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Pursuance Assessment and Discharge Characteristics Studies of Compression Ignition Diesel Engine by using Cashew Nut Shell Oil as Bio-Diesel Blends

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Abstract

Petroleum is non renewable source of energy and the diminution of natural fuel resources, results in search for alternative fuels for automobiles. The demanding alternative search for fuels for compression ignition engines has been paying interest on fuels obtained from bio mass and cashew nut oil plays a vital role in alternate fuel for C.I Engines. The aim of this research effort is to appraise the property of cashew nut shell oil blends recital on a compression ignition diesel engine. This actually gives the discharge uniqueness of cashew nut oil, and its blends with diesel. In this paper cashew nut shell oil with diesel blends are taken up for study on vertical, four stroke, water cooled procedure of the investigation engine with cashew nut shell oil blends for a extensive series of engine load conditions such as B20, B40, B60, B80 and B100 were performed. The possessions of cashew nut oil are acquired by means of appropriate analysis methods. During the experiments, the performance uniqueness of the test engine was analyzed and compared with the precise diesel fuel performance. The results were successful even without any engine modifications. The brake thermal competence of B20 is found nearly closer to diesel fuel. The elevated discharge level of the blends can be compact by mixing suitable additives with CNSL and Diesel blends.

Keywords: Biofuel; Biodiesel; Optimization; Cashew nut shell liquid oil; cardanol

INTRODUCTION

Biodiesel is considered as a potential alternate fuel, which is renewable and provides decreased atmospheric carbon emission compared with natural diesel fuels. It has advantages which includes lower emissions of CO, hydrocarbons HC and particulate matter PM, but with slightly increased NOx emissions compared to fossil diesel fuels. Amplified ecological consciousness and exhaustion of vestige fuel possessions are motivating the researchers and the fuel producers to build up alternative fuels that are more acceptable and renewable in nature [1]. The thought of using vegetable oils as fuel for diesel engine is actually followed usually Vegetable oil proficient of being used in diesel engines either directly, or be competent of being used as biodiesel. The possessions such as flash point, viscosity, fire point, density, calorific value, corrosive nature, miscibility, sulphur content, molecular weight, cetane number, etc of biodiesel are to be noticed [8].

It was very remarkable that most of the properties were very closer to the conventional diesel fuel. The viscosity, though on the higher side at room temperature, reduces drastically at higher temperature. Observed viscosity at 30°C for cardanol was 31.97 cSt, and at 60°C it was 15.96 cSt. The flash point and fire point of the cardanol was registered at 208°C and 220°C respectively. The density value was 0.92gm/cc. The calorific value shows that 9845 Kcal/kg[2]. Corrosive nature of cardanol is very mild on copper and stainless steel. Cardanol is completely miscible in alcohol and diesel and they are insoluble in water. Cashew nut Shell Liquid (CNSL) is a by-product of the cashew industry which is the pericarp fluid of the cashew nut. India is a foremost producer of CNSL which is a flexible honey scour composition encloses a dappled flushed brown viscose liquid. Untreated cashew nut shell encloses about 25% cashew nut shell oil [10]. The preponderance functional scheme exclusion of oil in India encloses of fascination of the cashew nut in a boiling wash of CNSL at 185-190°C. This procedure recuperates about 50% of CNSL and the scorching extraction produces a dissimilar CNSL from the customary, obtained by frosty extraction. With respect to the elevated temperature the anacardic acid endures de-carboxylation and it is converted to cardanol and it is called scientific CNSL [1] Cashew nut shell liquid (CNSL) a spin-off of the manufacturing process from cashew has steadily becoming a valuable raw material for the petroleum area. Because of being high produced derivatives, the cardanol is at present being experienced, as an antioxidant in the petrochemical industry [3]. In India, cashew cultivation covers a total area of about 0 .77 million hectares of land, with annual production of over 0.5 million metric tons of raw cashew nuts. The average productivity per 100000 m_2 is around 760 kg [11]. The world production of cashew nut kernel was 907,000 metric tons in 1998 The cashew nut shell liquid (CNSL) is reported to be 15-20% by weight of unshelled nut in Africa and 25-30% by weight in India and 25% overall. Considering the shell weight is about 50% of the weight of the nut-in-shell (NIS), the potential of CNSL is about 450000 metric tons per year [12]. In India processed cashew dominates more than half the world cashew market. Various methods encompass accounted in review for the removal of CNSL from Cashew Nut Shell (CNS), which comprise, unwrap pan frying, and drum frying, boiling oil frying, icy extrusion and solvent removal etc. The removal all the way in the course of vacuity pyrolysis has been accounted recently [4]. Naturally the composition of scientific CNSL is roughly 55% cardanol, 12% cardol and 33% polymeric material, with residue completed up of other material [13]. The cardanol is affluent in CNSL attained through vacuum pyrolysis. The scientific CNSL is then processed by distillation at reduced pressure to eliminate the polymeric material. The composition of the purified scientific CNSL is concerning 80% cardanol, 10% cardol and 5% polymeric substance and the left over other substances [9]. Normally processed at 100-180˚ C, the CNSL forms shady brown oil. This oil is then incineration at 500˚C beneath vacuum (730mm Hg) [4].

