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Characterization of the DI diesel engine powered by mango seed oil methyl ester with fuel additive

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ABSTRACT

In the present work approach to reduce the viscosity of the bio diesel and in order to improve the calorific value of bio diesel extracted from the mango seed oil 1, 4 dioxane has been used as a fuel additive. The methyl ester mango seed oil is prepared by employing transesterification process and blended with 2.5 %, 5%, 7%, and 10% of fuel additives blended with bio diesel. The optimum blend ratio of fuel additives was identified and 10% of additives shows better performance than others. The experiment was conducted in a single cylinder DI diesel engine coupled with eddy current dynamometer. From the experimental investigation it is found that, viscosity has been reduced up to 0.5% and it shows marginal increase in calorific value. The brake thermal efficiency for 10% additive fuel is slightly increased and significantly reduced NOx emission about 200 ppm.

INTRODUCTION

The automobile pollution has severe influence on climatic changes and urban pollution because of the largely increased numbers of automobiles and depends completely on the fossil fuels. In this context, globally many researches has been carried out in finding the suitable alternate fuel. The more promising alternate fuel globally accepted in future bio fuel options are already available and is in the use of commercial applications. The state of current technology is focused on commercialization of biodiesel production and gives a future development for transportation sector and agriculture sector. Main issues related to biofuel usage are efficiency of the system technology, negative environmental impact and energy supply security. The chemical properties of the biodiesel long chain hydro carbons, oxygen content, sulphur content varies from conventional fuel. In connection to exhaust emissions from diesel engine the use of biodiesel reduces Carbon monoxide and hydrocarbon emissions. Many technical papers revealed that the application of bio diesel in diesel engine is suitable for better performance, combustion and emission properties. However more disadvantages of using biodiesel are high viscosity, low volatility and aromatic contents when compared to that of conventional fuel. The solution to the above mentioned problem has been approached in several ways such as preheating the oil, thermal cracking, catalytic cracking and fuel additives. Among these method fuel additives is one the promising method without changing the fuel supply system or changing system design to solve the above problem easily.

The addition of fuel additive to reduced the long chain hydrocarbons to short chain hydrocarbons and less expensive and more oxygen available

D.C. Rakopoulos, et al studied the use of four straight vegetable oils like sunflower, cotton seed, olive and corn oil on mini bus engine. It is reported that the olive oil has very high content of the un saturated oleic acid (one double carbon bond) and very low content of the unsaturated linoleic acid (two double carbon bonds), in context with the other three vegetable linoleic acidsmany researchers are focused on non edible oil which is not suitable for human

consumption due to the presence of toxic components present in the oil. Further non edible oil crops grow in the wastelands that are not suitable for cultivation. The cost of cultivation is much lower because this crops can still sustain reasonably oils that contain high free fatty acids. Thus they may require multiple chemical steps to produce bio diesel, which will increase the production cost and may lower the ester yield of bio diesel below the standards.

Zhenzhong Wen et al., studied biodiesel production by transesterification process with methanol presence of catalyst NaOH. KOH and alkoxides acid-catalyzed transesterification process using homogenerous nongreen catalysts that give more yield of biodiesel. YanLi. reported that super acid catalyst such as sulfated zirconia, sulfated tinoxides used for preparation of biodiesel process that showed good catalytic activity. It is observed that most of the research paper reported that the use of biodiesel in diesel engine with various blend ratios increase the NOx emission but 2.5% of blend of biodiesel shows good performance and emission level. The present work focused on fuel additives blended methyl ester of mango seed oil. The objective of the present work is focused on adding 1,4 dioxane as a suitable additive blended with methyl ester of mango seed oil to improve fuel properties.

MATERIALS AND METHODS

1.1 Preparation of Bio-Diesel

Mango seed oil is produced from mango seed which is commercially available in market. Generally it is used in soap industry and cosmetic industry. The mango seed is dried in room temperature and the shell is removed and subjected to crusher to crush the mango seed and finally oil is derived. Mango seed oil is slight yellowish in colour, sticky volatile and combustible mixture of hydrocarbons.

