

Thermal effect of drain gas recirculation arrangement combined with intercooler for two wheelers

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Abstract. Automobiles play imperative part to 'Place the globe in Motion'. When we discuss air pollution, the major contributions of pollutants are from the automobile sector. Especially in developing countries like India, the use of motorcycles (MC) is too high which eventually leads to high air pollution rate. There is pollution control system available for CI engine operated LMV and HMTV but an efficient system to control pollution is yet to be designed for motorcycles. An automobile emission primarily adds CO, NO_x, HC that is carbon monoxide, nitrogen oxide and hydrocarbons correspondingly and a few particulate discharges. The mounting discharge is ensuing into the worldwide menace approximating 'Global Warming'. Therefore it is currently essential to hub on the behaviors to diminish these impurities. Among the pollution control system available, we found that a system based on exhaust gas recirculation (EGR) with the inter-cooler might be apt to overcome the above mentioned problem. We hope that this prescribed system might be implemented in motorcycles to be launched in future.

Keywords. Hydrocarbons, Exhaust gas recirculation, Inter-cooler, Pollution control system.

1. Introduction

Exhaust gas recirculation (EGR) is a NO_x (nitrogen oxide and nitrogen dioxide) diminution procedure used in diesel engines. Since the use of SI engines (i.e.) two wheelers is rapidly increasing in this years, the implementation of this technique in two wheelers could be a possible solution to reduce pollution. NO_x is a standard tenure for a range of nitrogen oxides formed throughout ignition. They are thought to exacerbate asthmatic circumstances, respond among the oxygen in the air to generate ozone, which is also an annoyance and ultimately outline nitric acid, while suspended in water. While suspended in atmospheric humidity the outcome can be acid rain which can harm mutually trees and complete forest ecosystems.

In an internal combustion engine, a mingle of air and fuel is glowed. When the combination is refrained so as to devour each particle of reactant (here fuel and oxygen) it is assumed to be "operating at stoichiometry". While this glows, ignition temperatures attain a elevated altitude to constrain endothermic effects among nitrogen and oxygen in the flare, acquiescent a range of oxides of nitrogen, the consequences of which can be seen above chief towns.

2. Emission standards in India



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There is a general illusion that the pollutants from two wheelers is very less when compared to LMV and HMVs[1]. This recent emission control standards followed in India says that the pollutants especially NO_x is very high from two wheelers only. Since NO_x control method are already available for LMV and HMVs wherein the NO_x emission is lesser than 2-wheelers, our work on NO_x emission control is worth to be implemented as early as possible[2].

3. Diluent in intake

The easiest realistic technique of dropping utmost flare temperature is to reduce the air-fuel blend with a non retorting sponge gas. This gas attracts energy throughout ignition devoid of causative any force effort. The net consequence is the inferior flame temperatures which eventually decreases the NO_x structure in an engine. Any non reacting gas would effort as diluents [3-5]. Those gases with superior specific heat would attract the majority energy per unit mass and fewer of those gases would consequently be requisite; thus fewer CO₂ would be requisite than argon for the related maximum temperature. Though neither CO₂ nor Argon is voluntarily obtainable for exercise in an engine. Air is obtainable as diluents but is not completely none retorting. Counting air alters the air-fuel percentage and ignition uniqueness. The solitary non-retorting gas that is accessible to employ in an engine is drain gas [7].

4. Principle of EGR

EGR works by reticulating a section of an engine's drain gas reverse to the engine containers. Combining the inward air with re-circulated drain gas reduces the blend with static gas, inferior the adiabatic flame temperature and dropping the quantity of surplus oxygen. The drain gas also augments the specific heat capability of the blend infuriating the peak combustion temperature. NO_x arrangement grows much quicker at elevated temperatures, EGR provides to bind the making of NO_x. NO_x is principally produced while a blend of nitrogen and oxygen is subjected to high temperatures.

