Investigation of Performance and Air Pollution of Charcoal Blended Diesel on CI Engine

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Abstract - **The paper presents the research on biomass charcoal-Diesel oil mixture and its use as an alternative fuel for combustion in diesel engine. The employment of charcoal slurry fuel intends to reduce heavy fuel oil consumption and would reduce green house emissions into the atmosphere. In the investigation, wood chips were used for the production of charcoal that was successfully emulsified with Diesel oil. The paper investigates the formulation, emulsification, spray, and analysis of charcoal-diesel slurry. The results of the investigations in sprays of this fuel show the fuel, non-Newtonian fluid, is able to atomize well. It is demonstrated that the new emulsification process proposed in this paper is able to produce fuels from biomass charcoal and diesel, for vehicles operated on compression ignition system. The critical aspect of operation is the internal flow into the injector with the tendency to form deposits and wear in the injector. Performance and exhaust emission of a diesel engine is almost similar to 100% diesel oil fuelled engine**

Keywords: wood charcoal, emulsion, surfactant, viscosity.

I. INTRODUCTION

Wood is a renewable energy sources. It can be re grown easily and within short period as compare to fossil fuels. Charcoal is made from wood by pyrolysis process. Charcoal has calorific value almost 29000-30000 kJ/kg which is quite good compare to the calorific value of wood which is near to 15000 kJ/kg[1]. So use of wood charcoal by emulsifying technique is being valuable in bio fuel study. Charcoal-diesel slurry can be used in internal combustion engine as an alternative fuel which reduces the consumption of heavy diesel oil and good for environment condition.

II. MATERIALS AND METHODS

CHARCOAL

Charcoal using for the experiment is Indian Babul's charcoal. We can use any wood charcoal for the experimental procedure. While choosing wood charcoal, ash content in wood charcoal should be kept in consideration. This is because the ash is unburnt matter which is always there in wood charcoal. Charcoal powder using for the experiment is with very fine particle size.

Figure 1.1 : actual photograph of charcoal used for testing

The average particle size of charcoal powder is 10 microns and average lump size measured by suspending charcoal in water is 25 microns. Following are the properties of wood charcoal used for emulsion process.

Table 1.1 : Charcoal Properties

Carbon	91.77%
Ash	5.23%
Moisture	0.5%
Ave. Particle size	10 microns

SURFACTANT

Surfactant plays most important part while making mixture of two immiscible liquids. It increase surface tension and make the mixture homogeneous. Choice of surfactant depends on the HLB (Hydrophile-Lipophile Balance) number. Cost of surfactant is comparatively high which restrict more use of it. By reviewing research papers, it has been decided to utilize the surfactant having single chain of ethylene for charcoal-diesel emulsification[2]. Five surfactant having chain of ethylene: cetyl alcohol, palm oil, polyoxyethylene, glyceride ethoxylate, polyethylene Glycol are used to check the mixture stability[4].

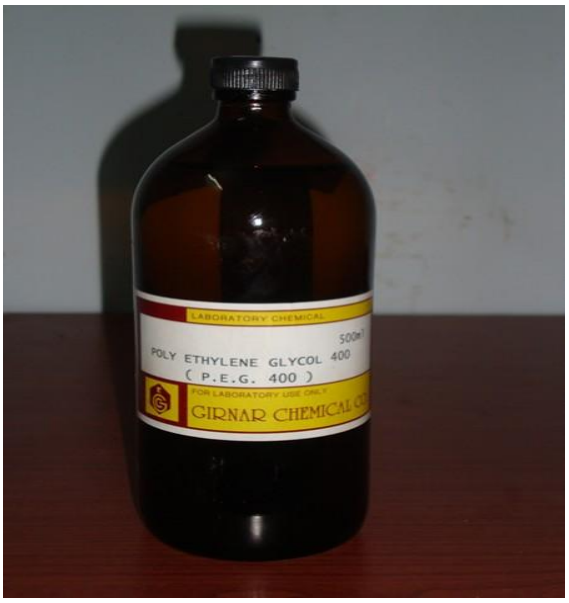

Figure 1.2 : actual photograph of container of PEG-400 used as surfactant

HOMOGINIZER

Stability of emulsion is most important in case of charcoal diesel emulsion. For more stability, it has been require to provide external energy by steering the mixture. Homogenizer is the mean used to steer the mixture which has speed of 8500 rpm. Better stability is obtained by steering the mixture 10-12 min with shown homogenizer

Figure 1.3: actual photograph of shat of homogenizer used for steering mixture

WATER

Water is added to the mixture to increase the burning time of mixture. As charcoal-diesel mixture is used for the combustion process, burning time of charge should be more. Water also reduces the production of NOx in exhaust emission. Surfactant is selected considering this too[3].

III. VISCOSITY STUDY

Using nonionic surfactant with single chain of ethylene, better stability of charcoal diesel mixture can be obtained. Glycerin ethoxylate and poly ethylene glycol were observed best suited for the preparation of charcoal-diesel mixture. Comparison of mixture using different surfactants is as shown in table 1.2.