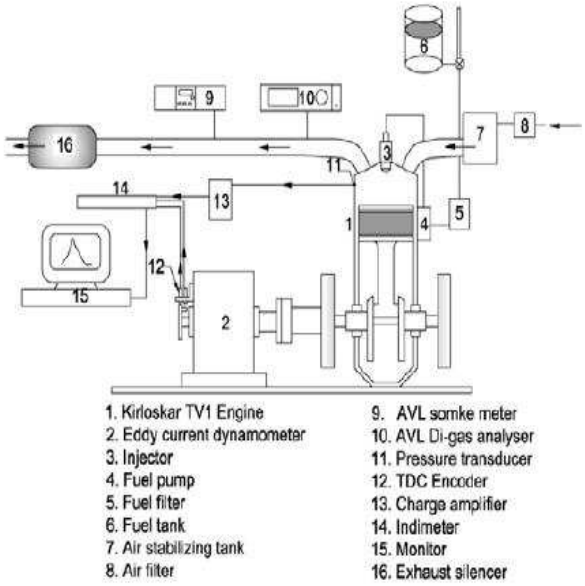
Preparation of biodiesel from mango seed oil is done by transesterification. It is the process of using methanol (CH3OH) in the presence of catalyst (potassium KOH) to chemically brake the molecules of raw mango seed oil into ester and glycerol. This process reacts with the oil mixed with alcohol to remove the glycerin, a byproduct of biodiesel production. The methyl ester of mango seed oil is mixed well with 1,4 dioxane with the help of a mechanical stirrer. The stirring takes place at 1500 rpm for about 15min and there is no separation is observed and it becomes a homogeneous mixture.

Table 1. Fuel properties

Property	**Diesel**	**Raw oil**	**Biodiesel (B100)**	**Biodiesel & 10% of 1,4 dioxane**
Specific gravity	0.8298	0.9171	0.8823	0.8796
Kinematic viscosity @ 40°C in CST	2.57	20.97	5.62	5.18
Flash point °C	37	298	160	166
Fire point°C	40	315	170	178
Gross calorific value in KJ/kg	44738.09	41803.00	41924.43	42401.74

Table 1 shows the properties of diesel fuel, raw mango seed oil, biodiesel and biodiesel. For comparing the diesel fuel and biodiesel with 10% of fuel additive shows marginal increase in the values of specific gravity, kinematic viscosity and calorific value.

Figure 1. Experimental setup



2. Experimental Set – Up

The experimental investigation was carried out in single cylinder water cooled DI diesel engine with 87.5 mm bore, 110mm stroke, and 17.5 : 1 compression ratio. It is shown in the figure 1 the test engine was coupled with eddy current dynamometer to apply different engine loads.

The engine was started on sole diesel fuel and allowed to run in steady state conditions while the engine cooling water temperature was maintained at 55° C. The fuel injection pressure was maintained at 205 bar throughout the experiment. Then the fuel consumption, exhaust gas temperature and exhaust emission of NOx, CO, HC, smoke combustion parameters were measured and recorded for different loads at each operating point and stored in computer for post processing of the results. The experimental work started with sole diesel fuel to determine the engine operating variables and emission levels , constituting the 'baseline' that is compared with the corresponding cases when using each of the bio-diesel blends. The same procedure was repeated for each fuel blends by keeping the same operating conditions. The same procedure was repeated for various blends of bio diesel with fuel additive. For every fuel change, the fuel lines were cleaned and the engine was left to operate for half an hour to stabilize at its new desired condition.

Table 2. Measurement system

Fuel consumption	Gravity type
Temperature	Thermocouple
In-cylinder pressure	AVL Piezoelectric transducer air cooled
CO, HC & NOx	AVL 444 di-gas analyzer
Smoke	AVL smoke meter

RESULTS AND DISCUSSION

Figure The experimental investigation consists of two phase of work the first phase of the work having without fuel additives, the second phase of work having with fuel additives blended with 100% biodiesel. The additives concentration varies from 2.5%, 5%, 7.5%, and 10% by volume blended with 100% methyl ester of Mango seed oil. The influence of fuel additives in the Biodiesel (BD) to analyze the performance and the emission and identify best concentration of fuel additives.

