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Abstract— The performance, emission and combustion characteristics of a single cylinder four stroke LHR engine when fuelled with Neem biodiesel and are investigated and compared with the results of standard diesel with Exhaust Gas Recirculation system. It has demonstrated that biodiesel fuelled engine deliver less carbon monoxide, unburnt hydrocarbon and smoke emission contrasted with diesel fuel but higher NOx emission. EGR is as viable method to reduce NOx from LHR engine as it brings lower flame temperature and decrease oxygen concentration in the combustion chamber. The primary point of this exploration is to examine the utilization of biodiesel and EGR at the same time to diminish the emissions of all regulated pollutants from diesel engine. For this a single cylinder, water cooled, constant speed direct injection LHR engine was utilized and EGR was produced and fitted in engine. Different emissions, for example, HC, NOx, CO and smoke opacity were measured. The engine parameters were computed from measured data.

Key words: Biodiesel, LHR Engine, EGR, Performance, Emissions and Combustion Parameters

I. INTRODUCTION

A. General Introduction

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) happens with an oxidizer (usually air) in an combustion chamber that is a fundamental piece of the working fluid flow circuit. In an internal combustion engine, the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. This force is transferred to crankshaft through the connecting rod, transforming chemical energy in to useful mechanical energy.

With a growing demand for transportation, I.C. engines have gained lot of importance in automobile industry. It is hence prominent to deliver efficient and economical engine. While developing an IC engine it is obliged to take in thought every one of the parameters influencing the engine configuration and execution. There are tremendous parameters to record them while designing an engine. Performance tests are important to do for a engine to survey the fuel and thermal efficiency. Further, it is additionally needed to study the effect of distinctive parameters on the engine performance. Automotive emission is one of the main concerns. The main pollutants present in this type of air are carbon monoxide (CO) unburn hydrocarbons (UBHC), oxides of nitrogen (NO) & lead & other particulate pollutants. The significant reasons for these outflows are combustion, separation of nitrogen, and contaminations in the fuel & air. The emissions of concern are unburnt hydrocarbons (HC), oxides of carbon, oxides of nitrogen, oxides of sculpture, strong carbon particulates. It is the fantasy of designers and researchers to develop the engines and fuels such that very few quantities of harmful outflows are created, and these could be let into the surroundings without a major effect on nature. The need of the hour is to have engines of high performance in terms of fuel and thermal efficiencies. Internal combustion engines operating under fossil fuels are proved to be the better media for producing high performance, particularly for transportation sector.

However, much of improvement is still required for petroleum fuel operated engine emissions. Expanding interest and quick exhaustion of fossil fuels have together incited the explores of numerous nations to search for exchange renewable fuels. Several sources of energy, especially for driving the automotives are being developed and tested, vegetable oils offer a better and promising alternative for the fossil. These oils can be used to operate internal combustion engine, particularly compression ignition engines, due to the fact that the fuel made from vegetable oils have higher cetane number compared to mineral oil. These issues are because of high consistency, low instability and poly unsaturated character of vegetable oils. Transesterified vegetable oil subsidiary called biodiesel, appear to be most convenient way of being most helpful method for using vegetable oil as a substitute fuel in diesel engines. Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting long chain alkyl (methyl, propyl or ethyl) esters. It is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat) with an alcohol producing fatty acid esters. It is an alternative to traditional diesel fuel, is biodegradable, renewable, non-harmful and basically free of sulphur and aromatics.