4.1. Emanation uniqueness of NO_x

In a distinctive SI engine, 15 to 20 percent of the drain gas is reverted back to the ingestion as EGR (thus encompassing 15 to 20 percent of the blend ingoing the containers). The utmost measure is restricted by the prerequisite of the blend to prolong a nearby flame front through the ignition occasion; too much EGR in an engine grounds misfires and fractional flames.

5. Typical SET-UP

An EGR set up for a SI engine has been formulated below with a diagram in figure 1. The SI engine considered for the set up is 100 cc, Four stroke, Air cooled engine. The following set up has to be added or adjusted accordingly to a normal SI engine setup.

5.1. Optimum re-circulation

As data for an effective EGR function an optimum level of 10% to 15% of exhaust gas should be reticulated. Initially the discharge of exhaust gas through the exhaust pipe is determined by finding the pressure head difference (h) using a venturimeter or an orificemeter with a U-tube manometer attached to the exhaust pipe. The approximate velocity of the exhaust is then calculated using the relation $V = C_d \cdot \sqrt{2 \cdot g \cdot h}$. (C_d value is assumed)
Now the Discharge $Q = A \cdot V$ where A is the cross sectional area of the exhaust pipe.
Then a separate pipe of suitable diameter is drawn from the exhaust pipe with an adjustable valve for the flow of exhaust gas. The other end of the pipe is fitted to the carburetor output immediately next to the throttle valve.

Now the discharge through this pipe is varied until it is 0.1 to 0.15 of the discharge through the exhaust pipe (Q). For every repetition of the experiment, the flow is adjusted using the valve provided.

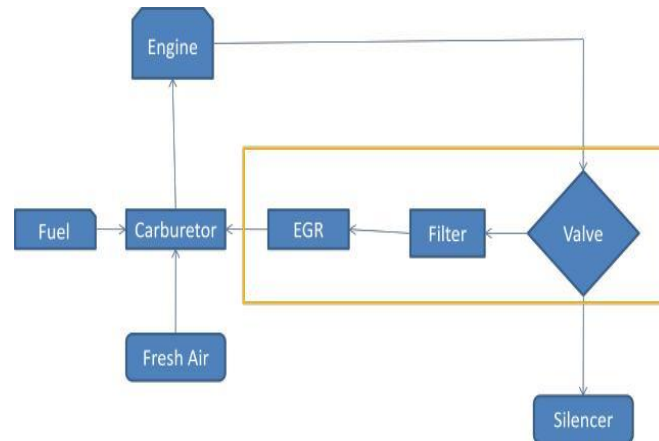


Figure 1. Engine setup

5.2. Carbon filtration

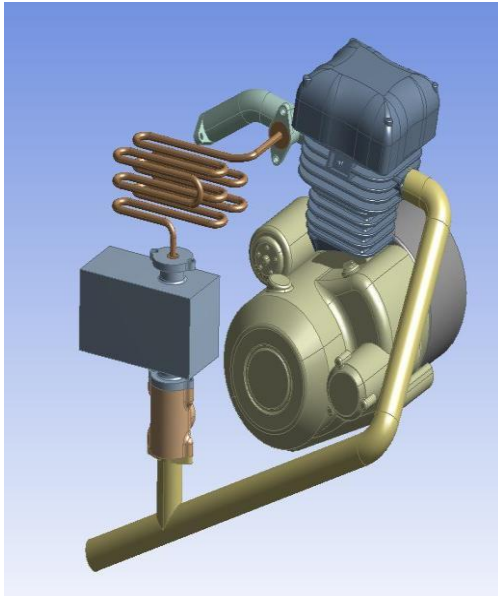
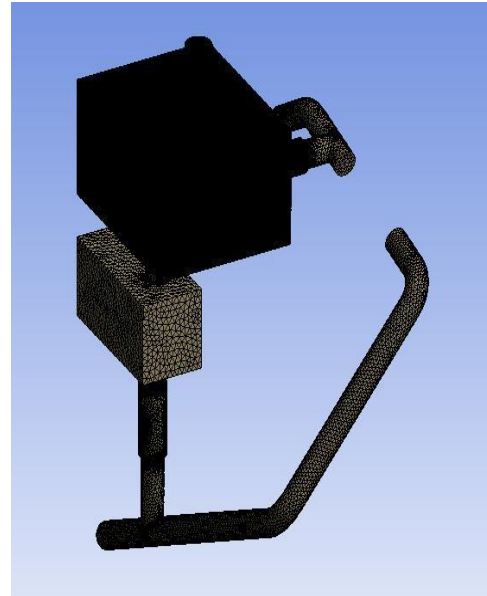
A suitable carbon filter is placed in the tube set up before the exhaust gas reaches the mark. This allows a sufficient absorption of carbon content from the exhaust gas to prevent carbon deposition in the cylinder lining and unbalanced combustion.

