DESIGN AND CFD ANALYSIS OF EXHAUST GAS RECIRCULATION HOUSING

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Abstract

Compressed ignited (CI) engines, commonly known as diesel engines are widely used power sources in on-road and off-road applications with complex emissions. Determining the impact of diesel exhaust emissions on human health and environment requires evaluating both regulated and unregulated properties of exhaust gas.

The diesel engine provides a high efficiency and hence it can help to reduce CO2 emissions, which are believed to be the main cause of global warming. Diesel exhaust also contains toxic gases, mainly nitrogen oxides (NOx) and soot particles. The authorities in most countries therefore limit these emissions. A way to reduce the nitrogen oxide emission of a diesel engine is the use of Exhaust Gas Recirculation (EGR). Here a part of the exhaust gases is rerouted into the combustion chamber, this leads to lower peak combustion temperature which in turn reduces the formation of NOx.

EGR is an effective strategy to control NOx emissions. The EGR reduces NOx through lowering the oxygen concentration in the combustion chamber, as well as through heat absorption. Several configurations have been proposed, including High-pressure and Low-pressure loop EGR, as well as hybrid systems.

EGR path can be built up in different kinds of ways one is short route system where the valve can be placed on either hot or the cold side of the cooler and other one is long route system.

Problem Statement:

To avoid the lacquering issue (formation of carbon particles which leads to locking of valve opening) in EGR valve due to high temperature, valve has to be protected by reducing the temperature surrounding the EGR valve, so that valve will not be affected. To avoid this issue EGR housing has been implemented as it protects the valve by reducing the temperature.

Main aim of the research is to design and CFD analysis of the EGR housing.

1. INTRODUCTION

INTRODUCTION OF EXHAUST GAS RECIRCULATION:

The Exhaust gas recirculation system is designed to reduce the amount ofnitrogen oxides (NOx). This NOx is created by the engine during operating periodsdue to high temperature of combustion. When the combustion temperature exceeds2500oF, a highly concentrated NOx is formed. The EGR system works by re-circulatinga small amount of exhaust gas back to the combustion chamber throughthe intake manifold where it mixes with the incoming air/fuel charge. The high temperature and

the pressure are reduced by diluting the air/fuel mixture under that condition

2. LITERATURE SURVEY

Considerable amount of research have been carried out on the effect of Low heat rejection engines on engine performance and emission characteristics. The present study is focusing on the reduction of Nox emissions by applying various methods in EGR system.

Diesel Emissions:

During the combustion process of a diesel engine, chemical energy is converted into mechanical energy at high temperatures and under high pressure. A variety of combustion products are formed when diesel fuel is burnt. These are typically carbon monoxide, hydrocarbons, oxides of nitrogen, carbon dioxide, and fine particles. For diesel combustion the most important engine out emissions are oxides of nitrogen (NOX), particulates and smoke. NO (Nitric Oxide) and NO2 (nitrogen dioxide) are lumped together as NOx. NO is a colourless and odourless gas, while NO2 is a reddish brown gas with pungent odour. Both gases are toxic, but NO2 is 5 times greater toxic than that of NO. Although NO2 is largely formed from oxidation of NO, attention has been given on how NO can be controlled before and after combustion. Mechanism of formation and control of NOx in diesel engine is very complex owing to heterogeneous and transient combustion nature of diesel fuel combustion. Although NO2 is largely formed from oxidation of NO, attention has been given on how NO can be controlled before and after combustion. NOx can cause severe health problems like irritations in the respiratory system mainly a cause forasthma, lung cancer and cardiovascular diseases. NOx has detrimental environmental impacts like ground-level ozone, acid aerosols, acid rain, toxic chemicals and deterioration of water quality.

NOx Formation Parameters:

