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INVESTIGATIONS ON THE PERFORMANCE AND EXHAUST EMISSIONS OF A DIESEL ENGINE USING PREHEATED MADHUCA INDICA OIL AS FUEL

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ABSTRACT

The concerns about clean environment and high oil prices are the driving forces for the research on alternative fuels. The research efforts directed towards improving the performance of Compression Ignition engines using edible oil or nonedible oil as fuel. This paper deals with the performance of a four stroke, single cylinder C.I. engine fueled by the preheated (30^0C to $135^{0)}$ edible Madhuca Indica oil. The performance of the engine and emission evaluation was studied for a high speed, with the engine operated at 75% of full load and at full load conditions. The performance parameters were considered for comparing are variationof Crank Angle (CA), specific fuel consumption, brake thermal efficiency, brake power, NOx emissions of the engine. It is observed that the engine offers higher thermal efficiency when it is powered by preheated Madhuca Indica oil at higher speed rather than powered by unpreheated oil and the obtained thermal efficiency is little closer to the thermal effficiency obtained with diesel alone. The emission of NOx was due to peak flame temperature of the combustion. The fuel developed the peak flame temperature less than diesel and producing low NOx. Since the advanced injection timing must have effect

on increase in peak flame temperature at high loads with the engine is also at hot working temperature.

1. INTRODUCTION

Madhuca Indica oil is an edible oil if suitably processed as per PFA rules. Madhuca indica is a botanical name of Mahua also known as Ippa in Telugu Mowrah in Hindi and Illuppai in Tamil, Butter tree in English. The Madhuca Indica oil is obtained from the seeds of Madhuca Indica trees of two major species namely Madhuca latifolia (Roxb) Mac bride and Madhuca longifolia (Ienig) Macbride; both belonging to the from Mac bride and Madhuca longifolia (Koenig) Macbride; both belonging to the from Sapotaceae. These two are so closely related that no distinction can be made in the trade of their seed or oil.

The tree grows up to 7- Ft and matures 8^{th} year and yield fruits up to 60 years. The bark and root has medicinal value. The bank is also root has medicinal value. The bank is also useful for dyeing ant tanning. The corolla part of the flower is fleshy, thick and sweet and an important source of good source of fatty oil known in commerce as Mohwa butter Mohwa cake obtained after extraction of oil from seed is used as manure and as an insecticide. Fruit is a good source of fatty oil known in commerce as Mohwa butter. The oil is extensively used in the manufacture of soaps and lubricating greases and for edible purpose.

It is a large deciduous tree and grows in semi arid, tropical and sub-tropical areas, in altitude up to 1200m. It grows even on rocky, sandy, dry shallow soils and tolerates water logging conditions. Madhuca Indica longifolia grows only in South India.

Fruits mature and fall in April to July in North, August to September in South. They are fleshy, green berry, yellowish or orange brown when ripe.2.5 to 5 cm long; latifolia oblong and longifolia ovoid, contain 1 to 4 tiny seeds, the yield pr tree is 20 to 40 kg kernels.

The fallen are picked or felled by shaking of branches. The rind has to be removed by hand and seed is decorticated by beating with stones. The drying and decertification yield 70% kerned on the weight of seed. The oil content of kernel is about 46% in Latifolia and 52% in longleaf. The oil yields in an expeller are nearly 35%, 37%.

2. PREHEATING

The preheating was aimed to bring down the viscosity to improve the fuel injection pattern. The pumped fuel is preheated before injection and the temperature was monitored by a thermocouple and temperature indicator.

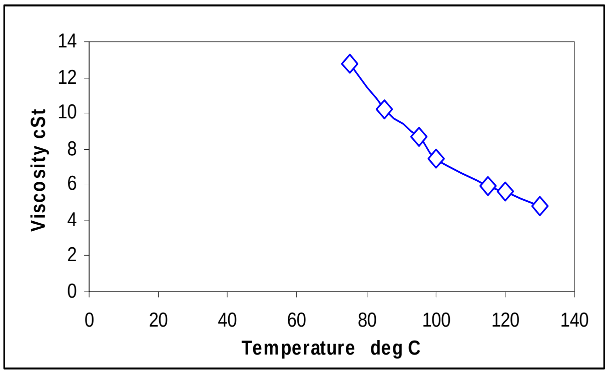

Figure :1 Effect of temperature on Viscosity

3. INJECTION TIMING

The engine was started easily without and difficulties however the effective methods of use of MI oil was injected into cylinder by retarding and advancing the injection timing by 3^0 CA. the injection advance was made by removing the shims already available in between the pump and engine block, but the addition of shims make the injection timing retard. Here the thicknesses of the shims available are 0.13m.m, o.25mm and 0.38mm.