An important alternative for diesel fuel is methyl ester made of vegetable oils. Direct utilization of these fuels without change in diesel engine causes a few harms on the Parts of the engine and also, the viscosity of the methyl ester fuel is very higher than that of diesel fuel and their calorific quality is lower. In this way it is unrealistic to acquire more advantage. Coating combustion chamber parts with a ceramic material appears a viable solution for enhancing performance of these lower-quality fuels. The cylinder head, cylinder liner, piston surface, exhaust, and inlet valves of a diesel engine are coating with the ceramic material of Al₂O₃ by the plasma spray technique. Along these lines, a thermal...
It can be seen that the engine’s effectiveness increments by the utilization of Bio-diesel. This will have an incredible effect on Indian economy. The procedure of changing over vegetable oils in to Biodiesel is called Transesterification. A liquor and an impetus are mixed with the oil in request to “split” the oil into esters and glycerol. Amid this strategy, the impetus allows the liquor to substitute itself for the glycerin besides, the heavier glycerin drops out of the blend, leaving alkyl esters. The glycerol is uprooted and what remains is the “alkyl esters of unsaturated fats”

India on of the developing countries with a stable monetary development, which varies the demand for transportation in numerous folds. Fuel utilization is straight forwardly proportionate to this interest. India depends predominantly on imported fuels because of absence of fossil fuel stores and it has a great impact on economy: India needs to search for a distinct option for maintain the development rate. Recent studies and research have made it conceivable to extract biodiesel at economic cost and qualities. The mixture of bio-diesel with fossil diesel has numerous advantages like reduction in emissions, increment in effectiveness of engine, higher cetane rating, lower engine wear, low fuel utilization, diminish in oil consumption and so on. “The emission issue reached at alarming level. The lethal gasses radiated to atmosphere via automobiles are at risk to bring about damage to human health, other living creatures plants and environment by going into bio-legitimate framework”. Diesel engine ordinarily known as compression ignition (C.I) engine is extensively used as power source. Fumes gas radiated from compression ignition (C.I) engine, is a mix of numerous undesirable constituents known as pollutants.

The fumes gasses fundamentally comprise of dormant carbon dioxide, nitrogen and have high specific heat. At the point when recycled to engine gulf, it can diminish oxygen fixation and go about as a heat sink. This procedure lessens oxygen focus and peak combustion temperature, which brings about lessened NOx. EGR is a standout amongst the best methods right now accessible for decreasing NOx emissions in internal combustion engines. Biodiesel can be produced using an extensive variety of effortlessly renewable plant oil sources and creature fats even waste oils discarded by most restaurants. Vehicle producers already give vehicle warranties covering the utilization of 100% Biodiesel and Biodiesel has been being used for quite a while in Europe. Germany has over stations that supply Biodiesel less expensive than petrol-diesel.

France is the world's biggest maker of biodiesel where all petrol-diesel fuel sold their contains 5% Biodiesel. The USA has a couple of suppliers and the number is expanding. The US made Biodiesel, at present, is more costly petrol-diesel in light of the fact that it is generally produced using costly new virgin soybean oil. As the quantity of plants making waste-oil biodiesel increases and the interest ascents, the costs should drop. One thing that is neglected by an extensive number of individuals is the way that quality biodiesel can without much of a stretch be by just about anybody in their back yard, carport or shed, once you’ve made your first clump of Biodiesel, you will have the capacity to appreciate the advantages of this clean burning, non-harmful, biodegradable fuel.

II. PROPERTIES OF DIESEL AND BIO-PRODUCTS
The different properties of diesel and Neem oil methyl ester (NOME) are resolved and given in beneath table. After transisterification process the fuel properties like kinematic viscosity calorific value, density, gimmer point and fire point get enhanced in the event of biodiesel. The calorific estimation of methyl ester is lower than that of diesel as a result of oxygen substance. The blaze and fire point temperature of biodiesel is higher than the immaculate diesel this is valuable by safety Contemplations which can be put away and transported without any risk.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Characteristics</th>
<th>Diesel</th>
<th>NOME</th>
<th>Apparatus used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Density (kg/m³)</td>
<td>830</td>
<td>880</td>
<td>Hydrometer</td>
</tr>
<tr>
<td>2</td>
<td>Lower calorific value (k/kg)</td>
<td>42600</td>
<td>37850</td>
<td>Bomb Calorimeter</td>
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<tr>
<td>3</td>
<td>Kinematic Viscosity (cst)</td>
<td>3.21</td>
<td>5.70</td>
<td>Redwood Viscometer</td>
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<tr>
<td>4</td>
<td>Flash Point (°C)</td>
<td>50</td>
<td>173</td>
<td>Pensky Marten’s Apparatus</td>
</tr>
<tr>
<td>5</td>
<td>Fire Point (°C)</td>
<td>55</td>
<td>189</td>
<td>Pensky Marten’s Apparatus</td>
</tr>
</tbody>
</table>

