Performance and Emission Characteristics of CRDI Engine with Blends of Cardanol

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Abstract: **In this study the performance and emissions tests were conducted on a single-cylinder3.5kW diesel engine using a non-edible plant-based bio-fuel Cardanol produced from cashew nut shell liquid (CNSL) blend with Hongeand diesel. The bio-fuel blends 5C10H85D (5% cardanol+10% Honge+85% diesel),10C10H80D, (10% cardanol+10% Honge +80% Diesel) 15C10H75D (15% cardanol +10% Honge + 75% Diesel) and 20C10H70D (20% cardanol+10% Honge+70% diesel) were prepared and tested at various loads (0%,25%, 50%, 75% and full load conditions) and compared with baseline diesel at 300 bar, 400 bar and 500 bar injection pressure and 18:1 compression ratio. The experimental results show that at full load, the brake thermal efficiency of 10C10H80D is 28.78% comparatively similar to that of diesel is 29.75%. The lower emissions of CO, hydrocarbon except NOx are encouraging to recognize 20C10H70D as an optimized fuel blend for a compression ignition engine. The significant factors of cardanol bio-fuel include its low cost, non-edible, abundance, and it is a by-product of the cashew nut industries.**

Keywords: **Injection Pressure, biodiesel, blends, Cardanol, Honge oil, Emission**

I. INTRODUCTION

The creating economy combined with population development has added to an exponential interest for energy sources. The disappointment of oil based goods to meet these proceeded with essential demands and pollution related issues as a result of far reaching usage of non-renewable sustainable power sources have required the advancement and the adjustment of inexhaustible and eco-pleasing fuel communicated by Kulkarni BM et.al (2008). Increasing familiarity with the utilization of non- renewable energy resources similarly as their negative characteristic impact has actuated excitement for the potential benefits of biofuels, for example, biodiesel, which is a substitute fuel for diesel engines revealed by Pullen and Saeed (2011). Vegetable oils contain many fatty acids. Four fatty acids, namely palmitic, stearic, oleic and linoleic acids, present in higher compositions. The variation of fatty acid content in the biofuel affects the performance and emissions in a compression ignition (CI) engine reported by Dinesh (2017). Suresh Kumar et al. (2008).Presented their results of performance and emission characteristics of a diesel engine fuelled with blends of Pongamiapinnata methyl ester (PPME) with diesel. The test results revealed that up to 40% biodiesel blend provided better engine performance (BSFC and BSEC) and improved emission characteristics. The blends B40 and B60 showed lower CO and HC and higher CO2 and NOx emissions due to better combustion of fuel blends Chauhan et al. (2012) tested a Kirloskar single-cylinder diesel engine fuelled with biodiesel Jatropha oil to observe its performance, emissions, and combustion characteristics. Das and Ganesh (2003) studied the methods of extraction of CNSL from cashew nut shell. The authors studied the yield of CNSL at low temperature pyrolysis (CNSL-1) and high temperature pyrolysis (CNSL-2). They did not report much difference in properties like ash content, moisture, and density. It was observed that the viscosity changed drastically as the temperature rose from room temperature to higher temperature (60 and 80^{o}C). They noticed a slightly higher calorific value and lower flash point in the case of CNSL-2 compared to CNSL-1 and the 100% miscibility with methanol and diesel showed good indication for blending with these fuels.Mallikappa et al. (2012) conducted an investigation on the performance and emission characteristics of a four stroke double-cylinder CI engine with cardanol biofuel volumetric blends of 0–25%. As the biofuel percentage in the blend increased, reduction in BSEC was obtained. The brake thermal efficiency obtained for cardanol biofuel blends was less than that of diesel. NOx emissions increased with increased proportion of blends and also with higher EGT (exhaust gas temperature). The nominal value of HC emissions was obtained up to B20 and more at B25 due to incomplete combustion.