Diesel combustion is characterized by heterogeneous air-fuel mixture but there exist local stoichiometric air–fuel ratios resulting in to high flame temperatures. The formation of NOx is dependent on temperature, local oxygen concentration and duration of combustion. The most critical parameters contributing to the formation of NOx is local combustion temperature, which is directly a function of several hardware and operating parameters such as; load, compression ratio, boost level, charge temperature, injection timing, mixture formation (nozzle configuration) cylinder peak pressure, Cetane number, etc. The higher the combustion temperature (above 1800 K) inside the cylinder during combustion, the more energy is available to split the strong triple-bonding between the atoms of the molecular nitrogen of the combustion air to generate atomic nitrogen chain carriers resulting in NO formation. The second most critical parameter is availability of oxygen. Diesel combustion requires excess percentage of oxygen for better and complete combustion. Due to the heterogeneous air fuel mixture during combustion in CI engines, local air/fuel ratio (λ) influences the NOx formation and not the overall λ value. The third most important parameter is time. Only a short period of time is available to the NO formation process, since the most critical gas temperatures are achieved between the start of combustion and shortly after the occurrence of peak cylinder pressure. However, investigations have shown that the formation process of NO takes place in both flame as well as the post-flame area, providing a sufficient amount of time for the NO formation reaction. Of all three

factors local reaction temperature and Oxygen concentration has greater influence in the formation of NOx. Therefore any factor that can reduce the maximum combustion temperature along with reduced availability of oxygen can reduce the emission of NOx. Exhaust gas recirculation is gaining importance in the recent past as a measure to control NOx emissions. In this technique a measured volume of engine out exhaust is re-circulated along with fresh intake air. EGR application modifies the normal combustion process as it reduces the amount of oxygen and presents combusted products like CO_2 and H_2O, principle constituents of EGR, during combustion. Reductions in oxygen entry into the cylinder due to EGR is referred to as dilution effect and where as high specific heat gases CO_2 and H_2O contained in EGR absorbing more heat during combustion is thermal effect . The net result of both these effects is to reduce combustion temperature leading to reduced NOx emissions. Literatures indicate the adverse effects of EGR at higher load and higher percentage of EGR in terms of fuel penalty and particulate emissions.

3.EGR

3.1 Reactions involved in generation of NOx:

Diesel engines function on lean mixture that is a high quantity of air is mixed with a low proportion of fuel. This associated with the high temperature in the combustion chamber leads to appearance of nitrogen oxide. These reactions take place at high temperature.

$$O + N_2 = NO + N$$

$$N + O_2 = NO + O$$

$$N + OH = NO + H$$
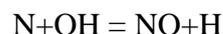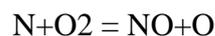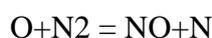
NO can further react to form NO_2 by various means.

$$NO + H_2O = NO_2 + H_2$$
$$NO + O_2 = NO_2 + O$$
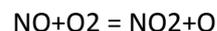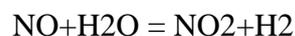
Therefore, to reduce NOx emission the peak temperature of engine cylinder must be lowered.

3.2 About Exhaust Gas Recirculation:

EGR is an effective technique to reduce NOx formation in the combustion chamber. Exhaust mainly consists of CO_2, N_2 and water vapours. When a part of this exhaust gas is re-circulated to the cylinder, it acts as diluents to the combustion mixture. It also reduces the O_2 concentration in the combustion chamber. Because of high specific heat of EGR, heat capacity of the intake charge upsurges, thus decreasing the temperature rise for the same heat release in the combustion chamber.

$$\% EGR = \frac{Volume\ of\ EGR * 100}{Total\ intake\ charge\ into\ cylinder}$$

The amount of EGR that is re-circulated should be efficiently managed; otherwise it would lead to lower the efficiency of the engine.

Ignition delay, up surged heat capacity and dilution of intake charge with inert gases are the three popular explanations for the effect of EGR on NOx reduction. EGR causes an upsurge in ignition delay which is equivalent as retarding the injection timing. The heat capacity hypothesis asserts that addition of exhaust gases into the intake charge upsurges the heat capacity which lowers the peak

combustion temperature. According to the dilution theory, increasing amount of inert gases in the mixture reduces the adiabatic flame temperature thus reducing NOx formation inside the chamber.

3.2 **Classification of EGR system:**

Classification Based on temperature:

- Hot EGR: Exhaust gas is re-circulated without being cooled which results an upsurged intake charge temperature.

- Fully Cooled EGR: Exhaust gas is fully cooled before mixing with fresh intake air using water cooled heat exchanger.

- Partly Cooled EGR: The temperature of the exhaust gas is just kept above its dew point temperature to avoid water condensation.

Classification Based on Configuration:

- Long Route system (LR): In LR system, the pressure drop across the air intake and the stagnation pressure in the exhaust gas stream make the EGR possible.

- Short Route System (SR): These systems differed mainly in the method used to set up a positive pressure difference across the EGR circuit.

