

PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE FUELLED WITH CASHEW NUT SHELL PYROLYSIS OIL EMULSION AS FUEL

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ABSTRACT

The main scope of this work is to study the effect of cashew nut shell pyrolysis oil emulsion used as fuel in diesel engine. Cashew nut shell pyro oil (CWSPO) is the bio oil obtained from pyrolysis of cashew nut shell. Being a renewable source of energy, CWSPO possess many attractive properties which is very close to conventional diesel fuel, hence an attempt is made in this work to use it as an alternate fuel in diesel engine. Thus CWSPO is made to blend with neat diesel at various proportions and at around 40% maximum stability is established. Being highly viscous liquid the performance characteristics of CWSPO40 were found to be promising due to its higher calorific value than diesel. Brake thermal efficiency of diesel is found to be around 30% whereas CWSPO 40 is around 29% at part load condition. At the same time emission characteristics were found to be not as good as diesel. Hence CWSPO40 is made to emulsion and its outcome states that there is significant reduction in oxides of nitrogen and smoke emission as compared to that of CWSPO 40.

Keywords: Bio Mass, Pyrolysis, Bio-Oil, and Emulsion, Cashew shell pyrolysis oil CWSPO)

Introduction

As the fossil fuels were depleting day by day and on another hand world energy demand is rising exponentially, it is exact time to explore an efficient alternate energy source to replace conventional non-renewable resources. Keeping this in mind an investigation is made to study the use bio oil obtained from the pyrolysis of biomass in the diesel engine. Biomass is the organic matter which has considerable amount of carbon content. Many researchers were found that bio-oil obtained from biomass has a potential to use as a fuel in diesel engines. Cashew nut shell is a kind of biomass which is been concentrated in this work. Cashew nut shell pyro oil is the bio oil extracted from Cashew nut shell, through fast pyrolysis techniques by heating it in elevated temperature in the absence of oxygen. CWSPO is blending easily with diesel up to around 50% by its volume. The performance and emission characteristics were found to be very interesting in comparing with diesel. Emulsification is the techniques of mixing two immiscible liquids in the presence of a surfactant. The reason behind going for the emulsion is to reduce the oxides of nitrogen and smoke emission.

As a result of emulsion, peak cycle temperature of the fuel is found to be reduced thus leads to drop in the oxides of nitrogen emission. Micro explosion of fuel droplets which resulted by emulsification, will lead to secondary atomization which will enhance the combustion there by reducing the smoke level.

In this part of work CWSPO 40 is been concentrated since it has a maximum stability around a week. Performance and emission characteristics were compared against conventional diesel fuel. An attempt is also made in this work to form its emulsion, in order to govern its emission characteristics.

Fuel Preparation

CNSO40 Preparation

Cashew Nut Shell Pyro Oil is made blend in to diesel at various proportions and finally found that around 40% maximum stability is attained. Thus CWSPO40 is prepared in the laboratory with 40% volume of cashew nut pyro shell oil and 60% of neat diesel. Its properties were measured using suitable apparatus which is listed down in the Table.1. From the literature review it is found that calorific value of CWSPO is around 45 MJ/kg

CWSPO 40 Emulsion preparation

The main need of going to emulsion is to simultaneously reduce the oxides of nitrogen and smoke emission with the result of reduced peak cycle temperature and micro explosion respectively. Emulsion is nothing but mixing of two immiscible liquid in the presence of a stabilizer called surfactant. In this work water in oil emulsion is made with SPAN 80 as a surfactant whose HLB value is 4.3 and it remains stable.

Ternary Diagram

It is the graphical representation of all possible combination of mixtures of the fuel, water and surfactant with which an emulsion is formed. Ternary diagram is the tool from which most stabilized mixture of emulsion can be chosen. The ternary diagram is the one by which an emulsion is made with different proportion of its constituents. From the observation it is found at around 91% of CWSPO40, 4% of water and 5% of SPAN 80 by its volume is stable over a period of long time.

