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Review on Preparation of Alternative Fuel from Waste Transformer Oil and Studying Performance Characteristics on Diesel Engine for Different Blends

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Abstract: ***Reuse and recycling are better options to derive energy or value added products from waste substances and to minimize the disposal problems. Transformer oil is generally used as a coolant in welding transformers, power transformers and electromotive units. After a prolonged use in these devices, the transformer oil becomes waste and is disposed of. The disposal of waste transformer oil (WTO) causes an environmental pollution. However, the WTO has properties that are similar to that of diesel fuel with a marginally higher viscosity and lower calorific value. The present investigation is aimed to reuse the WTO as a possible source of energy to run a small powered, single cylinder, four stroke, and diesel engine. Different techniques such as blending, operating the engine with different injection timings, nozzle opening pressures, compression ratios, preheating and dual fuel mode were adopted to study the engine behaviour in terms of combustion, performance and emission when the engine is fueled with the WTO. The results are analyzed and compared with diesel operation of the same engine.***

Keywords: waste transformer oil, engine performance, emission parameters, efficiency, properties of diesel etc.

1. Introduction

An engine is a device that transforms one form of energy into another form. While transforming energy from one form to another, the efficiency of conversion plays an important role. Heat energy is a device that transforms the chemical energy of fuel into thermal energy and utilizes thermal energy to perform useful work. Thus, thermal energy is converted into mechanical energy in heat engine. Increase in automobile indicates that there will be great demand for the fuel in future. India imports most of the fuel from middle east. India imports approximately 34% millions ton of crude oil each year. The energy consumption in terms of oils and other energy sources is growing drastically, and it is increase in the world by 36% in the year 2035. The growing demand is caused by an exponential increase in the population that predicted to increase further by 25% in the next 20 years, with major population increases particularly China and India. The increasing uses of automobiles causes air pollution because discharge of particulates, or biological materials into the atomosphere, causing discomfort, disease, or death to humans, and damage to living organisms. The disposal of solid or liquid or gaseous waste materials in open land or underground can contaminate the soil or ground water, threaten public health, and cause land pollution. Water pollution occurs when pollutants or waste disposals are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.The result of this causes global warming, ozone depletion, human health problems, death of forests, and infertility of the soil. Alternative fuel technology, availability will more common in coming decades. In this point of view, waste transformer oil (WTO) can be an alternative source for petroleum oils. In India, there is a huge amount of transformer oil is rejected every year.WTO has similar physic-chemical properties. Transformer oil is used mainly in electrical transformer for insulation purpose. At present 100 percent transformer oil is not used in place of diesel fuel [DF] to run engine rather blends of WTO and DF is used to run the engine. The current study investigated the possibility of using WTO as a diesel substitute.

2. Waste Transformer Oil (WTO)

The electrical transformer is an essential piece of equipment used in the transmission and distribution of the electrical energy that is installed in small, medium and large electrical distributing stations. It is also used in arc welding equipment and the electromotive units in trains. The performance and the life of an electrical transformer depend on the effective insulation and cooling.

Figure 1: Pure Transformer Oil

2.1 Degradation of Transformer Oil

The transformer oil will deteriorate rapidly at high temperatures and moisture acts as a catalyst for its aging.

There are also other substances and metals present in a transformer that are responsible for oil degradation. These include copper, paint, varnish and oxygen. The principal mechanism of transformer oil aging is oxidation which results in acids and other polar compounds being formed. When transformer oil is subjected to thermal and electrical stresses in an oxidizing atmosphere, it gradually loses its stability and becomes decomposed and oxidized, its acidity increases, and finally, it begins to produce mud.

Figure 2: Photograph of the WTO sample after procuring

2.2 Filtering of the waste transformer oil

Figure3 shows the schematic of the steps involved in the disposal of the WTO from transformer oil. Once the life of the oil was determined, the transformer oil was removed from the transformer and sent to settling.

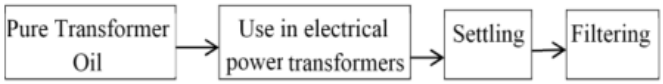

Figure 3: Disposal of the WTO from transformer

Now the disposed transformer oil has been categorized as WTO, a further two processes are involved in processing the oil (a) settling and (b) filtering. The processes are discussed below;

(a) Settling: Foreign particles and sediments of the WTO settle at the bottom of the oil tank. The settling works better in warm conditions and over a number of days or weeks. The settled WTO was drained from the oil tank.

(b) Filtering: Fine filters may be required depending on the application. For this study the WTO was filtered with the help of a fabric filter of size 30 microns.

3. Experimental Setup

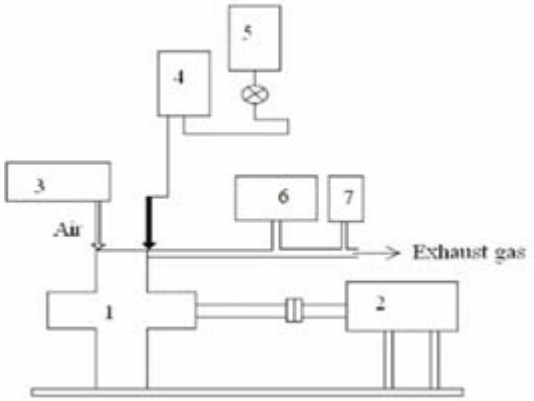

Figure 4: Engine Specification

1.Engine 2. Dynamometer 3.Air plenum 4.U-tube Manometer 5. Tank 6.Exhaust gas analyzer 7. Smoke meter

4. Literature Review

Wang [1] have applied methanol in diesel engines for achieving fuel diversity and reduction of engine emissions. Dual fuel application is the most promising method, but its combustion characteristics have been less extensively studied. The authors have measured the cylinder pressures of the operational engine using both diesel and dual fuel (methanol-diesel) and the engine combustion characteristics were investigated. The high methanol mass fraction showed a reduction in the smoke and NOx emissions under all the operating conditions, whereas the carbon monoxide (CO) and unburnt hydrocarbon (HC) emissions were found to increase emissions.

