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Production of Fuel from Waste Engine oil and Study of performance and emission characteristics in a Diesel engine

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Abstract : The study presents the treatment of waste engine oil and studying the performance, combustion and emission characteristics of blends of recycled engine oil-diesel in a diesel engine. The recycled oil was prepared in two stages. First the waste engine oil was treated with acetic acid and with clay at 80°C-100°C. Recycled oil was blended with diesel at various proportions. Various properties like flash point, kinematic viscosity, calorific value, cetane number, cloud point, pour point and density were determined as per American Standards for Testing and Materials (ASTM). Blends were tested in a diesel engine and the results compared with diesel as a base fuel. The results indicate an increase of brake thermal efficiency, exhaust gas temperature when compared with that of diesel. Also there is a decrease of brake specific fuel consumption and emissions of NOx and HC. Hence the blend of recycled engine oil with diesel reduces the consumption of diesel and also minimizes the disposal problems of engine oil.
Keywords : Recycling of waste oil: acid-clay treatment: performance: emission.

1. Introduction

The coal was the basic type of fuel used in industries, however technological advancements over the years has led to cheaper, easy to process, easy to transport, easy to mine liquid and gaseous fuels called petroleum and natural gas that cater for the worlds energy needs. [1].Fossil fuel sources (coal, petroleum, natural gas) play a major role in the world wide energy consumption. These power the transportation, agricultural and industrial sectors. However, problems like depletion of petroleum resources, fluctuating fuel prices, environmental concerns over the recent years has paved way for researchers to develop alternate fuel sources that are cheaper and ecofriendly. Considering waste lubricant oil as an alternative or extending fuel has multiple benefits like utilization of waste energy sources thereby protecting environment from toxic and hazardous chemicals, reducing dependence of fossil fuels, less petroleum imports thus improving on foreign exchange, inexhaustible source of energy since they lubricate moving parts in a machine and enhancement of regional development and social structure in developing countries. Waste engine oil is an important type of waste lubricating oil, since it will last as long as engines exist. [2,3].One gallon of waste oil pollute million gallons of drinking water and also form a film on the surface of water, which prevents oxygen from being dissolved in water hampering all kinds of aquatic life and the process of photosynthesis. Waste lubricating oil contains degraded additives, impurities and residues resulting from the combustion process like PCB (Poly Chlorinated Biphenyls), or PAH (Poly Aromatic Hydrocarbons). Disposal of used oil into the ground has the potential to pollute land, water, crops and even public health [4-6].

Recycling of waste oil using economical, nontoxic substances can be an effective method. Using sulphuric acid, nitric acid, hydrochloric acid in acid treatment method creates large quantities of acidified sludges, higher acid value of the treated oil and higher operating temperatures. The waste generated from acid clay process can be incorporated into the ceramic industry. [7].Characteristics of base oil generated using solvent extraction was higher than acid treated oil. Oil generated using methyl ethyl ketone (MEK), 2-propanol, composite solvents, xylene, etc. have properties superior to that of oil from the acid –clay method.[8,9]. Higher investment cost is the shortcomings of this method [10, 11].Solvent extraction using Propane, being a hazardous and flammable solvent is considered unsafe, as it involves the loss of solvent, expensive solvent extraction plants, huge amounts of toxic residues. [12, 13] Membrane technology is the next alternate for waste oil recycling and it involves the usage of polymer hollow fiber membranes. Disadvantage of this method is that exorbitant membranes may get affected by large particles. [14]. Vacuum distillation, hydrogenation, Kinetics Technology International (KTI) clubs vacuum distillation and hydro finishing. This method effectively removes contaminants from waste oil. The quality of oil is superior, but involves high investment cost and is economically feasible for bulk production [15-18].

From the previous studies the necessary for the proper treatment for waste engine oil before disposal to save the environment is mandatory. Even though more advanced methods of waste oil recycling has been developed, it requires higher investments. The present study is about the treatment of waste engine oil by acid and clay treatment in a cost effective manner and to study the performance, combustion and emission characteristics of blends of recycled oil –diesel in a diesel engine at various loads.

2. Experimental Methods

Used engine oil was mixed with acetic acid of 8% by wt of oil in a flat bottomed flask. This was continuously stirred using a magnetic stirrer for 3 hours at room temperature. The mixture was allowed to settle for 1-2 days and filtered using a normal filter cloth, sediments were discarded. The resultant oil was heated to 80-100°C. At this temperature fuller's earth of 20% wt. of oil was added and stirred continuously for 3 hours .The mixture was allowed to settle for 2-3 days. Clear separation between oil and clay was formed. The treated oil was black in color.

