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Investigation of Resin Oil as an Alternative Fuel in Low Heat Rejection CRDI CI Engine

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ABSTRACT: With modernization and increase in the number of automobiles worldwide, the consumption of diesel and gasoline has enormously increased. As petroleum is non-renewable source of energy and the petroleum reserves are scarce nowadays, there is a need to search for alternative fuels for automobiles. Generally CO, HC, NO_x, SO_x, CO₂, particulate matters and smoke are treated as emissions from the exhaust gas of engines. Among these emissions, HC and CO are more toxic in nature which leads to air pollution. The diesel engine being predominant than petrol engine in developed countries like India, these engines are widely used in the sectors like agriculture, power and automobile. Pine oil not only from wood but even the needles and cones of Pine tree extracted has been used in CRDI CI engine as an alternate fuel which has some similar and some better properties as that of diesel. In the present work, this pine oil is replaced with diesel to obtain properties and efficiency in a Low Heat Rejection, four stroke, 2 cylinder Turbocharged diesel engine at different load conditions. Thereafter, the Power output is determined and emissions like CO, HC from the exhaust gasses are compared and represented in a graphical form.

KEYWORDS: CRDI CI Engine, Low heat rejection, Turbocharged diesel engine.

I. INTRODUCTION

The environmental pollution caused by the automobile industry has knocked many researchers to think over to reduce the pollution with this automobile industry. The present automobile industry like petrol engine, diesel engine uses the fossil fuel like petrol and diesel as fuel. Awareness of the society towards the impacts of human activities on the environment is increasing and environmental considerations are changing the way in which the materials are being utilized. Thus, it is important to manufacture products with minimal environmental impact. Wood is a biologically derived renewable raw material with a low processing energy demand. It is recyclable and biodegradable. Timber products with prolonged life can be used as a repository for CO₂ (Bruce and Lucy 2006) and can be considered as a future-oriented material to achieve the universal goal of sustainable development and a low carbon future.

Generally, biofuels are obtained from the living plant sources. These oils may be obtained from resin and plant seeds. They are renewable and have low sulphur content. Pine oil can be used in an IC Engine either in pure form or blended with Diesel in appropriate proportions. Pure pine oil if used then related modifications have to be made on IC engine.

II. LITERATURE REVIEW

This section reviews the various emission techniques tried by researchers admitting larger fraction of high volatile, low cetane fuels in CI engines. Generally, octane fuels are suitable for SI engines and the cetane fuels for CI engines. However many researchers have proved that the octane fuel of considerable fraction can also drive the CI engine in association with high cetane fuel. A performance and emission test was conducted on a dual fuel engine using propane and diesel fuel (Jorge and Barata, 1995). It is reported that, up to 90% of the diesel fuel energy input was

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replaced with propane gas without any loss of thermal efficiency. He also reported that this engine emits more CO and less NO_x at all load conditions than that of standard diesel operation.

The performance and emission characteristics were examined on dual fuel engine fueled with jatropha oil and orange oil (Senthilkumar et al, 2001). Their results showed that the induction of orange oil reduces smoke and NO_x emission and improves thermal efficiency with all pilot fuels. Ethanol direct injected, multi spark assisted diesel engine (SADE) is developed to study the combustion and emission performance of ethanol (Ubong, 1990). SADE offers superior combustion characteristics at higher loads than that of conventional turbocharged diesel engine. It was reported that this engine burns learner at all operational limits and does not require throttling of inlet air. It was also reported that this engine emits near zero smoke emission at all load conditions and operated smoothly without any components failure up to 176.5 hours of engine operation.

An experimental investigation on CRDI diesel engine was attempted using minimally processed methanol to study the combustion and emission characteristics (Thomas et al, 1994). In this work, a minimally processed methanol was introduced into the engine through regular diesel injection system and the preheated air was inducted through inlet manifold. The hot air supplied to the engine helps to self-ignite the injected methanol. It was reported that the engine was operated with very low smoke and NO_x emissions at all loads. An experiment was conducted on hot air assisted turpentine in CRDI diesel engine to study BTE, NO_x emission and smoke emission (Karthikeyan et al, 2010). In this work, 50% smoke free operation compared to diesel fuel is observed at all loads.

It is learned from literature survey that the semi adiabatic engine will work out efficient for the reduction of HC, CO, particular material and smoke as for the experiment conduction by the researchers which are slighter under reference. It is also learnt from the literature survey that the semi adiabatic engine will suite for low cetane fuel and high viscous oil.

