Cardanol "An Alternative Fuel for Diesel"

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ABSTRACT

The increased number of automobiles in recent years has resulted in great demand for fossil fuel.[1] This has led to the development of automobile by using alternative fuels which include gaseous fuels, biofuels and vegetables oils as fuel. Energy from biomass and more specific bio-diesel is one of the opportunities that could cover the future demand of fossil fuel shortage. [2]Biomass in the form of cashew nut shell represents a new energy source and abundant source of energy in India. The bio-fuel is derived from cashew nut shell oil and its blend with diesel are promising alternative fuel for diesel engine. In this work the pyrolysis Cashew Nut Shell Liquid (CNSL)-Diesel Blends (CDB) was used to run the Direct Injection (DI) diesel engine. The experiments were conducted with various blends of CNSL and Diesel namely B20, B40, B60, B80 and B100 [3]. The results are compared with neat diesel operation. The brake thermal efficiency was decreased for blends of CNSL and Diesel except the lower blends of B20. The brake thermal efficiency of B20 is nearly closer to that of diesel fuel. Also the emission level of the all CNSL and Diesel blends was increased compared to neat diesel.[4,5] The higher viscosity and lower volatility of CNSL leads to poor mixture formation and hence lower brake thermal efficiency and higher emission levels[6]. The higher emission level can be reduced by adding suitable additives and oxygenates with CNSL and Diesel blends[7].

Keywords: *cardanol blend, CNSL,B20*

Introduction

Cashew (Anacardium occidentale) is an important plantation crop of India. India has the largest area under cashew (9.23 lakh ha) and stands as the second largest producer of cashew in the world (CEPC, 2012)[8]. Today, India is the largest processor and

exporter of cashew in the world. Maharashtra ranks first in the production (28.78 % of the country) and productivity of cashew nut in India. The cashew nut

consists of kernel, shell and test[9]. It contains on an average 20 to 22% kernel (edible portion), 2-5 %

testa and 65-75% shell (outer covering). The cashew nut shell contains 25-30% dark reddish brown viscous phenolic liquid known as Cashew Nut Shell Liquid and abbreviated as CNSL[10]. The physical properties of CNSL studied are moisture content, Specific gravity and Viscosity. The cashew nut has a shell of about 1/8 inch thickness with soft honey comb structure inside. It contains a dark brown liquid, called CNSL. The CNSL is extracted by various methods like roasting nuts and collecting liquids, superheated steam treatment method, solvent extraction method etc.[11], The traditional method of removing CNSL involves roasting the nut in drums. This method results in the loss of most of CNSL. To extract the retained CNSL fully and to dispel the unpleasant fumes the nuts are roasted in baths at a temperature. The major pollutants from automobiles are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NOx), lead compounds, sulphur compounds and particulates[12].

Extraction process of cardanol

1 Hot oil bath method

By and large, this is the most common method of commercial extraction of CNSL in practice nowadays. The technique can be different depending upon the raw material, which is either raw cashew nut shell or cashew nut. For the first, cashew nut shells were collected in the cylinder, where steam heating was applied at temperatures around 200-250ºC for 2-3 minutes. CNSL was then released from the shells and the process was repeated. This method yields CNSL of around 7-12% by weight. For the latter, the raw nuts are passed through a bath of hot CNSL itself, when the outer part of the shell bursts open and releases CNSL. This method produces CNSL which was around 6-12 % by weight of nut.[13]

2.Using Solar cooker

Cashew nut shell oil was extracted using concentrating solar cooker 38 of 1.4 kW capacity and a diameter of 1.4m. The focal point diameter of the cooker was 30m and was used to collect the reflected heat from reflector and achieved a temperature of 225-3000C.Solar cooker of the following specifications was used for carrying out the extraction.[14]

3.Screw press method

The raw cashew nut shells are put in the hydraulic press on screw pressing and then exert high pressure in order to release CNSL from shells. This method is rather straightforward and quick among others. Work was reported for extraction of CNSL by means of tapered compression screw, feeding rollers of transversal zigzag surface type and cylindrical casing with 2 mm diameter holes.[15] By using screw speed of 7-13 rpm and feeding rate of 54-95 kg/h, the percentage of CNSL extracted was 20.65-21.04 percent, the percentage of CNSL purity was 85.5387.8 wt % and the rate of extraction was 11.93-14.90 kg/h 40. However, the residue from this method still contained significant proportions of CNSL, around 10 to15%. Moreover, this method of extraction had higher levels of impurity, higher viscosity, lower thermo-oxidative stabilities and lower ebullition temperature. The CNSL obtained by this process contained 42% cardanol, 47% anacardic acid and 3% Cardanol 41 [16].