The incineration oil is said to be having a extremely elevated calorific value (45MJ/kg) and consequently can be well thought-out to be capable bio oil with a possible as a fuel [5]. The utilization of CNSL as an impending fuel in internal combustion engines has also been recommended by [6]. The current discovery is recount to Biofuel. It involves disclosure of purified scientific cashew nut shell liquid (CNSL) as major component for biofuel and process for its manufacture and formulation. In this effort the cardanol of incinerated CNSL oil was utilized to run the direct injection (DI) diesel engine with a range of blends of diesel and the outcome and emission uniqueness are match up to with diesel engine. The removal of CNSO is done through vacuum pyrolysis method in this paper.

ENGINE SPECIFICATION AND FUEL PROPERTIES

The investigational effort was conceded out on single cylinder water cooled four stroke direct injection compression ignition diesel engine and naturally aspirated. The compression ratio of the engine is 17.5:1 and runs at 1500 rpm speed and produces 3.7kW BHP. The fuel injection timing is set as 23 deg btdc. The power measurements were carried over by an eddy current dynamometer which is directly coupled to the engine. The engine equipment is completely digital system. The speed and different temperatures is note down from the digital indicator. The detailed specifications of the engine are specified in Table 1. The air flow rate was measured with help of disparity pressure unit.

Table I

ENGINE SPECIFICATION

Make	Vertical, Water cooled, Four stroke
Number of cylinder	KIRLOSKAR AV-1
Bore	One
Stroke	87.5 mm
Maximum power	17.5:1
Compression ratio	661 CC
Displacement Volume	110 mm
Speed	3.7 kW
Injection opening angle	Eddy current dynamometer
Injection opening pressure	23° b TDC
Dynamometer	1500 rpm

In this scrutinize effort the pyrolysis cashew nut shell liquid (CNSL) (named as cardanol) is worn with diesel namely CNSL-Diesel blends (CDB). The intermingled fuels contain 20%, 40%, 60%, 80% and 100% by volume of CNSL and are identified as B20, B40, B60, B80 and B100 fuels. The major properties of the fuels are shown in Table II and Table III.

TABLE II

Properties of diesel and CNSL oil
(Source: ITA laboratory- chennai)

Properties	Diesel	CNSL
Density at (g/cc)	0.8/0.84	0.9326
Kinematic Viscosity @ 40 °C (cSt)	2.0 to 4.5	12.27
Calorific value (kJ/kg)	48838	9838
Flash Point (°C)	80	98
Fire Point (°C)	86	108

EXPERIEMENTAL ANALYSIS

The engine was optimized for preeminent insertion timing and injector starting pressure for diesel fuel. This optimized insertion timing and pressure are used for CNSL blends. The accumulation stream of fuel was calculated by throng source. The fatigue gas investigator (AVL DI gas investigator) was employed to estimate HC, CO and NOx. The smoke density was deliberate by AVL smoke meter. In this revise, the diesel engine was not personalized throughout all the trials. At each engine operational method, trials were agreed out for the diesel fuel and each one of the CDB blends and are illustrated in fig.1.

