Experimental Analysis of Fuel Produced from Automotive Waste Lube Oil

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Abstract - *In this study, an experimental investigation was carried out to determine the effects of blends of pyrolysis fuel with diesel with ratios of 10%, 20%, 30% and 50% on the performance and emission characteristics of a diesel engine. As microwave heated pyrolysis has recently shown promise as a route for the treatment and recycling of the waste automotive oil. In this process, waste oil is mixed with a highly microwave-absorbent material such as carbon rod; as a result of microwave heating the oil is thermally cracked in the absence of oxygen into shorter hydrocarbon chains. The oil obtained by pyrolysis of automotive waste oil can be used as an alternate fuel for diesel engine without making any modification to the engine.*

Properties of the pure pyrolysed fuel were checked. A series of engine performance and emission tests were conducted using the blends of fuel samples in the test engine. Effects of the fuels on the performance parameters, and emissions of NO_x, CO, CO_2, and HC were discussed. The results indicated that brake thermal efficiency decrease due to increase in brake specific fuel consumption with increasing amount of blends with diesel. The main effect of 10%, 20%, 30% and 50% blends of pyrolysed fuel additions to diesel on pollutant formation was that the NOx ratio increased with increase in load, whereas that of CO also increased due to insufficient oxygen in the engine cylinder.

Keywords: *Waste automotive oil(WAO), Pyrolysis, Microwave Pyrolysis, Diesel engine, Brake thermal efficiency.*

1. INTRODUCTION

1.1 Automotive Waste Oil

Nowadays, we find increasing demand for lube oil use, which results in more waste lube oils. Waste lubricant oils are important alternative fuel sources proved to be the best substitutes for existing petro fuels, since waste generated oils represent more than 60% of used lubricant oils. Since the energy resources related to fossil fuels diminish and are limited, the research focuses on finding alternative energy resources and utilizing them. The recycling of the automotive waste oils and lubricants is an alternative for energy resources. The high-volume waste oils can be turned into valuable fuel products by refining and treating processes. Converting of the waste oils into diesel and gasoline-like fuels to be used in engines without disposing is very important. Consumption of the diesel like fuel and gasoline like fuels prepared from the waste automotive lube oils, and blending of the produced fuels with gasoline or turpentine decrease consumption of petroleum based fuels, protecting environment from toxic and hazardous chemicals. It also saves of foreign exchange, reduces greenhouse gas emissions and enhances regional development especially in developing countries [1,2].

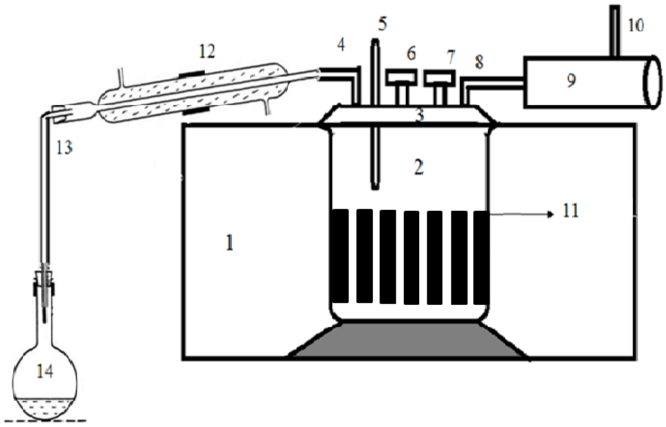
1.2 Pyrolysis

Waste oils can be reconstructed chemically by being heated in an oxygen-free environment. This process is called pyrolysis, which is defined as chemical decomposition by the action of heat and refers usually to chemical decomposition of organic materials heated in an environment of insufficient oxygen for combustion. Pyrolysis process has certain advantages over other treatment methods of waste disposal. The most important advantage of this method is that it does not pollute the environment when carried out in an appropriate way, because pyrolysis products such as gases, liquid oils and carbonaceous residue can be used as fuels.