II. MATERIALS AND METHODOLOGY

2.1 Materials

Honge oil is additionally called Karanja oil. Its plant name is Pongamiapinnata, has a place with group of Leguminaceae or papilionaceae. Karanja is a medium estimated quickly developing evergreen tree. The time required by the tree to develop ranges from 4 to 7 years and relying upon the extent of the tree the yield of portions per tree is between 8 to 24 kg and the yield of potential per hectare is 900 to 9000 kg/hectare reported by V.S.Yaliwal (2010).Extraction requires the seeds through a screw crusher, for the most part called expellers. The oil is then separated to make it clean enough to process as expressed by C.V. Mahesh (2012). Honge oil collected locally and Cardanol was collected from Adarsh cashew industry Karkala area Karnataka.

2.2 Transesterification

As indicated by Srivastava and Prasad R (2004) there are four distinctive courses through which non-consumable oils can be converted into methyl esters are transesterification, blending, emulsion and pyrolysis out of which transesterification is commonly used. Dharmadhikariet.al (2012) expressed that Free unsaturated fat (FFA) substance should to be known for the crude oil.FFA will be determined by basic chemical titration

2.3 Methodology

One litre of honge oil was warmed in open beaker to a temperature for 100^{o}C to expel water particles present in oil pursued by filtration of oil. The oil was prepared under alkali base based catalyzed transesterification method. Since FFA value was observed to be 2.41%.The oil was blended with 300ml of methanol and 6 grams of sodium hydroxide pallets in round bottom flask mixed on a hot plate magnetic stirrer for a one and half hour at 60^{o}C and after that it was permitted to settle down for around 6 to 8hrs to get biodiesel and glycerol. The biodiesel obtained in the process was further washed with water to remove moisture content. Hence pure Honge biodiesel was obtained.

2.4 Properties of biodiesel

HaiterLenin and thyagarajan(2012), Senthil Kumar et.al(2012) expressed that some of the properties like flash point, viscosity, density, specific gravity and calorific value are needed for using the bio-diesel as vehicular fuel. The Physico-chemical properties such as higher calorific value, density, kinematic viscosity, flash and fire points are determined as per ASTM standards for biodiesel.In this study 4 blends were used 5C+10H+85D(5%Cardanol+10%hongeoil+85%diesel),10C+10H+80D,15C+10H+75D and 20C+2010H+70D

Sr No.	Diesel (%)	Biodiesel (%)		Kinematic Viscosity @ 40^{0}C	Specific Gravity (cSt @ 40 ◦C)	Density (kg/m3)	Calorific Value (kJ/kg)	Flash Point (^{0}C)
		Honge	Cardanol					
1	100	_	_	2.28	0.834	834	42000	42
2	_	100	_	5.43	0.829	829	38996	203
3	_	_	100	8.5	0.930	930	39770	185
4	85	10	5	4.12	0.834	838.3	41588.1	74
5	80	10	10	4.369	0.839	843.1	41476.7	81
6	75	10	15	4.608	0.849	847.9	41365.2	88
7	70	10	20	9.73	0.850	852.7	41253.8	94

III. EXPERIMENTAL PROCEDURE

The engine tests were conducted on a computerized single cylinder four four-stroke, water-cooled CRDI diesel engine test rig (Fig. 1). It was specifically coupled to a current dynamometer. The engine and the dynamometer were interfaced to a control board, which was associated with an advanced PC, utilized for recording the test parameters can be retrieved when required. The set of experiments were conducted at the designed speed of 1500 RPM and compression ratios of 18:1. The experiments were conducted at no-load, 25% of full load, 50% of full load, 75% of full load and full load with neat diesel and blends Cardanol raw oil and Methyl ester of Honge oil with Diesel as fuel. The exhaust gases are analyzed by using gas analyser.