Classification Based on Pressure:

- Low pressure route system: The passage for EGR is provided from downstream of the turbine to the upstream side of the compressor. It is found that by using the low pressure route system, EGR is possible up to a high load region with significant reduction in NOx.

- High pressure route system: The EGR is passed from the upstream of the turbine to downstream of compressor. In this method, although EGR is possible in high load regions, the excess air ratio decreases and fuel consumption upsurges remarkably.

The Exhaust gas recirculation system is designed to reduce the amount of nitrogen oxides (NOx). This NOx is created by the engine during operating periods due to high temperature of combustion. When the combustion temperature exceeds 2500^oF, a highly concentrated NOx is formed. The EGR system works by re-circulating a small amount of exhaust gas back to the combustion chamber through the intake manifold where it mixes with the incoming air/fuel charge. The high temperature and the pressure are reduced by diluting the air/fuel mixture under that condition.

The EGR flow has three operating conditions. The first condition is the high EGR flow; where it is necessary during cruising and mid-range acceleration. This is a condition where the combustion temperature is very high. Meanwhile the second condition is low EGR flow. Low EGR flow is needed during low speed and light load conditions. Finally, the third condition is the no EGR flow condition. When the engine warms up and idle the

wide open throttle, no EGR flow should occur during that condition. EGR operations could adversely affect engine operating efficiency or vehicle derivability.
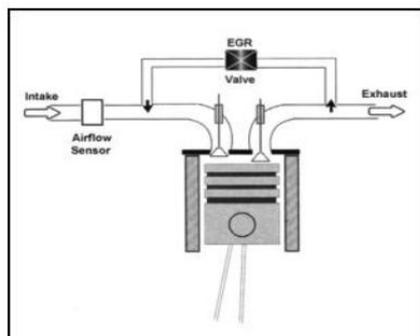
Concept of exhaust gas recirculation system

Exhaust gas recirculation is use to re-circulate the exhaust gas back to the combustion chamber at intake manifold. In other words, to supply exhaust gas to the fresh mixture or to the air sucked into the cylinder. The use of exhaust gas recirculation is needed to control the production of NOx emission for gasoline and diesel engines (Richard 2006). The NOx reduction is primarily caused by the following factors:

- The heat capacity (Cp) of the re-circulated exhaust gas is higher than the heat capacity   (Cp) of the air. This makes the low temperature increases for the same amount of energy release by combustion.
- Reduction of the O2 partial pressure and therefore, lower oxygen mass inside the cylinder, because a portion of the combustion air is replaced by exhaust gas with lower oxygen content.
- Reduction of the combustion speed and therefore lower temperature increase. When the combustion temperatures are too high it forms a nitrogen oxides (NOx). Any

measure to decrease NOx and emission lead to reduce the combustion temperature. The use of EGR will increased the soot and other solid paniculate loading of lubricant oil. Re-introduction of the acidic exhaust gas product (sulphuric acid) into the engine will rapidly increase the total acid number (TAN) of the lubricant (S. Aldajah et al. 2006) Using high exhaust gas recirculation (EGR) rates by increased boost pressure to avoid the negative impact on soot emissions is the one efficient method to control NOx in order to achieve future emissions limits (Hountalas et al. 2006). The combustion noise and the thermal efficiency of the dual fuel engine are found to be affected when EGR is used in the dual fuel engine (Selim 2001).

EGR theory of operation

The purpose of EGR system is to precisely regulate EGR flow under different operating condition. EGR system also has to override flow under conditions which would compromise good engine performance. Like the engine load change, the precise amount of exhaust gas which must be metered into the intake manifold varies significantly. This results in the EGR system operating on a very fine line between good NOx control and good engine performance. The engine performance will be suffered if too much exhaust gas is metered. The engine may knock and will not meet strict emissions standards if too little EGR flows. The EGR ratio is referred as the theoretical volume of re-circulated exhaust gas. The graph in figure 2.4 shows the EGR ratio increases as engine load increases.