2.1 Preparation of Blends

Recycled oil of 5%, 15% and 20% by volume were blended with commercial diesel. The nomenclatures of the blends are D95R5, D85R15 and D80R20 for the blend containing 5%, 15% and 20% of recycled oil respectively.

2.2 Property Testing

The properties such as Flash point, Kinematic viscosity, calorific value, cetane number, cloud point, pour point, density are determined for Diesel, D95R5, D85R15,and D80R20) as per American Standards for Testing and Materials.(ASTM) and are tabulated in Table 1.

Table 1 Properties of Blends

Property	Diesel (D)	D95R5	D85R15	D80R20
Kinematic Viscosity (cst)	3.5	3.3	3.6	4.2
Flash Point (°C)	65	64	64	65
Cloud Point (°C)	-6	-8	-10	-10
Pour Point (°C)	-25	-23	-20	-20
Calorific Value (KJ/Kg)	42700	43303	43920	43934
Cetane Index	50	51	52	53
Density(kg/m^3)	840	827.5	815.75	816.5

2.3 Specification of test engine setup

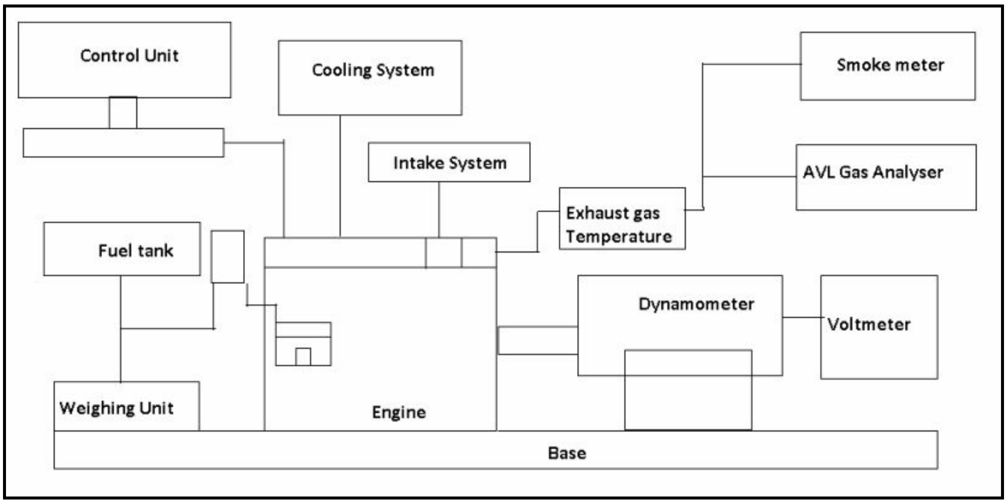

Figure1: Engine Setup

Schematic diagram of the test engine is shown in Fig.1. The diesel test engine was connected to a SWINGFILED Electrically controlled eddy current Dynamometer of the make power stars. It has the specification of KVA-5 , PH-1, Hz-50, Volt-240, Amps-21, and RPM-1500 The test engine used is Kirloskar oil engine TAF-1 which is a four stroke, single cylinder, vertical air cooled diesel engine .The engine has a compression ratio of 17.5:1, rated power output of 4.4KW at a rated speed of 1500rpm with bore diameter (D) of 87.5mm and stroke length(L) of110mm.A three hole fuel injector with an opening pressure of 200bar was used. The performance, combustion and emission characteristics are necessary to investigate the effect of the blends on engine performance. Each test was conducted by the following procedure. The consumption of fuel was observed for diesel and the blends, time taken for 10cc was taken as base for total fuel consumption. Each test was repeated three times and the average of three was taken for calculation of performance parameters such as BTE and BSFC.