III. EXPERIMENTAL PROGRAMME

1. ENGINE SPECIFICATIONS:

TWO CYLINDER, FOUR STROKE, CRDI ENGINE.

BRAKE HORSE POWER (BHP)	: 20.11HP (15KW)
SPEED (N)	: 1500 RPM
BORE DIAMETER (D)	: 107 mm
STROKE LENGTH (L)	: 126 mm
COMPRESSION RATIO	: 17.5:1
CALORIFIC VALUE OF DIESEL (C _v)	: 43200 KJ / Kg.
SPECIFIC GRAVITY OF DIESEL (S)	: 0.84
CALORIFIC VALUE OF PINE OIL (C _v)	: 45000 KJ/ Kg
SPECIFIC GRAVITY OF PINE OIL (S)	: 0.86

2. EXPERIMENTAL SETUP:

The experimental setup is shown in figure below. A Twin cylinder, CRDI diesel engine of 15 K.W, 1500 rpm, oil cooled and with turbo charging was employed in the experimentation, the details of which are given in the appendix. The engine was coupled to an electric generator for obtaining power developed by the engine. A high pressure fuel feed pump was fitted on the inlet manifold for inducting pine oil during suction stroke at high pressures of 1800 bar. Diesel fuel was injected in the conventional manner and then same was followed for Pine oil. The injection pressure was maintained and compression ratio was fixed at 17.5:1. The loading of engine was done by using water loading technique. Salt is added and copper plate is continuously immersed in water bath supplied with power generated by engine to obtain different loading conditions. The emissions from the exhaust are measured for emissions at the outlet using emission apparatus. Two separate burette tank arrangements were made for measuring quantities of Pine oil and diesel consumption.

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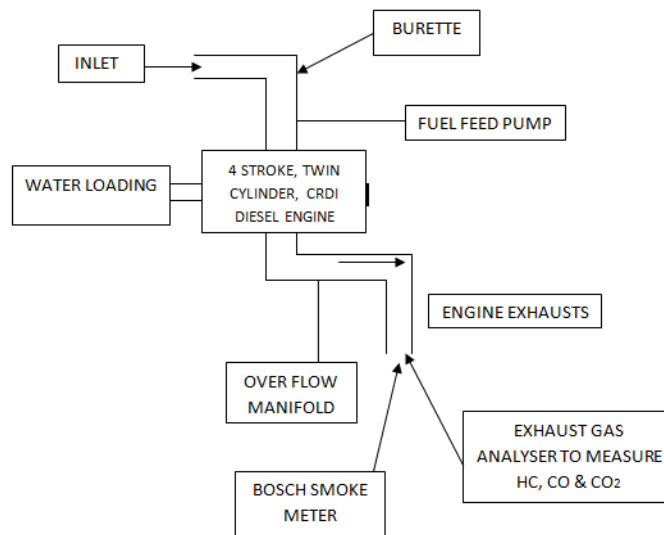


Fig.1 shows the schematic arrangement of Experimental Set-up.

3. COMPONENTS OF EXPERIMENTAL SETUP:

The experimental setup consists of the following different components:

- Fuel Tanks
- Measuring burette (Inlet and Outlet fuel flow)
- Feed Pump
- Engine
- CRDI injector
- Turbocharging
- Engine
- Coolant
- Coupling
- Water loading
- Exhaust emission analyser.

FUEL TANKS: The fuel tanks act as reservoir for the fuel that is used for combustion in engine to produce energy. Two fuel tanks are placed on stand at an elevation. One of these tanks is filled with Diesel and the other with Pine oil. The engine is started with diesel as fuel and after reaching an equilibrium condition, simultaneously the flow of diesel is seized and pine oil flow is turned on. This continuous flow will help in running the engine with bio-diesel and at the end of experiment; the engine is made to run with the diesel and is stopped.

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Vol. 6, Issue 10, October 2017



Fig.2 shows the fuel tanks.

MEASURING BURETTE: The fuel from the fuel tanks is passed through a three way valve. The three way valve is used to maintain the direction of flow and type of fuel flowing. One of the directions in valve is used to fill the burette to measure the flow of fuel into the cylinder in a prescribed time. Other two directions are used to arrest the fuel in burette and to pass the fuel arrested in burette to the engine. Measuring flask is used to measure the outflow of the fuel from the engine.



Fig.3 shows the measuring burette.