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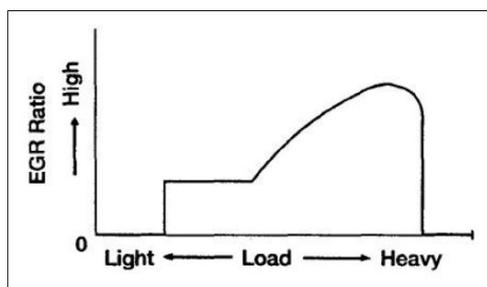
Relationship between EGR ratio and engine load

EGR system also gives impact on the engine control system (ECS). The ECM considers the EGR system as an integral part of the entire engine control system (ECS). The ECM is capable of neutralizing the negative performance aspects of EGR by programming advanced additional spark and decreased the fuel injection duration during periods of high EGR flow. By integrating fuel and spark control with the EGR metering system, engine performance and fuel economy can actually be enhanced when the EGR system is functioning as designed. To regulate exhaust gas flow from the exhaust to the intake manifold, the EGR control valve is used by means of a pintle valve attached to the valve diaphragm. A ported vacuum signal and calibrated spring on one side of the diaphragm are balanced against atmospheric pressure acting on the other side of the diaphragm. The valve is pulled further from its seat when the vacuum signal applied to the valve increases.

EGR cooling system

The re-circulated exhaust gas can be cooled down to reduce the NOx emissions. Meanwhile, reduction for radiators is possible up to 50% following the design accordingly. Cooling the re-circulated exhaust gas is one of the ways to reduce the emissions that caused pollution; without significant additional fuel consumption. NOx generation can be reduced by lowering gas temperature in the combustion chamber. To achieve this, a specially developed EGR cooler is installed between the EGR valve and the intake manifold entry point for the exhaust gas. It uses water as a cooling medium to reduce the exhaust gases temperature and the amount of pollutants. It is believed that it is more effective than using air as a cooling medium. Exhaust emission NOx decreased but the particulate matter concentration in the exhaust gases increased when cooled EGR rises in ratio (Nidal 2002).

A system with controlled EGR cooling system combined with a controlled engine cooling system shows that it decreased the warm up times for fast warm up of after treatment devices, decreased power consumption, and gave better engine temperature control (Chalgren et al. 2007). Using a cooled EGR system raises the density of the intake air thus, the amount of air entering the combustion chamber increases. A complete combustion then is achieved, thereby reducing the generation of PM.

3.3 Different EGR systems:

The EGR-path can be build up in different kinds of ways.

3.3.1 Short-Route System (SR)

The short-route system is the standard system in today'sproduction engines, both for passenger car engines and forheavy duty applications. In the short-route (SR) system, a pipeleads some of the exhaust gases from the exhaust manifoldinto the intake manifold where it is mixed with the fresh air. Thepipe usually contains one or more coolers for

the EGR and avalve to regulate the amount of EGR. The valve can be placedon either the hot or the cold side of the cooler. A placement onthe hot side gives advantages in transient response [20], whilea placement on the cold side makes the choice of valve easier,as it will be placed in a colder environment.
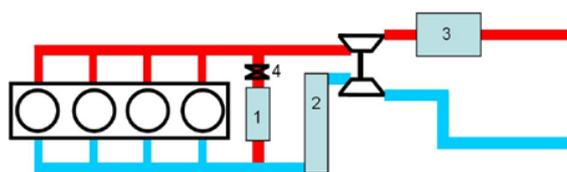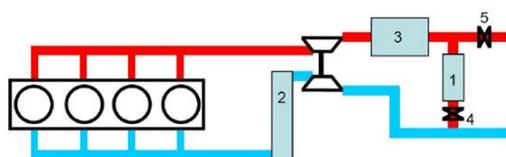

SR-system, 1: EGR-cooler, 2: CAC, 3: DPF, 4: EGR-valve

For cold conditions or cold-start there can be bypasses aroundthe EGR-coolers.A certain pressure difference over the EGR loop is needed todrive the EGR from the exhaust side to the intake side. At loadpoints with good turbocharger efficiency, this pressuredifference does not always exist naturally. To increase it, VGTturbochargers can be used as well as throttles in the exhaustor intake piping.As the exhaust can contain high amounts of soot, fouling of theEGR cooler can be an issue [21]. Also the EGR valve has tobe able to handle the fouling effects.The advantages of the short-route system are its simplicity andits fast response on EGR demands. Drawbacks are thethrottling that often is needed and the risk of soot deposition inthe whole intake system. Another problem can be theturbochargers ability to deliver sufficient charging pressure, asonly part of the exhaust gas passes the turbine while anotherpart is used as EGR.