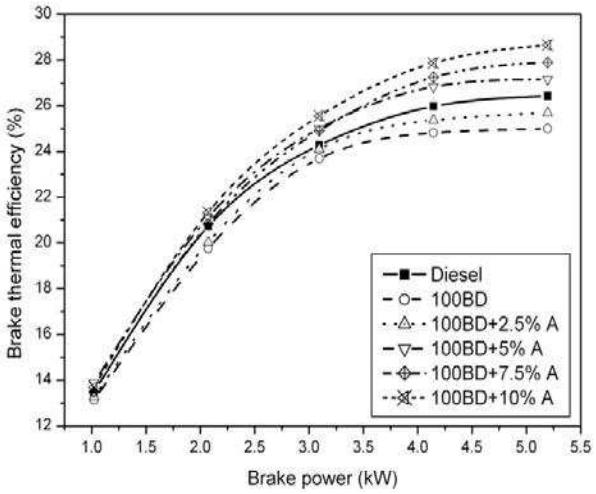


Figure 2. Brake power Vs brake thermal efficiency

Figure 2 show the influence of fuel additives concentration on 100%, 100 biodiesel with respective brake power of the engine. Generally biodiesel have lower unsaturated acid and vary high content of acid (saturated). The presence of 1,4 dioxane fuel additives in the biodiesel influence the complete combustion of fuel during the combustion. Among the concentration 10% volume shows maximum brake thermal efficiency when compared to other concentration and sole fuel. The maximum brake thermal efficiency achieved for 10% additive with biodiesel volume 28.65 %. This is due to reduce the viscosity of the biodiesel and improved the combustion and hence increase the brake thermal efficiency.

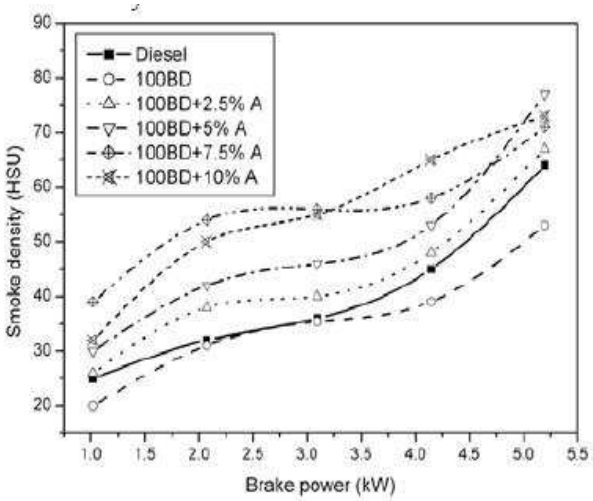


Figure 3. Brake power Vs smoke density

Figure 3 shown the smoke density of sole fuel and 2.5%, 5%, 7.5% and 10% blend of biodiesel at different loads. It can be seen that smoke density emitted by all the blend is higher to that of sole fuel. However without fuel additives shows 100 biodiesel almost equal to that of sole fuel up to part load after that marginally decreased. This is attributed to the combustion being mixing controlled for these biodiesel blends, as it is also the case for the sole diesel fuel case, which is however now assisted by the presence of the fuel bound oxygen even is locally rich zones.It is seen from the graph up to part load the smoke density gradually decrease and increased marginally at the maximum break power of the engine for 2.5% volume fuel additives.

Figure 4 shows the different loads of the engine, the emission of NOx for different concentration of fuel additives blended biodiesel. It is observed that NOx emission for all the cases are lower than corresponding diesel fuel. The increasing concentration of fuel additives on the biodiesel the NOx level significantly reduced. For 10% concentration shows maximum reduction of NOx level 200 ppm at maximum brake power of the engine. The reduction of NOx emission is mainly associated with the reduce premix rate followed by delay period.

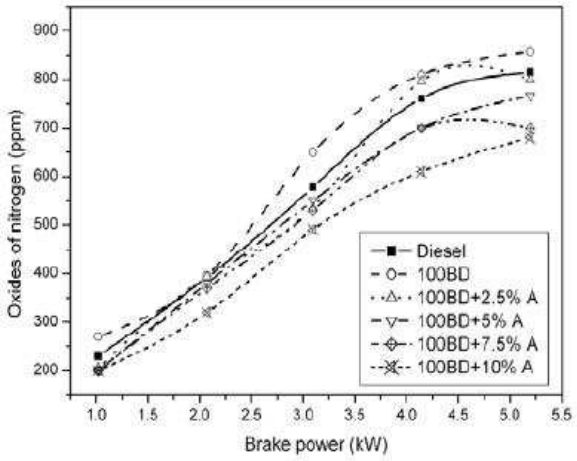


Figure 4. Brake power Vs Oxides of nitrogen

It is evident that in the heat release rate is decreases for all the cases of fuel additives blended biodiesel.

Influence of combustion process

The combustion process of fuel additives blended

BD with various concentrations. The only difference is observed in the cylinder pressure and heat release rate characteristics for sole fuel and additives blended fuel. In diesel engine the cylinder pressure depends upon the combustion rate in the initial stage which intern influenced by amount of fuel tank part in the uncontrolled combustion. The uncontrolled combustion phase is governed by delay period and spray characteristics of the injected fuel. The cylinder pressure for all the concentration of fuel additives blended with biodiesel significantly reduce the cylinder pressure than sole fuel the reason is that low viscosity fuel additives mango seed oil reduces the cylinder pressure. The maximum cylinder pressure for sole fuel is and for 10% fuel additives bidiesel is 65.472 bar.

