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Study about EGR System

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ABSTRACT

Concern of environmental pollution and energy crisis all over the world have caused the research attention on reduction of diesel engine exhaust emissions and saving of energy simultaneously. An experimental study has been carried out for combined effect of Exhaust Gas Recirculation (EGR) system and varying inlet air pressure on performance and emission of diesel engine. As we know that the diesel engine are known for their high NO_x formation and Exhaust Gas Recirculation (EGR) is being used widely to reduce and control the oxides of nitrogen (NO_x) emission from diesel engines.

Introduction

Diesel engines are among the most effective engines in the world. Known as strong, economical and robust, they are also recognized for their traditional smoke and high level of nitrous oxides, NOx emissions. The diesel cycle was developed by the German engineer, Rudolf Christian Karl Diesel, considered the first engineer who applied the thermodynamic theory to develop combustion engines. Continuous research and development turned the diesel engine highly efficient. Its application includes propulsion units for ships, train and load vehicles such as buses and trucks besides; it is used as power source in auxiliary machinery, such as emergency diesel generators, pumps and compressors. At the same time, a drawback of diesel engines is that they are harmful to human health and the environment due to pollutant emissions. A Comparison between Otto engines, largely applied to passenger cars and diesel engines, in general terms, shows a diesel engine characterized by low specific fuel consumption and low CO and UHCs (unburned hydrocarbons) emissions. On the other hand, NOx emissions are huge in the diesel cycle [3].Hence, in order to meet the environmental legislations, it is highly desirable to reduce the amount of NOx in the exhaust gas. In most of the global car markets, record diesel car sales have been observed in recent years [1]. The exhorting anticipation of additional improvements in diesel fuel and diesel vehicle sales in future have forced diesel engine manufacturers to upgrade the technology in terms of power, fuel economy and emissions. Diesel emissions are categorized as carcinogenic [2]. Therefore Diesel manufacturers and researchers have been investigating a variety of techniques in the hope of reducing diesel emissions and comply with exhaust emission legislation as far as reasonably practicable. For reducing vehicular emissions, several baseline technologies are being used.

These technologies can be classified into two different categories, according to their emission-control techniques. The first prevents emission formation in the engine cylinder through the use of improved combustion technologies, such as high-pressure injection, low compression ratio bowls, and exhaust gas recirculation (EGR). The second uses purifying devices, such as diesel particulate filters (DPFs), selective catalytic reduction (SCR).

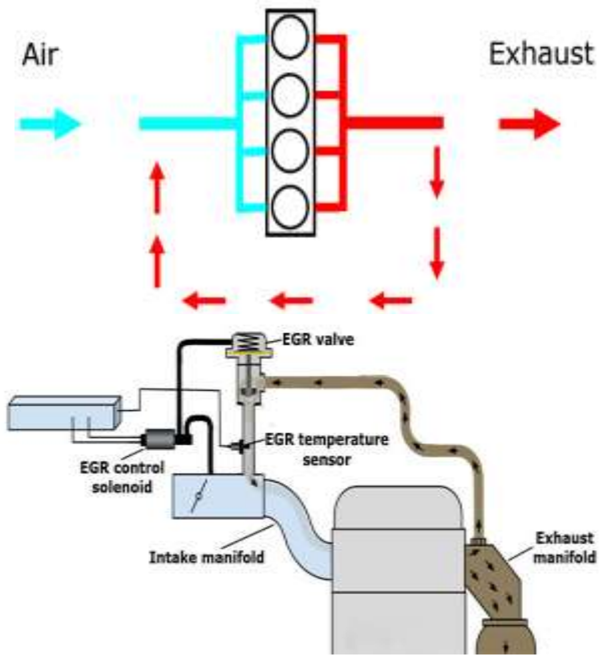

Figure 1. Exhaust Gas Recirculation

Instead of using after-treatment systems to comply with exhaust emission legislation, it is also possible to avoid the formation of emissions during the combustion. The raw emissions are reduced and thus no after-treatment is needed. It is common practice nowadays, to use EGR to reduce the formation of NOx emissions. Exhaust Gas Recirculation (EGR) System Exhaust Gas Recirculation (EGR) is an effective pre-treatment technique, which is being used widely to reduce and control the oxides of nitrogen (NOx) emission from diesel engines. The exhaust mixture has higher specific heat compared to atmospheric air. EGR controls the NOx because it lowers oxygen concentration and flame temperature of the working fluid in the combustion chamber. Re-circulated exhaust gas displaces fresh air entering the combustion chamber with carbon dioxide and water vapor present in engine exhaust. As a consequence of this