FEED PUMP: Feed pump is a device which feeds fuel to the engine from the reservoir tank. The fuel is made to flow into a mid-way tank after the fuel consumed is calculated. It should be taken care that the pump is immersed in fuel half way and minimum level of the fuel is to be maintained. The pump sucks the fuel and passes it to the fuel injector at a high pressure of 1800 bar. This high pressure of fuel injection helps in atomization of fuel droplets into fine particles which helps in instantaneous combustion.

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Vol. 6, Issue 10, October 2017



Fig.4 shows the feed pump.

ENGINE: Four stroke CI engine is similar to four stroke SI engine except that a high compression ratio is used in the former, and during the suction stroke air alone is inducted instead of fuel-air mixture. Due to high compression ratio, the temperature at end of compression stroke is sufficient to ignite the fuel which is injected into the combustion chamber. In the diesel engine a high pressure fuel pump and an injector is provided to inject fuel in to combustion chamber.

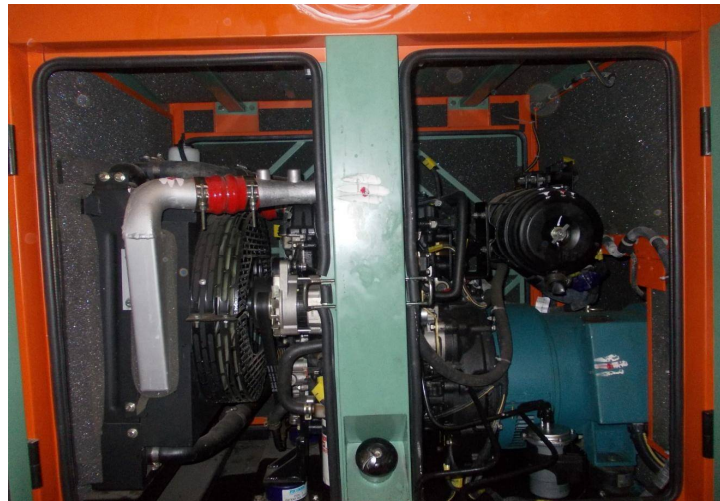


Fig.5 shows the engine.

The working of a cycle is completed in four strokes and diesel oil is used as fuel. The working of the engine is described as follows.

1. **SUCTION STROKE:** Only air is taken in to the cylinder and during this stroke intake valve is open and exhaust valve is closed.
2. **COMPRESSION STROKE:** Both valves remain closed, but near the end of compression, pressure and temperature of the air is about 60 bar and 600°C respectively.
3. **EXPANSION STROKE:** Both the valves remain closed during expansion stroke. Fuel is injected at the beginning of the expansion stroke. The temperature of air at the end of compression stroke is sufficient to ignite the fuel. The combustion of fuel is continued at constant pressure as long as the fuel valve is open. The high pressure and high temperature gases push the piston down even after valve is closed.

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Vol. 6, Issue 10, October 2017

4. EXHAUST STROKE: During this stroke, the inlet and fuel valve remain closed and exhaust valve remains open. The piston moves up in the cylinder and pushes out the burned gases. The piston reaches the TDC completing the exhaust and is ready for the next cycle.

The compression ratio of diesel engine ranges from 14 to 22. The overall air-fuel ratio may vary from about 100:1 at no load to 20:1 at full load.

COOLANT: This is an oil cooled engine. Lube oil is used as a coolant which acts as efficient coolant which helps in dissipation of heat from the engine. The main function of this lubricating oil is protecting the internal combustion engines in motor vehicles and powered equipment. A lubricant is a substance introduced to reduce friction between moving surfaces. It may also have the function of transporting foreign particles.

COUPLING: A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. Couplings do not normally allow disconnection of shafts during operation. In this engine the coupling is used to connect the engine shaft to the generator shaft which will power up the generator to produce electricity.

WATER LOADING: Water loading was used to load the generator connected to the engine. Once the engine is started, it can be loaded in steps of 9 amps using the water loading setup. Internally built voltmeter and ammeter which is connected to the generator to measure the voltage current, and the power developed in KW. The setup consists of a water drum as main load and salt is added continuously to increase the load along with immersing the copper plate in water gradually. The power is supplied to storage tank and copper plate using copper bolts to load the engine.



Fig.6 shows the water loading system.

EXHAUST EMISSION ANALYZER:

The exhaust gases are measured for the emissions and their variations for different oils. The exhaust gas CO and HC are measured by using gas chromo tog. All the readings are obtained in ppm and readings are taken for different partial loads and at full loads.

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Vol. 6, Issue 10, October 2017



Fig.7 shows the exhaust gas analyser.

