International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

CFD Analysis of Exhaust Gas Recirculation Cooler

***Pragati Mankar*[1], *Dr Roopesh Tiwari*[2]**

[1]PG scholar, Department of Mechanical Engineering, SAGE University, Indore
[2]Associate Professor, Department of Mechanical Engineering, SAGE University, Indore

ABSTRACT

The Euro 6 standards have significantly reduced NOx emissions. The NOx limit is reduced from 0.18 g/km to 0.08 g/km, a 56% reduction when compared to Euro 5 standards. This has significant implications for control technologies, necessitating, for the first time, the integration of emission control aftertreatment for NOx emissions, such as improved exhaust gas recirculation (EGR) coolers. Exhaust Gas Recirculation coolers (EGR) must withstand high thermal stresses due to large temperature gradients between the hot exhaust gas and the coolant. The effectiveness of five different designs of EGR coolers is determined using the CFD technique. The EGR cooler is a shell and tube design with a single coolant entrance in the first design and numerous coolant entries in the succeeding design, in which the coolant travels through the shell to cool the exhaust gas inside the tubes. The thermo-flow characteristics inside the EGR Cooler as well as the surface temperature were examined using the CFD code ANSYS CFX 14.0. For analysis, the standard k-epsilon turbulence model is utilised. The mathematical validation of the EGR cooler is completed, and the results are compared to each design.

Keywords- Emission, Thermal stress, EGR, CFD, $NO_{x,}$

1.INTRODUCTION

A multitude of variables, including the air-to-fuel ratio, cylinder size, ignition timing, and fuel injection system, affect engine performance. Without an EGR assembly, any CI engine only has a rich mixture (more fuel than air or a low A/F ratio) intake, which increases fuel consumption. In contrast, CI engines with EGR coolers have leaner mixture intake (higher A/F ratio or less fuel than air), which reduces fuel consumption. Installing an EGR cooler is therefore useful for improving fuel efficiency. With its three-stage combustion process and EFR cooler, the CI engine helps produce more power while emitting fewer NOx emissions. Automobile pollution is decreased as a result. EGR mountings also lessen throttling losses on spark ignition engines. The engine's life would be improved as a result of the lower cylinder temperatures. EGR feeds burned gases back into the engine, improving the cooling effect of exhaust gases. The generation of NOx emissions is slowed down by an inert gas found in exhaust gases that cannot participate in the burning of fuel in engine cylinders. Diesel exhaust fluid, which is currently expensive, is not required for EGR, which lowers the cost of running and maintaining the engine. EGR improves fuel economy by lowering flame temperature more than power reduction does. EGR is a useful tool for reducing nitrogen oxide emissions from internal combustion engines without increasing other pollutants.

2.PROBLEM IDENTIFICATION

Due to the single inlet layout of the shell design, the EGR cooler's cooling capacity is severely constrained. EGR cooler failure causes a rise in NOx emissions, which contributes to pollution by failing to cool EGR gases to the desired amount. The investigation of coolers employing various inlet configurations was necessary because prior designs were restricted to a single inlet configuration, which limited the cooling properties. The traditional EGR cooler used in CRDI diesel engines is inefficient and has to be improved. Similar to the typical EGR cooler, the log mean temperature difference is minimal and needs more design optimization to raise its value.

3.OBJECTIVES

The main objectives in this research work are

- CAD modelling of EGR cooler using CREO 2.0.
- CFD analysis of EGR cooler base design using ANSYS CFX.
- Design optimization using multiple inlet entries (1, 2, 3, 4, 5) for shell.
- CFD evaluation of numerous designs with varying inlets.