2. EXTRACTION OF PYROLYSIS OIL BY USING MICROWAVE

Pyrolysis using microwave heating is a relatively new process in which the, waste hydrocarbons are mixed with a highly microwave-absorbent material such as carbon rod; as a result of microwave heating, they are then thermally cracked in the absence of oxygen into smaller hydrocarbon chains. The resulting gaseous products are subsequently condensed into liquid oils of different compositions depending on the features of the input substances and reaction conditions. The use of microwave radiation as a heat source is known to offer additional advantages over traditional thermal heat sources and the combination of carbon-based material and the novel use of microwave heating in pyrolysis processes are of increasing interest as reflected by considerable recent research. Microwave systems show a distinct advantage in providing a rapid, energy efficient, and targeted heating process compared to conventional technologies, thus facilitating increased production rates and decreased production costs. Moreover, thermal energy is targeted only to microwave receptive materials and not to gases within the heating chamber or to the chamber itself. It can promote certain chemical reactions by selectively heating the reactants, leading to a more uniform temperature profile and improved yield of desirable products.

The experimental setup for production of pyrolysis oil by using microwave is shown in fig. 2.1 & fig. 2.2



1. Microwave oven 2.Kettle 3.Lid 4.Outlet 5.Thermocouple pocket 6.Stirrer Neck 7.Inlet for Nitrogen gas 8.Suction Port 9.Vacuum pump 10.Exhaust 11.Carbon Rods 12.Condenser 13.Receiver 14.Collecting Vessel

Note: Each joint in the setup is a Standard joint i.e. air tight joint and each joint is adhered with silicon grease in order to hold joints firmly

Fig.2.1 Schematic diagram of Experimental setup

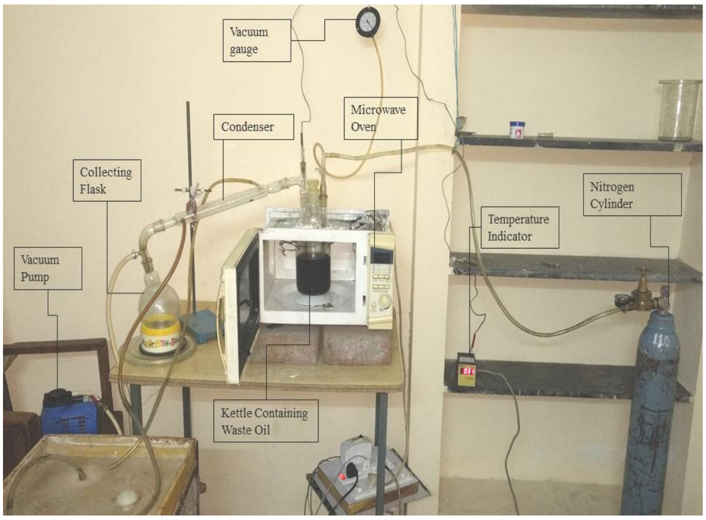


Fig.2.2 Actual Experimental Setup of producing pyrolysis oil

2.1 Experimental Procedure

The waste oil was collected from the engine of two wheelers from local service station. Before pyrolysis, the oil samples were filtered and 1.2 to 1.5 litre of waste oil was poured in the kettle. Carbon rods used as microwave energy absorbent to heat the waste oil. A total of half kg of carbon was fixed into the kettle reactor. The apparatus was assembled as in Fig.2.2, each joint was made leak proof with the help of silicon gel and preventive measures were taken. N_2 gas was vented through the apparatus air is sucked out of the kettle to remove oxygen from the kettle with the help of vacuum pump. Nitrogen is flushed in the kettle to ensure that the atmosphere inside the kettle is inert. A complete purge of all air within the apparatus was ensured by flushing the system with N_2 gas for at least 10 min before heating commenced. After that power supply is switched ON and the heating of microwave gets started carbon rod were heated to temperatures ranging from 250 to 500°C, as carbon rod gets heated the waste oil present near by the carbon also gets heated. It took 3 hours to reach from room temperature to 250°C, and first drop of condensate oil was formed at 195°C, after that slowly formation of condensed oil gets started. After that it took 5-7 hours of process to get pyrolysis oil collected in the flask, by that time it was continuously under the observation, to prevent any accident and continuously operation of vacuum pump is done in the system to make oxygen free environment. When the accumulation of liquid product had stopped and further evolution of vapour phase products was no longer observed in the system, the reactor was visually inspected to ensure that the reaction was fully completed. Once the reaction had finished, the microwave oven was switched off and the reactor cooled with the aid of a fan. The N_2 flow was continued until the temperature of the reactor had fallen to 80°C. The reactor was then disconnected from the condensation system and sealed to prevent contact of the carbon bed with air. After some time pyrolysis oil was taken out and about 500 to 600ml of pyrolysis was collected in the flask which when measured with measuring flask and will be analysed to identify their chemical and physical properties. Then fuel so obtained will be compared with diesel for its chemical and physical properties. The fuel so produced will be tested for performance properties. The fuel can be tested in C.I. Engine purely or in a blended form with diesel.

