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Study on Di-Ci Diesel Engine Characteristics by Exhaust Gas Recirculation Using Waste Cooking Methyl Ester

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ABSTRACT

Fossil fuels are limited in nature. Fuel consumption rate is increases and there will be the need of alternate fuels in future. Replacing biodiesel as a fuel in the place of standard fuel to study the characteristics of performance, combustion and emissions of the DI-CI diesel engine. DI-CI engine with biodiesel all the characteristics are investigated. The results of engine characteristics with biodiesel were compared with standard baseline petroleum diesel. Fuel in any engine burnt with air. Air is a mixture of gases and it contains approximately 78% nitrogen and 21% oxygen. Some of the oxygen is used to burn the fuel during the combustion process and the rest is supposed to just pass through unreacted. But when the peak temperatures are high enough for long periods of time, the nitrogen and oxygen combine to form a class of compounds called nitrogen oxides, collectively referred to as NO_x. These compounds are one of the chief constituents of smog, which have an adverse effect on ecological systems. NOx emissions can be reduced by lowering the cylinder temperatures. This is done by recirculating some exhaust gas and mixing it into the engine inlet air. This process is known as Exhaust Gas Recirculation (EGR). The objective of Exhaust Gas Recirculation (EGR) is to reduce the amount of NO_x produced. The EGR valve recirculates gases into the intake stream. Exhaust gases have already combusted, so they do not burn again when they are recirculated. These gases displace some of the normal intake charge. This chemically slows and cools the combustion process by several hundred degrees thus reducing NO_x formation.

1 INTRODUCTION

Fossil fuels currently meet 80% of global energy demand. Even if current policy commitments and pledges made by countries to tackle climate change and other energy-related challenges were to be put in place, global energy demand in 2035 is projected to rise by 40% – with fossil fuels still contributing 75%. Demand over the coming decades will stem mainly from energy needs of emerging markets such as China and India. The use of coal, gas and oil to fuel the power, industry, buildings and transport sectors is set to rise

1.1 AVAILABILITY OF FOSSIL FUELS

Fossil fuels are abundant in many regions of the world and they are in sufficient quantities to meet expected increasing demands. However, most of them are still classified as resources and not yet as reserves. This distinction is important as it reflects the likelihood that the fossil fuels will be brought to the market. Resources are those volumes that have yet to be fully characterized, or that present technical difficulties or are costly to extract, for example where technologies that permit their extraction in an environmentally sound and cost-effective manner are still to be developed.

1.2 EXHAUST GAS RECIRCULATION

1.2.1 History OF EGR

The first EGR systems were crude; some were as simple as an orifice jet between the exhaust and intake tracts which admitted exhaust to the intake tract whenever the engine was running. Difficult starting, rough idling, and reduced performance and fuel economy resulted. By 1973, an EGR valve controlled by manifold vacuum opened or closed to admit exhaust to the intake tract only under certain conditions. Control systems grew more sophisticated as automakers gained experience; Chrysler's "Coolant Controlled Exhaust Gas Recirculation" system of 1973 exemplified this evolution: a coolant temperature sensor blocked vacuum to the EGR valve until the engine reached normal operating temperature. This prevented driveability problems due to unnecessary exhaust induction; NOx forms under elevated temperature conditions generally not present with a cold engine. Moreover, the EGR valve was controlled, in part, by vacuum drawn from the carburetor's venturi, which allowed more precise constraint of EGR flow to only those engine load conditions under which NOx is likely to form.

1.2.2 EGR IN SPARK-IGNITED ENGINES

The exhaust gas, added to the fuel, oxygen, and combustion products, increases the specific heat capacity of the cylinder contents, which lowers the adiabatic flame temperature.

In a typical automotive spark-ignited (SI) engine, 5 to 15 percent of the exhaust gas is routed back to the intake as EGR. The maximum quantity is limited by the requirement of the mixture to sustain a contiguous flame front during the combustion event; excessive EGR in poorly set up applications can cause misfires and partial burns. Although EGR does measurably slow combustion, this can largely be compensated for by advancing spark timing. The impact of EGR on engine efficiency largely depends on the specific engine design, and sometimes leads to a compromise between efficiency and NOx emissions.