3.3.2Long-Route System (LR)

In the long-route system, the EGR is taken out of the exhaustsystem downstream of the turbocharger and driven into theintake upstream of the compressor, Figure 12. This leads tohigher power input into the turbocharger, as the whole exhauststream passes the turbine. On the other hand, it leads to ahigher mass flow in the compressor, as both EGR and fresh airhave to be compressed.

In the long-route system, also the compressor and the chargeair cooler have to withstand the passing exhaust gases.Especially the compressor is a sensitive part. Any droplet thatcould build due to condensation could possibly damage thecompressor wheel. Therefore, attention has to be paid to thecooling effect of the EGR-cooler, to avoid condensation. The problem of clogging in the LR-system can be avoided byplacing the EGR-loop downstream of the particulate filter. Thisway, the re-circulated exhaust gas is almost free from sootparticles and the clogging risk for the intercooler is limited.Still there is a risk for the compressor wheel as the exhaustcan accelerate corrosion on it [22].Downstream of the particulate filter, as well as upstream of thecompressor, the gas pressure is close to ambient pressure.This means, that there is no natural pressure drop that coulddrive the flow of EGR. It has to be created either by throttlingthe exhaust or by throttling the intake air. Simulations haveshown that a throttling of the exhaust is to prefer with respectto fuel economy [20].A negative aspect of the LR-system is the long piping that isfilled with EGR. Almost the entire intake piping, includingcompressor and intercooler, is filled with a mix of fresh air andEGR. This results in a poor reaction to changing EGRdemands, as the volume has to be emptied before the gas witha new EGR-rate arrives in the combustion chambers.

LR-system, 1: EGR-cooler, 2: CAC, 3: DPF, 4: EGR-valve, 5: Exhaust throttle
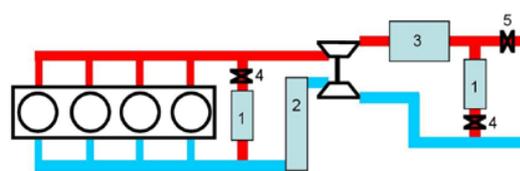
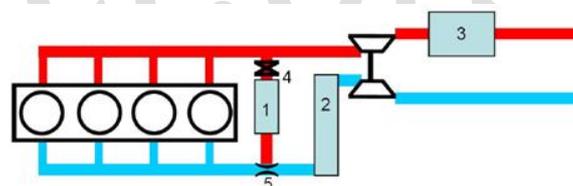Hybrid system, 1: EGR-cooler, 2: CAC, 3: DPF, 4: EGR-Valve, 5: Exhaust throttle

Anotherdrawback is the risk of fouling of the intercooler, as the exhaustgas is not perfectly soot free after the DPF.An advantage is the increase in mass that passes both theturbine and the compressor. Especially in low load points of theengine, where EGR-rates are high and the overall gas flow issmall, the operating point of the turbocharger is moved intoareas with higher efficiency. This helps to improve the enginesfuel economy, compared to a SR-system. Another point thathelps to reduce the fuel consumption is the higher coolingcapacity in the LR-system. As the EGR is cooled by the EGRcoolerand by the intercooler, the intake temperatures for theLR-system will be lower and thus the heat losses in the enginecan be reduced [23].

3.3.3 Hybrid EGR System

The hybrid EGR system combines the long-route and theshort-route system, as Figure 13 illustrates. This way, it ispossible to use the EGR-path that fits the actual drivingsituation best. Even a combination of both ways can lead to thebest engine efficiency in certain load points [24, 25].

3.3.4Venturi in EGR System

The venturi system works after the same principle as anejector pump. At the EGR-mixing point, the intake pipe iscontracted. This leads to a locally reduced static pressure. Atthe point with the lowest pressure, the EGR is introduced. Thismakes it possibly to locally increase the pressure drop thatdrives the EGR flow. Downstream of the mixing point, thediameter is increased to regain the static pressure.

Venturi system, 1: EGR-cooler, 2: CAC, 3: DPF, 4: EGR-valve, 5: Venturi

A system that is marketed with this technology is the Variventsystem by Haldex, Figure 17. Here, a moveable body in thecentre of the venturi pipe allows a regulation of the pumpingeffect. A higher pumping effect with more EGR-flow leads to anincreased pressure in the intake piping.