Table 1 Property of Diesel and CWSPO40

Properties	Diesel	WSP0	%CWSPO 50% Diesel	%(40%CWSPO+60Diesel) +4% Water+5% Span-80
Density(kg/m ³)	860	957	975	986
Viscosity at 50° C (cst)	3.42	10.3	7.92	9.45
Flash point	51	63	59	65
Fire point	56	96	64	78
Calorific value (kj/kg)	4500	5000	43963	39081
PH value	5.6	5.7	5.65	6.5

Engine Setup

A mono cylinder (KIRLOSKAR-AV1), 4-Stroke, water-cooled, direct injection (bowl in piston) diesel engine develops a power output of 3.7 kW at 1500 rpm was used. An eddy current dynamometer (BENZ SYSTEMS) was used for loading the engine. The test engine setup can be seen in Fig.1. The fuel flow rate was measured on the volumetric basis using a burette and stop watch. An infrared AVL 5 gas exhaust analyzer was used for measuring HC, CO and NO in the exhaust. Black carbon smoke levels were measured by using a standard AVL smoke meter. Tests were conducted for 4 different loads such as 25%, 50%, 75% and 100% of the maximum power output with the fixed engine speed of 1500 rpm. All the tests were carried out with the injection timing of 27° before TDC (optimized static timing) for all the tested fuels. The engine was thermally stabilized before taking all measurements. Readings for engine speed, fuel flow, air flow, were recorded for obtaining performance parameters. Exhaust gas analyzers were calibrated before making measurements. Observations were made for smoke, NO, HC and CO to analyze the emission characteristics.

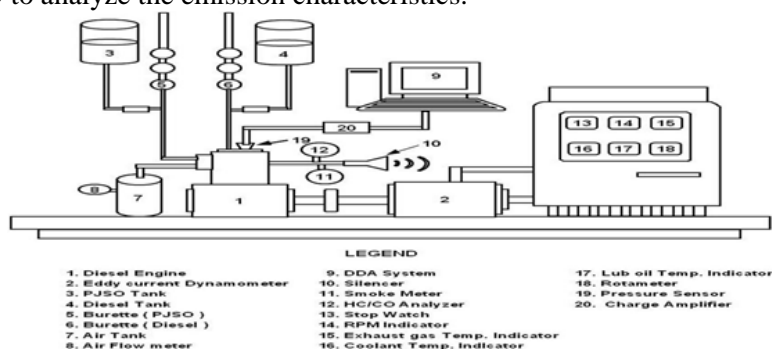


Fig.1 Engine Setup

Results and Discussion

Thermal Efficiency

Fig.2 shows the variation of thermal efficiency with brake power for diesel, CWSPO 40, and its emulsion. Increasing trend in the thermal efficiency is inferred from the graphs for all the fuels as load increases, it is mainly due to combustion chamber temperature. Thermal efficiency of diesel is found to be around 31.51% at 4.2kW and for the same power output CWSPO 40 and its emulsion had around 29% and 27.3% respectively. Even though the calorific value of CWSPO 40 is quite higher than diesel it is inferred that there is slight reduction in the thermal efficiency of CWSPO 40 as compared with diesel, it is mainly due to the higher viscosity of CWSPO 40 which results in inferior combustion. On making its emulsion, it results in further increase in its viscosity which leads to further decrease in the thermal efficiency of CWSPO 40 emulsion as compared to CWSPO 40 and Diesel.

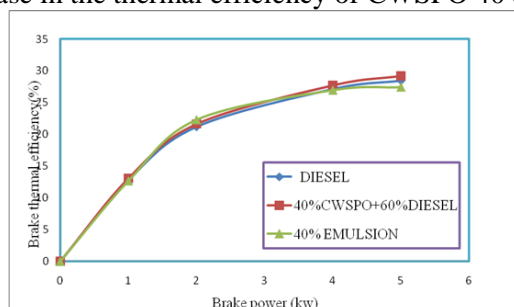


Fig.2 Variation of Brake Thermal Efficiency with Brake Power

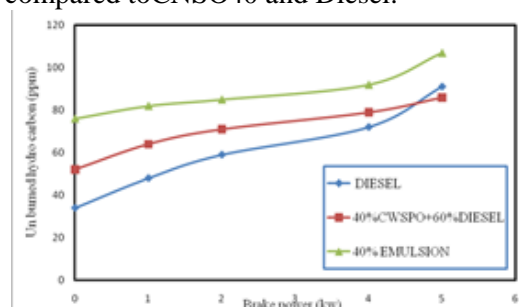


Fig.3 Variation of UHC with Brake Power

Unburnt Hydrocarbon (UHC)

Variation of Unburnt Hydrocarbon(UHC) with brake power for diesel, CWSP040 and its emulsion is shown in the Fig.3. It is found that there is increasing drift in the unburned hydrocarbon emission as the load increases for all the fuels; it is mainly due to the shorter combustion duration. At part load, diesel fuel experiences around 80 ppm of UHC, whereas CWSP040 and its emulsion emit about 86ppm and 107ppm. Unburnt hydrocarbon emissions of the CWSP040 and its emulsions is quite higher than diesel due its higher viscosity resulting in poor atomization which leads to improper combustion.

