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Analysis on Turbo Charger Outer Case of Different Materials at Various Engine Speeds

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ABSTRACT

To prevent the common turbocharger housing problems of different machinery applications could utilize a better turbocharger housing than, which is provided. Depending on the application, this improved turbocharger housing should be constructed of material that is light, long wearing and which has a low thermal expansion and low heat capacity, so as to conserve heat in the exhaust gases. Lower thermal conductivity, to conserve heat in the exhaust gases and so enhance thermal efficiency and if applicable catalytic converter effectiveness best material.

Temperatures at compressor & turbine side vary with different Engine speeds. Hence the Turbo charger Housing experience increased temperatures when Engine speed increased & vice versa. This will result in increase or decrease of Thermal stress and corresponding deformations & ultimately leads to failure of the housing when the stresses are equal to or greater than the allowable strength at the operating temperatures encountered in the housing. Analysis has been done on turbocharger outer casing by using commercial ANSYS Workbench 15.0 and effects of engine speeds (700 – 1000 rpm) on Turbo Charger Housing.[Turbo Charger Housing Materials: INCONEL 718, Super Alloy A – 286].

Temperatures at compressor & turbine vary with different Engine speeds. Output at different speeds with different materials overall temperature distribution, Stresses developed due to thermal load resulting deformations in the housing Heat flux in X, Y, Z directions.

INTRODUCTION

Turbocharger is that you get more power output for the same size of engine (every single stroke of the piston, generates more power energy output per second, and the law of conservation of energy tells us that means you have to put more energy in as well, so you must burn correspondingly more fuel. In theory, that means an engine with a turbocharger is no more fuel efficient than one without. They might save up to 10 percent of your fuel.

Since they burn fuel with more oxygen, they tend to burn it more thoroughly and cleanly, producing less air pollution.

TURBOCHARGER

A turbocharger is a device that uses engine exhaust gases to power a compressor that increases the pressure of the air entering the engine, which results in more power from the engine. Air enters the compressor from the left, is compressed and then directed to the intake valve of the cylinder. Exhaust exits the exhaust valve of the cylinder, spins the turbine and is expelled. The three major pieces of a turbocharger introduced in the previous section and shown in Fig. are the compressor, bearings section and turbine. Each of these sections has an important function and deserves further attention.

It is also important to recognize in any discussion of turbo charging that turbo charging an engine involves more than just slapping a turbocharger on to the engine. An entire system must be developed for the turbocharger, including a means of temperature and pressure control.

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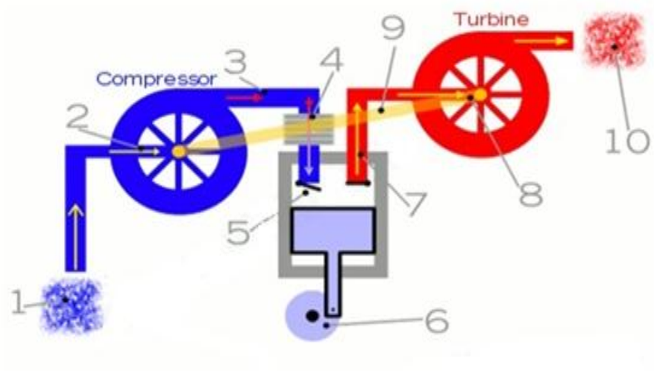
Turbocharger Working



1. Cool air enters the engine's air intake and heads toward the compressor.
2. The compressor fan helps to suck air in.
3. The compressor squeezes and heats up the incoming air and blows it out again.
4. Hot, compressed air from the compressor passes through the heat exchanger, which cools it down.
5. Cooled, compressed air enters the cylinder's air intake. The extra oxygen helps to burn fuel in the cylinder at a faster rate.
6. Since the cylinder burns more fuel, it produces energy more quickly and can send more power to the wheels via the piston, shafts, and gears.
7. Waste gas from the cylinder exits through the exhaust outlet.
8. The hot exhaust gases blowing past the turbine fan make it rotate at high speed.
9. The spinning turbine is mounted on the same shaft as the compressor (shown here as a pale orange line). So, as the turbine spins, the compressor spins too.
10. The exhaust gas leaves the car, wasting less energy than it would otherwise.

