



RESEARCH ARTICLE

COOLING OF TURBOCHARGER WITHOUT CHARGE AIR COOLER

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ABSTRACT

In current scenario, cooling process of turbo charger is done by Charge Air Cooler. The CAC is placed in front of the radiator and can obstruct the passage of air through its fins it decreases the work efficiency of the radiator. Furthermore, if there is any problem in the radiator the CAC must be disconnected before getting to the radiator. By providing direct cooling into the turbo charger inlet part itself, all the unwanted joints existing of CAC can be eliminated. There is more free space and this would allow for development of further components.

Key words:

Turbo charger,
Radiator, CAC,

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INTRODUCTION

In the present scenario CAC is employed in heavy vehicles. When the exhaust gas (at 380-400^oC) enters the Turbocharger, it rotates the impeller. Due to this the impeller at the inlet region also rotates. When the inlet impeller rotates it sucks in more fresh air and sends to the engine^[2]. Since the exhaust gas and inlet air (fresh air) both were in the turbocharger the heat of exhaust gas is transferred to the inlet air. Due to this heat transfer the temperature of fresh air is increased to 120^oC. To cool this Fresh air, it is passed through Charge Air Cooler (CAC). The heated air passes through CAC, gets cooled down to 50% from the heated temperature.

the coolant passes down the cooling passage provided around the combustion chamber, it absorbs the heat liberated and maintains a constant temperature around it. As the coolant reaches the bottom region of the combustion chamber, it is sent to the top region of radiator with the help of a pump. When this hot coolant reaches the top region of the radiator, it passes through the fins in the radiator. As it moves down the radiator, the temperature of the coolant decreases with the help of fresh air.

Experimental Setup

This is achieved by providing cooling directly into the turbo charger inlet part itself, which eliminates all the unwanted joints existing due to Charge Air Cooler. So when the space is reduced in the altered design more technology can be added making it less complicated and a compact design with higher efficiency.

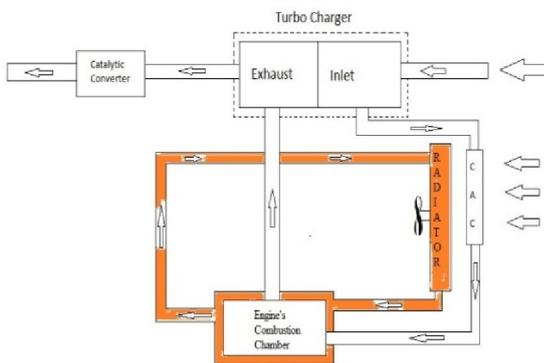


Fig. 1. Schematic Diagram with CAC

After passing through the CAC the air is sent to the engine for combustion process after which, the exhaust gas goes to the turbocharger and the process repeats itself continuously. During this process the cold coolant from the radiator bottom passes from engine top to remove the heat produced during the combustion process. As

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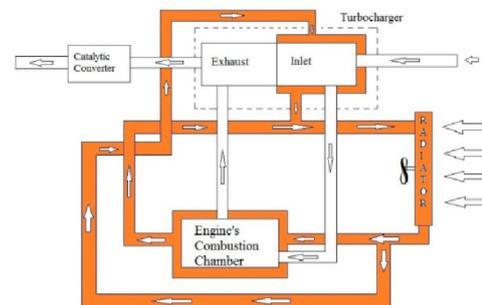


Fig. 2. Schematic Diagram without CAC

When the exhaust gas at 380-400^oC enters the Turbocharger, it strikes the impeller blades, due to which the compressor at the inlet region also rotates. When the inlet impeller rotates it sucks in more fresh air and sends to the engine^[2]. Since the exhaust gas and inlet air (fresh

air) both were in the turbocharger the heat of exhaust gas is transferred to the inlet air. Since we provide cooling over the inlet region of the turbocharger the temperature of the inlet gas gets reduced. So the transfer of heat between the exhaust gas and the inlet (fresh air) gets reduced. So the inlet air can be sent directly to the combustion chamber without sending to the CAC. For Cooling the inlet region of turbocharger the coolant from the radiator bottom region is taken with the help of pump and circulated from the top region of turbocharger. When the coolant passes the turbocharger and reaches the bottom region of the turbocharger it absorbs the heat from the inlet gas and moves to the top region of radiator. The Cooling process of engine is same as in the current process. The coolant is cooled when it passes from the top region of the radiator, as it passes down through the radiator. It is cooled with the help of air passing through the radiator.