Oxides of Nitrogen

The Fig.4 shows the variation of oxides of nitrogen emission with brake power for diesel, CWSP040 and its emulsion. For all the load condition, oxides of nitrogen emission is increased due to the higher cycle temperature at elevated power output. Diesel emits about 970 ppm at the part load condition and for the same load, CWSP040 and its emulsion experiences around 930ppm and 900ppm respectively. Higher viscosity of CWSP040 leads to incomplete combustion, resulting in reduced NO_x emission than diesel, however on making it to its emulsion leads to further reduction in the peak cycle temperature than CWSP040. Thus leads to reduction in oxides of nitrogen emission than diesel and CWSP040.

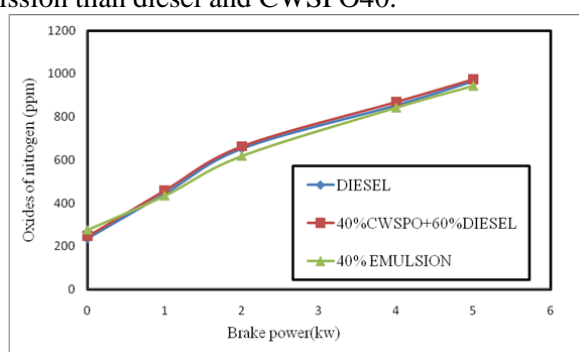


Fig.4 shows the variation of oxides of nitrogen emission with brake power

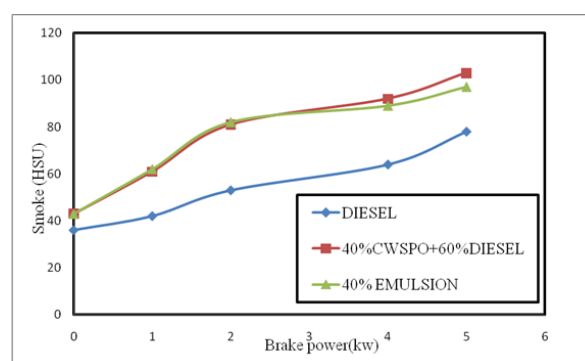


Fig.5 shows the variation of Smoke with brake power

Smoke

Variation of smoke level with brake power for diesel, CWSP040 and its emulsion is shown in the Fig.5. It is clear smoke level increases as the load increases for all the blends of fuel which is mainly due to the reduced time availability for the oxidization of the fuel. Viscosity and density of CWSP040 is quite high as compared to diesel which paves way for poor atomization of fuel droplets, thus smoke level is found to be higher for CWSP040 than diesel. But on making it in to its emulsion results in micro explosion which is responsible for the secondary atomization, its leads to smoother combustion. Thus smoke level of CWSP040 emulsion is quite lower than CWSP040 Diesel. From the experiment conducted at part load condition diesel practices around 90 HSU and for the same load condition CWSP040 emulsion experience 105 HSU and 95HSU respectively.

Conclusion

The above Experiment results revealed that the performance characteristics of cashew nut shell pyro oil is very close to diesel since its calorific value is higher than the conventional diesel fuel. On the other hand its emission characteristics were found too distant from diesel; however on making it to its emulsions, it yields good results in the reduction of oxides of nitrogen and smoke emission. Thus with some further development in enhancing the performance characteristics of CWSP040 emulsion we can make cashew nut shell oil as an effective alternate source of energy resource, to meet out the energy demand in the future.

References

- Lu Qiang, Li Wen-Zhi, Zhu Xi-Feng Overview of fuel properties of biomass fast pyrolysis oils Energy Conversion and Management 50 (2009) 1376–138
- A.K.Hossain, P.A.Davies Pyrolysis liquids and gases as alternative fuels in internal combustion engines – A review Renewable and Sustainable Reviews 21 (2013) 165–189
- S. H. Sengar, A.G. Mohod, Y. P. Khandetod Performance Evaluation of Kiln for Cashew Nut Shell Carbonization and Liquid International Journal of Energy Engineering 2(3) (2012) 78-85
- Piyali Das, T. Sreelatha, Anuradda Ganesh Bio oil from pyrolysis of cashew nut shell-characterization and related properties Biomass and Bio energy 27 (2004) 265–275
- Velmurugan.A., Loganathan.M Performance and Emission Characteristics of a DI Diesel Engine Fuelled with Cashew Nut Shell Liquid (CNSL)-Diesel Blends World Academy of Science, Engineering and Technology 5 (2011) 10-28.