For this experiment the advance/retard timing of 3^0 CA was done by removing /adding of 0.13 mm shim.

4. MADHUCA INDICA (MI OIL) WITH PREHEATING

The Madhuca Indica oil was used as neat fuel in diesel engine and produced thermal efficiency less than diesel therefore preheating was done before injection. The preheating is normally done by the heat from exhaust gases/ by heating the injection pipe with electrical heater and controlled by a dimmer stat and maintained the temperature at 135^0 C. The test report for the oil find to temperature at which the viscosity of the Madhuca Indica oil is approximately equal to diesel and the preheating test was conducted only at that temperature. The performance diagram for advance and retard timing was discussed in this and since the advance injection timing gave better performance that alone was considered for further discussion in this.

4.1 BRAKE THERMAL EFFICIENCY(BTE)

The figure.2 shows the brake thermal efficiency of Madhuca Indica oil in diesel engine without and with preheating with respect to Brake power. It can be seen that the engine is operated with maximum efficiency at full load. At the same time at 75% of full load 25.8% efficiency obtained for diesel fuel, 19.9% for Madhuca Indica oil without preheating and 21.8% efficiency with preheating. The raw MI oil without preheating has high viscosity and it affects poor spray characteristics and homogeneity of air fuel mixture.

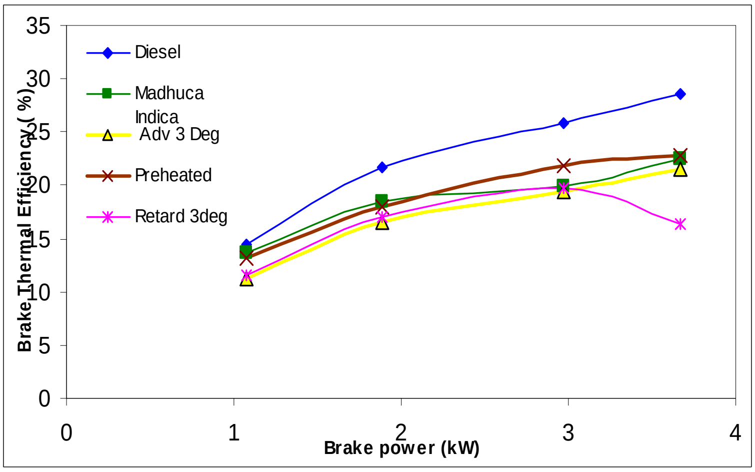

Figure. 2 B TE of MI Oil with preheating and without preheating

The improvement in BTE by preheating was 10.5%. The preheating may assist the vegetable oil to spray better; mixing and evaporating would be the reason for improvement in efficiency than raw oil. At 75% of full load the 3 dog advancement did not show any improvement in efficiency but by retarding the timing the engine efficiency at full load from 22.5% for raw oil dropped to 16%. The reduce in BTE may be due the late ignition delay caused the irregular combustion inside the cylinder.

4.2 BRAKE SPECIFIC FUEL CONSUMPTION (BSFC)

The figure.3 shows the variation of BSEC for Madhuca Indica with and without preheating with respect to brake power. It is seen from the figure that the bsec decreases with increase in load. The energy consumption of MI oil was more than diesel because of lower calorific value. The preheating of oil shows considerable improvement at higher loads 75% of full load without preheating 4.9 and with preheating 4.58 and at full load without preheating 5.5 and with preheating 4.38. The improvement in BSEC at 75% of full load is 6.5% and at full load 20% was measured due to preheating. Oil preheating at 130^{0}C temperature might have caused more release of heat energy due to better mixing of fuel the main reason for this improvement is due to the improved fuel spray, better mixing and vaporization to better extent helped the preheated oil to release more heat energy resulting less consumption of fuel.