TURBOCHARGER HOUSING MATERIAL PROPERTIES

- Depending on the application, this improved turbocharger housing should be constructed of material that is light, long wearing, and which has a low thermal expansion and low heat capacity, so as to conserve heat in the exhaust gases.
- It is an object of this study to provide a lightweight, but high strength turbocharger housing which is ductile and fracture resistant and also it can be formed into complex shapes and sizes as desired.
- It has improved insulation characteristics and lower thermal conductivity, to conserve heat in the exhaust gases and so enhance thermal efficiency.
- A turbocharger housing which is capable of withstanding high temperatures and thermally-induced strains.

TYPES OF MATERIALS

INCONEL 718

Alloy 718 is a precipitation harden able nickel based alloy designed to display exceptionally high yield, tensile and creep rupture properties at temperatures up to 1300°F.The sluggish age hardening response of alloy 718 permits annealing and welding without spontaneous hardening during heating and cooling. This alloy has excellent weldability when compared to the nickel base super alloys hardened by aluminum and titanium. This alloy has been used for jet engine and high speed airframe parts such as wheels, buckets, spacers, and high temperature bolts and fasteners.

IRON-BASED SUPERALLOY286

Alloy 286 is an iron-base super alloy useful for applications requiring high strength and corrosion resistance up to 1300°F (704°C) and for lower stress applications at higher temperatures. This heat and corrosion resistant austenitic alloy can be age hardened to a high strength level.

The alloy is also used for low temperature applications requiring a ductile, non-magnetic high strength material at temperatures ranging from above room temperature down to at least -320°F (-196°C). The alloy may be used for moderate corrosion applications in aqueous solutions.

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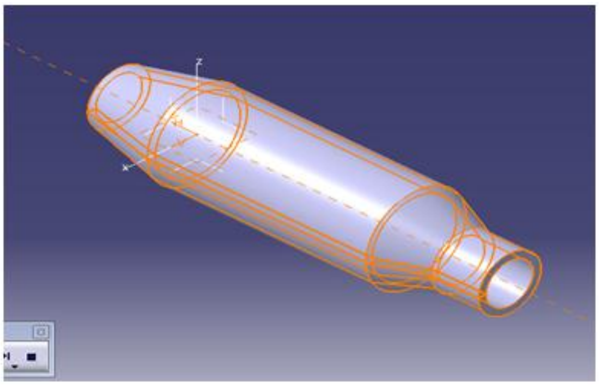
3D MODELLING OF TURBOCHARGER OUTER CASE



1.6.2 Material Properties

DIFFERENT TURBOCHARGER OUTER CASE MATERIALS

PROPERTIES	INCONEL - 718	IRON-BASED SUPERALLOY 286
Density	8.192 g/cm3)	7.92 g/cm3
Tensile strength, Ultimate	1317Mpa	620 MPa
Modulus of Elasticity (E)	186GPa	201 GPa
Tensile Strength, Yield	1076Mpa	275Mpa
Coefficient of Thermal Expansion	$14.2 10^{-6}$/°C	$16.8 10^{-6}$/°C
Specific Heat Capacity	0.46 (kJ/(kg K)	0.420(kJ/(kg K)
Thermal Conductivity	10.5 (W/m K)	17.8(W/m K)
Melting Point	1210-1344°C	1370-1430°C
Electrical resistivity	1210 microhmmm	1156 microhmmm

THERMAL ANALYSIS

It involves determination of temperature distribution throughout the turbocharger housing. It requires the determination of heat transfer co-efficient on the turbocharger outer case turbine side to compressor side. It also involves the determination of heat fluxes. These are the essentially the boundary conditions to be assigned.