Kowalewicz and Pajaczek [2] have used ethanol in a CI engine with diesel fuel, which was injected into the inlet manifold. The CO2 and NOx were found to decrease with amount of ethanol. The optimization of the energy ratio of both fuels and injection timing of diesel fuel were also studied in the investigation.

Murugan [3] have carried out tests to evaluate the performance and emission characteristics of a single cylinder, four stroke, air cooled, direct injection, diesel engine fueled with 10, 30 and 50% blends of tire pyrolysis oil (TPO) with diesel. TPO was derived from waste automobile tires through vacuum pyrolysis in one kg batch pyrolysis unit. Results indicated that the brake thermal efficiency of the engine fueled by TPO-diesel blends increased with increase in blend concentration and higher than diesel at full load. The HC, CO and smoke emissions were found to be higher at higher loads due to high aromatic content and longer ignition delay at original injection timing. The cylinder peak pressure increased from 71.4 to 73.8 bar. The ignition delays were longer than diesel.

Murugan [4] have taken 80% and 90% of distilled tire pyrolysis oil (DTPO) blended with 20% and 10% diesel respectively and conducted investigations in a four stroke, single cylinder, air cooled, diesel engine without any engine modification. The performance, emission and combustion characteristics of a single cylinder, four stroke, air cooled, DI diesel engine running with the DTPO-diesel blends at higher concentrations were studied. There was approximately 3% reduction in the brake thermal efficiency. The NO emissions were found to be lower by about 18% and smoke emissions were found to be higher by about 38% compared to that of diesel at full load.

Murugan [5] have done experimental investigation for TPO as an alternative fuel in a diesel engine. TPO was desulphurised and then distilled through vacuum distillation. Also, two DTPO-diesel blends at lower (20% DTPO) and higher concentrations (90% DTPO) were used as fuels in a four stroke, single cylinder, air cooled, diesel engine without any engine modification. The results were compared with the diesel fuel (DF) operation of the same engine. Results

indicated that the engine can run with 90% DTPO and 10% diesel fuel.

Hariharan [6] have conducted experiments on a single cylinder, four stroke, DI diesel engine using TPO as a main fuel. Results indicated that the engine performs better and with lower emissions when DEE was admitted at the rate of 170 g/h with TPO and NO emission in TPO-DEE operation reduced by 5% compared to diesel fuel operation.The HC, CO and smoke emissions were higher for the TPO-DEE operation by 2%, 4.5% and 38% than diesel mode.

Dogana [7] have studied the effect of tire-derived fuel (TDF) on engine performance and exhaust emissions in a diesel engine. The authors tested the TDF in a single cylinder, four stroke, unmodified, and naturally aspirated DI high speed diesel engine at full load and four engine speeds (1400, 2000, 2600 and 3200 rpm) by using six test fuels. The experimental test results showed that the DI diesel engine can run with the TDF fuel blends up to TDF90. The smoke opacity, HC, and CO emissions reduced while the NOx emissions increased with the increasing TDF content in the fuel blends.

Arpa [8] have examined WLO as an alternative fuel in a single cylinder, four stroke, air cooled, naturally aspirated, direct injection diesel engine developing a maximum power of 10 kW at 2000 rpm. Results of the investigation indicated that there was a marginal increase in the brake thermal efficiency, brake mean effective pressure and exhaust gas temperature obtained for WLO at full load. The brake specific fuel consumption for WLO was found to be marginally lower compared to that of diesel fuel. In terms of emissions; the CO, NO and sulphur dioxide increases by about 14.7, 12.7,

Tajima [9] carried out an experimental investigation to utilize the used lubricating oil (ULO) as an alternative fuel in a diesel generator plant. The combustion characteristics of a diesel engine were determined by observing the burning flames in the engine, while on a test run. The results were compared with heavy fuel oil. The ULO showed better ignition quality and the smoke emission was found to be lower by about 64.71% compared to heavy fuel oil operation. However, a thick deposit of combustion products was noticed in the combustion chamber after a short run. It was suggested that to remove the additives from ULO, before utilizing it as a fuel in diesel engines.

Mani [10-11] has analyzed the properties of WPO and compared with the petroleum products they reported that it had properties similar to that of diesel. After the analysis of oil, the WPO was used as an alternate fuel in a DI diesel engine without any engine modification. They also conducted an experimental investigation to study the performance, emission and combustion characteristics of a single cylinder, four-stroke, air cooled DI diesel engine fueled with the WPO. They analysed the results in comparison with diesel operation throughout engine operation. The experimental results have also showed a stable operation and comparable brake thermal efficiency for the WPO with that of diesel. The unburnt HC emission from the WPO fueled engine was found to be higher by about 15% compared to that of diesel operation at full load. The CO emission for the WPO was noticed higher by about 5% than that of diesel at full load. Smoke was found to be reduced by about 40% for the WPO at all loads.

5. Conclusion

The objective of this experiment was to use transformer oil as an alternative fuel. The pure diesel was used as base fuel for comparing the properties and performance parameters.

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