4. PROCEDURE:

STEP 1: The engine is started by cranking the fly wheel. The engine runs on pure diesel initially. The engine is gradually brought to stable condition by allowing it to run for few minutes. Two tanks one for diesel and one for pine oil is arranged, After few minutes Pine oil is allowed to flow and the flow of the diesel is terminated.

STEP 2: Check for the circuit connections and switch on the circuit. Special type of loading called as Water loading is arranged, Then close the circuit and initially run the engine at no load condition and then apply load of 9 amps and allow the engine to come under stable condition, loading is done by adding salt to the water.

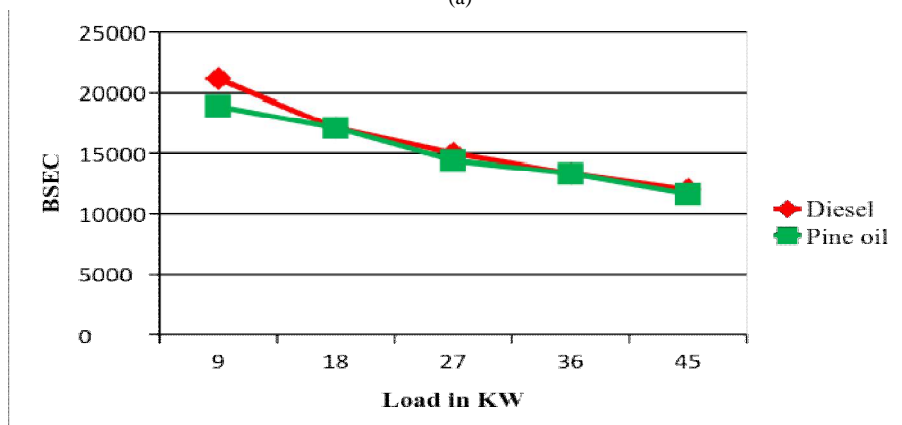
The following parameters are noted at this load.

- Voltage
- Current
- Power
- CO,HC is measured
- Diesel consumption

STEP 3: Manometer reading showing both inlet and outlet fuel consumed is tabulated to know the total fuel consumption. After reaching the stable condition, the parameters like voltage, current, speed, power etc. are noted from the led display provided. The exhaust gases were allowed to pass through air flow meter from the exhaust manifold to know the quantity of different emissions produced during combustion by measuring using emission testing device and smoke meter.

IV. RESULTS AND DISCUSSION

(a)



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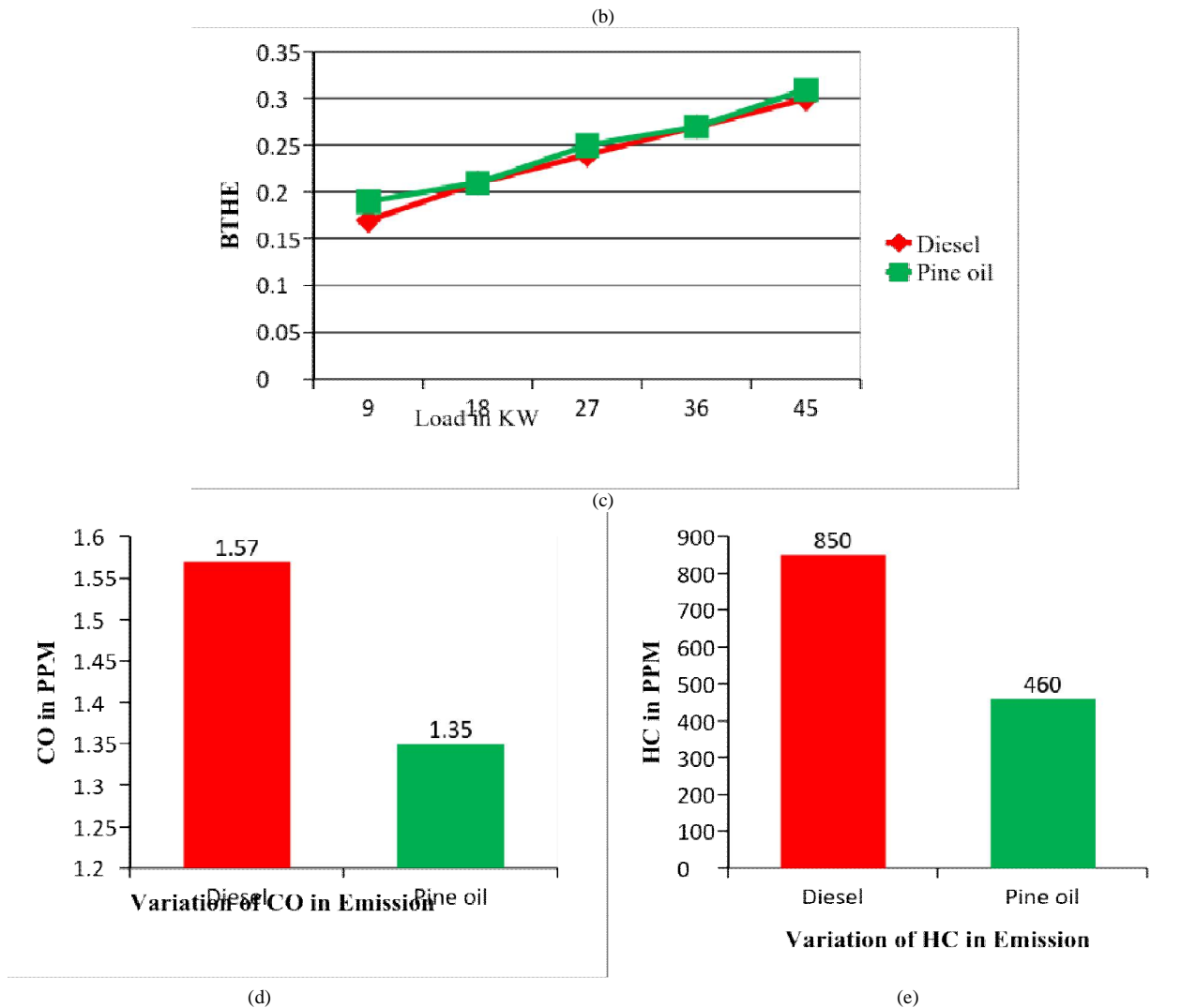