Table.2.1 Properties of Obtained waste oil fuel and Diesel fuel

Property	Waste oil fuel	Diesel fuel
Density at 20°C (kg/m³)	810– 820	820 - 840
Lower heating value (MJ/kg) and Higher heating value (MJ/kg)	42.5 - 43.2	45 - 46.5
Flash point (°C)	57	55
Viscosity (mm²/s)	2.54 - 4.21	2.5 - 4.1

3. EXPERIMENTAL SETUP:

A single cylinder 4-stroke air-cooled diesel engine is used. An eddy current dynamometer is used for loading the engine. The parameters related to the performance of the engine are: brake specific fuel consumption, brake thermal efficiency, brake power, exhaust gases and smoke density were evaluated for diesel and each fuel Blends and at different engine loading conditions. Dynamometer mounted with speed sensor, this sensor feeds output to the control panel. Fuel meter is connected to the engine fuel intake line. Airflow meter measures inlet air flow at suction line of engine air inlet. Cylinder pressure is measured by probe inserted in cylinder, which feeds its output to control panel.

microwave energy absorbent produced more oil than that of conventional heating.

2. The blends of waste automotive pyrolysis oil are suitable fuel for a diesel engine and can be used without any modification made on the engine.

3. The brake thermal efficiency of blends B10%, is near to the efficiency of diesel at lower brake power, but as brake power increases the efficiency decreases, higher efficiency for blend B10% is obtained at 1.924 kW brake power than other three blends.

4. Thermal efficiency of blended fuel is decreased due to more brake specific fuel consumption as increase in brake power.

5. HC emissions were found to increase with the blending of pyrolysis fuel with diesel fuel; B10% curve followed the diesel curve with small increase in HC emission.

6. The formation of NO_x depends upon gas temperature and ignition delay. As load increases NO_x emission increases which is due to increase in temperature in combustion chamber.

7. The reason for the increase in CO in case of different blends is not enough oxygen to convert all carbon to CO_2. Rich mixture is required during starting or when accelerating under increasing load.

8. Heavy imports in the field of petroleum can be reduced by converting the waste automotive oil to fuel. This increase the economic stability.

NOMENCLATURE:	
DLF	Diesel like fuel
GLF	Gasoline like fuel
CV	Calorific value (MJ/kg)
P	Pressure(bar)
Bmep	Brake mean effective pressure (bar)
BP	Brake power(kW)
BSFC	Brake specific fuel consumption (kg/kWh)
N	Engine speed (rpm)
W	Load (kg)
TFC	Total fuel Consumption(kg/min)
B10%	Blend 10% of Pyrolysis fuel with Diesel
B20%	Blend 20% of Pyrolysis fuel with Diesel
B30%	Blend 30% of Pyrolysis fuel with Diesel
B50%	50% of Pyrolysis fuel with Diesel
WAO	Waste automotive oil
HC	Hydrocarbon (ppm)
NO_X	Oxides of nitrogen (ppm)
CO	Carbon monoxide (%vol)
CO_2	Carbon dioxide (%vol)
AFR	Air fuel ratio
L	Length of stroke(m)
D	Diameter of piston (m)

Greek Symbols:	
P	density of fluid (kg/m^3)
θ	Crank angle

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