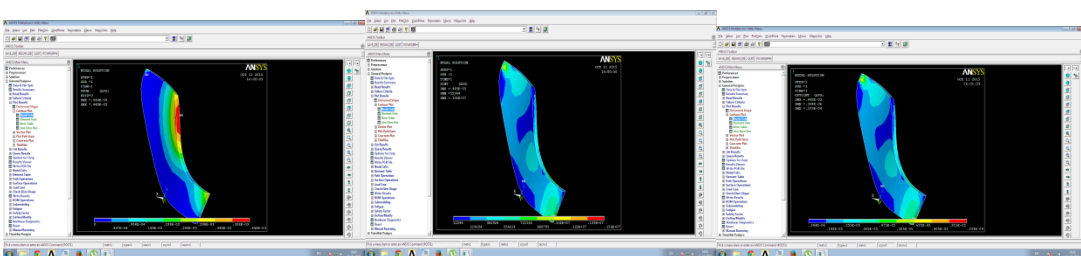


Fig. no 31 Total deformation Fig. no 32 Stress intensity Fig. no 33 Strain intensity

c. Steel

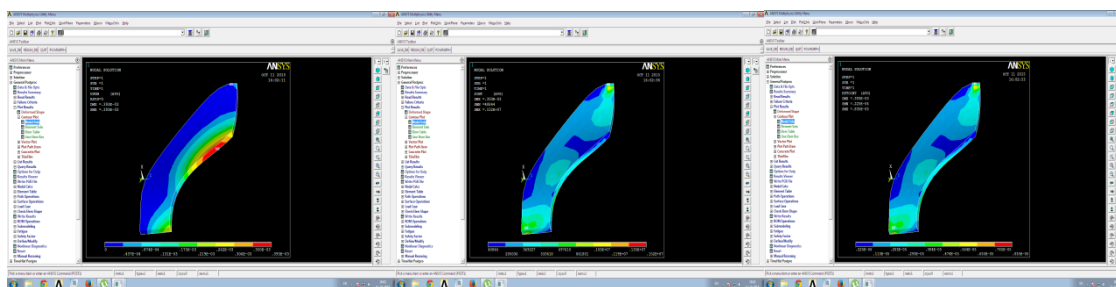


Fig. no 34 Total deformation

Fig. no 35 Stress intensity

Fig. no 36 Strain intensity

5.4 Comparison of results

SNO	MATERIAL	TOTAL DEFORMATION	STRAIN INTENSITY
1	Alloy 706	.003311	.685E-04
2	Composite alloy	.002982	.597E-04
3	Steel	.003423	.676E-04

Table no 1. Comparison of actual blade model with thickness = t

SNO	MATERIAL	TOTAL DEFORMATION	STRAIN INTENSITY
1	Alloy 706	.865 E-03	.245E+07
2	Composite alloy	.756E-03	.211E+07
3	Steel	.853E-03	.239E+07

Table no 2. Comparison of modified blade model with thickness = t – 0.5 mm

SNO	MATERIAL	TOTAL DEFORMATION	STRAIN INTENSITY
1	Alloy 706	.450 E-03	.152E+07
2	Composite alloy	.393E-03	.152E+07
3	Steel	.448E-03	.156E+07

Table no 3. Comparison of modified blade model with thickness = t + 0.5

V. Conclusion

The analysis of supercharger compressor blade done to investigate the effect of pressure and induced stresses on the blade. A structural analysis has been carried out to observe the stresses, strains and displacements of the blade.

- The analysis is performed by two alloy materials with actual steel material.
- After the analysis the comparison is made.
- By those values we observed that the stress and deformation values of the actual material steel and alloy 706 are nearly same.
- And we conclude that the stress values of the composite alloy are better than the other two materials.
- The deformation is also less for the composite alloy when compared to other two materials.

So we suggest composite alloy material to the companies to increase the performance of the super charger compressor blade.

And also by observing the results of the actual blade thickness with the increasing and decreasing thick about 0.5mm the results are slightly changed.

By this we conclude that with the good composite material we may reduce the size (thickness) of the model also.

REFERENCES

- [1] Dipl.-Ing. Jonas Belz and Dipl.-Ing. Ralph-Peter Müller “rapid Design and Flow Simulations for Turbocharger Components” EASC ANSYS Conference 2009 RAPID, CFDnetwork® Engineering, CFturbo® Software & Engineering GmbH.
- [2] Meinhard Schoeberl. Turbo machinery Flow Physics and Dynamic Performance. Springer, 2005.
- [3] Kirk, R. G., 1980, “Stability and Damped Critical Speeds: How to Calculate and Interpret the Results,”
- [4] Compressed Air and Gas Institute Technical Digest, 12(2), pp. 1-14.
- [5] Alsaeed, A. A., 2005, “Dynamic Stability Evaluation of an Automotive Turbocharger Rotor- Bearing System,” M.S. Thesis, Virginia Tech Libraries, Blacksburg, VA.
- [6] Encyclopedia
- [7] Wickypedia
- [8] Machine design text book by RS kurmi
- [9] Material Handbook of High Performance Alloys, Special Metals Corp., (2001) Mikio Oi, Mariko Suzuki, Natsuko Matsuura “Structural Analysis and Shape Optimization in Turbocharger Development” published in Ishikawajima-Harima Heavy Industries Co., Ltd.
- [10] V Rammurti (iitm), D.A Subramani (TEL), Dhridhara (TEL) “Free vibration analysis of turbocharger centrifugal compressor blade” published in mech march .theory vol 30, No 4, pp 619-628, 1995 Elsevier science Ltd