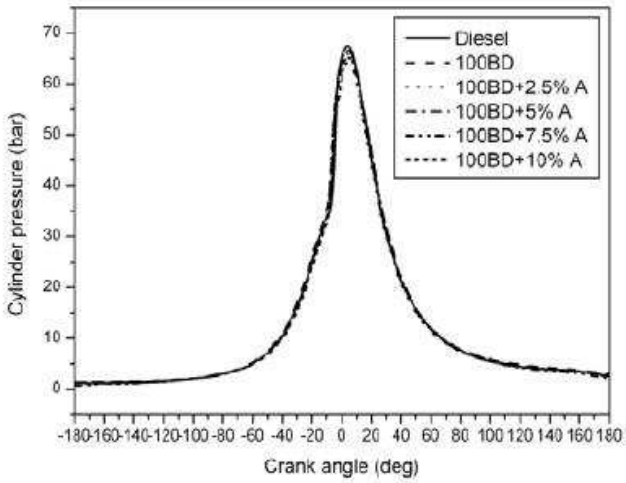


Figure 5. Crank angle Vs cylinder pressure

Figure 6 shows the heat release rate date obtained for four cases of BD under study.It is observed that premix burning rate is more for diesel than fuel additives blended mango seed oil. It can be seen that all the cases heat release rate is lower than sole fuel. Among the blend 10% volume concentration shows lower heat release rate than other concentration the reason is lower combustion the highest chamber temperature is lower for biodiesel and an reduction in NOx emission is achieved.

Figure 7 shows the variation of cylinder pressure for 100 cycles with different fuel additive blends of biodiesel and maximum cylinder pressure is higher for sole fuel than other blends of fuel additive in biodiesel. The average cylinder pressure is 66.3 bar for biodiesel. It is seen that 10% fuel additive biodiesel show more cylinder pressure than other concentration of biodiesel. Biodiesel with fuel additive shows relatively low fluctuation in all the cycles.

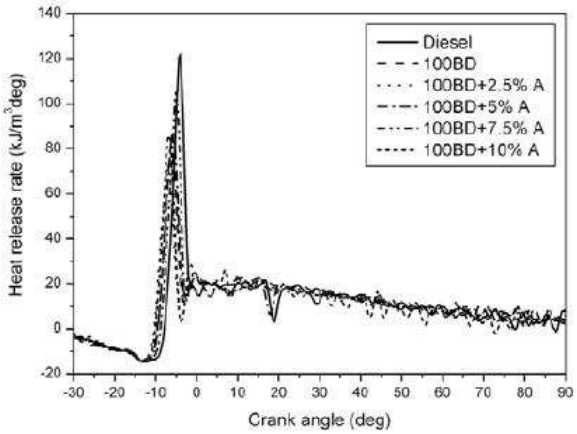


Figure 6 Crank angle Vs heat release rate

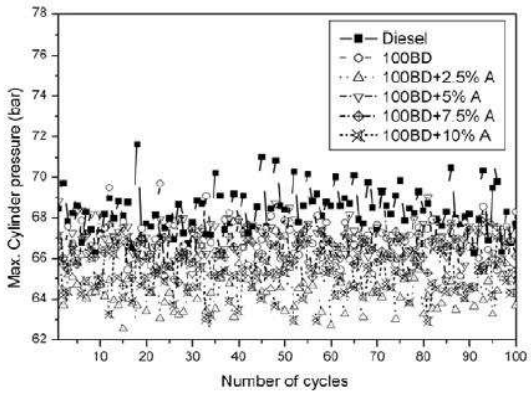


Figure 7 Number of cycles Vs maximum cylinder pressure

CONCLUSION

From the experimental investigation it is concluded that based on the performance and exhaust emission for different concentration of the fuel additives with biodiesel. The addition of fuel additive to reduce viscosity up to 0.5% and marginal increased calorific value of biodiesel. The NOx level reduce by use of additives blended biodiesel with respective diesel fuel. The 10% fuel additives shows maximum reduction of NOx emission. The smoke level slightly increase for all the cases. The thermal efficiency for all the cases slightly increase than sole fuel. The cylinder pressure and heat release rate were slightly decrease with the use of fuel additives blends with respective sole fuel.

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