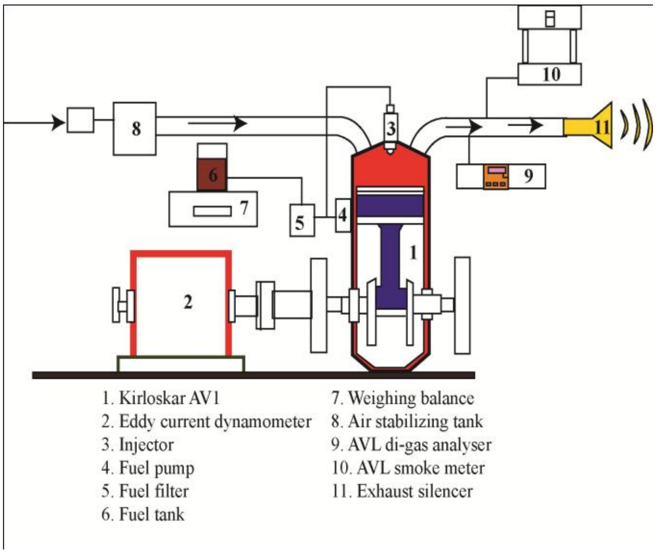

Figure 1: Schematic diagram of the experimental engine setup

A. CNSL oil Extraction

Extraction of CNSL oil from cashew nut shell includes open pan roasting, drum roasting, hot oil roasting, cold extraction, solvent extraction, super decisive solution removal (Rajesh N. Patel 2006), pyrolysis process (Das 2004, Tsamba 2004), Soxhlet extraction method (Castro 1998, Tyman 1989) and research have been carried out to improve the percentage of yield from unprocessed cashew nut by using new extraction methods like Sub Critical Water extraction and two-step extraction methods (Maria Yuliana 2011).The proportion succumb of oil differs by means of the type of extraction process.

As the extraction method varies, the quantity and quality of oil differs by means of the composition percentage of Anacardic acid, Cardanol and cardol. Immature oil (iCNSL) and technical oil (tCNSL) were the major types of CNSL oils. The compositions of iCNSL are anacardic acid 75%, cardol 19%, Cardanol 7%, and remaining are the other phenols and less polar substances.

B. Experimental procedure

The tests were performed by considering various parameters. The analysis was accomplished for cashew nut oil and its blends at different proportions (20%, 40%, 60%, 80% and 100%) for conservative engine. The analyses were performed with zero loads to full load conditions. The analyses such as consumption time for 20cc of fuel consumption, engine speed, temperatures, etc, were noted. The remarks were documented in tabular column and calculations are made using appropriate equations. The tests were performed on a compression ignition diesel engine. The common provisions of the engine are given in table 2. By taking the engine performance and plot the graphs.

RESULTS AND DISCUSSION

EMISSION CHARACTERISTICS STUDY OF CNSL OIL

A. Variation on Unburnt Hydrocarbon emission

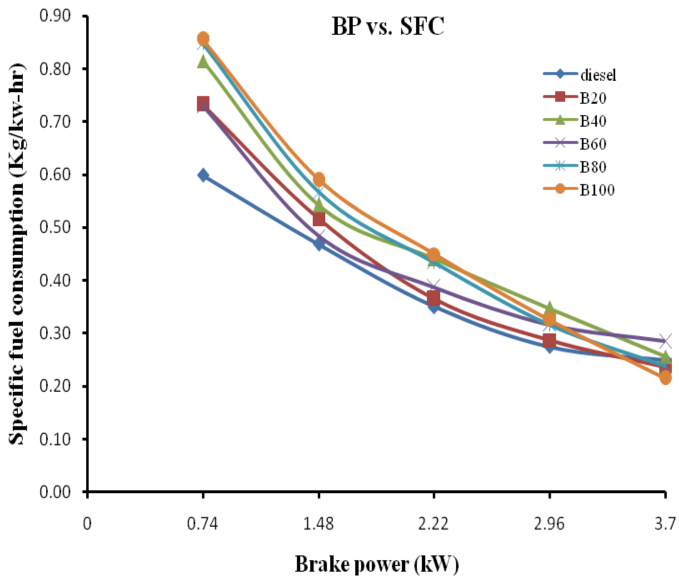

Figure 2: Variation on Hydrocarbon emission

The Unburnt hydrocarbon emission of CNSL oil blends with precise diesel are varied at three different injection pressures and is shown in fig.2. When the opening pressure increases, the HC emissions are reducing because higher injection opening pressures will lead to proper spray while the injection starts. This will enhance the performance with B20 CNSL oil have higher viscosity. Also a lower thermal efficiency with these blends will direct to addition of elevated magnitudes for the similar load condition.