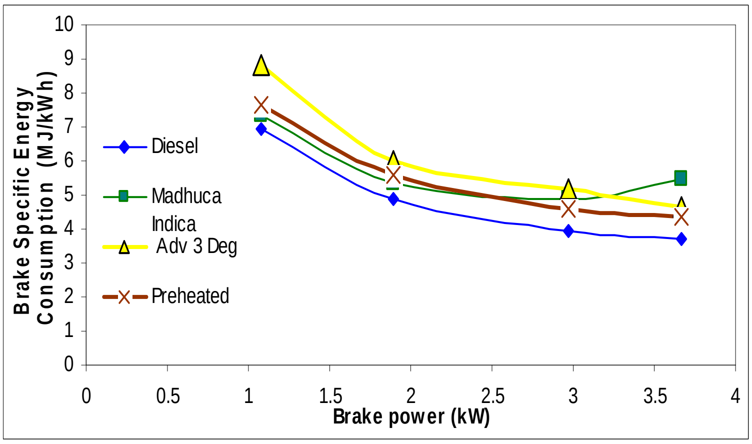

Figure : 3 BSEC (MJ/KWh) for MI Oil with preheating and without preheating

This shows that the advance in injection at full load helped by reducing delay period and the hot environment also favour to release heat energy than at retarded timing. Further from the test the MI oil can perform efficiency with the same injection timing.

4.3 CARBON MONOXIDE (CO)

The figure 4 shows the emission of carbon monoxide from the MI oil without and with preheating with respect to brake power. It is seen from the figure that the CO increase with increase in load Basically the emission of CO is high in case of MI oil from 0.35% volume at no loan 1.74% volume at full load and it clearly indicates that the combustion is poor in case of MI oil. However the preheated MI Oil showed 50% reduction in CO emission at loads than without preheating. The preheated MI oil gave 16% at no load and 1.26% at full load. The Reduction in CO emission is 54% at no land and 28% at full load for preheated oil. The values clearly indicate the improvement in combustion due to preheating. The heavier molecules of the oil due low energy density the quantity of oil injected is also more further the poor ignition qualities of oil ten to emit more amount of carbon monoxide. In the case preheating helped oil to participate better in combustion resulting lower CO emission than raw oil by 47% at 75% of full load. The CO emission was high for advance/retard injection timing at high loads only. At high loads the altered injection timing has direct impact on ignition delay. The delay period is important period at which the fuel preparation for combustion by self ignition. This clearly indicates that if the injection timing altered the emission is increased due to poor combustion of MI oil.

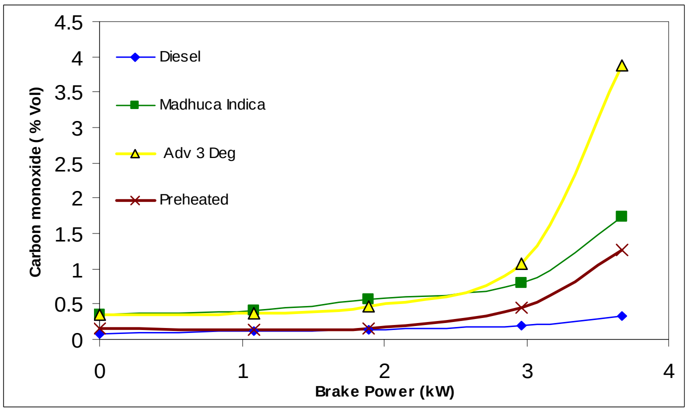

Figure: 4 CO emission for MI Oil with and without preheating

4.4 HYDROCARBONS (HC)

The figure .5 shows the emission of Hydrocarbon (HC) from the engine for MI oil without and with preheating with respect to brake power. It is seen from the figure that the hydrocarbon increase with increase in load it may be observed that the MI oil without preheating shows higher values of hydrocarbon emission from 98ppm at no load to 175 ppm at full load and that of diesel shows 71 ppm at no load and 120 ppm at full load. It is very interesting to not that the preheated oil shows 32 ppm at no load and 90 ppm at full load.

