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Design and Analysis of CI Engine Turbocharger with Different Material

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***Abstract*: In the present work the turbocharger was design with three different materials (Nickel, Titanium and structural steel). The design can be done using CREO and ANSYS (R15) software. The CREO software is used for modeling the turbocharger and analysis is done in ANSYS.A Modest attempt has been made to investigate the effect of force, pressure and induced stresses on the turbocharger. A structure analysis has been carried out to investigate the various stresses, strain and displacement of the turbocharger. Based on the results the better properties and is recommended for its further usage in turbocharger.**

***Keywords*: Turbocharger, Three different material, Static structural analysis, Stresses, properties.**

1. Introduction

A turbocharger is a turbine-drive forced device that increases as internal combustion engines efficiency and power output by forcing extra air into the combustion chamber. This improve over a naturally aspirated engines power output is due to face that compressor can force more air into combustion chamber than atmospheric pressure. A turbocharged engine produces more power than any other engine. This can mostly improve the power to weight ratio for the engine. In order to obtain boost, turbocharger compressor pull ambient air and compresses is before it enters into the intake manifold at increased pressure. This gives a greater mass of air entering the cylinders on each stroke. The power required to spin the centrifugal compressor derived from the kinetic energy of the engines exhaust gases.

The aim of the turbocharger is improve an engines volumetric efficiency by increasing density of the intake gas (usually air) allowing more power per engine cycle. The turbocharger compressor draws in ambient air and compressor it before it enters into the intake manifold at increased pressure. The purpose of a turbocharger is to increase is to increase the power output of an engine by supplying compressed air to the engine intake manifold so increased fuel can be utilized for combustion. The purpose of the altitude compensator is to maintain consistent power output and efficiency of an engine operation at all altitude.

A turbocharger is a special type of supercharger in which a gas turbine is used to raise the pressure of air or air-fuel mixture that is to be supplied to the engine. Turbochargers are by the kinetic energy of exhaust gases from the engine. Turbochargers are a type of forced induction system. They compress the air flowing into the engine. The advantages 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, we get more power from each explosion in each cylinder. A turbocharger engine produces more power overall than the same engine without the charging.

This can significantly improve the power-to-weight ratio for the engine. In order to achieve the boost, the turbocharger uses the exhaust flow from the engine to spin a turbine, which is turn spin an air pump. The turbine in the turbocharger spins at speed of up to 150,000 rotations per minute (rpm)—that’s about 30time faster than most car engine can go. And since it is hooked up to the exhaust, the temperature in turbine is also very high.

2. Experimentation

The dimension of the turbocharger used for this investigation is taken from the real diesel engine turbocharger. The dimensions were measure and it is use for the development of 3D model by using CREO software. The picture of the turbocharger considered for this study is show in figure1 as follows.

The properties of the structure steel, titanium alloy and nickel alloy material selected for the analysis is shown in table 1, 2 and 3 respectively. Based on the material properties assumed the required dimension were designed by using the CREO software. The error in the geometrical file is checked carefully by analyzing the overlapping of facets, geometrical data redundancy and vertex to vertex rule between the facets. After confirming the geometrical error now the created solid model is check for the mass property calculations like mass, volume, density. After analyzing the mass property calculation carefully, the created 3D model are exported to a neutral file format called standard for exchange of product data to facilitate the easy file transfer data to facilitate the easy file transfer between various vendor software.