Varivent system [27, 28]

vacuum operated egr valve
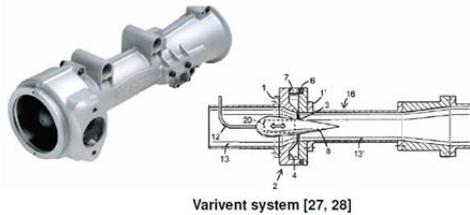
3.4 Drawbacks of EGR systems:

- Decreased Engine operation
- Above idle speed
- EGR flow calculation

3.5 EGR valve:

Since the 1960s, vehicle manufacturers have installed Exhaust Gas Recirculation (EGR) valves to reduce nitrous oxide (NOX) emissions. The EGR valve re-circulates a small amount of exhaust into the combustion cycle. The warmth of the exhaust lets the combustion chambers warm up quickly, while the spent, inert gases keep the chambers from getting too hot when the engine fully warms up. Whether mechanical or electronic, EGR valves open and close to control the gas flow. If left open, the excess vacuum will cause the engine to act like it wants to stall, idling roughly or surging. If the valve stays closed, detonation could occur in the combustion chambers; this knocking or pinging will lower mileage and the lifespan of the engine. To smooth a rough idle, or hesitant or surging acceleration, and reduce knocking, clean your EGR valve.
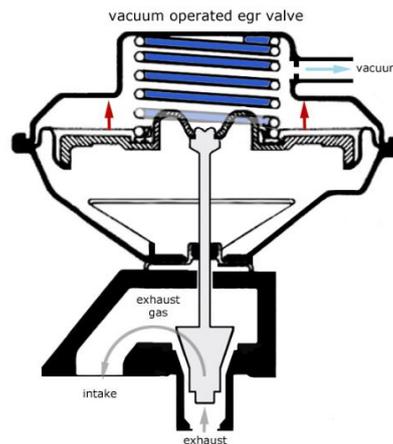
The Exhaust Gas Recirculation (EGR) valve is designed to re-circulate cooled exhaust gas from the engine back into the combustion chamber. The purpose of exhaust gas recirculation is to reduce Nitrous Oxide, or "NOx", emissions. NOx emissions are caused by extremely high combustion chamber temperatures. NOx is a major O-zone pollutant. The re-circulated exhaust gas is an inert gas that takes up space in the cylinder and effectively lowers the combustion temperature, thus lowering NOx emissions.

The EGR valve you see in Figure 2 has accumulated a lot of soot, or particulates. Particulates are basically pieces of partially burnt fuel. Partially burnt fuel can be created in a variety of ways. It can be caused by poor air to fuel mixing in the combustion chamber or it can be the result of poor fuel quality.

Figure 1 — Typical New EGR Valve

Figure 2 — Soot-Contaminated EGR Valve

Most EGR valve failures are experienced in vehicles that are subjected to extended idle times. The operating temperature of a
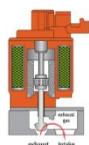
diesel engine, unlike a gas engine, will be reduced during idle. Since a diesel is a compression ignition engine, the combustion process loses efficiency at idle and therefore tends to create more particulates. A gas engine is ignited by a spark plug, so idling a gas engine will have little to no effect on the amount of particulates generated.

Types of EGR valves:

To be sure of fitting the correct replacement Exhaust Gas Return valve it is good to have an understanding of the different types available. There are many different types of EGR valves, some have electronic controls and some have mechanical controls, some of which work strictly on vacuum and others which work on a combination of vacuum and pressure.Petrol and diesel powered engines have various EGR valve system designs. Vehicles on the road today may use one of six or more different valve configurations.
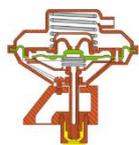
Vacuum Operated (click to enlarge)   Electronically Operated (click to enlarge)

On older models, a small diameter vacuum hose operates a basic EGR valve. The hose connects the top of the valve to the throttle body or carburettor. The EGR valve's metal disk typically houses a vacuum diaphragm, spring, and plunger. Newer vehicle models use electronic EGR valve systems that may include additional components, even a digital valve that eliminates the need for vacuum control altogether.Later models may come equipped with electronic vacuum EGR valves inside a small block or cylinder. The valve works the same way as in older models, except that an electronic EGR position sensor communicates with the cars ECU computer for better control.

You may see electric solenoids connected through vacuum lines to the valve as well.Later models may come equipped with electronic vacuum EGR valves inside a small block or cylinder. The valve works the same way as in older models, except that an electronic EGR position sensor communicates with the cars ECU computer for better control. You may see electric solenoids connected through vacuum lines to the valve as well.