5.3. Coolant

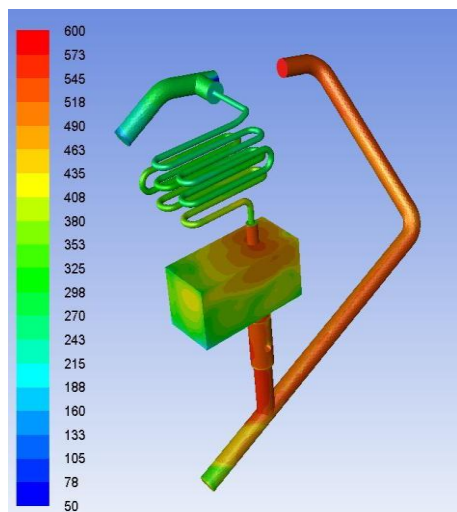
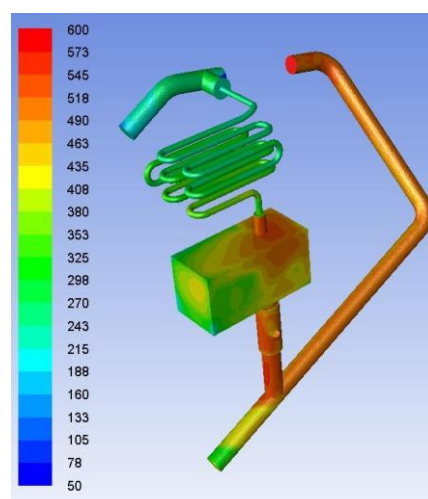
The exhaust gas routed from the exhaust pipe is passed through a coolant setup in order to reduce its temperature. Coolant set up consists of cooling oil through which the exhaust gas is re-circulated to reduce the temperature. This further ensures that there will not be auto ignition when the exhaust gas mixes up with the incoming air-fuel mixture.

6. EGR Design

Different design were done to meet the requirement of the exhaust temperature below 120°C and given in figure 2. Initially steel was used as the evaporator coil material. Since the temperature does not meet with the desired temperature, copper was used as an alternate material which was well below the safe limit. Mesh was carried out using Ansys meshing. Tetrahedral mesh was used to meet the desired quality of the cells as given in figure 3. These cells have better convergence when compared to other type of mesh types. Mesh contains around 6 million cells.

**Figure 2.** EGR Design**Figure 3.** Ansys Meshing

At 100% recirculation of the exhaust gas, the cooler is sufficient to cool the exhaust gas which is coming out of the engine as given in figure 4. After effective cooling the average temperature of exhaust gas temperature which comes out of the cooler is 356°C.

**Figure 4.** At 100% recirculation**Figure 5.** At 75% recirculation

At 75% recirculation of the exhaust gas, the cooler is sufficient to cool the exhaust gas which is coming out of the engine as given in figure 5. After effective cooling the average temperature of exhaust gas temperature which comes out of the cooler is 287°C.

At 50% recirculation of the exhaust gas, the cooler is sufficient to cool the exhaust gas which is coming out of the engine as given in figure 6. After effective cooling the average temperature of exhaust gas temperature which comes out of the cooler is 239°C.