B. Variation on Brake Specific fuel consumption

The variation of Brake specific fuel consumption for different loads using CNSO blends with diesel is illustrated in Fig.3. The specific fuel consumption of B20 blend at 210bar is slighter with compared to diesel for 3rd and 4th loads which is further compared to other injection pressure. It happens because of more intermingled fuel is utilized to produce same influence as balanced to diesel. Therefore, if the amount of CNSL oil is increased with diesel then the mixture formation is very poor. Hence the B20 blend offers a lesser amount of fuel utilization matched up to B100 merge and it is given clearly in the graph. The calorific values of fuel decreases with increase in mingle percentage and due to this, the specific fuel consumption of the higher percentage of blends increases as compared to that of diesel.

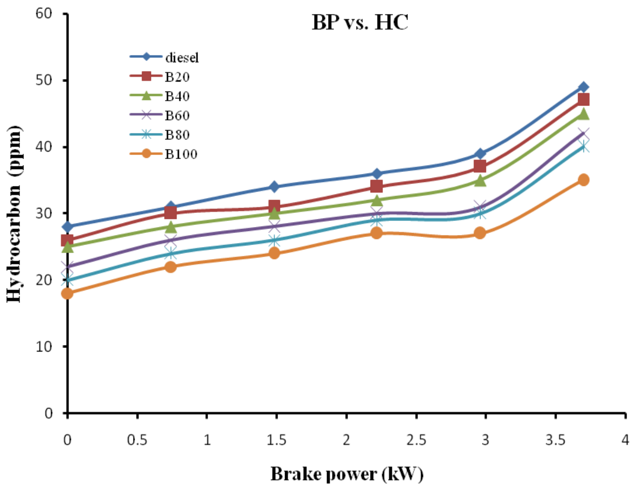

Figure 3: Effect on Brake specific fuel consumption

C. Carbon monoxide variation

The discrepancy of carbon monoxide emissions for dissimilar heaps at dissimilar injector pressure through diesel and CNSL mingle as an infused fuel is exemplified in fig.4. The Carbon monoxide emancipations are abridged whilst escalating heaps at all pressures.

The CO discharge for B20 CNSL oil is inferior whilst assessed to unpolluted diesel. The CNSL oil engineers a better-quality ignition proficiency prime to substandard quantity of CO. The CO discharge stage augments by means of mounting CNSL mingle and it is elevated than that of diesel at utmost mingle condition. This is for the reason that of amplified tackiness and reduced atomization affinity of CNSL oil guides to deprived ignition and elevated carbon monoxide discharge.

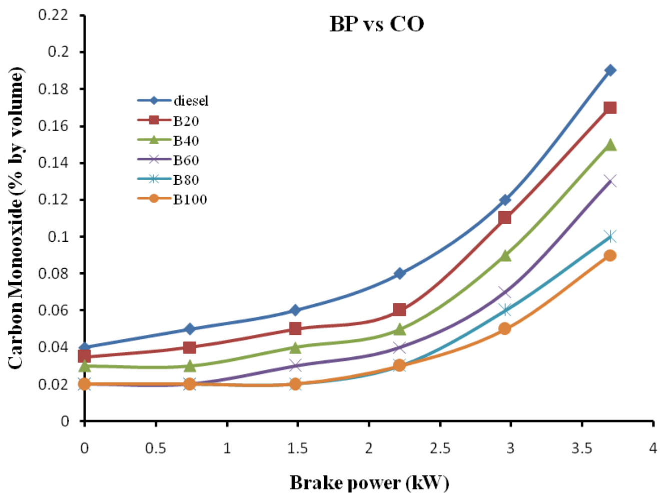

Figure 4: Variation on Carbon monoxide emission

D. Brake thermal effectiveness variation

The brake thermal effectiveness variation for no load to maximum load with different injector opening pressures like 180 195 and 210 bar using diesel and B20 CNSL fuels as an instilled fuel is demonstrated in fig.5. The brake thermal effectiveness is noted to be higher for B20 mix at 210 bars when compared with diesel at 80% load. The efficiency is decreased, when increasing the load up to higher limit load because of improper combustion.