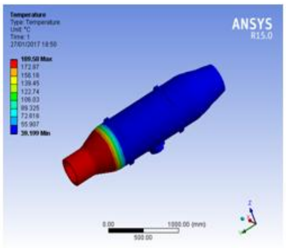
STRESS ANALYSIS

There are several yield criterion used in practice. Some of these are- the maximum shear stress criterion, the maximum principal stress criterion and the von mises stress criterion. These criterion could be expressed in terms of material constants obtained from different physical tests e.g. a shear or a uniaxial tensile test. According to the Von mises stress criterion, yielding depends on the deviator stress and not the hydrostatic stress.

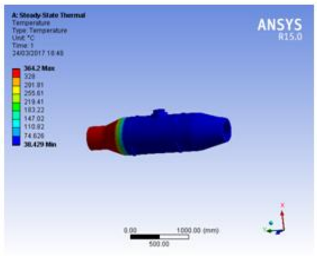
INCONEL 718

Temperature distribution

50 Nm

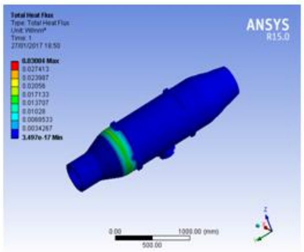


150 Nm



Total heat flux

50Nm



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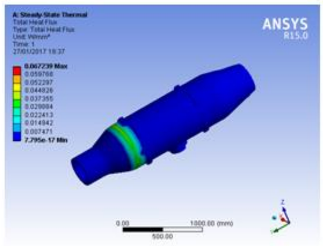
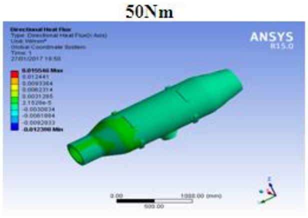
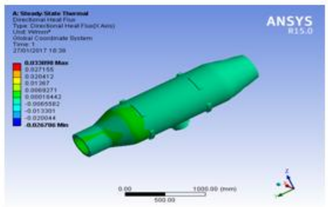


Directional heat flux (x-axis)

50Nm

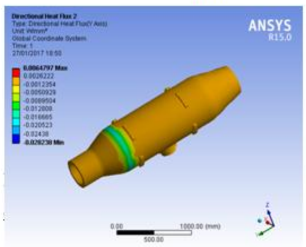


150Nm

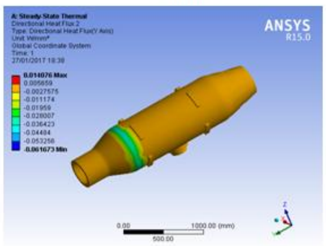


Directional heat flux (Y-axis)

50Nm

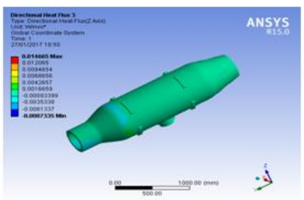


150Nm

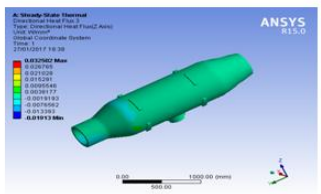


Directional heat flux (Z-axis)

50Nm

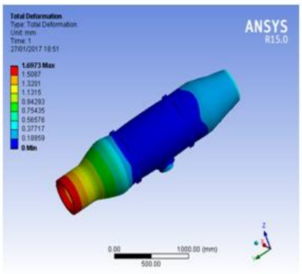


150Nm



Total Deformation

50Nm



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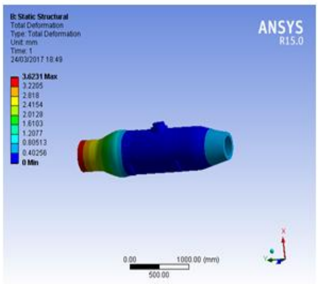
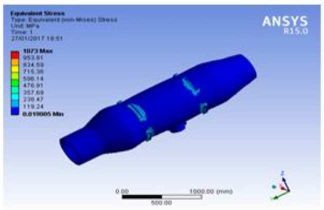
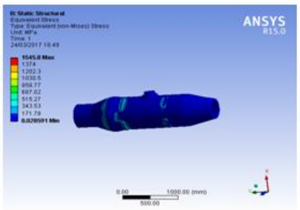