At 25% recirculation of the exhaust gas, the cooler is sufficient to cool the exhaust gas which is coming out of the engine as given in figure 7. After effective cooling the average temperature of exhaust gas temperature which comes out of the cooler is 214°C.

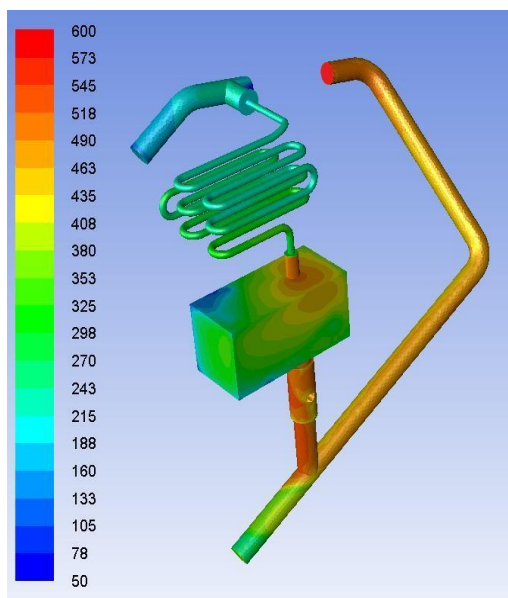


Figure 6. 50% recirculation

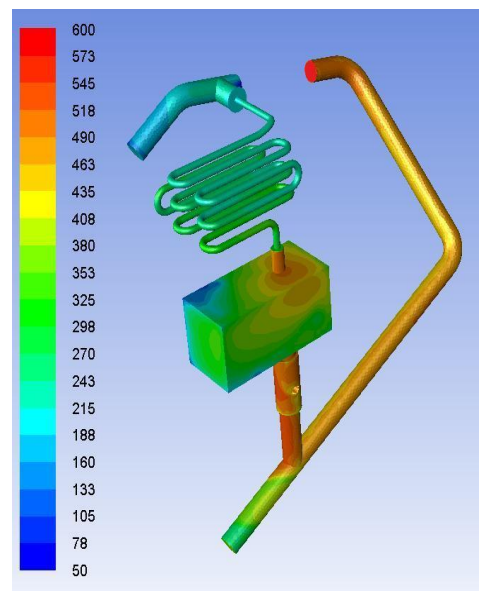


Figure 7. 25% recirculation

Based on the thermal calculation as given in Fig. 8, the cooler is able to cool the exhaust gas even if the complete exhaust gas is re-circulated.

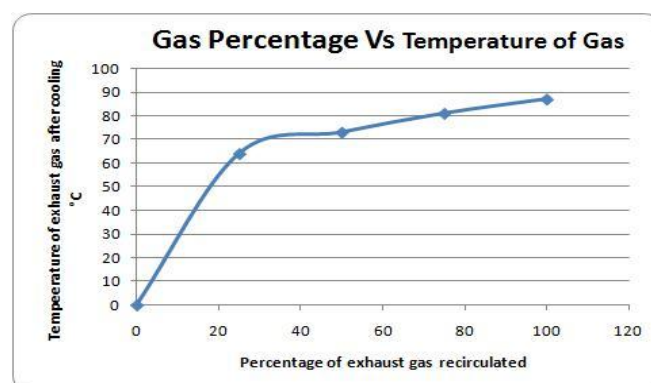


Figure 8. Gas percentage vs. Temperature of gas

7. Conclusion

Since two wheelers has seen a very high utility these days, any method of decreasing NO_x emission which is a major pollutant is a must to be implemented by the motorcycles manufacturing units in their future launches to conserve environment and prevent from global issue of Global warming. The formation of NO_x is a function of temperature. Since the exhaust gas transmitted inside the cylinder head is completely inert, it considerably reduces the peak combustion temperature by diluting the air-fuel mixture. So based on the thermal simulation, We can conclude that with the help of intercooler the exhaust gas which is mixing with the air is within the desired limit of 120°C.

8. References

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