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Design & Analysis of Turbocharger Impeller

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Abstract:

This paper presents structural analysis of turbocharger impeller by using different materials under different static and dynamic conditions to obtaining the stress values and strain values and deformation ranges. After structural analysis of impeller the most suitable material is selected among others for manufacturing of impeller. For designing the impeller 30,000 rpm is considered for this project. Impeller was designed by CATIA software and analysis was done by ANSYS software.

1.INTRODUCTION:

Present project deals with turbocharger impellers designing and analysis for finding the most suitable material under different conditions for having better efficiency for impeller.In this project four different materials are using according to their physial properties and suitability for impeller etc., has taken in to account. Turbocharger is used mostly in diesel engines and it is used to increase power for an engine.Specific fuel oil consumption is reduced and mechanical, thermal and scavenging efficiencies are improved.By using turbocharger exhaust gases energy has reutilised to supply power to compressor and turbine for improving efficiency.Use of exhaust gases power is done with the help of turbocharger. On both sides of turbocharger impellers are fixed namely compressor impeller and turbine impeller both are having special applications called compressor impeller has to compress the air more and turbine impeller has to expand the air.

So the impellers design plays main role and these are designed specially to have less weights,more strengthbecause when air enters in to the engine the compressor impeller has to compress the air to increase the air pressure and when happening this impeller blades are pressurised when compressing the air,So the design has mainly focused to reduce the blade size according to the requirements and geometricalmodeling is used when designing this impellers of turbocharger. when designing the impeller type of material has to select because impeller strength, weight, status of durability are decided according to use of material. So proper material has to select for manufacturing of impeller. In this project we are using four different materials namely AISI 4063 STEEL, INCONEL 718, TECHNITIUM, TITANIUM 2-6-4-6. Turbocharger impeller has to withstand high centrifugal loads and high pressures and temperatures when working, So these materials are selected in this project for impeller depending on their properties. Each material is having special applications and having its own characteristics.Inconel alloys are oxidation and corrosion resistant materials well suited for service in extreme environments subjected to heat and pressure, and these are used in high temperature applications.inconel alloys are austenite nickel chromium based super alloys and this material is used for impeller manufacturing and inconel 718 is a grade of material having special applications.

Titanium material also uses in impeller because of its low density, high strength and this titanium material shows corrosion resistance greatly and this material is mostly used in military aerospace and industrial processes. It has high melting point and high strength to weight ratio compared to other materials. AISI steel called american iron and steel institute is also used in this project and it is a special grade of steel called 4063 steel is used. Other material called technitium is also used in this project for impeller because of its special advantages. All these materials shows great impact for working of impeller so by knowing and comparing and analysing stresses and strains the suitable material is selected for better efficiency of turbochargerimpeller.

2.WORKING OF TURBOCHARGER:

A turbocharger contains a gas turbine coupled to a compressor. Both the turbine and the compressor are keyed to the same shaft. Whenever the turbine rotates, the com pressor is operated. Exhaust gases from the engine is allowed to fall on the gas turbine. The turbine rotates. This makes the compressor work. The compressor compresses air (in case of petrol engines) or air-fuel mixture (in case of diesel engines) that is to be fed to the engine.

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This raises the pressure of air or air-fuel mixture above atmospheric pressure. Such an increase in pressure fuels the output power of the engine. It facilitates smooth operation of the engine in different ambient condit.

IMPELLERS IN PUMPS:

An impeller is a rotating component of a centrifugal pump, usually made of iron, steel, bronze, brass, aluminum or plastic, which transfers energy from the motor that drives the pump to the fluid being pumped by accelerating the fluid outwards from the center of rotation. The velocity achieved by the impeller transfers into pressure when the outward movement of the fluid is confined by the pump casing. Impellers are usually short cylinders with an open inlet (called an eye) to accept incoming fluid, vanes to push the fluid radially, and a splined, keyed or threaded bore to accept a drive-shaft. The impeller made out of cast material in many cases may be called rotor, also. It is cheaper to cast the radial impeller right in the support it is fitted on, which is put in motion by the gearbox from an electric motor, combustion engine or by steam driven turbine. The rotor usually names both the spindle and the impeller when they are mounted by bolts.



3.LITERATURE SURVEY:

The first exhaust gas turbocharger was completed in 1925 by swiss engineer Alfred buchi.several researches have been implemented to improve the turbochargers efficiency and alfredbuchi specifically intended to use turbocherger in diesel engines. This turbocharger technology was improved greatly during worldwar2 and subsequent development of gas turbine. Coming to the materials, inconel family of alloys was developed in 1940s by research teams at wiggin alloys england.several grades of inconel are present called inconel 600,625,690,751 etc., are there. Titanium can be alloyed with iron, aluminium, vanadium among other elements to produce light weight alloys. Several scientistscontuining researches for advancement of turbo charges and efficient usage of materials and turbocharger technology was improving for usage in various applications.