Table 2.1: Fuel Properties

III. EXPERIMENTAL SET-UP

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Manufacturer</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Kirloskar oil engines Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>02</td>
<td>TV1- SR, naturally aspirated</td>
<td>Television</td>
</tr>
<tr>
<td>03</td>
<td>Single cylinder, DI</td>
<td>Single cylinder, DI</td>
</tr>
<tr>
<td>04</td>
<td>87.5mm/110mm</td>
<td>87.5mm/110mm</td>
</tr>
<tr>
<td>05</td>
<td>17.5:1</td>
<td>17.5:1</td>
</tr>
<tr>
<td>06</td>
<td>1500 RPM, constant</td>
<td>1500 RPM, constant</td>
</tr>
<tr>
<td>07</td>
<td>5.2 KW</td>
<td>5.2 KW</td>
</tr>
<tr>
<td>08</td>
<td>Four stroke</td>
<td>Four stroke</td>
</tr>
<tr>
<td>09</td>
<td>4 micro seconds</td>
<td>4 micro seconds</td>
</tr>
</tbody>
</table>

IV. RESULTS AND DISCUSSIONS

A. Introduction

This section comprises three sorts of trial examination, initial one is performance characteristics like brake thermal efficiency, specific fuel consumption, exhaust gas temperature, against brake power, second one is combustion attributes like pressure and heat release rate, against crank angle, lastly third one is emission characteristics like carbon monoxide (CO), carbon dioxide (CO2), unburned hydrocarbon (HC), NOx and nitrogen against brake power.

B. Performance, emission and combustion characteristics of Neem bio-diesel with EGR on LHR diesel engine

1) Variation Brake Thermal Efficiency with brake power

The Fig 4.2.1 demonstrates the variation of the brake thermal efficiency with power for diesel on normal engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with immaculate biodiesel on LHR engine. The brake thermal efficiency for all the fuel increases as the heap increases. For 75% of load all the fuel demonstrate the maximum brake thermal efficiency. At full load the brake thermal efficiency diminishes. For diesel at 75% heap the brake thermal efficiency is 27.45% and that for unadulterated biodiesel is 27.16 Without EGR. With expansion in % of EGR the brake thermal efficiency diminishes. Brake thermal efficiency at evaluated load for 5%, 10% and 15% is found to be 27.04%, 26.98% and 26.5% respectively. At evaluated load thermal efficiency is diminished by 2.5% for 15% EGR compared with that of diesel on normal engine.

2) Variation of specific fuel consumption with brake power

The Fig 4.2.2 demonstrates the variation of specific fuel consumption with brake power for diesel on normal engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with immaculate biodiesel on LHR engine. The specific fuel consumption for all the fuel increases as the heap increases. For 75% of load all the fuel demonstrate the maximum specific fuel consumption. At full load the specific fuel consumption diminishes. For diesel at 75% heap the specific fuel consumption is 1.4 kg/kW-h and that for unadulterated biodiesel is 1.3 kg/kW-h Without EGR. With expansion in % of EGR the specific fuel consumption diminishes. Specific fuel consumption at evaluated load for 5%, 10% and 15% is found to be 1.38 kg/kW-h, 1.36 kg/kW-h and 1.34 kg/kW-h respectively. At evaluated load specific fuel consumption is diminished by 2.5% for 15% EGR compared with that of diesel on normal engine.
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engine, immaculate Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with unadulterated biodiesel on LHR engine. Specific neem biodiesel for 5%, 10%, and 15% EGR biodiesel is higher than diesel at lower load. At part stack the specific fuel consumption steady (level) for all the fuels except of diesel. At the full load specific fuel consumption is more for biodiesel and different % of EGR compared to diesel. At the rated load specific fuel consumption of biodiesel without EGR is 0.36 kg/kW-hr, against 0.34kg/kW-hr of diesel. With expanding of EGR that is 5%, 10% and 15% with biodiesel expands the specific fuel consumption. Specific fuel consumption at appraised load for 5%, 10%, and 15% EGR biodiesel is observed to be 0.38 kg/kW-hr, 0.39 kg/kW-hr and 0.43 kg/kW-hr respectively. It is found that specific fuel consumption is 23.3% expanded in 15% EGR than that of biodiesel without EGR at full load. However the base specific fuel consumption for diesel is 0.34 kg/kW-hr against 0.36 kg/kW-hr Neem biodiesel on LHR engine without EGR.