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air displacement, lower amount of oxygen in the intake mixture is available for combustion reduced oxygen available for combustion lowers the effective air–fuel ratio. This effective reduction in air–fuel ratio affects exhaust emissions substantially. In addition, mixing of exhaust gases with intake air increases specific heat of intake mixture, which results in the reduction of flame although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow temperature.

Thus combination of lower oxygen quantity in the intake air and reduced flame temperature reduces rate of NOx formation reactions [4, 5].The EGR (%) is defined as the mass percent of the recirculated exhaust (MEGR) in the total intake mixture(Mi).

NOx Formation Mechanism

A major hurdle in understanding the mechanism of formation and controlling NOx emission is that combustion is highly heterogeneous and transient in diesel engines. While NO and NO2 are lumped together as NOx, there are some distinctive differences between these two pollutants. NO is a colorless and odourless gas, while NO2 is a reddish brown gas with pungent odour.

Both gases are considered as toxic; butNO2 has a level of toxicity 5 times greater 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 [3].

NO is formed during the post flame combustion process in a high temperature region. The most widely accepted mechanism was suggested by Zeldovich. The principal source of NO formation is the oxidation of the nitrogen present in atmospheric air. The nitric oxide formation chain reactions are initiated by atomic oxygen, which forms from the dissociation of oxygen molecules at the high temperatures reached during the combustion process. The principal reactions governing the formation of NO from molecular nitrogen are,

$N_2 + O \rightarrow NO + N$,

$N + O_2 \rightarrow NO + O$,

$N + OH \rightarrow NO + H$.

In diesel engine NO2 can be 10 to 30% of total exhaust emissions of oxides of nitrogen. A plausible mechanism for the persistence of NO2 is as follows. NO formed in the flame zone can be rapidly converted to NO2 via reactions such as

$NO + HO_2 \rightarrow NO_2 + OH$.

Subsequently, conversion of this NO2 to NO occurs via

$NO_2 + O \rightarrow NO + O_2$

Unless the NO2 formed in the flame is quenched by mixing with cooler fluid. This explanation is consistent with the highest NO2=NO ratio occurring at high load in diesels, when cooler regions which could quench the conversion back to NO are widespread [12].

Equations

(1) Torque (T) = W x Re

Where, W = Weight acting on engine in Newton,

= Load (kg) x Gravity (9.81 m/s2)

Re = Effective radius of drum.

= Radius of drum (m) + Thickness of Belt (m)

= 0.135 + 0.006 = 0.141 m

(2) Brake Power (kW) = 2πNT/(60 ×1000)

Where, N = Speed of engine in RPM,

T = Torque in Nm

(3) Friction Power (kW) is calculated with the help of William line's method by plotting graph fuel consumption (g/s) vs. brake power (kW).

Indicated power (kW)=Brake power (kW)+Friction power (kW).

(4) Mechanical Efficiency:

ηm (%)=(Brake Power (kW))/(Indicated Power (kW))x 100

(5) Fuel consumption (FC): $\frac{10 \times 3600 \times \text{DensityofDiesel (0.8226 gm/cc)}}{\text{tf} \times 1000}$

Where, tf = time required for 10 cc fuel in second.

(6) Brake thermal efficiency (%):

$$\eta_{bth(\%)} = \frac{\text{Brake Power (kW)} \times 3600}{\text{mass of fuel (kg/hr)} \times \text{Calorific Value (kJ/kg)}} \times 100$$

(7) Indicated thermal Efficiency (%):

$$\eta_{ind}(\%) = \frac{\text{IndicatedPower (kW)}}{\text{Massoffuel (kg/hr)} \times \text{CalorificValue(kJ/kg)}} \times 100$$

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