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Performance and Exhaust Analysis of Ultrasonic Transesterified Blends of Pongamia Oil with Diesel

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***Abstract*— The results of the experimental work carried out to study the engine performance and emission from bio-diesel production from Pongamia oil and diesel blend as fuel is presented in this paper. A single cylinder water cooled CI engine was used in this experiment. Unlike the conventional Transesterification to condition the oil, here the two fluids are agitated by means of application of an ultrasonic waves (waves of frequency >20Khz). Ultrasonic Transesterification uses cavitation bubbles induced by high frequency pressure (sound) waves to agitate a liquid. The merits observed are shorter reaction time, Higher yield of bio diesel etc.**

***Keywords*— Pongamia Oil, Ultrasonic Transesterification blend, CI engine, Cavitation, High Frequency**

I. INTRODUCTION

India imports about 70% of its petroleum consumption mainly from gulf countries which are under disturbed supply system. This has made the potential users including India to search for an alternate renewable fuel which make them not only self sufficient in the resources but also to think of an alternate fuel for petroleum based products[2]. Present day Internal combustion (IC) engines are operating essentially on petroleum base fuels, which is non-renewable in nature and lead to depletion in short period due to its indiscriminate use in different sectors[4]. There arises the necessity of alternative fuels. India has the high potential in the production of vegetable based oilseeds. Vegetable oils from crops such as soyabean, peanut, sunflower, rape, coconut Karanja, neem, cotton, mustard, jatropha, linseed and caster have been evaluated in many part of the world. Compare to other non-edible oil seeds in India, potential production of Pongamia oil seed availability is more.

II. CHARACTERISTICS OF PONGAMIA TREE

Pongamia pinnata has been found to be one of the most suitable species in India being widely grown, it is N_2-fixing trace, not brought by animals and oil is non-edible. It is tolerant to water logging, saline and alkaline soils; it can withstand harsh climates (medium to high rainfall). It can be planted on degraded lands farmer's field boundaries, Wastelands / fallow lands and could be grown across the country .Pongamia seeds contain 30-40% oil. Pongamia tree with pods is as shown in Figure 1and 2.The Table No.1. Summarize the potential production of Pongamia oil seeds in India compared with mahu, neem and undi. The Table No.2 summarizes the chemical analysis of Pongamia oil.

Fig 1 Pongamia tree

Fig 2 Pongamia pods and seeds

Table 1: Potential production of tree born oil seeds in India

Sl No	Oil Seeds	Availability(tons)			Total potential(tones)		
		Seeds	Oil	Seed	Yield (%)	Total oil production	nature of oil
1	Neem	100000	20000	418000	20	83600	Semi-hard
2	Mahu	71428	25000	490000	35	17100	Hard
3	Pongamia	25900	111000	111000	27	30000	Semi-hard
4	Undi	-	-	3800	60	2300	Semi-hard/soft
	Total	233515	590006	670800		10234000 or 1000000	

Table 2: Chemical analysis of Pongamia oil

Sl.No	Particulars	Honge oil (%)
1	Carbon	70.44
2	Hydrogen	12.08
3	Nitrogen	0.011
4	Oxygen	17.45

Table 3 : Fatty acid composition of Pongamia oil [4]

Oil/fatty acid	Honge oil (%)
Palmitic $C_{16:0}$	11.6
Stearic $C_{18:0}$	7.5
Arachidic $C_{20:0}$	4.1
Behenic $C_{22:0}$	5.3
Lignoceric $C_{24:0}$	2.4
Oleic $C_{18:1}$	50.1
Linoleic $C_{18:2}$	19.0

A. Ultrasonic Transesterification:

In this method, transesterification occurs between the two fluids by means of application of an ultrasonic waves (waves of frequency >20Khz). It is the process of agitation of particles in a sample by the application of sound waves. Ultrasonication uses cavitation bubbles induced by high frequency pressure (sound) waves to agitate a liquid. The agitation produces high forces on contaminants adhering to substrates like metals, plastics, glass, rubber, and ceramics. This action also penetrates blind holes, cracks, and recesses. The intention is to thoroughly remove all traces of contamination tightly adhering or embedded onto solid surfaces. Water or solvents can be used, depending on the type of contamination and the workpiece. Contaminants can include dust, dirt, oil, pigments, rust, grease, algae, fungus, bacteria, lime scale, polishing compounds, flux agents, fingerprints, soot wax and mold release agents, biological soil like blood, and so on. Ultrasonication can be used for a wide range of workpiece shapes, sizes and materials, and may not require the part to be disassembled prior to cleaning.