3) Variation of exhaust gas temperature with brake power

The Fig 4.2.3 demonstrates the variation of exhaust gas temperature with brake power for diesel on normal engine, immaculate Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with pure biodiesel on LHR engine. As the heap increases the EGT additionally increases for all the fuels. EGT at full load without EGR for biodiesel is 542.61°C compared to that of diesel which is 538.97°C. With expansion in 5%, 10% and 15% of EGR, EGT is increased. At evaluated load for found 545.7°C, 548.67°C and 562.37°C respectively.

4) Variation of carbon monoxide emission with brake power

The Fig 4.2.4 demonstrates the variety of CO emission with brake power for diesel on typical engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with pure biodiesel on LHR engine. Up to 75% of engine load all the fuels without and with EGR have same amount of CO emission and having a typical esteem 0.04% by volume. However at full load CO outflow will increases. At appraised load CO discharge biodiesel without EGR is 0.35% by volume against 0.43% by volume of diesel. With expanding % of EGR 5%, 10% and 15% with biodiesel increase in CO emission. At appraised load for 5%, 10% and 15% EGR is observed to be 0.47% by volume, 0.49% by volume and 0.79% by volume respectively.

5) Variation of hydrocarbon emission with brake power

The Fig 4.2.5 demonstrates the variation of hydrocarbon outflow with brake power for diesel on typical engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with pure biodiesel on LHR engine. Up to 75% of engine load the HC emission is more in diesel than that of biodiesel without EGR and with EGR. At 75% of engine load it is observed that HC emission for 5%, 10% and 15% with biodiesel increases with respect to diesel. At appraised load for 5%, 10% and 15% EGR HC outflow is found to be 42.51 ppm, 24.78 ppm and 116.39 ppm respectively. Emission is expanded for 15% EGR with biodiesel than that of biodiesel without EGR.

6) Variation of smoke emission with brake power

The Fig 4.2.6 shows the Variation of smoke emission with brake demonstrates the variety of smoke outflow with brake power for diesel on typical engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with immaculate biodiesel on LHR engine. At full load the smoke emission is almost same for all fuels except unadulterated Neem biodiesel without EGR on LHR engine. At rated load on EGR 5%, 10% and 15% with biodiesel the smoke emission is 98.42%, 99.02% and 99.74% respectively.

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Fig. 4.2.6 Variation of smoke emission with brake power

7) Variation of NOx emission with brake power

The Fig 4.2.7 demonstrates the variety of NOx emission with brake power diesel on typical engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with immaculate biodiesel on LHR engine. The quantity of NOx emission increases and afterward diminishes at full load. The NOx emission is less for biodiesel than that of diesel at all loads. For biodiesel NOx emission is 516.37 ppm against, 544.85 ppm of diesel without EGR. At rated load with expansion in 5%, 10% and 15% of EGR diminish in NOx emission. The most extreme NOx for Neem biodiesel in LHR engine is lower 974.68 ppm at 75% load against 1042.88 ppm of diesel. seen that by expanding the % of EGR NOx emission considerably diminishes.