2 RELATED WORK

According to K.Rajan[1] experimental results on EGR engine tests were carried out using diesel at 1500 rpm and different EGR rates in order to study the effect of EGR on the smoke density and NO_X concentration in the exhaust emissions. Higher amount of smoke in the exhaust is observed when the engine is operated with EGR compared to without EGR. Smoke emissions increases with increasing engine load and EGR rates.EGR reduces availability of oxygen for combustion of fuel, which results in relatively incomplete combustion and increased formation of PM and reducing NO_X emissions from diesel engine. Using biodiesel in diesel engine, smoke is decreased with increase in NO_X. Thus, biodiesel with EGR In this report the performance and emission characteristics of diesel fuel and diesel-SFME blends with exhaust gas recirculation were investigated. The results obtained of this study are summarized as follows.

1. Methyl ester of sunflower oil was prepared with lye catalyst NaOH and methanol.
2. Compared with conventional diesel fuel, the exhaust NO_X was reduced about 25% at 20 % biodiesel blends with 15% EGR due to less oxygen available in the recirculated exhaust gases which lowers the flame temperature in the combustion chamber.
3. SFME blend with 15% EGR, which improves the 4% of brake thermal

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efficiency and 10 % increase in BSFC due to lower calorific value of the biodiesel The total unburnt HC and CO emissions were decreased by 5 % and 10 % for 20 % biodiesel blends respectively compared to diesel fuel with EGR and smoke emissions were observed as increases, due to incomplete combustion. Engine operation with biodiesel while employing EGR was able to reduce 25 % NO_X, and reduction in brake thermal efficiency and increase in smoke, CO.

M.P.Poonia[2] experimental investigations, a direct injection Dual-fuel engine fuelled with LPG and diesel were tested to Determine its performance and exhaust emission Characteristics with the objectives of improving engine Efficiency and exhaust emissions at part loads. The Parameters considered to achieve these objectives were Gaseous fuel quantity, pilot fuel quantity, pilot fuel injection Rate, intake air throttling, EGR and the intake air temperature. First engine operation was optimised at different operating Conditions and then percent gas substitution was varied at Optimum conditions. The main conclusions of the present Study are summarized as follows:

1. Intake air throttling at low loads can improve both engine Efficiency and HC emissions. However the effect is more Significant at 20% load as compared to 40% load.

2. It is seen that as the percent gas substitution increases the Brake thermal efficiency and HC emissions deteriorate with increasing gas substitution beyond the optimum Value of 25% (8.4 mg/cycle pilot). However this effect is not significant at 40% load.

3. With optimum throttling, at every gas substitution, the Engine performance was found to be better as compared to that of without throttling. This does indicate the ability of Air throttling to improve the engine performance at higher Gas substitution at light loads. HC emissions were also found to be lower at every gas substitution value.

4. Lower rate of injection with 5 mm plunger, results in poor brake thermal efficiency due to improper mixture Formation. Longer dynamic injection timing and ignition Delay period is observed to be the cause of poor brake Thermal efficiency and deteriorated HC emissions.

5. An improvement in the combustion process was achieved by advancing the injection timing because of the Corresponding high pressure and temperature, with no Decrease in the combustion duration. The increase in NO_X Emissions with advance of the injection timing was attributed to the increase in the maximum temperature of the charge. Meanwhile, the reduction in carbon monoxide And unburned hydrocarbons was also observed due to Increase in temperature

S.Sorathia[3] conducted experiments on EGR and concluded that EGR is a very useful technique for reducing the NO_X Emission. EGR displaces oxygen in the intake air and dilute the intake charge by exhaust gas recirculated to the combustion chamber. Recirculated Exhaust gas lower the oxygen concentration in Combustion chamber and increase the specific heat of The intake air mixture, which results in lower flame Temperatures. It was observed that 15% EGR rate is found to be effective to reduce NO_X emission Substantially without deteriorating engine Performance in terms of thermal efficiency, bsfc and Emissions. Thus, it can be concluded that higher rate of EGR can be applied at lower loads and lower rate Of EGR can be applied at higher load. EGR can be applied to diesel engine fueled with diesel oil, biodiesel, LPG, hydrogen, etc without sacrificing its Efficiency and fuel economy and NO_X reduction can thus be achieved.

BIO DIESEL PREPARATION

3.0 Selection of oil

A study was conducted on the various possible bio diesels that could be effectively used as alternatives to diesel. The various parameters that were considered for the selection of the oil are density, viscosity, calorific value, flash point, fire point, pour point etc.