The reduction of HC emission is 58% at 75% of full load and 48% at full load compared to without preheating and for that of diesel was 52% reduction at no load and 25% for full load. The preheating of oil shows the effective combustion of MI oil due to better injection leads to better vaporization, mixing and improved combustion in the combustion chamber result in lower fuel consumption and reduced HC emission.

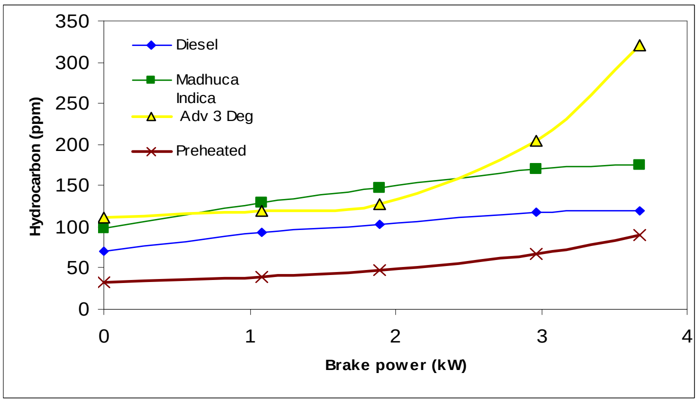

Figure: 5 HC emissions for MI Oil with and without preheating

It is seen from the figure that the HC increases with increase to brake power. The measured hydrocarbon level was 71ppm at no-load to 120 at full load for diesel, 98ppm at no load to 175 ppm at full load for MI oil, 110 ppm at no load to 321 ppm at full load for advanced injection timing and 110 ppm at no load to 320 ppm at full load for retarded injection timing. Again the higher hydro carbon emission was due to improve combustion and advance/retard by 3 deg CA did not favour much to reduce HC emission.

4.5 OXIDES OF NITROGEN (NO_X)

The emission of Oxides of Nitrogen is formed due to high flame temperature, nitrogen content in fuel and air. If combustion at overall lean stoichiometry, the NOx problem might be relieved. The figure.6 shows the emission of Oxides of Nitrogen for without and with preheating for MI oil with respect to brake power. It is seen from the figure that the NOx increases with increase in load. The diesel produced 180pp, at no load and 942 ppm at full load. The MI oil without preheating 66ppm at no load, 310 ppm at 75% of full load and 325 ppm at full load and with preheating83 ppm at no load 249 ppm at 75% of full load and 300 ppm at full load.

The reduction of NOx for preheated oil is 53% at no load, the reduction of 56% at 75% of full load and reduction of 68% at full load than diesel. However the Raw MI oil shows lower NOx at all loads than diesel operation, the reduction in NOx emission is due to lower air entrainment and fuel air mixing rate with MI oil compared to diesel. Thus the peak flame temperature is very low resulting less emission of NOx. The reduction on NOx emission was 55% at initial loads for MI oil, with/without changing the injection timing. At 75% of full load the NOx emission was 689 ppm, raw MI oil 310 ppm, 398 ppm for advance injection timing and 207 ppm for retard injection timing. The emission of NOx was due to peak flame temperature of the combustion. The fuel developed the peak flame temperature less than diesel and producing low NOx. Since the advanced injection timing must have effect on increase in peak flame temperature at high loads with the engine is also at hot working temperature.

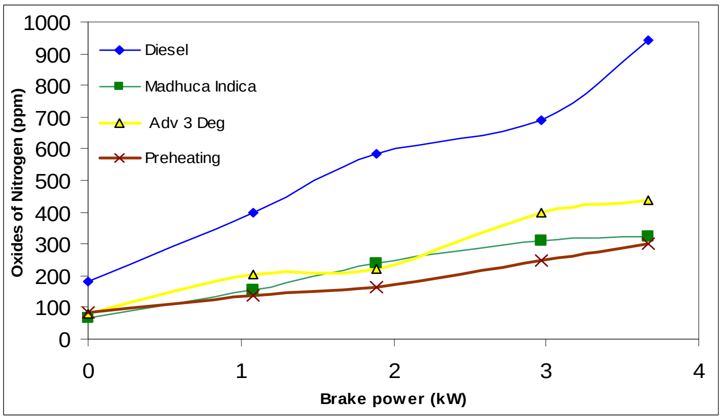

Figure: 6 NO_x for MI Oil with/without preheating

4.6 SMOKE EMISSION

The smoke emission will be normally low if the combustion is homogeneously mixed combustion and it is a solid suspended particle in exhaust gases. The figure.6 Shows the smoke emission for MI oil without and with pre heating with respect to brake power.