Table 1
Properties of the structural steel

Sr. No.	Parameter	values
1	Density	7850kg/m^3
2	Young's modulus	2*10^11pa
3	Poisson's ratio	0.3
4	Thermal conductivity	60.5w/mk

Table 2
Properties of the titanium alloy

Sr. No.	Parameter	values
1	Density	4430kg/m^3
2	Young's modulus	1.138*10^11pa
3	Poisson's ratio	0.342
4	Thermal conductivity	25000w/mk

Table 3
Properties of the nickel alloy

Sr. No.	Parameter	values
1	Density	4430kg/m^3
2	Young's modulus	1.138*10^11pa
3	Poisson's ratio	0.342
4	Thermal conductivity	25000w/mk

The finite element analysis was carried out over all the three assumed materials separately. The analysis was carried out by using Ansys version R15 software. The meshing turbocharger design is below:

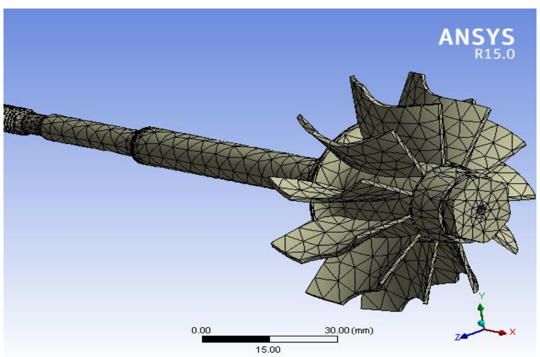

Fig. 1. Meshing model of the turbocharger

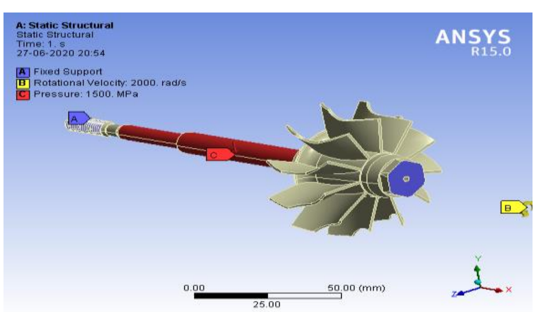

Fig. 2. Specification of maximum pressure

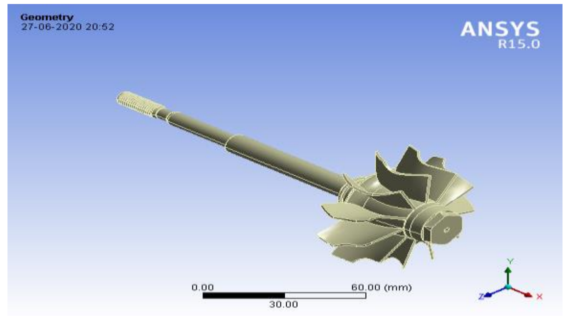

Fig. 3. Model of the turbocharger

3. Result and Discussion

The finite element analysis of the structural steel was carried out for analyzing the important properties namely static structural analysis. The total deformation, equivalent stress analysis, equivalent strain analysis of the structural steel is as below:

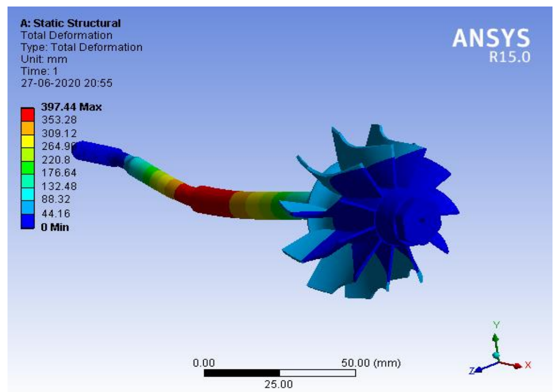

Fig. 4. Total deformation for structural steel

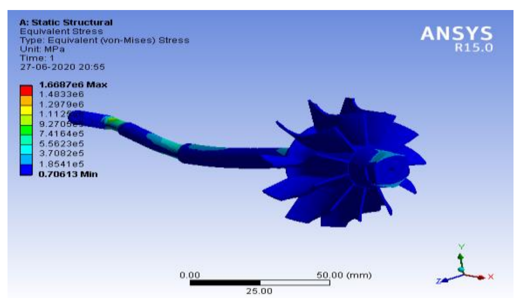

Fig. 5. Equivalent stress for structural steel

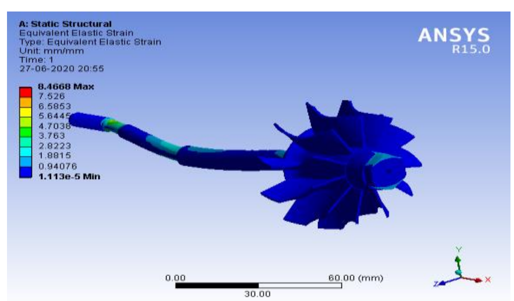

Fig. 6. Equivalent strain for structural steel

The total deformation, equivalent stress analysis, equivalent strain analysis for the titanium alloy is show in below:

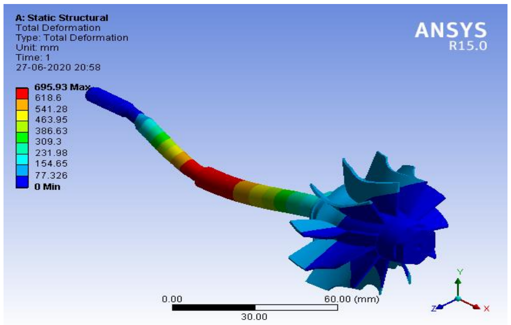

Fig. 7. Total deformation for structural steel

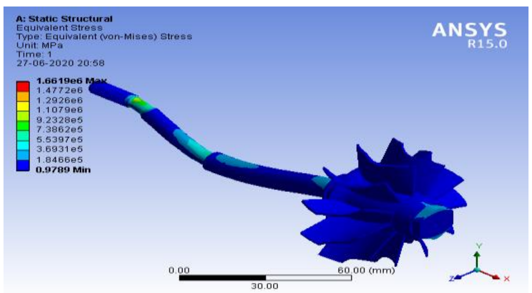

Fig. 8. Equivalent stress for structural steel

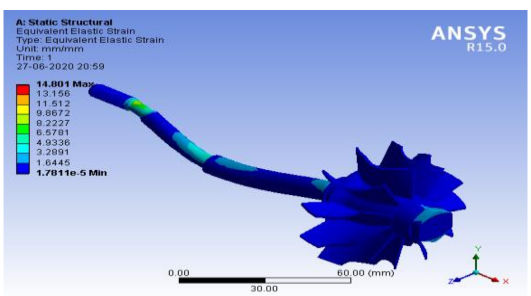

Fig. 9. Equivalent strain for structural steel

The total deformation, equivalent stress analysis, equivalent strain analysis for the Nickel alloy is show in below:

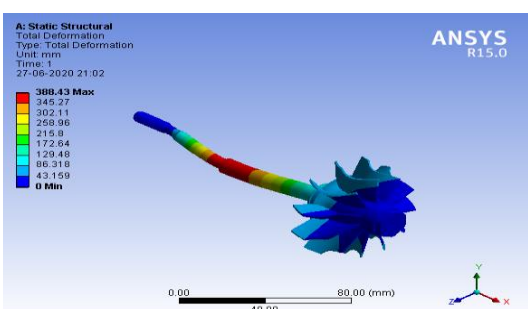

Fig. 10. Total deformation for structural steel

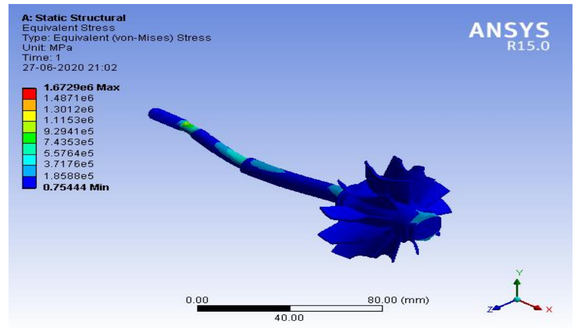

Fig. 11. Equivalent stress for structural steel

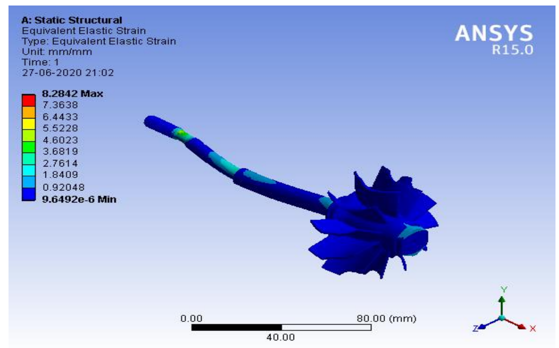

Fig. 12. Equivalent strain for structural steel

Table 4
Static structural analysis comparison

Sr. No.	Parameter	Structural steel	Titanium alloy	Nickel alloy
1	Total deformation (mm)	176.64	309.63	172.64
2	Equivalent stress (mpa)	7.14	7.389	7.43
3	Equivalent strain(mm)	3.763	6.578	3.681

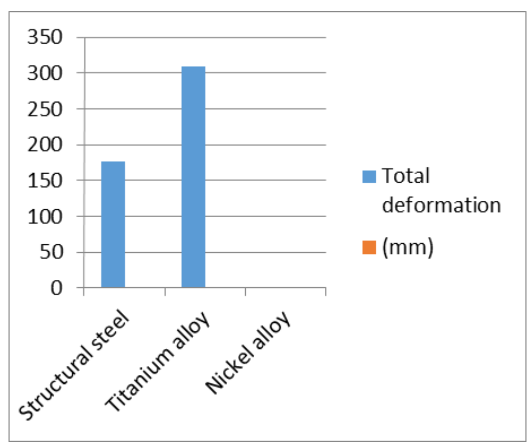

Fig. 13. Comparison of total deformation

The graphs clearly shows the comparison among the structural properties between the three materials. Out of the three material titanium seems to undergo more deformation compared to nickel alloy and structural steel.

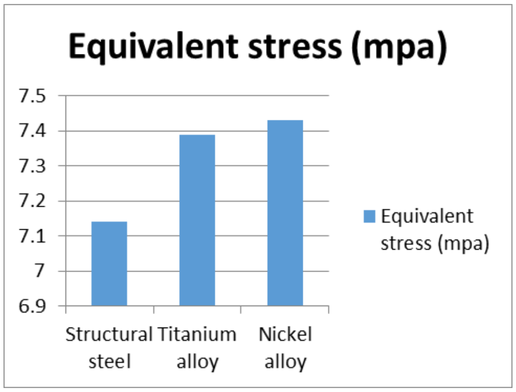

Fig. 14. Comparison equivalent stress

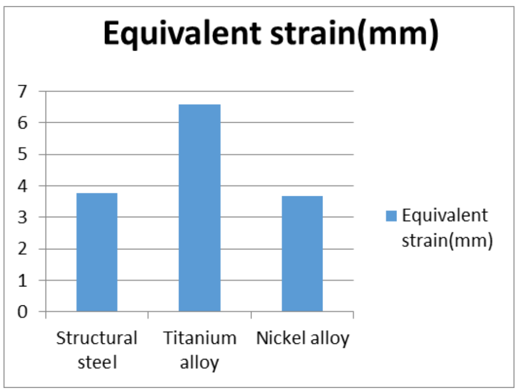

Fig. 15. Comparison equivalent strain

4. Conclusion

The analysis was carried out for the turbocharger using ANSYS. In the analysis part the model of the turbocharger was created using CREO and the file were saved in STEP format and imported to ANSYS. The analysis is carried out on the redesigned model with different materials (structural steel, Nickel alloy and Titanium alloy) and the results were compared. From the above result summary table we conclude that nickel alloy was found better than structure steel and titanium alloy. Form the above data we observed that minimum stress and deformation is obtained for Nickel alloy.

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