Pneumatic EGR Valves

Activated by vacuum through electromagnetic valves which generally have an open – closed function only. The vacuum is generated from the inlet manifold or by a vacuum pump, depending on vehicle type, and may incorporate an EGR position sensor.

A small pipe from the exhaust manifold or an internal crossover passage in the cylinder head and intake manifold routes exhaust to the valve. When vacuum is applied to the EGR valve, it opens. This allows intake vacuum to suck exhaust into the engine. To prevent the EGR valve from opening when the engine is cold, the vacuum line to the EGR valve may be connected to a parted vacuum switch or an ECU controlled solenoid. Vacuum is not allowed to pass to the valve until the engine is warm, as the EGR valve isn't needed when the engine is cold, only when it is warm and under load.

Electric EGR Valves

Activated directly by the engine control unit (ECU) and no longer needs a vacuum source or electro–pneumatic valves.

Type 1 – Linear Electric EGR Valve
The Linear EGR valve is generally activated under the following conditions:

- Warm engine operation – using Engine coolant temperature (ECT) sensor
- Above idle speed and utilises the following signals:
- TPS
- MAF Sensor
- Engine RPM

Type 2 - ECU Controlled EGR solenoid with vacuum operated EGR valve.

Type 3 – ECU Controlled EGR Solenoid With Vacuum Operated EGR Valve utilizing Differential Pressure Sensor. EGR Differential Pressure Sensor Measures the difference in pressure across a restriction placed in the EGR exhaust gas supply.
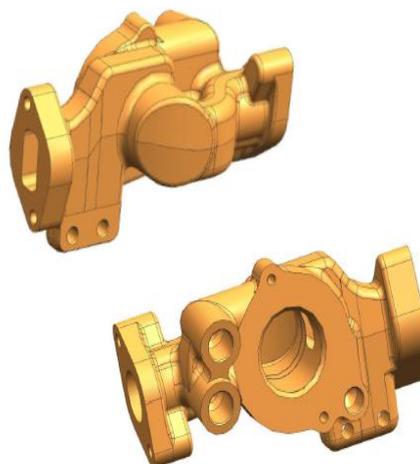
EGR

4. DESIGN OF HOUSING:

EGR valve housing is the part which protects the EGR valve from high temperature and lacquering issues to not to damage the valve. Housing to be designed by considering the valve function and the design of the valve and other parameters like cooler profile, EGR pipe etc. Inside the housing, flow passage has to be smooth as it involves in gas flow and other coolant profile also has to be done.

EGR valves .
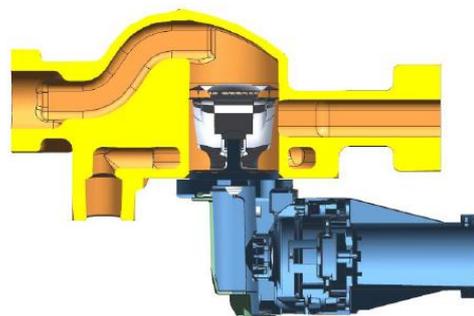
EGR VALVE HOUSING

5. RESULTS
CFD ANALYSIS OF EGR HOUSING:

Main objective of the analysis is to predict the flow pattern and temperature distribution of the EGR housing.

VIEW 1 and VIEW 2 showing the assembly of the EGR housing with the interface parts in engine level.

View 1

View 2

Material Properties:

Table (a) Material Properties

Targets: EGR Valve flange temperature < 200 C

Coolant Properties:

Fig (b) Velocity vectors near valve (in m/s)   Fig (c) Temperature contours near valve (in C)
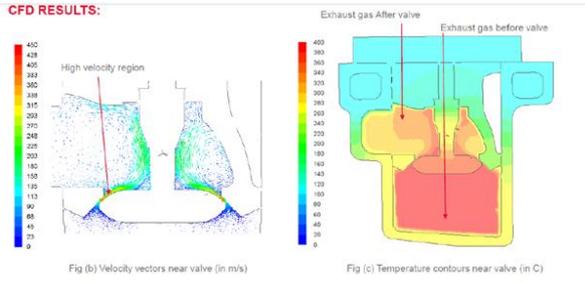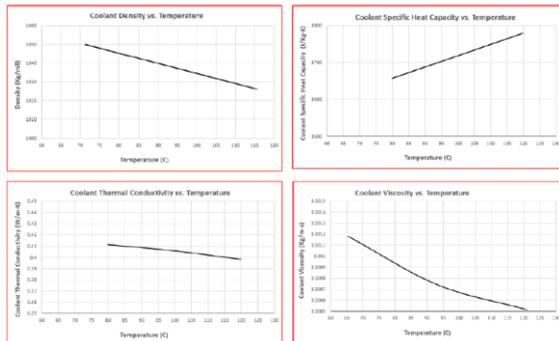
Fig (b) shows velocity vectors near poppet valve. High velocity region is formed near valve opening due to small valve lift of 0.5 mm.