IV. RESULTS AND DISCUSSION

Initiallytheexperimentswereperformed fordiesel at 300bar, 400bar and 500bar injection pressures and 18:1and then4 blends of cardanol honge with diesel were carried out.The engine performance like brakepower,brake specific fuel consumption, brake thermalefficiency, and emission like HC, CO and NOx wereobtainedandthencomparedthe performance ofblendswith those of D100 at 18:1 compression ratio. Based on the experimental methodology the following results were obtained

4.1. Brake specific fuel consumption

The variation of BSFC against load for four blends is shown. From the results it was observed that the load increases the brake specific fuel consumption decreases for the fuel samples used in the test. It was observed that 20C+10H+85D blend gives the minimum BSFC of 0.32 kg/kW-hr and minimum BSFC of 0.31 kg/kW-hr for 10C+10H+80D blend and which found to be more than diesel i.e. 0.26 kg/kW-hr at full load.BSFC decreases with respect to load and shows close results to diesel. This may be due to improved combustion, low viscosity and high volatility of the test fuels.

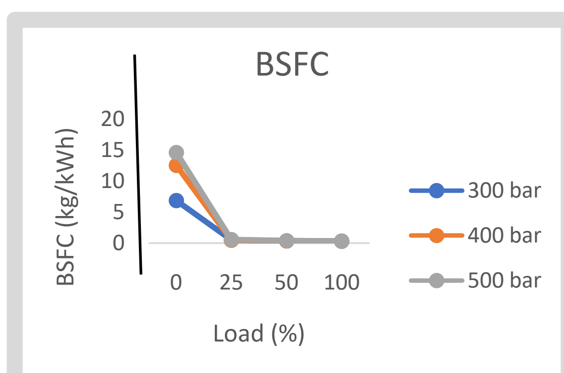

Fig 1. BSFC at 100% Diesel

As shown in the figure 1 it is seen that BSFC variation with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum BSFC that is 0.26kg/kWh so it has the maximum efficiency compared to diesel at other injection pressure.

The figure 2 shows the variation of Brake specific fuel consumption vs load and this graph is the comparison of B10, B20 oil with diesel oil at different injection pressure. It is observed that B10 oil at 300bar pressure shows the minimum BSFC 0.31 kg/kWh on various loading condition so B10 oil at 300 bar has the value close to that of diesel so B10 oil at 300bar injection pressure can be used as an alternative for diesel

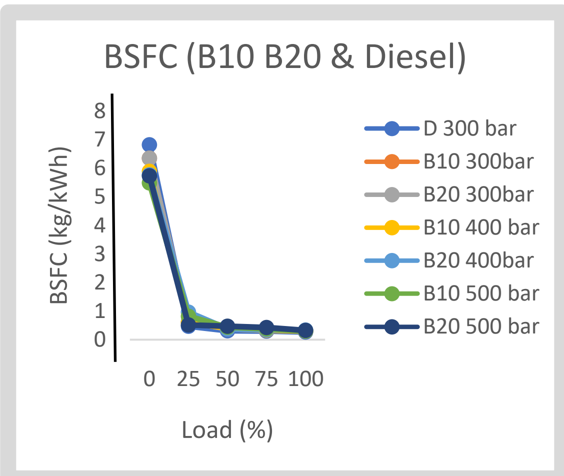

Fig 2. BSFC of B10, B20 & Diesel

4.2. Brake Thermal Efficiency

Figure 3 shown in the that BTE variation with respect to load condition and it is observed that diesel at 500 bar pressure shows the maximum BTHE that is 32.72% so it has the maximum efficiency compared to diesel at other injection pressure.