SPECIFICATION OF EGR

Table 1.1: Physical dimensions of EGR

Parameters	EGR Dimensions (in mm)
No. of tubes	28
No. of baffles	3
Tube length	185
Total length	240
Inlet coolant side diameter	20.5
Outlet coolant side diameter	20.5
Inlet exhaust side diameter	32
Outlet exhaust side diameter	32

CAD MODELLING

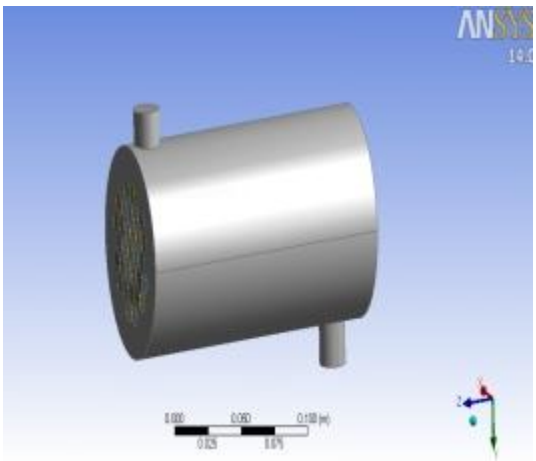

Figure 1.1 CAD model of EGR cooler

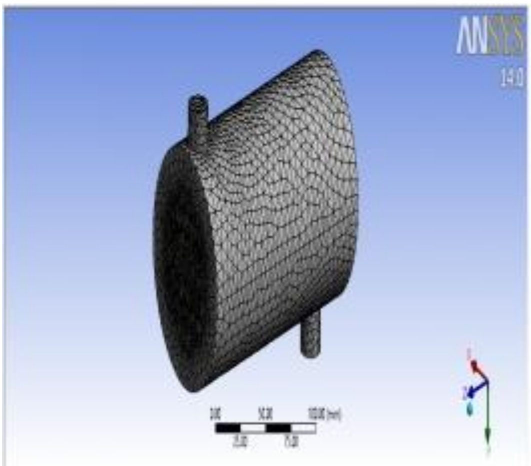

Figure 1.2 Meshing of EGR cooler

RESULT

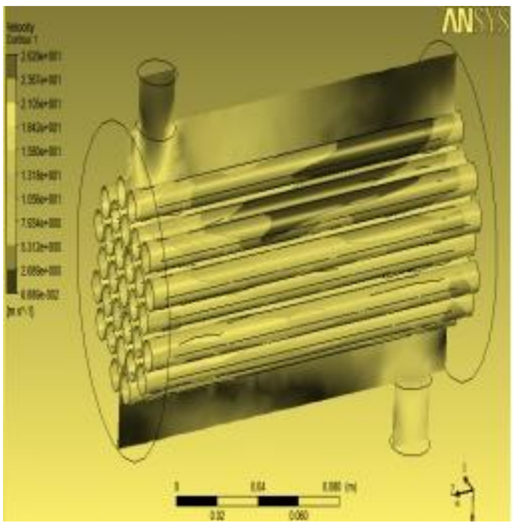

Figure 1.3 Velocity at 420^{0}C temp.

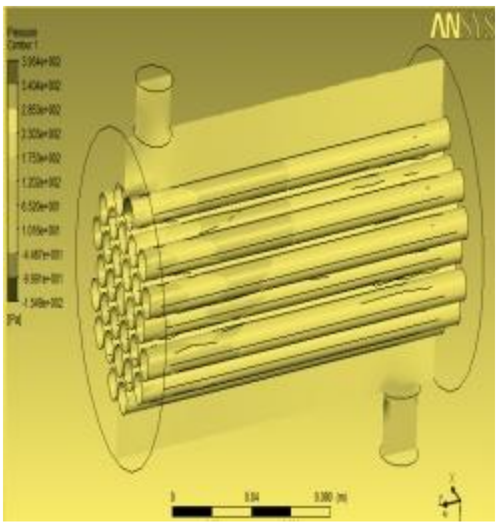

Figure 1.4 Pressure contour at 420^{0}C temp.