Fig 3: Front view of the ultrasonic set up

Fig 4: Top view

III. ENGINE TEST

The engine used for the study is kirloskar make single cylinder four stroke constant speed vertical water cooled direct injection , 5HP diesel engine. The computer assisted experimental set up of engine shown in Figure4. The eddy current dynamometer was used for load measurement the engine speed was sensed and indicated by an inductive pick up sensor with digital meter output. Figure5 shows AVL make smoke meter used for smoke measurement the carbon-di-oxide (CO_2), carbon monoxide (CO), hydro carbons, nitrous oxide and oxygen content was measured by MRU air fair emission monitoring systems shown in Figure 6. The engine was operated on diesel first and then the 5 different blends of the pongamia oil. Tests were repeated for three times and average value has taken for analysis. The performed data were analyzed from graph regarding thermal efficiency, brake specific fuel consumption, smoke density, unburnt hydro carbon and carbon mono oxide for all fuels.

Fig 5: Experimental Set up

Fig 6: AVL Smoke Meter

Fig 7: MRU Emission Monitoring System

IV. RESULT & DISCUSSIONS

A. Specific Fuel Consumption (BSFC)

Figure 7 shows the variation as specific fuel consumption (SFC) with brake power (BP) of engine for diesel, bio-diesel blends and pure bio-diesel. The fuel consumption decreased with increasing the brake power due to higher percentage of conversion of heat energy into useful work. The specific fuel consumption for B-20 and B-40 is 8-12% higher than diesel. In case of B-60 to B-100 the fuel consumption is 10-20% higher than that of diesel. This may be due to decrease in calorific value and increasing viscosity with increase in percentage of blend of methyl esters of Pongamia oil [6, 8].

B. Brake Thermal Efficiency (BTE)

Figure 8 shows the variation of brake thermal efficiency with brake power for diesel, neat bio-diesel and blends of bio-diesel. Marginal drop in BTE was found with blends of methyl esters, when compared to conventional fuel, because of poor combustion characteristics of methyl esters due to their high viscosity. B20 methyl ester shows almost equal efficiency with diesel. Hence, B20 can be suggested as best blend for bio-diesel preparation with Pongamia oil [7, 8,].

C. Carbon Monoxide (CO)

Figure 9 the variation of carbon mono oxide emission with brake power of the engine for all fuels is represented. When percentage of blend of methyl ester increases, CO decreases. But CO increases for B60 B80 and B100 due to insufficient combustion. The level of carbon mono oxide has decreased at part load and again increase at higher load for all blend ratios. It is observed that CO emission of bio-diesel and its blends are lower than diesel fuel approximately by 27% as compared with corresponding value of diesel. It is also observed that CO emission is still lower for B20 fuel at full load condition. This reduction indicates more complete combustion of the fuel [7, 8].

D. Unburnt hydro carbon (UBHC)

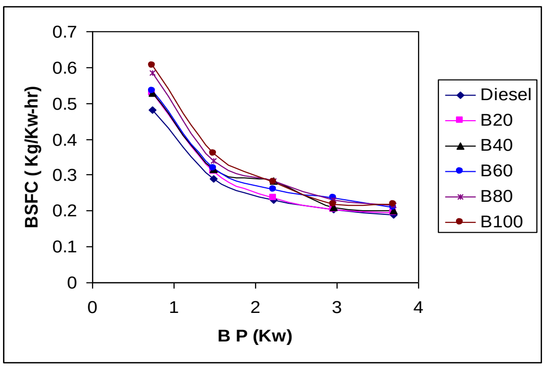
Figure 10 represents the variation of unburnt hydro carbon (UBHC) emission with brake power of the engine for all fuels. It is observed that unburnt hydro carbon (UBHC) emission for bio-diesel and its blends at full load is approximately 20% lower than the diesel value. When percentage of blend of bio-diesel increases hydro carbons decreases, but this is increase for B60, B80 and B100 due to insufficient combustion. A hydro carbon also increases when load increases [7, 8].

E. Carbon di oxide (CO_2)

Figure 11 represents the variation of Carbon di oxide (CO_2) emission with brake power of the engine for all fuels. The CO_2 emission increased with increase in brake power. The amount of CO2 has decreased in increasing the blends ratio, compared to net diesel. This is due to carbon content is relatively lower in the same volume of fuel consumed at the same engine load. And bio-diesel contains oxygen in stricture it burns clearly all the fuels.

F. Smoke opacity

The variation of smoke opacity with brake power of the engine for diesel, bio- diesel blends and neat bio-diesel is shown in Figure 10.Opacity is marginally lower for bio- diesel and blends compared to the diesel fuel. The opacity at full load for neat methyl esters is 78% which is lower when compared to 88% of diesel fuel. The presence of oxygen in the blends and improved combustion may be the reason for better reduction is smoke opacity [9, 11].