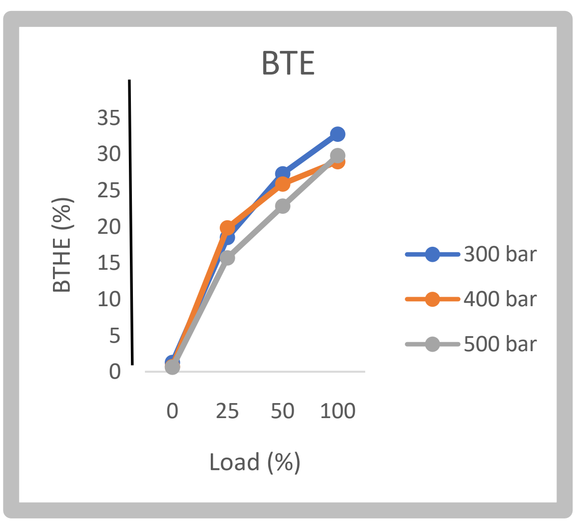

Fig 3. BTE of 100% Diesel

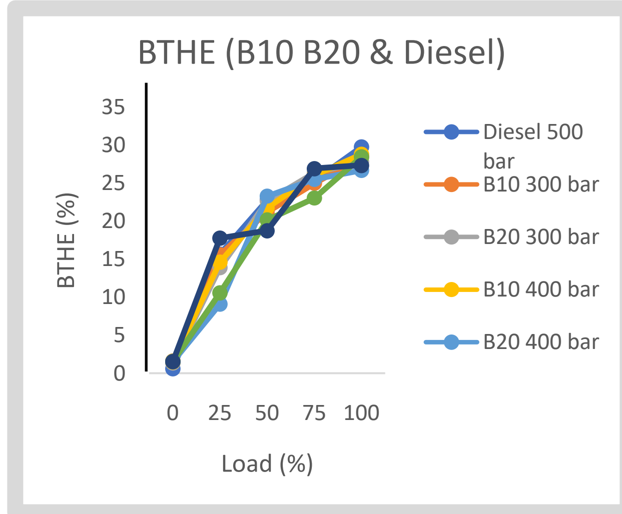

Fig 4. BTE of B10, B20 & Diesel

The figure 4 shows the variation of Brake thermal efficiency vs load and this graph is the comparison of B10, B20 oil with diesel oil at different injection pressure. It is seen that B20 oil at 500bar pressure gave the maximum BTHE 28.78%.This may be higher heat content, low viscocity,lower density and higher volatility. Since the viscosity and density of that blend nearer to that of diesel ensures finer breakup of fuel droplets at higher compression ratio providing more surface area and better mixing with air.

4.4 Hydrocarbon

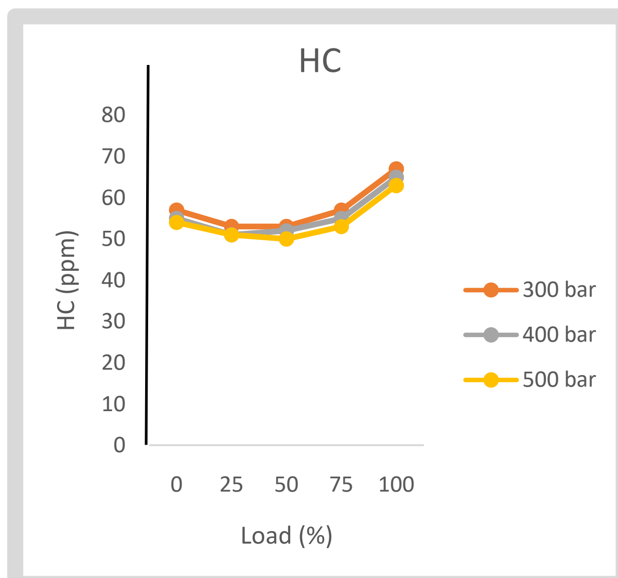

Fig 5. HC of 100% Diesel

Figure 5shown that HC variation with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum HC that is 51ppm so it has the maximum efficiency compared to diesel at other pressure.