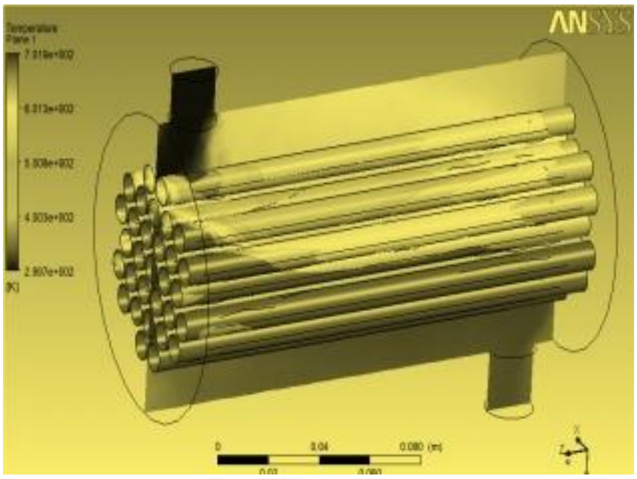

Figure 1.5 Temperature at 420^{0}C

CONCLUSION

Following is a discussion of conclusions based on a numerical investigation.:

Pressure drop is found to be maximum for four inlet design configurations for shell side with value of 555Pa and minimum value of 480Pa for double entry design.

Pressure drop is found to be maximum for four inlet design configurations for tube side with value of 365Pa for four entry design and minimum value of 253Pa for triple entry design.

EGR gas outlet temperature is found to be maximum (701 K) for 3 inlets design with operating temperature (1059.26 K).

REFERENCES

[1] Tatsuya Shiraishi, Mitsuo Hirata, Ruotaro Nishida "Nonlinear feed forward controller design for air path system with transport dynamics of external EGR system" IFAC Papers Online 54-10 (2021) 1–6.

[2] Ali Azam, Asad Naeem Shah, Shoukat Ali, Zafar Abbas, Ammar Ahmed , Adnan Iqbal " Design, fabrication and implementation of HE-OBCU-EGR emission control unit on CI engine and analysis of its effects on regulated gaseous engine emissions" Journal of king Saud University Volume 33, Issue 1, January 2021, Pages 61-69.

[3] Martin Keller, Severin Geiger, Kevin Kluge, Marco Gunther, Stefan Pischinger, Dirk Abel, Thivaharan Albin "Setup and Control of a Two-Stage Turbocharged Gasoline Engine with Low Pressure EGR in a Prototype Vehicle" IFAC Papers Online 53-2 (2020) 17578–17585.

[4] Getachew Alemayehu, Deresse Firew , Ramesh Babu Nallamothu, Amana Wako, Rajendiran Gopal " Operating parameters optimization for lower emissions in diesel engine with PCCI-DI mode using Taguchi and grey relational analysis" Heliyon Volume 8, Issue 6, June 2022, e 09679.

[5] Mario Ditaranto, Tarjei Heggset, David Berstad "Concept of hydrogen fired gas turbine cycle with exhaust gas recirculation: Assessment of process performance" SINTEF Energy Research, Volume 192, 1 February 2020, 116646.

[6] Jacek Hunicza, Jonas Matijošiusb, Alfredas Rimkusc, Artūras Kilikevičiusb, Paweł Kordosa, Maciej Mikulski "Efficient hydrotreated vegetable oil combustion under partially premixed conditions with heavy exhaust gas recirculation" fuel 268 (2020) 117350.

[7] Jacek Hunicz , Maciej Mikulski, Pravesh Chandra Shukla , Michał S. Gęca " Partially premixed combustion of hydrotreated vegetable oil in a diesel engine: Sensitivity to boost and exhaust gas recirculation" fuel 307 (2022) 121910.

[8] Jinlin Hana, Shuli Wanga , Ruggero Maria Vittorib , L.M.T. Somersa " Experimental study of the combustion and emission characteristics of oxygenated fuels on a heavy-duty diesel engine" fuel 268 (2020) 117819.

[9] Jelmer Rijpkema , Olof Erlandsson , Sven B. Andersson , Karin Munch " Exhaust waste heat recovery from a heavy-duty truck engine: Experiments and simulations" Energy 238 (2022) 121698.

[10] S. Dey , N.S. Mehta " Automobile pollution control using catalysis" Resources environment and sustainability Volume 2, December 2020, 100006.