The engine was coupled with a AVL Pressure Transducer GH14D/AH01 used to measure the cylinder pressure with a sensitivity of 18.99pc/bar, linearity of < ± 0.3% and natural frequency of 115KHZ and AVL INDIMICRA 602-T10602A, AVL di gas 444 (five gas analyzer) for exhaust gas analysis. The emission measurements were repeated 5 times and the average of five is taken for analysis

3. Results and Discussion

3.1 Performance Characteristics

3.1.1 Brake Thermal Efficiency

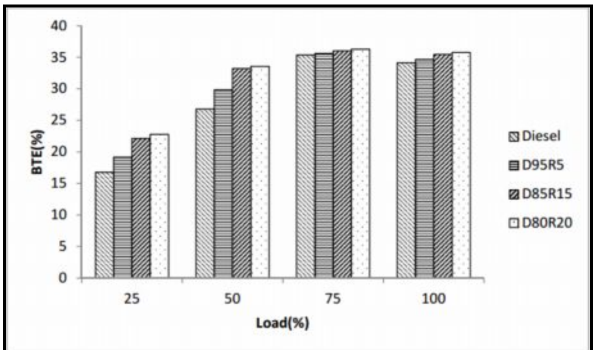

Figure 2: Brake Thermal Efficiency

BTE for the blends are presented in Fig. 2. It is observed that there is an increase of BTE for both the blends at all loads. This is due to the reason of higher energy content and Cetane number of the blends compared to diesel. The higher calorific value results in the higher amounts of heat produced in the combustion chamber, allowing complete combustion. Increasing trend of BTE of the blends is proportional to the increasing amounts of recycled oil added to diesel. Blends containing 20% recycled oil, 15% recycled oil and 5% recycled oil shows an increase of 5%, 4%and 2% respectively compared to diesel at full load.

3.1.2 Brake Specific Fuel Consumption

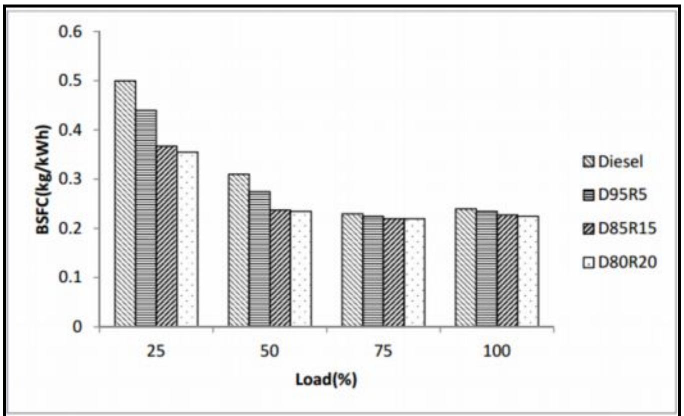

Fig.3. Brake Specific Fuel Consumption

BSFC for the blends are presented in Fig. 3. It is observed that there is a decrease in BSFC for all blends at all loads. Decreasing trend of BSFC is proportional to the amount of recycled oil added to diesel. Blends containing 20% recycled oil, 15% recycled oil and 5% recycled oil shows a reduction of 6%, 5%and 2% respectively compared to diesel at full load. Increase in the calorific value throughout the blend results in lower quantity of fuel required for combustion thereby reducing BSFC.

3.1.3 Exhaust Gas Temperature

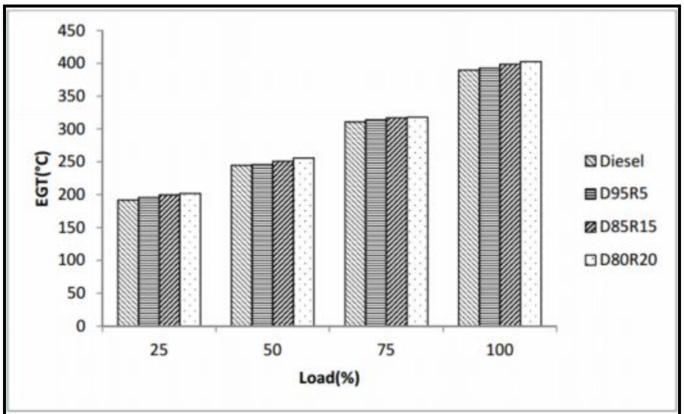

Fig.4. Exhaust gas temperature

EGT for the blends are presented in Fig.4. It is observed that there is an increase of EGT at all loads due to higher brake thermal efficiency achieved from the engine by using the blends. Blends containing 20% recycled oil, 15% recycled oil and 5% recycled oil shows an increase of 3%, 2%and 1% respectively compared to diesel at full load. Higher energy content of the fuel results in better combustion of the blends resulting in higher EGT. Increasing trend of EGT is proportional to amount of recycled oil added to diesel.