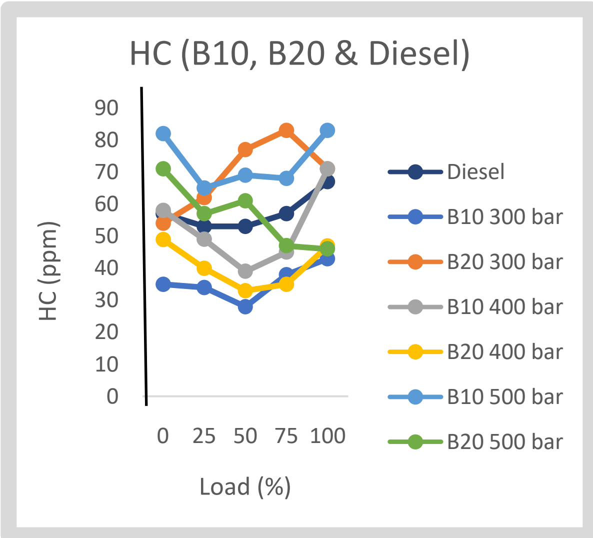

Fig 6. HC of B10, B20 & Diesel

The figure 6 shows the variation of HC vs load and this graph is the comparison of B10,B20&Diesel oil at different injection pressure .It is seen that B10 oil at 300bar pressure shows the minimum emission of HC i.e 28ppm on various loading condition so B10 oil at 300 bar gives out less HC.The unburnt hydrocarbons emissions are higher at 10C+10H+80D blend because low atomization and large droplets are formed leading to more unvapourised hydrocarbons in the exhaust.

4.5 Carbon monoxide

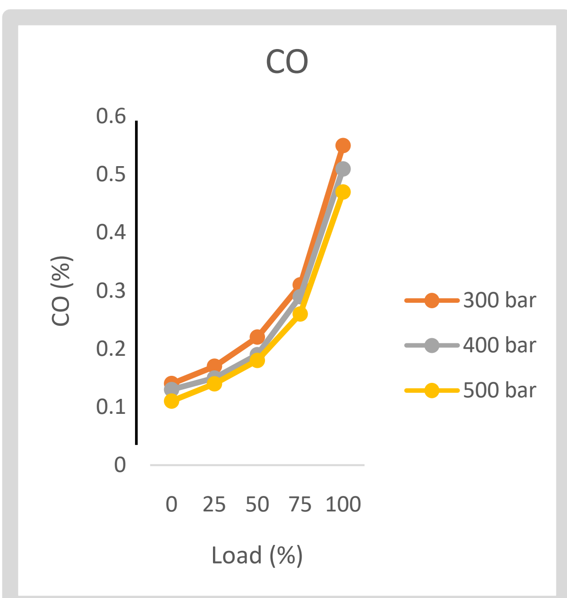

Fig 7. CO of 100% Diesel

As shown in the figure 7 it is seen that CO emission with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum CO emission 0.11% so it has the maximum efficiency compared to diesel at other pressure.

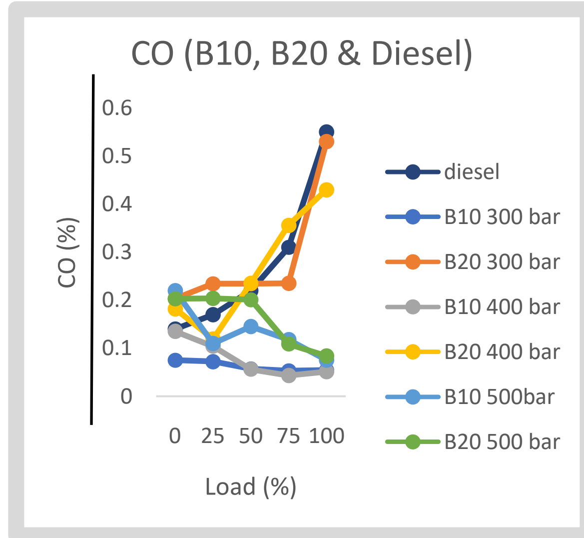

Fig 8. CO of B10, B20 & Diesel

The figure 8 shows the variation of CO vs load and this graph is the comparison of B10,B20&Diesel oil at different injection pressure .It is seen that B10 oil at 300bar pressure shows the minimum emission of CO 0.053% on various loading condition so B10 oil at 300 bar gives out less CO emission.likely due to oxygen content inherently present in the biodiesel which helps in the more complete oxidation of fuel.