Properties of cardanol

Compounds	Composition of CNSL (%)	
	Natural	Technical
Anacardic acid	71.0 – 82.0	1.1 – 1.8
Cardanol	1.2 – 9.2	60.0 – 68.0
Cardanol	3.8 – 20.1	15.0 – 18.1
2-methylcardol	1.6 – 3.9	1.0 – 3.3
Other	0 – 2.0	0 – 7.4

Properties	
Ash	0.01
Moisture	3.5
Absolute viscosity (cSt) at 30□C	33
Flash point □C	180
Pour point □C	-5
Solid content (%)	Nil
Calorific value (kJ/kg)	40,000

Specifications of the engines used

The various performance and emission characteristics tests were conducted on four stroke single cylinder CI engine,VCR CI engine and twin cylinder CI engines manufactured by Kirloskar company limited[17,18].

Specifications of the Single cylinder engine: Engine:- four stroke, single cylinder diesel, Rated power-5.2 kW, Bore & stroke (mm)- 87.5&110.0, Nominal compression ratio17.5:1, Dynamometer type-eddy current175 mm lever arm at load cell load dynamometer, Fuel flow measurement-fuel measurement with DPT, Air flow measurement-orifice meter with monometer and DP Orifice diameter 20 mm, Water flow measurement-rotameter, Temperature measurement RTD PT-100 sensors, Cylinder pressure measurements- by piezo sensor, Analysis- through computer software.

Specifications of the Variable Compression Ratio engine:- Single cylinder 4 stroke Kirloskar diesel engine water cooled [computerized] modified to VCR Engine [CR: 12-18] 3.7kW, 1500rpm, Dynamometer-eddy current water cooled, Air box- MS fabricated with orifice meter and manometer, Calorimeter- type pipe in pipe, Piezo sensorrange 5000 PSI, with low noise cable,Temperature sensortype RTD,Software-"EnginesoftLV" engine performance analysis software[19].

Engine specifications of the twin cylinder engine:Engine type- Kirloskar, AV2, double cylinder, water cooled, and four stroke CI engine, Rated power output-10 HP, Speed-1500 RPM, Stroke length-110 mm, Bore diameter102 mm, Loading type- hydraulic dynamometer load - coupled to the engine through flexible coupling, Exhaust gas calorimeter- shell and pipe type vertical condenser with water inlet and outlet connections and control valve, Air Intake measurement- air tank size 0.5 x 0.5 x 0.5m fitted with baffle orifice plate 0.02 m diameter and 'U' tube manometer to measure differential pressure, Fuel intake measurement- using fuel tank, 3 way cock and burette, Temperature measurement-using thermocouple sensor with a multipoint digital temperature indicator for jacket water and exhaust calorimeter temperatures[20].

The properties of Cardanol biofuels obtained by transesterification from crude cardanol oil compared with diesel oil which have been utilized for testing various performance and emission characteristics in compression ignition engines.