Table -1.2

Surfa-ctant Type	**Content % by Vol.**				**Stab-ility (hours)**	**Viscosity (P) at 25 deg. C**
	Surfa-ctant	**Charcoal**	**Diesel**	**Water**		
Cetyl alcohol	1	10	87	2	5 hours stable , small bottom deposits	56
Palm oil	1	10	87	2	5 hours stable, large bottom deposit afterwards	124
Poly oxy-ethylene	1	10	87	2	10 hours stable	76.5
Gly-ceride etho-xylate	1	10	87	2	20 hours stable	40.5
Poly-ethy-lene Glycol	1	10	87	2	25 hours stable	32.25

The results from the viscosity studies on the charcoal-diesel mixture fuel are presented for single surfactant[5]. Charcoal-diesel slurry has blackish colour as shown in figure 1.

Figure-1.4 viscosity of slurry

The viscosity studies revealed that the charcoal-diesel mixture fuel is a non-Newtonian fluid. Figure-2 shows the fuel containing 10% charcoal and produced with mixtures of surfactants, had a lower viscosity, 32.25 P at 60 rpm viscometer spindle's speed and 25 deg. C, giving good sprays prospects[6].

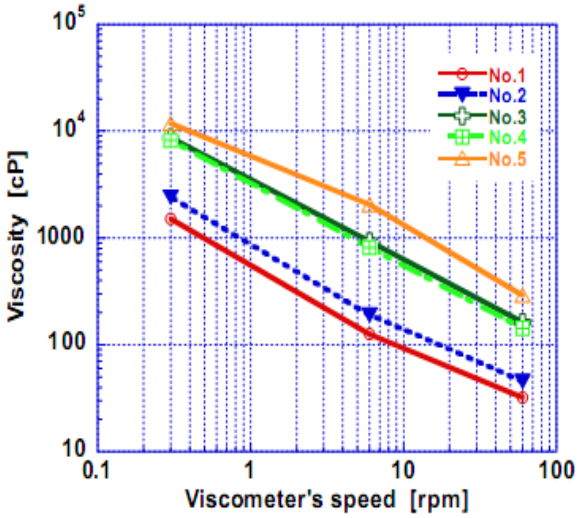

Figure – 1.5 viscosity measurement of slurry at diff speed of viscometer.

IV. SPRAY FORMATION

Charcoal diesel mixture requires to check spray formation for engine compatibility and performance. An multi-point nozzle is used to check the spray formation at given injection pressure. Figure shows the spray formation, carried out at 180 bar injection pressure on injection test rig in lab at room temperature[7].

Spray formation is carried out with 10% of blend of charcoal in diesel oil. Mixture ratio of diesel :charcoal :surfactant :water is 87 : 10 :0.5 :2.5 (%) is kept to check spray formation[8].

Figure 1.6: spray formation of charcoal-diesel mixture

V. OPTIMIZATION METHOD

Experiment has been conducted on 3.7 kW single cylinder water cooled. Direct injection, diesel engine coupled with eddy current dynamo. Taguchi's optimization technique is used to optimized the charcoal-diesel blend for diesel engine. For optimized blend , three parameters have been chosen and they have been varied at three different level as shown.

Table : 1.3

Parameters	Level of variation		
Injection timing (BTDC)	26	28	30
Injection Pressure(bar)	180	190	200
% blend	5	10	15

According to the Taguchi's optimization method, by varying 3-parameters at 3-levels , L27 array has been created for the experiment. L27 array contains 27 runs of those 3-parameters with different combination.
After conducting 27 experimental runs with different load condition, optimization point for charcoal-diesel slurry has been found. With Injection Pressure of 200 bar, Injection Timing of 30 Deg before TDC and 10% /blend proportion , Single cylinder CI engine gives better performance and lower exhaust emission as compare to the other combination of these three parameters.

VI. RESULT

Performance parameters include mainly Brake Thermal Efficiency and Brake Specific Fuel Consumption for diesel engine. Following are the performance curve for the optimized charcoal diesel slurry blend, comparing with the 100% diesel fuelled performance.