4.6 Nitrous oxides

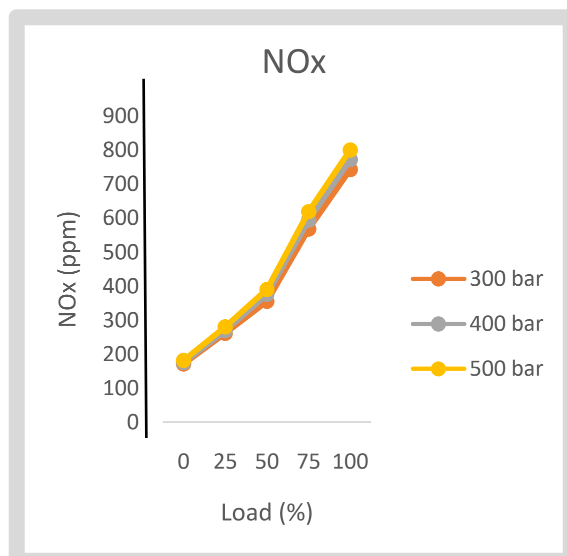

Fig 9. NOx of 100% Diesel

As shown in the figure 9 it is seen that Nitrous Oxide variation with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum NOx that is 171ppm so it has the maximum efficiency compared to diesel at other pressure.

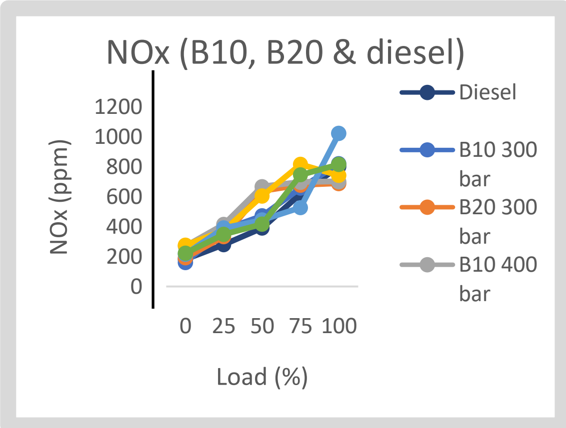

Fig 10. NOx of B10, B20 & Diesel

The figure 10 shows the variation of NOx vs load and this graph is the comparison of B10,B20&Diesel oil at different injection pressure .It is seen that B10 oil at 300bar pressure shows the minimum emission of NOx that is 160ppm on various loading condition so B10 oil at 300 bar gives out less NOx.High temperature and availability of oxygen are the two primary reasons for high NO_X formation as nitrogen and oxygen respond at higher temperature anddue to high cylinder pressure and temperature at higher loads

V. CONCLUSION

Honge,,Cardano l& Diesel and blending ratios(5%C+10%H+85%D),(10%C+10%H+80%D),(15%C+10%H+75%D),(20%C+10%H+70%D),where C, H & D are Cardanol, Honge& Diesel respectively. We have conducted the experiment using 3 injection pressure which are 300bar,400bar &500bar with loading condition of 0%, 25%, 50%, 75% & 100%.

After observing the graph and comparing the values of B10&B20 with values of 100% diesel oil, we can conclude that in terms of Brake Thermal Efficiency when the values of B10, B20&Diesel is compared the value of BTHE is maximim for B20 at 500bar pressure 28.78% so it is more efficient. In case of Brake Specific Fuel Consumption when compared the values of B10, B20 & Diesel the value of B10 at 300 bar injection pressure is minimum 0.3 kg/kWh and close to that of diesel value so it is more efficient. In case of Hydrocarbon emission when the value of B20&B10 is compared with Diesel it was seen that the HC emission of B10 at 300 bar pressure is the minimum 17ppm and hence more efficient compared to others. In case of Carbon Monoxide emission when the value of B20&B10 is compared with Diesel it was seen that the CO emission of B10 at 300 bar pressure is the minimum 0.053% and hence more efficient compared to other blend. In case of Nitrous oxide emission when the value of B20&B10 is compared with Diesel it was seen that the NOx emission of B10 at 300 bar pressure is the minimum 160ppm and hence more efficient compared to others.