3.2 Emission Characteristics

3.2.1 Hydrocarbons

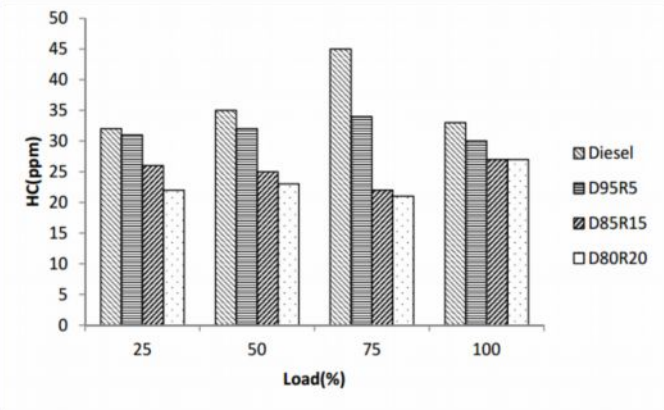

Fig.5. Variation of HC emission with engine load

HC for the blends are presented in Figure 5. It is observed that emissions of HC are lower than diesel at all loads. Blends containing 20% recycled oil, 15% recycled oil and 5% recycled oil shows a decrease of 18%, 18%and 9% respectively compared to diesel at full load This is due to higher energy content of the blends which results in higher average temperature in the combustion chamber and also higher cetane number of the blends led to better combustion. Decreasing trend of HC emissions of the blends is proportional to the amount of recycled oil added to diesel.

3.2.2 Oxides of Nitrogen

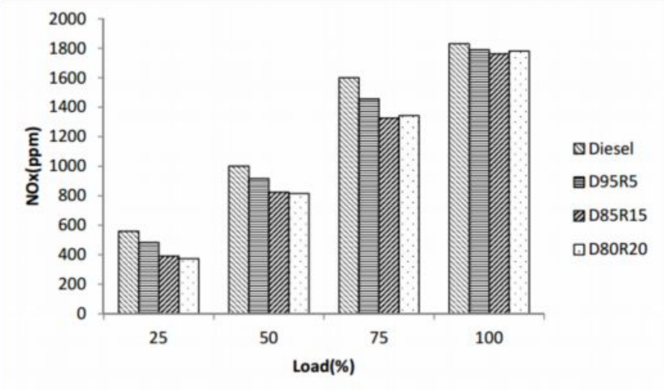

Fig.6. Oxides of Nitrogen

NOx for the blends are presented in Figure 6. It was observed that there is a reduction of NOx emission for all the blends compared to diesel at all loads. Uniform distribution of temperature in the chamber reduces the formation of NOx. It also depends upon the ignition conditions. Blends containing 20% recycled oil, 15% recycled oil and 5% recycled oil shows a decrease of 3%, 3%and 2% respectively compared to diesel at full load. The prolonged ignition delay of the blends also results in NOx reduction.

4. Conclusion

An experimental investigation of performance, combustion and emission characteristics of blends of recycled oil-diesel were conducted and following conclusion are made.

- BTE for blends D95R5, D85R15 and D80R20 increased by 2%, 4% and 5% at full load respectively due to higher energy content

- Blends D95R5, D85R15 and D80R20 show a reduction of 2%, 5% and 6% respectively at full load due to higher calorific value.
- HC emissions for all the blends are lower than diesel due to higher energy content and calorific value.
- Uniform distribution of temperature in the chamber reduces the formation of NOx.

The recycled oil blended with diesel at 5%, 15% and 20% shows an increase in the brake thermal efficiency and decrease of bsfc. The recycled oil can reduce the dependence of diesel up to 20% and also various environmental imbalances caused by waste oil discharged onto the environment (land, water bodies etc.) can be eliminated in a cost effective manner.

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Nomenclature

KTI -Kinetics Technology International
PCB -Polychlorinated Biphenyls.
PAH -Poly aromatic hydrocarbons.
MEK- Methyl ethyl ketone.
CST- Centistokes
CN –Cetane number
ASTM- American standards for Testing and materials
D95R5- blend containing 95% diesel and 5% recycled oil.
D85R15-blend containing 85% diesel and 15% recycled oil
D80R20-blend containing 80% diesel and 20% recycled oil
BTE- Brake thermal efficiency (%)
BSFC- Brake specific fuel consumption (kg/Kw.hr)
RPM- Revolutions per minute
HC- Hydrocarbon (ppm)
NO_x- Oxides of Nitrogen (ppm)
TDC- Top dead centre
BDC- Bottom dead centre
EGT- Exhaust Gas Temperature

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