Fig. 8: Results and discussion. (a) Total fuel consumption vs. load. (b) Brake specific energy consumption vs. load. (c) Brake thermal efficiency vs. load. (d) Variation of HC in Emission. (e) Variation of CO in emission.

- Graph 1 shows the specific fuel consumption of diesel and pine oil, and we can say that specific fuel consumption of Pine oil is comparatively low with diesel for different loading conditions.
- Graph 2 shows the BSEC of diesel and Pine oil, and we can say that BSEC decreases for Pine oil at different loading.
- Graph 3 shows the Break Thermal Efficiency of Pine oil and Diesel, we can see that at various loads BTHE is same and at some loads it increases because CV of Pine oil is greater than the Diesel.
- Graph.4. shows the variation of Hydrocarbons (HC) in ppm using diesel and Pine oil, by histogram we can easily say that the HC is reduced by 45.88%.

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- Graph 5. shows the variation of Carbon monoxide in ppm using diesel and Pine oil, by histogram we can easily say that the CO is reduced by 14%.

V. CONCLUSION

From present experiment done by replacing the conventional diesel fuel with pine oil, we are clearly reducing the emission of CO which is emitted by burning of diesel in diesel engine. By the results of experiment we can say that 14% of CO & 45.88% of HC is reduced. One more advantage of using Pine oil over diesel will give approximately increased results in Brake thermal efficiency (BTE) with increased output power.

As Carbon-monoxide and hydrocarbons which come from exhaust emissions are very toxic in nature, emissions of Carbon-monoxide and hydrocarbons from the exhaust of engine with diesel operation pose severe pollution problems. By using Pine oil as fuel in diesel engine we can reduce the emissions of Carbon-monoxide and hydrocarbons compared with diesel engine.

VI. FUTURE SCOPE

- Modifications in piston like material, type of chamber, piston crown etc. are to be made so that proper and full combustion takes place and it can sustain high pressures, wear and tear considering economic aspects.
- Metal coatings on the piston can be made so that they act as catalytic converter and emissions can be drastically reduced.
- Mass production of the plantations which yield Bio-Fuel should be carried out so that per litre cost will be reduced and encouragement should be given from government, social societies etc.

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NOMENCLATURE:

CO ₂	Carbon dioxide
SO ₂	Sulphur dioxide
CO	Carbon monoxide
HC	Hydrocarbon
NO _x	Nitrogen oxides.
BTE	Brake Thermal Efficiency.
BSEC	Brake specific energy consumption.
TDC	Top dead centre.
CRDI	Common Rail direct ignition.
CI	Compression Ignition
CV	Calorific value
PPM	Parts per million.
SADE	Spark assisted diesel engine.

BIOGRAPHY

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