So by comparing the values of B10, B20 &Diesel we can come to a conclusion that the value of B10 at 300 bar injection pressure have the value close to that of 100% Diesel oil so it can be used as a alternative fuel for diesel.

REFERENCES

[1]. Bora, D.K.et.al(2012).”Performance of diesel engine using biodiesel obtained from mixed feedstock’s”. Renew Sust Energy Rev ,16, 5479-5484

[2]. Chauhan BS et.al(2012)”A study on the performance and emission of a diesel engine fuelled with Jatropha biodiesel oil and its blends. Energy.37 (1):616–622

[3]. Das P and (2003) Ganesh A. Bio-oil from pyrolysis of cashew nut shell—a near fuel. Biomass Bioenergy. 25(1):113– 117

[4]. Dharmadhikari.H.Met.al (2012)”PerformanceandemissionsofCIengineusingblendsofbiodieselanddieselatdifferentinjectionpressures. InternationalJournalofAppliedResearchinMechanicalEngineering(IJARME) ISSN: 2231 –5950, Vol-2,Iss-2,

[5]. Dinesha P et.al(2017) ‘Effect of varying 9 Octadecenoic acid (oleic fatty acid) content in biofuel on the performance and émission of a compression ignition engine at varying compression ratio. Biofuels. 2017; DOI: 10.1080/17597269.2016.1275491.

[6]. Haiter Lenin. A and K. Thyagarajan (2012), ‘Performance evaluation of diesel engine fuelled with methyl ester of pongamia oil’, International Journal of Energy and Environment, Vol. 3, pp. 939-948

[7]. Kasiraman G et.al (2012)”Performance, emission and combustion improvements in a direct injection diesel engine using cashew nut shell oil as fuel with camphor oil blending. Energy. ; 47:116– 124.

[8]. Kulkarni BM et.al(2008)Investigation of acid oïl as a source of biodiesel. Indian J Chem Techn. 15:467–471

[9]. Mahesh.V.SandE.T.Puttaiah(2012)”Studies on Performance and Emission characteristics of non-edible oil (honge oil) as alternate fuel in CI engine, *International Journal of Engineering Research and Applications*, Vol. 2, Issue 3 (2012) pp. 2288-2293

[10]. Mallikappa et.al(2012)”Performance and emission characteristics of double cylinder CI engine operated with cardanol bio fuel blends. Renew Energy.;38:150–154.

[11]. Pullen J and Saeed K.(2011) ‘Factors affecting engine performance and exhaust emissions- Part II: Experimental Study. Energy. 2014;72:17–34

[12]. Pushparaj T, Ramabalan S. Green Fuel Design for Diesel Engine, Combustion, Performance and Emission Analysis. Procedia Eng. 2013;64:701–709

[13]. SenthilKumar.RandR.Manimaran(2013)” ‘Performance and emission characteristics on 4-stroke single cylinder C I engine using cotton seed bio fuels’ Asian Journal of Engineering Research, 2013, Vol. 1,Issue II, pp. 1 – 3.

[14]. Srivastava A and Prasad R (2004) ”Triglycérides based biodiesel fuels, Renewable and sustainable energy reviews,4, 111-133

[15]. SureshkumarKet.al(2008)”Performance and exhaust emission characteristics of a CI engine fuelled with Pongamiapinnata methyl ester (PPME) and its blends with diesel. Renew Energy.; 33(10):2294–2302.

[16]. Yaliwal V.S.et.al(2010).”Production and Utilization of Renewable Liquid Fuel in a Single Cylinder Four Stroke Direct Injection Compression Ignition Engine, International Journal of EngineeringScience and Technology, Vol. 2(10) pp. 5938-5948