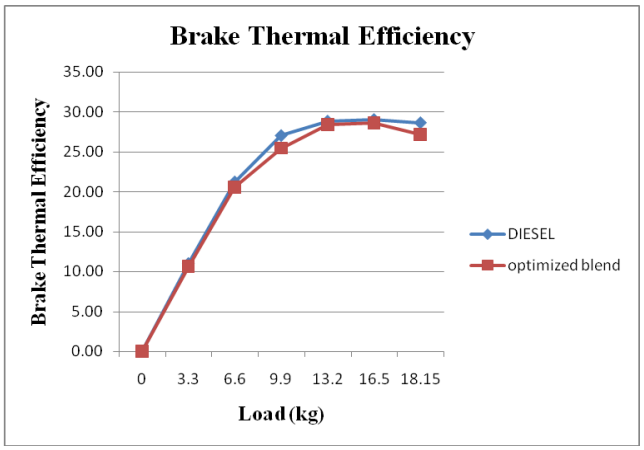

Figure 1.7

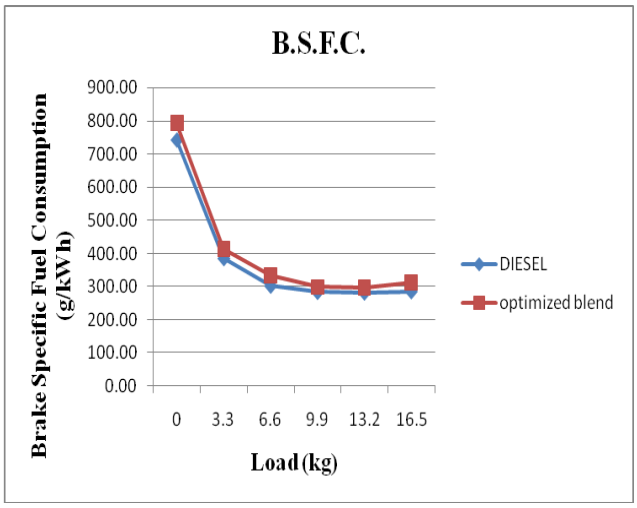

Figure 1.8

Exhaust emission of a diesel engine is equally important while optimizing it for other fuel. Following graph shows the comparison of HC emission and CO_2 emission of optimized blend comparing with 100% diesel oil.

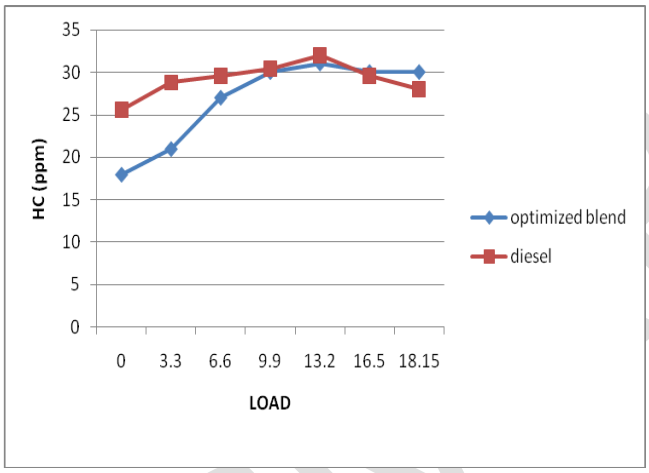

Figure 1.9

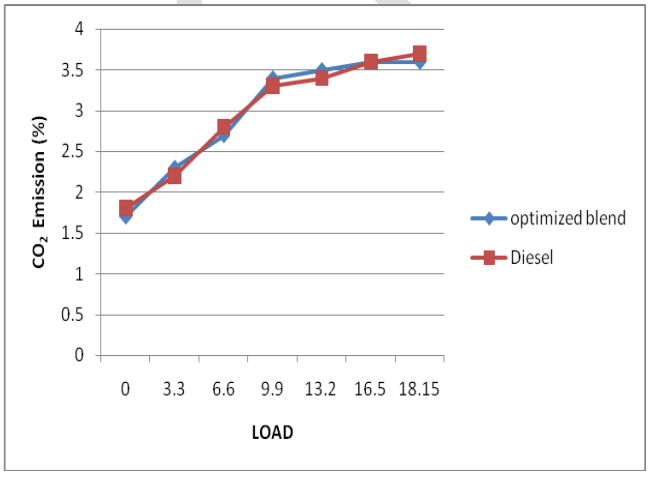

Figure 1.10

VII. CONCLUSION

Charcoal can be emulsified in diesel and better stability can be obtained by selecting proper surfactants. Polyethylene Glycol would be very effective considering viscosity of fuel. Viscosity can be obtained nearer to 30 P which is almost nearer to diesel oil. We can see in figure and conclude that Brake Thermal Efficiency of single cylinder diesel engine fuelled with charcoal slurry Diesel blend is almost nearer to the performance of Diesel oil fuelled engine. BSFC is also equal to the diesel oil as shown in figure.

Considering Exhaust emission of a diesel engine, HC and CO_2 , curves show that HC emission is lower than the diesel oil while CO_2 emission is almost same at all load with diesel oil.

ACKNOLEDGEMENT

It is indeed a pleasure for me to express my sincere gratitude to those who have always helped me throughout my thesis work.

First of all, I would like to thank my thesis guide **PROF S.K. DABHI** for giving his valuable time and for his help in selecting the thesis topic, understanding of the subject, stimulating suggestions, for their encouragement .

Finally, I am thankful to all the faculty members of Mechanical Engineering Department, Laboratory Technician, all my friends & colleagues who have directly or/and indirectly helped me during my thesis work.

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