It is seen from the figure.7 that the smoke increases with increase in load. Raw MI oil without preheating produced Smoke emission of 0.5 BSN at no load, 2.8 BSN at 75% of full load and 4.4 BSN at full load but the smoke with preheating was 0.5 BSN at no load

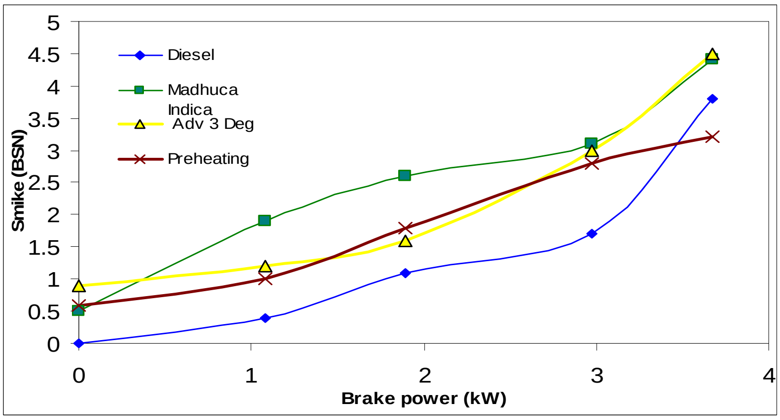

Figure : 7 Smoke for MI Oil with/without preheating

Smoke increases with increase in load. The smoke emission was 0.5 BSN at no load to 3.1 BSN at 75% of full load for raw oil, 0.9 BSN at no load to 3 BSN at 75% and 3.2 BSN at full load. Therefore the reduction in smoke was 10% at 75% of full load and 27% at full load than raw MI oil. The preheating proves that the heating effects very much in reducing the smoke emission by improving the combustion and oxidizing the soot particles to large extent.

The method of preheating infers the improvement of engine performance and reduction of engine emission to a considerable limit compared to that of without preheating. At full load for 3 deg CA retard injection timing the improvement in power output indicates the improvement in combustion, during that period the smoke gets oxidized to some extent.

5. CONCLUSIONS

In this work a single cylinder four stroke compression engine when it is powered by Madhuca Indica at different fuel inlet temperatures. The fuel inlet temperatures and kinematic viscosity coefficients were the only parameters which were varied, and the shifts in engine performance must be attributed to these temperature and viscosity variations only. The results obtained are summarized as under:

- The preheating of oil shows considerable improvement at higher loads 75% of full load without preheating 4.9 and with preheating 4.58 and at full load without preheating 5.5 and with preheating 4.38. The improvement in BSEC at 75% of full load is 6.5% and at full load 20% was measured due to preheating.
- At 75% of full load 25.8% Brake thermal efficiency obtained for diesel fuel, 19.9% for Madhuca Indica oil without preheating and 21.8% efficiency with preheating. The raw MI oil without preheating has high viscosity and it affects poor spray characteristics and homogeneity of air fuel mixture.
- In the preheating oil to participate better in combustion resulting lower CO emission than raw oil by 47% at 75% of full load. The CO emission was high for advance/retard injection timing at high loads only.
- The reduction of HC emission is 58% at 75% of full load and 48% at full load compared to without preheating and for that of diesel was 52% reduction at no load and 25% for full load.
- The reduction of NOx for preheated oil is 53% at no load, the reduction of 56% at 75% of full load and reduction of 68% at full load than diesel,the reduction in NOx emission is due to lower air entrainment and fuel air mixing rate with MI oil compared to diesel.
- The smoke increases with increase in load. Raw MI oil without preheating produced Smoke emission of 0.5 BSN at no load, 2.8 BSN at 75% of full load and 4.4 BSN at full load but the smoke with preheating was 0.5 BSN at no load.

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