Equivalent (Von mises) Stresses

50 Nm

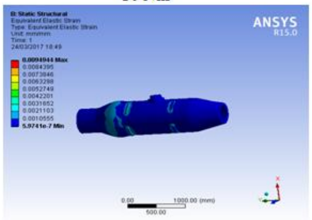


150 Nm



Equivalent Elastic Strain

50 Nm



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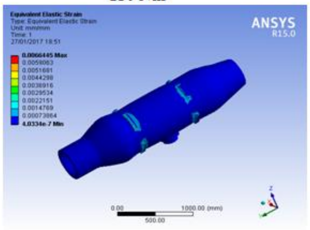
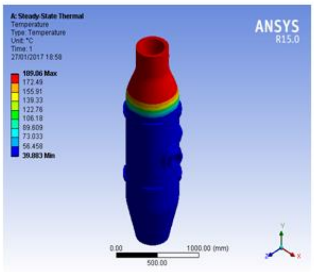


SUPER ALLOY A - 286

Temperature distribution

50 Nm



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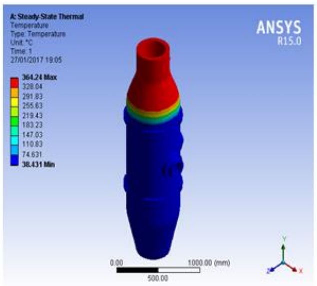
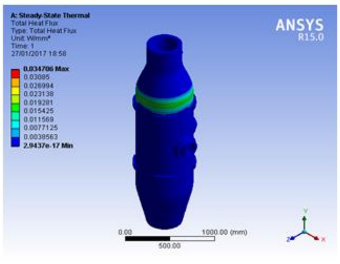
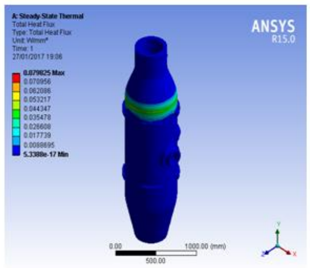


Total Heat Flux

50 Nm

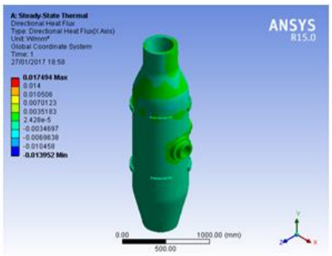


150 Nm

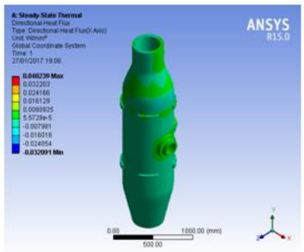


Directional heat flux (x-axis)

50 Nm



150 Nm



Directional heat flux (Y-axis)

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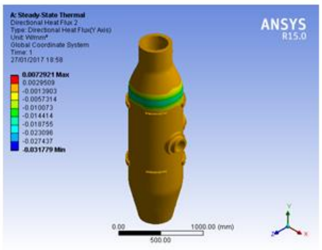
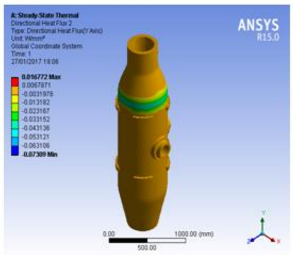
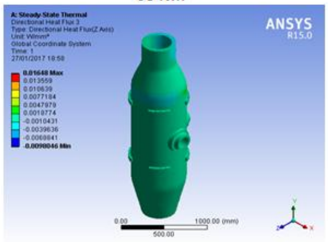