4.DESIGN:

For impeller designing in this project CATIA software is using called computer aided three dimenshional interactive application is used to design the impeller.surfacemodelling plays main role while designing in CATIA and this software contains special design features and special design modes like other cadcamprogrammes.Catia is advanced tool of cadcamprogrammes.The main advantage of design cad cam tools is when a design change is done on a particular part of impeller and assigned the parts it will automatically show impact on entire part,so we can easily handle the impact and entire assembly of component can be studied for correctness of drawing is possible with this design cad cam tools.

5.ANALYSIS:

Analysis plays main role for studying the impeller in various conditions and after designing the impeller it is necessary to analyse the impeller for study their stresses and strains in different using materials for studying the best suitable material for impeller. Type of analysis is to select and in this project structural analysis is carrying out for impeller. Analysis is carried separately for each using material and analysing their deformation ranges and stresses and strains. This analysis is carried in three stages called preprocessor, solution processor and post processor. Each stage is having its own characteristics for analysing.after analysis of each using material impeller designing, the suitable material is selected for impeller manufacturing according to necessary conditions. For analysing, intially the material proerties is to given like its youngs modulus and density etc., and type of mesh has to given whether free mesh or mapped mesh.

6.ANALYSIS RESULTS Imported model in to ansys AISI 4063 Steel



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Element Type: Solid 20 node 95 Material Properties: Youngs Modulus (EX) : 209 GPA Poissons Ratio (PRXY) : 0.29 Density : 7.75 Tensile strength ultimate:1855 MPA Tensile strength yield:1593 MPA Rotating speed : 30000 RPM

MESHED MODEL



Displacement



STRESS



STRAIN



INCONEL 718

Element Type: Solid 20 node 95 Material Properties: Youngs Modulus (EX) : 205 GPA Poissons Ratio (PRXY) :0.284 Density : 8.19g/cc Tensile strength ultimate: 1120 MPA Tensile strength yield : 827MPA Rotating speed : 30000 RPM

Displacement



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STRESS



STRAIN



TITANIUM TI6-2-4-6

Element Type: Solid 20 node 95 Material Properties: Youngs Modulus (EX) : 114 GPA Poissons Ratio (PRXY) : 0.33 Density : 4.65g/cc Tensile strength ultimate:1580 MPA Tensile strength yield : 1410MPA Rotating speed : 30000 RPM

Displacement



STRESS



STRAIN



TECHNETIUM

Element Type: Solid 20 node 95 Material Properties: Youngs Modulus (EX) : 322 GPA Poissons Ratio (PRXY) : 0.31 Density : 11.5 g/cc Tensile strength ultimate: 1510 MPA Tensile strength yield : 1290MPA Rotating speed : 30000 RPM

Displacement



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STRAIN



7.RESULTS TABLES STRUCTURAL ANALYSIS

MATERIALS	DISP	STRESS	STRAIN
	mm	N/mm²	
AISI 4063 Steel			
	0.5688	523.25	3.189E ⁻⁶
INCONEL 718			
	0.6148	554.69	3.468E ⁻⁰⁶
Titanium Ti6-2-4-6			
	0.6211	312.13	3.445E ⁻⁰⁶
Technetium			
	0.5467	774.94	3.053E-06

8.CONCLUSION:

In this project we did structural analysis with maximum rpm load condition on turbocharger impeller using ansys workbench software. For results we are considering stress values. The stress values are in under yield stress this impeller can be with stands with this load. It's under yields stress value. Come to results we are observed stress values titanium have less stress for Titanium Ti6-2-4-6 and inconel 718, steel 4063and Technetium getting slight increasing stress values have. Consider another parameter is displacement here we getting Technetium less displacement compare to all materials. Next materials Steel 4063, inconel 718 and Titanium Ti6-2-4-6 in order increasing displacements. Consider another parameter strain it is also main roles in gear life. By observing results we had seen less strain for Technetium and for Steel 4063, Titanium Ti6-2-4-6 and inconel 718 in orderly increasing.by the conclusion Titanium Ti6-2-4-6 Gives better life for impeller because its having less stress and displacement values compared to Technetium its slightly high. But seen to stress results Technetium having high value compares to remaining materials. Considering mass properties its half to base material Inconel 718. Here decreased mass and also increased impeller life.

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