The various bio fuels that were considered for the study are:

1. Dimethyl ether.
2. Fischer trope diesel.
3. Mustard oil.
4. Castor oil.
5. Cashew nut oil (shell).
6. Vegetable oil.

3.1 Waste cooking oil as biodiesel

Biodiesel is a renewable, biodegradable and nontoxic fuel for diesel engines. As alternative fuel biodiesel has attracted considerable attention during the past decades. The main hurdle to the commercialization of biodiesel is the cost of raw materials. The high value of soybean oil or canola oil as a food product makes production of a cost-effective fuel very challenging. Use of edible oils as biodiesel feedstock cost about 60-70% of raw material cost. Non-edible, inexpensive, low-grade oils with value added byproducts is utmost important to make the biodiesel production economical.

3.2 Preparation of bio diesel

3.2.1. First stage (Acid catalyzed transesterification)

1. Some known quantity of crude oil was taken in a conical flask.

2. The oil in the flask was then heated on a heating plate upto a temperature of 60°C.

3. A mixture of known quantity of potassium hydroxide (KOH) as acid catalyst and methanol was then mixed with the preheated crude oil.

4. The preheated oil mixture was then subjected to 1 hour constant stirring at a constant temperature of 60°C inside a water bath shaker.

5. After 1 hour of constant stirring the mixture was poured into a separating funnel for impurities to settle down and glycerin is separated.

3.2.2. Second Stage (Base catalyzed transesterification)

1. After 1 hour of constant stirring the mixture was poured into a separating funnel for glycerol to settle down.

2. After 2-3 hours settled down glycerol is separated and removed.

3.Remaining is methyl ester(biodiesel) of waste cooking oil (Yield 82%) which is further purified through washing and drying for removal of excess KOH, methanol and water.

3.2.3. Final stage (Base catalyzed transesterification)

1. Some known quantity of waste cooking oil was taken in a conical flask.

2. The oil in the flask was then heated on a heating plate up to a temperature of 120°C.

3. Now the oil is ready to use as fuel.

4 Analytical Study

Engine Description

This engine analysis software is lab view based software developed by TECHED for testing of performance analysis and combustion analysis of the given engine test setup.

This software helps in:

- Interface to setup and user with menu and commands
- Configuring as per engine test setup under use
- test setup measurement and analysis
- data acquisition and data logging
- online performance and combustion data calculations
- report and graph generation and printing

4.2 System Requirements

- PERSONAL COMPUTER : pc Pentium IV,512MB RAM, a VGA card, 2 serial ports, 1 parallel port, 40 GB hard disk space, key board and CD drive with an optical mouse and keyboard
- RS-232C COMMUNICATION PORT: COM port for interfacing data. select one port,COM1 or COM2
- CD drive: required for installing software.
- Operating system : use windows 98 and above

V CONCLUSION

In this experimental investigation on single cylinder DI-CI diesel engine the performance and emission characteristics of diesel fuel and diesel-WCME blends with exhaust gas recirculation were investigated. The following conclusions are made on the basis of experimental results.

1. Specific fuel consumption was lower in 10% EGR with diesel and 15% EGR with B10 fuel.

2. Brake thermal efficiency of biodiesel was found to be comparable with diesel, at all EGR rates and highest BTE is found with diesel is 41.567% at 5% EGR, with WCME 38.5% at 10% EGR.

3. The EGR level was increased HC emission also increased for biodiesel. This was due to oxygen content in biodiesel

compensating for oxygen deficiency and facilitating complete combustion.

4. In full load all EGR levels NOx was reduced in both diesel and biodiesel. With increases in EGR level, the NOx value gets reduced.

5. In EGR CO emissions slightly increases due to oxygen deficient operation but still at low level compared to diesel operation without EGR.

6. Brake Mean Effective Pressure (BMEP) and Indicated Mean Effective Pressure (IMEP) increases with increasing the rates of EGR with diesel and biodiesel.

7. Fuel Consumption is constant at all EGR levels for diesel is 0.72 and 0.78 for WCME biodiesel.

8. Analysis of combustion parameters have also indicated comparable heat release rates cylinder pressures, and with and without EGR at different blends of diesel with WCME.

Thus the present experimental analysis on a single cylinder diesel engine with diesel and WCME biodiesel blend has proved minimized pollution and improved performance. EGR technique is used for reduction of NOx concentration..

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