As the bio-diesel has high viscosity, it requires large heat source for combustion of fuel at lower injector opening pressure. But when the injector starting pressure is high, the instilled fuel has good atomization and diffusion property and hence the injector initial pressure 210 results in elevated brake thermal effectiveness for B20 blend.

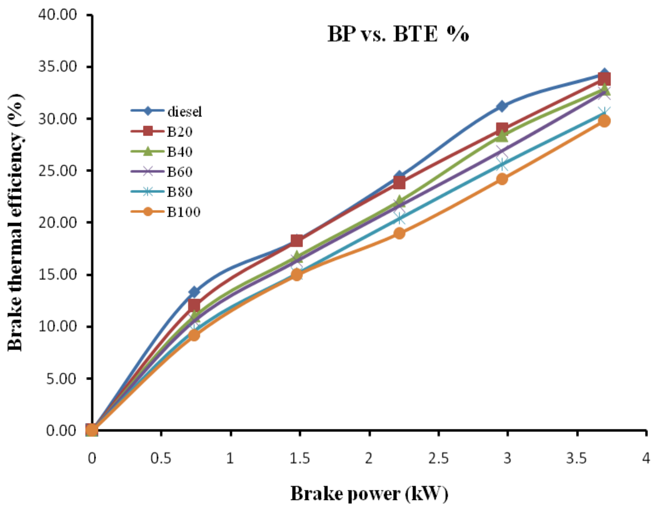

Figure 5: Variation on Brake thermal efficiency

The overall brake thermal effectiveness is increased for diesel from lower to higher load at 180 and 210 bars. This is because of reduction of heat loss from the engine and the producing power increases with increasing load. The overall thermal efficiency of B20 CNSL is to some extent lesser than that of the diesel at all pressures. The main reason is with effect of the deprived blend formation because of higher viscosity, higher density and reduced volatility of CNSL fuel.

E. NOx Emission Effects

Fig.6 illustrates NOx variation from zero loads to maximum load with B20 CNSL oil and diesel. This graph shows that because of the raise in combustion temperature, the NOx discharges are increased with increasing loads. But B20 blend of CNSL gives reduced NOx discharge matched up to standard diesel. This is because of reduced atomization of CNSL oil that leads to meager combustion and thereby lower NOx emission. The NOx discharges are increased with increasing the load for both fuels.

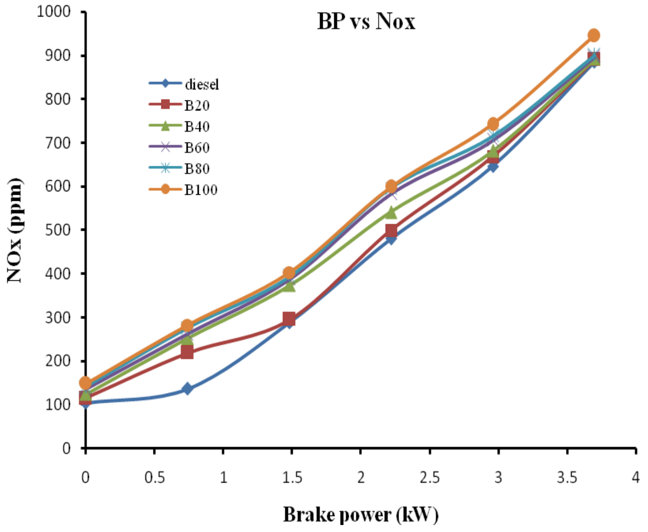

Figure 6: Variation on oxides of nitrogen (NOx) emission

F. Exhaust gas temperature variation

The discrepancy of exhaust gas temperature with respect to different loads for different blends of CNSO with diesel tested is illustrated in Fig.7.