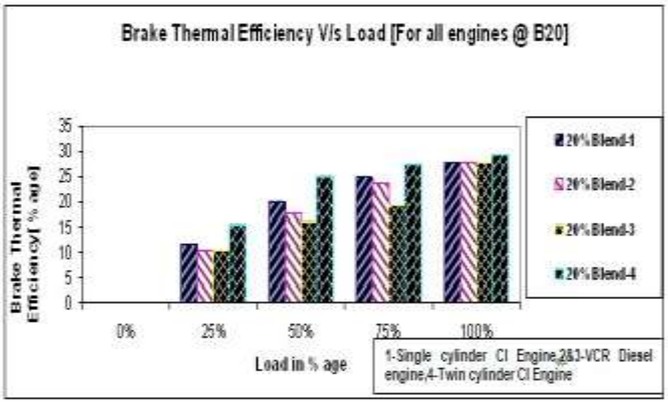
Properties of blends

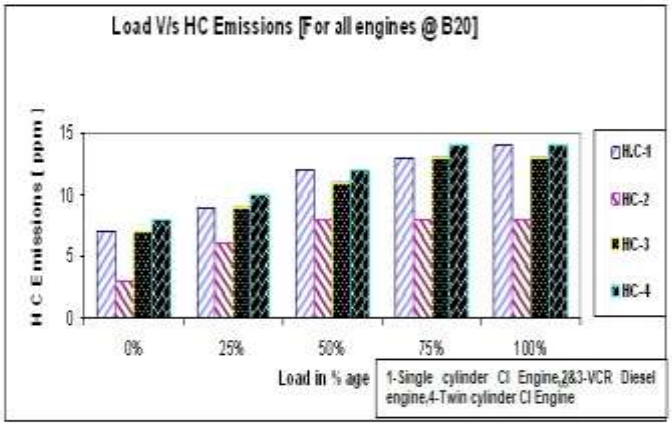
Results and discussions

Brake thermal efficiency v/s load

Properties	Diesel	B 10	B 15	B 20	B 25	B 30
Flash point (°C)	50	53	55	56	58	61
Density(kg/m^3)	817	823	829	836	841	846
Viscosity (mm^2/sec) at 40 degree C	2.00	2.50	3.10	3.50	4.20	5.50
Calorific value (kJ/kg)	40000	40130	40196	40261	40326	40392

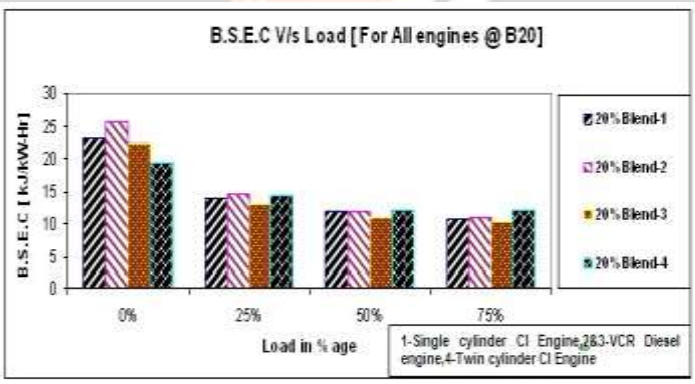
Figure 2 depicts that the brake thermal efficiency increases with higher loads. In all cases, it increases with increase in load. This is due to reduction in heat losses and increase in brake power with increase in load. The brake thermal efficiency obtained for single cylinder and VCR at 20% Cardanol biofuel volumetric blends is less than that of twin cylinder diesel engine. This lower brake thermal efficiency obtained could be due to lower [both in single cylinder and VCR engines] brake power and increase in fuel[21].





It is observed that slight variations of NOx emissions occur in all engines at 0% load and 100% load conditions; the reason for these variations could be malfunctioning of biofuel mixture. From the results it is observed that lower (30-50%) hydrocarbon emissions occur in the case of VCR engine at 18:1 CR compared to single cylinder and twin cylinder engines. The reason for this could be incomplete combustion and physical properties of the CBF.

The carbon monoxide emissions at different load conditions in different engines are not uniform. The reason for this could be malfunctioning of CBF volumetric blends in different injection systems and may be due to change of operating parameters in CI engines.From this work it is proved that, up to 20% CBF volumetric blends can be used in the diesel engines without any major hardware modifications[25].



Conclusion

The properties like density, viscosity, flash and fire points of cardanol biofuel volumetric blends under test are higher, and calorific values are lower and are in the range of 94-96%that of diesel.[22] .The brake thermal efficiency obtained for single cylinder and VCR at 20% cardanol biofuel volumetric blends is less than that of twin cylinder diesel engine.The reason for higher brake power in the case of twin cylinder engine could be higher brake mean effective pressure[23].The BSEC obtained for VCR engine at 18:1 Compression ratio is 25% more compared to twin cylinder engine at no load conditions, and 8-10% higher BSEC in twin cylinder engine compared to other two engines at full load conditions[24].

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