Fig (c) shows temperature contours near the valve region. Significant drop in gas temperature
is observed across EGR valve.

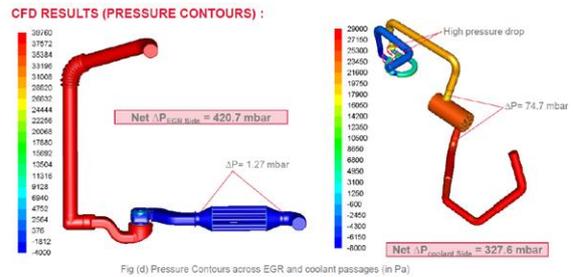Fig (d) Pressure Contours across EGR and coolant passages (in Pa)

Fig (d) shows pressure contours in exhaust gas and coolant passages. In next exhaust gas passage, due to very small valve lift of 0.5 mm, huge pressure drop occurs across it which is evident from completely red and blue contours at inlet and outlet of EGR valve respectively.
The pressure drop in coolant line s gradual. Net pressure drop is 327.6 mbar.

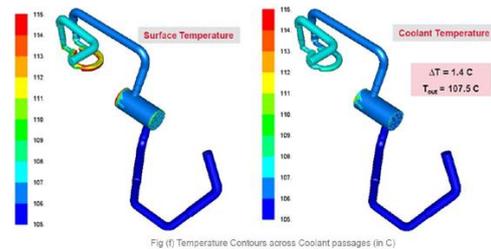Fig (f) Temperature Contours across Coolant passages (in C)

Fig (f) show wall & near coolant temperature contours for coolant passage. The net temperature rise in coolant is 1.4 C
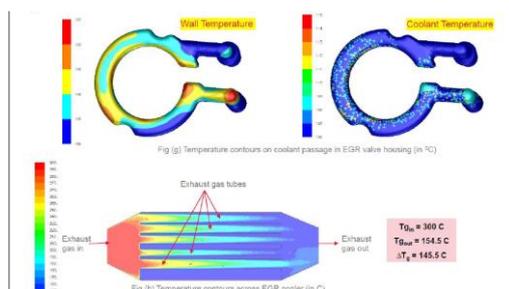
Fig (g) Temperature contours on coolant passage
In EGR valve housing (in °C)
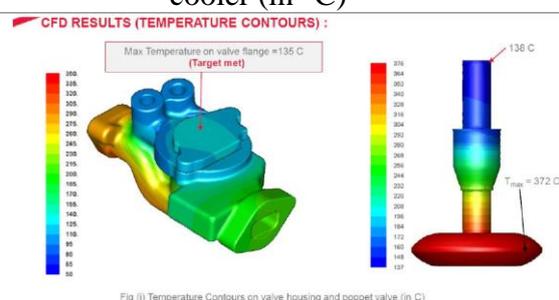Fig (h) Temperature contours across EGR cooler (in °C)

Fig (i) Temperature contours on valve housing and poppet valve (in C)

RESULT:

EGR valve is the part which allows exhaust gas to go intake, in this process due to valve failure issues EGR housing has been developed to protect the valve from temperature and lacquering. Here as per the design and flow analysis results EGR housing mating the temperature contours as 135°C, till it can withstand up to 200°C. So that the valve will be within the temperature so that valve failures will not happen and the amount of flow will be proper to the intake and the mixture will happen proper for the good combustion in the combustion chamber.

CONCLUSION:

EGR is a very useful method for dropping the NOxemission. EGR housing

is the part which protects the EGR valve from high temperature and lacquering issues. EGR displaces oxygen in the intake air and dilutethe intake charge by exhaust gas re-circulated to thecombustion chamber. Here it is concluded that EGR housing can meet the temperature contours so that it will overcome the lacquering issues and valve failure issues on field or off field.

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