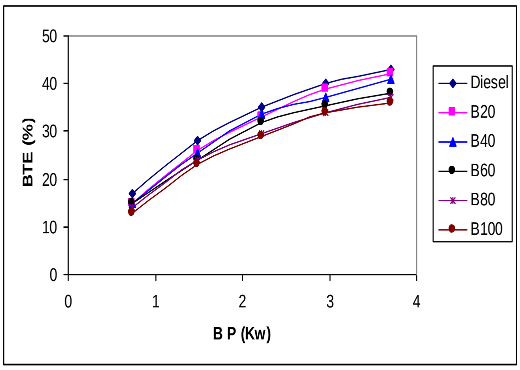
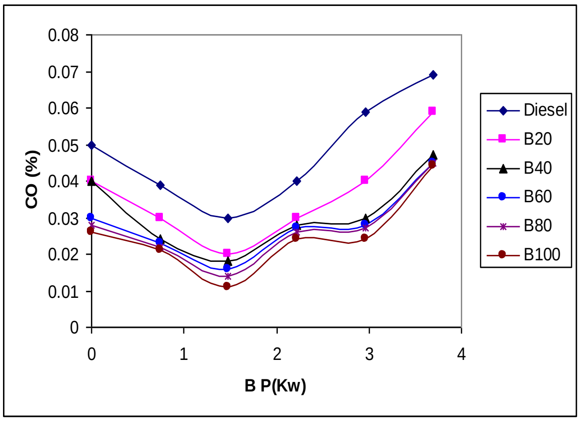


Fig 8: Variation of BSFC with BP

Fig 9: Variation of BTE with BP



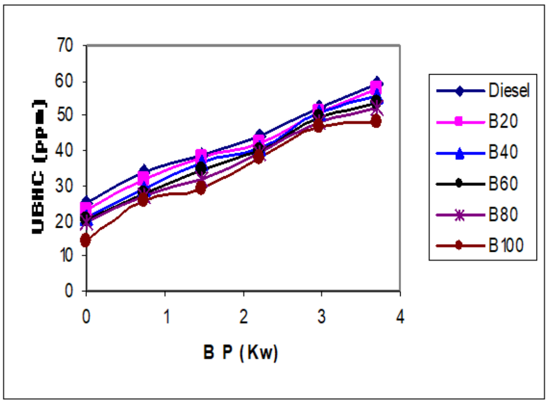
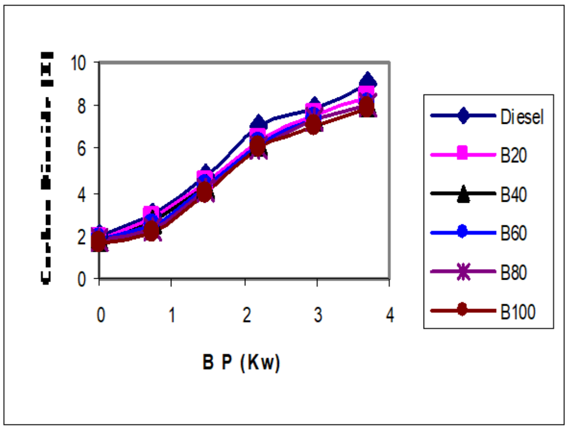


Fig 10 : Variation of CO Vs BP

Fig 11: Variation of UBHC Vs *BP*



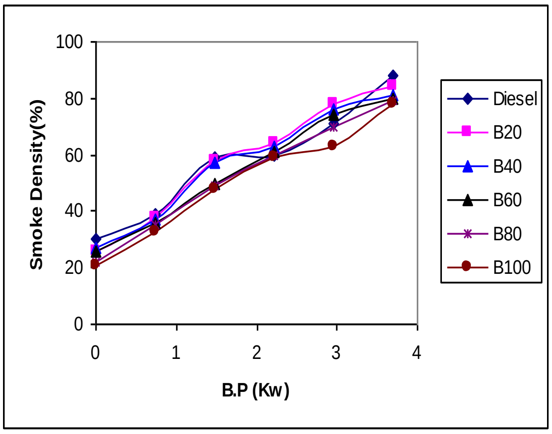


Fig 12: Variation of CO_2 Vs BP

Fig 13: Variation of smoke density Vs BP

V. CONCLUSIONS

1. Ultrasonic Transesterification leads to shorter reaction time,Higher yield of bio diesel.
2. Non edible vegetable oils are promising alternate fuels in IC engines when their physical properties are characteristically controlled.
3. After esterification of Pongamia oil the kinematic viscosity and specific gravity reduced to 6.3 centistokes and 0.934 from 37.42 centistokes and 0.968 respectively.
4. However the calorific value of Transesterification pongamia oil is increased to 31.142MJ/ Kg which is 10.34% higher than the crude pongamia oil.
5. The higher flash point of methyl ester of pongamia oils and its blends with diesel made safe storage and handling of these oils.
6. Pongamia oil based methyl esters (bio-diesel) can be directly used in diesel engine without any engine modifications.
7. Brake thermal efficiency of B20, B40 blends is better than B80 and B100 but still inferior to diesel.
8. The difference between fuel consumption of bio diesel blends and diesel is not significant the average brake specific fuel consumption was approximately 3-4 % higher than the diesel. In case of B20 and B40 higher brake specific fuel consumption is observed incase of B60 to B100. Because of reduction in calorific value at power output with increase in bio-diesel in the blend.
9. Smoke, HC, CO emission at different loads was found to be higher for diesel, compared to B20, B40 blends.

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