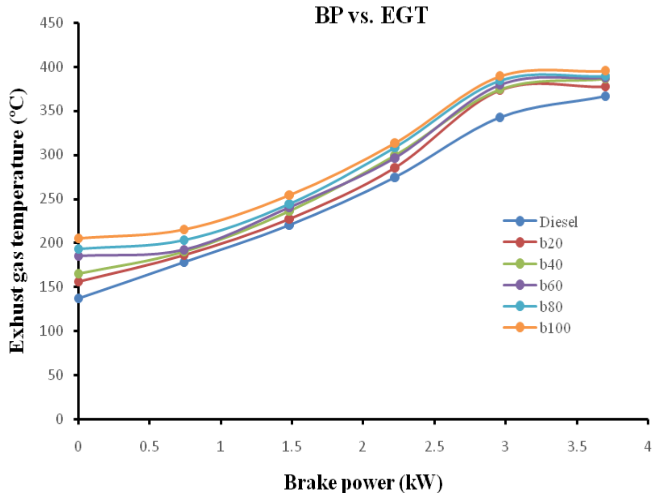

Figure 7: Variation on exhaust gas temperature

The exhaust temperature of CNSL oil is decreased because of deprived combustion occur compare to neat diesel and it gets increased to a small amount for both CNSO and neat diesel with injection pressure maintained in the range of 180 and 210bar pressure. When the pressure exceeds this range EGT decreases.

G. CO_2 Emission variation

A variation of CO_2 emissions for diesel and B20 CNSO blend is illustrated in Fig.8. For maximizing the loads for diesel and CNSO blend, the CO_2 emissions are increased. Carbon dioxide is considered as better compared to CO emission that is produced when the carbon from the Fuel is fully oxidized during the combustion process.

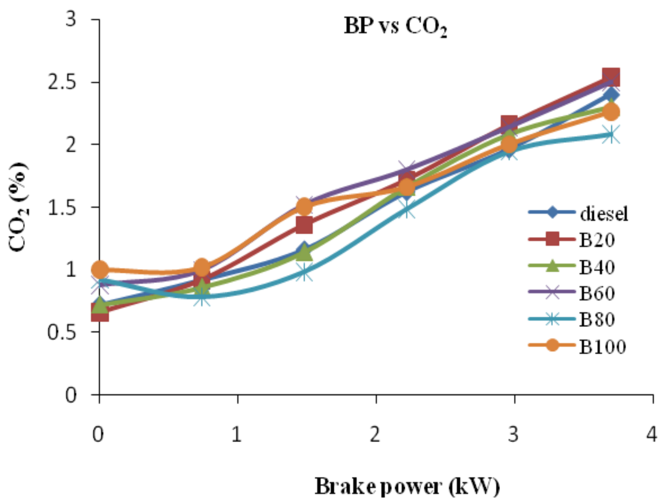

Figure 8: Variation on CO_2 emission

It is noted that CO_2 emissions is lower for B20 CNSL oil with effect to the neat diesel. This is obtained because of lower carbon content of biodiesel and highest emissions obtained for diesel at 180 bars. This is mainly because of improper combustion of fuel efficiency.

CONCLUSION

The evaluation of effect and discharge uniqueness of DI compression ignition diesel engine through pyrolysis cashew nut shell liquid as diesel blends have been studied and presented as follows. The optimized injection timing and optimized injection pressure is 19° bTDC and 22 Mpa respectively for diesel operation is identified. The brake thermal effectiveness gets decreased whenever blends of CNSL oil (B40, B60, B80 and B100) becomes higher compared to standard diesel procedure. However the brake thermal effectiveness is closer to diesel operation in the case of lower blend B20. The Oxides of Nitrogen (NOx) discharge level is decreased with the blends of CNSL oil compared to neat diesel. The drain gas temperature diminishes with respect to the mingle CNSL-Diesel compared to the standard diesel. The precise fuel utilization is increased in the case of CNSL-Diesel mingle match up to the standard diesel. The unburnt hydrocarbon and carbon monoxide discharges are increased with blends of CNSL-Diesel as match up to the standard diesel. In common the effect and discharge level of CNSL Diesel blends improves slightly, but it can be used as a low cost alternative fuel for diesel engine. In future the effect and discharge of direct injection diesel engine can be improved by using additives and oxygenates with CNSL–Diesel fuel.

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