150 Nm

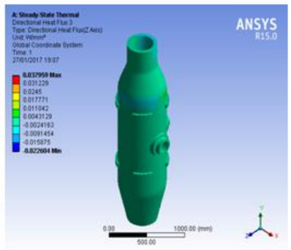


Directional heat flux (Z-axis)

50 Nm

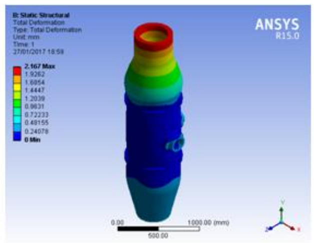


150 Nm



Total Deformation

50 Nm



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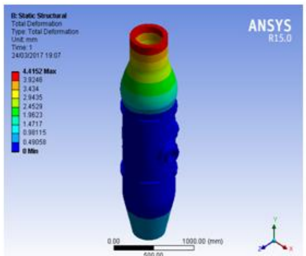
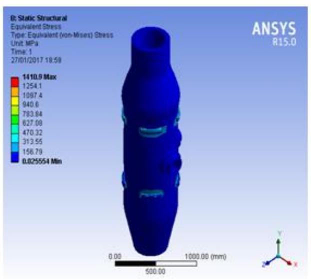
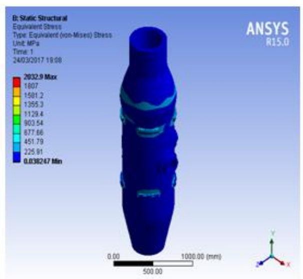


Equivalent (Von – Mises) Stress

50 Nm



150 Nm



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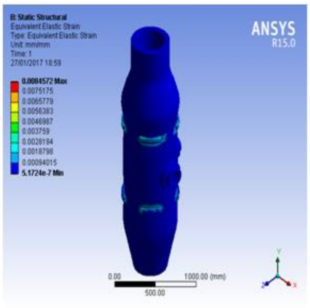
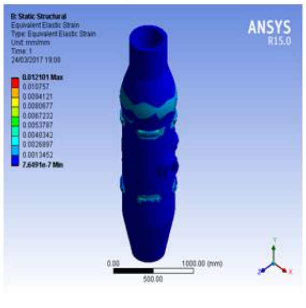
Equivalent Elastic Strain

50 Nm



150 Nm



Comparisons of Analysis Results:-

S.NO					OBJECTIVES	
1	Temperature Distribution	°c	39.199°.	38.429°	39.883°	38.431°
2	Heat Flux	w/mm2	0.017133	0.037355	0.019281	0.0044347
3	Directional Heat Flux(X-AXIS)	w/mm2	0.0031265	0.0069271	0.0035183	0.0080925
4	Directional Heat Flux(Y-AXIS)	w/mm2	-0.0012345	-0.0027575	-0.0013903	-0.0031976
5	Directional Heat Flux(Z-AXIS)	w/mm2	0.0016659	0.0038177	0.0018774	0.0043129
6	Total deformation	Mm	1.6973	3.6231	1.9262	4.4152
7	Equivalent(von-Mises) stress	Mpa	119.24	171.70	156.79	225.91
8	Equivalent Elastic strain	mm/mm	0.00073864	0.0010555	0.00094015	0.0013452

7. CONCLUSION

From the result shown above that the induced stresses and deformation are the main factor for comparison of those materials from analysis various results are obtained like maximum stress, maximum deformation and maximum heat fluxes are observed. The analysis is being carried out for various turbocharger housing materials which are discussed earlier with applying various materials like INCONEL 718 and IRON-BASED SUPERALLOY 286 with application of same thermal load for turbocharger housing with different torques .density of the material is also used for comparison but, stress and deformation tells us which is having more life time for all given conditions and best suited for present generation.

The above taken materials have minimum deformation because of its low temperature distribution compared to other material and from the comparison statement INCONEL 718 have maximum tensile and yield strengths compared to IRON-BASED SUPERALLOY 286, so from this properties INCONEL 718 is best suited for the manufacture of turbocharger casing.

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