Fig: 4.2.7 Variation of NOx emission with brake power

8) Variation of crank angle with cylinder pressure

The Fig 4.2.8 demonstrates the variation of cylinder pressure with brake power for diesel on normal engine, immaculate biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with unadulterated biodiesel on LHR engine. From the Fig it can be seen that biodiesel begins early combustion (6° BTDC) compared to that of biodiesel (5° BTDC). Peak pressure for biodiesel is little close to TDC than that of diesel. For EGR crest cylinder pressure falls between the point of confinement of biodiesel and diesel as shown.

Fig: 4.2.8: Variation of cylinder pressure with crank angle

9) Variation of crank angle with net heat release rate

Fig: 4.2.9: Variation of heat release rate with crank angle

The Fig 4.2.9 demonstrates the variation net heat release rate with brake power for diesel on normal engine, unadulterated Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with pure biodiesel on LHR engine. Because of the early combustion in biodiesel more heat will be discharged at the early phase of the combustion took after by that of diesel. Because of early burning of biodiesel exhaust temperature will be lower than that of diesel. By expanding EGR in biodiesel builds the pressure and temperature contrasted with biodiesel.

10) Variation of crank angle versus cumulative heat release rate

The Fig 4.2.10 shows variation of cumulative heat release rate with brake power for diesel on typical normal engine, immaculate Neem biodiesel on LHR engine without EGR, 5%, 10% and 15% EGR with unadulterated biodiesel on LHR engine. The cumulative heat release rate is same for the whole test carried out. Slight higher value is obtained for the 15% EGR contrasted with other. For 15% EGR the maximum cumulative heat release rate is obtained between 1410 to 1620 which is 1.47 kJ. The cumulative heat release rate is lower for biodiesel took after by diesel, 5%, 10% and 15% EGR. By expanding % more amount of heat is added during induction and cumulative heat release.

Fig: 4.2.10: Variation of cumulative heat release rate with crank angle

V. CONCLUSION

In this project Experimental investigations were conducted on a Kirloskar make single cylinder water cooled naturally aspirated 5.2 kW at 1500 rpm. Neem biodiesel and diesel were fuel considered in experimentation. Experimental setup
is prepared for EGR to reduce the concentration of NOx in the exhaust gas. The experiments were conducted for pure biodiesel without EGR, 5%, 10%, and 15% with EGR and neat diesel on normal engine. The performance, combustion and emission characteristics without EGR and with EGR using neat biodiesel are evaluated and the results compared with that of neat diesel in normal diesel engine. The conclusion of this experiment is as follows.

- The biodiesel produced from neem oil by transesterification process reduces the viscosity of biodiesel found to be higher than that of diesel and the calorific value of biodiesel is lower than that of the diesel.

- The maximum efficiency obtained in the case of LHR engine with EGR setup. The efficiency of biodiesel is lower than that of diesel fuel. However the efficiency of the LHR engine with EGR setup the biodiesel fuel is well within the expected limits.

- The smoke emission for biodiesel increases with increase in % of EGR, smoke emission is more in 5%, 10% and 15% EGR than that of diesel in normal engine.

- The CO and HC emission is lower for Neem biodiesel without EGR than that of normal diesel engine for entire load of operation. The increase in % of EGR increases the CO and HC emission.

- The NOx emission increases with increase in load and reaches maximum at 60-70% of load and then decreases. NOx emission is almost all comparable with diesel except a narrow band of part load. By increasing the % EGR there is a considerable reduction in the NOx formation.

- NOx emission with 5%, 10% and 15% is respectively lower than that of neat diesel.

- The pressure is maximum in LHR biodiesel without EGR when compared with biodiesel with EGR.

- A considerable reduction in NOx formation is possible at 15% EGR with a little scarifies in BTE. Hence 15% EGR is optimum.

The above comparatively study clearly reveals the possibility of using the biodiesel in LHR engine with EGR. The combustion, performance and emission characteristics shows the suitability of neem biodiesel in LHR engine with EGR.

REFERENCES