Material Selection

Material= CF8C Plus Cast Stainless Steel^[4]

Specification

| PARAMETERS | |
|---|------------------------|
| Thermal Conductivity (k) | 47.5 W/mK |
| Density | 7700 kg/m ³ |
| Coefficient of Thermal Expansion | 1.5 J/K |
| Specific Heat | 520 J/kgK |
| Coefficient of Heat Transfer(h _b) | 11W/m ² K |
| Diameter of the turbocharger inlet | 78mm |
| Area | 71.9mm ² |

Boundary conditions

Compressed Temperature, T₁= 130⁰C
 Inlet Temperature, T₂=30⁰C

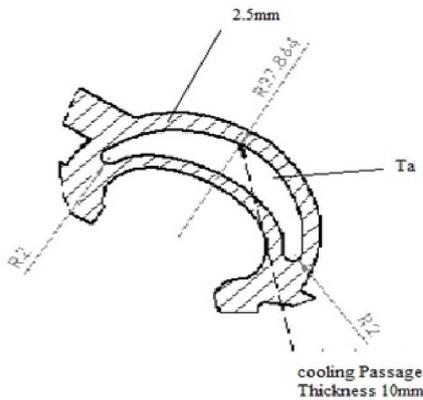


Fig. 3. Cooling Passage Dimensions

Design and Analysis

This work includes the design of the proposed model. The liquid cooling section provided in the turbocharger is 3cm from the outer casing of the turbo. This is the standard dimension for the cooling process. The design is shown in Fig 4 which was developed using CATIA software.

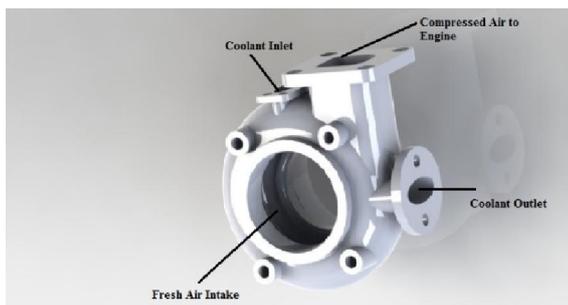


Fig. 4. Passage of Coolant and Air shown in design

The analysis of above shown design is done using Ansys and CFD software. This shows the effect on turbocharger before providing liquid cooling and after that as well. That clearly shows the results of this work. The results are shown in Fig 5 and 6.

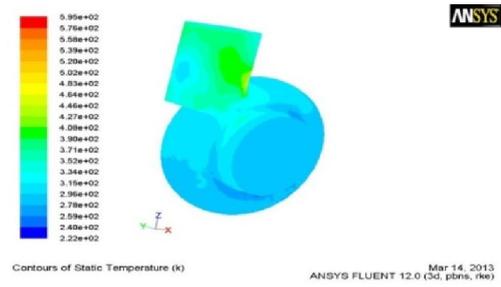


Fig. 5. Analysis Result before providing cooling

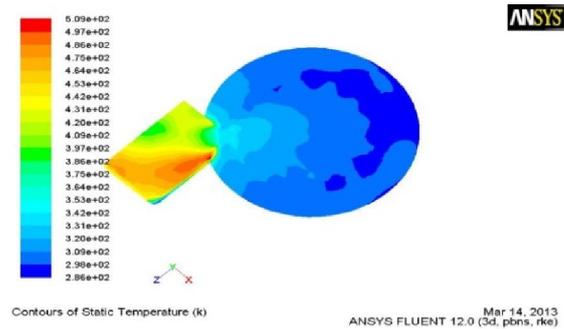


Fig. 6. Result of analysis done after providing cooling

RESULT AND DISCUSSION

| Parameters | With CAC | Without CAC |
|--------------------|------------|-------------|
| Air Flow Rate | 0.5 kg/sec | 0.5 kg/sec |
| Inlet Temperature | 303 K | 303 K |
| Cooling Provided | No | Yes |
| Outlet Temperature | 362 K | 322 K |

From the analysis done it is clear that that the outlet temperature of the air coming out of the turbocharger has decreased, when cooling is provided to the turbocharger. The temperature that is obtained after providing cooling will be enough for the combustion process.

Conclusion

From the analysis result and theoretical calculations mentioned above, it is clear that the cooling of turbocharger is with liquid cooling system is much easier and efficient. Thus, this work concludes that a better way to cool the turbocharger without using Charge Air Cooler is by providing liquid cooling in the turbocharger inlet section itself in heavy vehicles. It is a better way because it eliminates the efficiency reduced in the radiator because of Charge Air Cooler obstructing the passage of air. The other advantage of employing this way is that it eliminates the space occupied by the Charge Air Cooler and all its connections provided in heavy vehicles. This reduction of unwanted parts will make the maintenance of engine a lot easier and will do the same for radiator as well. It will simplify and reduces time in the fixing work during assemble. Furthermore, it reduces the heat transfer between exhaust and inlet section of the turbocharger. This will improve the compression process more effective in the engine of a heavy vehicle.

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