Experimental investigation of performance, emission and combustion characteristic of CI engine using methanol blended with Kusum biodiesel and diesel.

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Abstract - *In this study, biodiesel (15%)-methanol (5%)-diesel (80%), biodiesel (25%)-methanol (5%)-diesel (70%), biodiesel (35%)- -methanol (5%) -diesel (60%),biodiesel (45%)-methanol (5%)-diesel (50%) and standard mineral diesel as a baseline fuel are tested in a single-cylinder diesel engine. Those biodiesel-alcohol low proportion blends are investigated under the different blending ratio and determine the engine performance and emission of the diesel engine. Overall, biodiesel-methanol- diesel blends show higher break specific fuel consumption than mineral diesel. As methanol proportions in blends increase, NO emissions increase, while CO emissions are reduced. Also, biodiesel-diesel blend with 5% of methanol is more effective than biodiesel blend with 45% for reducing CO emissions.*

***Keywords*: Alternative fuels, diesel engine, performance, miss ion and combustion, kusum biodiesel**

1. INTRODUCTION

The use of alcohol additives include methanol and ethanol are very practical in the biodiesel blends due to its miscibility with the pure biodiesel [1] . Alcohol additives are very helpful to reduce the viscosity and density of the biodiesel which is higher compared to standard mineral diesel. The alcohol additives improve the combustion efficiency and produce lower exhaust emission when fuelled the diesel engines. Ethanol and methanol has approximately 35% and 30% higher oxygen in basis as compared to mineral diesel that help diesel engine to achieve higher complete combustion [2]. For the developing countries of the world, fuels of bio-origin can provide a feasible solution to the crisis. The fuels of bio-origin may be alcohol, vegetable oils, biomass, and biogas. Biodiesel is a nonpetroleum-based fuel defined as fatty acid methyl or ethyl esters derived from vegetable oils or animal fats and it is used in diesel engines and heating systems. Thus, this fuel could be regarded as mineral diesel substitute with the advantage of reducing greenhouse emissions because it is a renewable resource. However, the high cost of biodiesel is the major obstacle for its commercialization, the biodiesel produced from vegetable oil or animal fat is usually more expensive than petroleum-based diesel fuel from 10 to 40%. Moreover, during 2009, the prices of virgin vegetable oils have nearly doubled in relation to the early 2000. This is of great concern to biodiesel producers, since the cost of feedstock comprises approximately 70-95% of total operating costs at a biodiesel plant. Compared to neat vegetable oils, the cost of vegetable oils is anywhere from 60% less to free, depending on the source and availability. Even though the trade price of waste oils has been also raised, kusum oils are still at lower cost, because feedstock's making biodiesel production are more competitive to the production of petroleum-based diesel fuel. It is well known fact that, when oils are heated for an extended time (abuse), they undergo oxidation (degradation) and give rise to oxides. Many of these such as hydro peroxides, epoxies and polymeric substances have shown adverse health/biological effects such as growth retardation, increase in liver and kidney size as well as cellular damage to different organs when fed to laboratory animals. Thus, used cooking oils constitute a waste generated from activities in the food sectors (industries and large catering or community restaurants), which have greatly increased in recent years Still further if Kusum oil are poured down the drain, resulting in problems for wastewater treatment plants and energy loss, or integrated into food chain by animal feeding, causing human health problems, and their use for biodiesel production offers solution to a growing problem of the increased waste oil production from household and industrial sources all around the world. A major hurdle in the commercialization of biodiesel from virgin oil, in comparison to petroleum-based diesel fuel, is its cost of manufacturing, primarily the raw material cost. Used cooking oil is one of the economical sources biodiesel productions. However, the products formed during frying, such as free fatty acid and some polymerized triglycerides, can affect the transesterification reaction and the biodiesel properties. Commercial Biodiesel does have standards which must be met, just like commercial petro diesel does. The ASTM Standard for Biodiesel is ASTM 6751[3]. Found that fuel properties of diesel-kusum biodiesel-methanol blends were close enough to the baseline fuel diesel. Only the flash point differed a bit from the baseline diesel fuel. While inves- tigating the emission characteristics in a single cylinder, four stroke diesel engine, it was found that CO and HC emissions with the blended fuels were lower compared to those with diesel. However, NOx emission increased with the addition of biodiesel as well as methanol[4] When made to this standard, Biodiesel is a very high quality fuel which is superior to petro diesel in every way, except cold weather performance. In this project the following results has been obtained and studied using kusum biodiesel such as performance, emission, combustion characteristic on single cylinder diesel engine.

Technical specification of Kirloskar oil engines ltd, India

01	Manufacturer	Kirloskar oil engines ltd, India
02	Model	TV-SR, naturally aspirated.
03	Engine	Single cylinder ,DI
04	Type	4stroke, 1 cylinder, water cooled
05	Bore	87.5mm
06	Stroke	110 mm
07	Compression ratio	16.5:1
08	Rated Power	5.2kW @1500rpm
09	Fuel	Diesel

2. Experimental setup and methodology

For getting the base line data of engine first the experimentation is performed with diesel and then with biodiesel.

- Fill the diesel in fuel tank
- Start the water supply. Set cooling water for engine at 650 LPH and calorimeter flow at 150 LPH.
- Also ensure adequate water flow rate for dynamometer cooling and piezo sensor cooling.
- Check for all electrical connections. Start electric supply to the computer through the UPS.
- Open the lab view based engine performance analysis software package "engine soft" for on screen performance evaluation.
- Supply the diesel to engine by opening the valve provided at the burette.

Set the value of calorific value and specific gravity of the

- fuel through the configure option in the software.
- Select run option of the software. Start the engine and let it run for few minutes under no load condition.
- Choose log option of the software. Turn on fuel supply knob. After one minute the display changes to input mode then enter the value of water flows in cooling jacket and calorimeter and then the file name (applicable only for the first reading) for the software. The first reading for the engine gets logged for the no load condition. Turn the fuel knob back to regular position.
- Repeat the experiment for different load and speed.
- All the performance readings will be displayed on the monitor.
- Using AVL Dismoke 1000 and exhaust gas analyzer CO, CO_2, UBHC, smoke opacity will be recorded.
- Now clear the diesel present in the engine and use neat biodiesel as a fuel, repeat the same procedure.
- At the end of the experiment bring the engine to no load condition and turn off the engine and computer so as to stop the experiment.
- After few minutes turn off the water supply.

Fig-:2.1 Engine connected with dash board

2.2 The Properties of Diesel fuel and Kusum biodiesel

The different properties of diesel fuel and kusum seed biodiesel are determined and shown in table.3.2. After transesterification process the fuel properties like kinematic viscosity, calorific value, and density, flash and fire point get improved in case of biodiesel. The calorific value of mango seed biodiesel is lower than that of diesel because of oxygen content. The flash and fire point temperature of biodiesel is higher than the pure diesel fuel this is beneficial by safety considerations which can be stored and transported without any risk.

Fuel samples Properties	Diesel	Kusum biodiesel	Apparatus used
Fuel density in $\frac{kg}{m^3}$	817	880	Hydrometer
Kinematic viscosity at 40°C in cst	2.90	40.75	Saybolt
Flash point in °C	64	147	Ables apparatus
Fire point in °C	75	158	Ables apparatus
Calorific value in $\frac{kJ}{kg}$	45184	38529	Bomb calorimeter

3. RESULTS AND DISCUSSIONS

3.1 Performance characteristics of diesel, blends of Kusum biodiesel on diesel engine

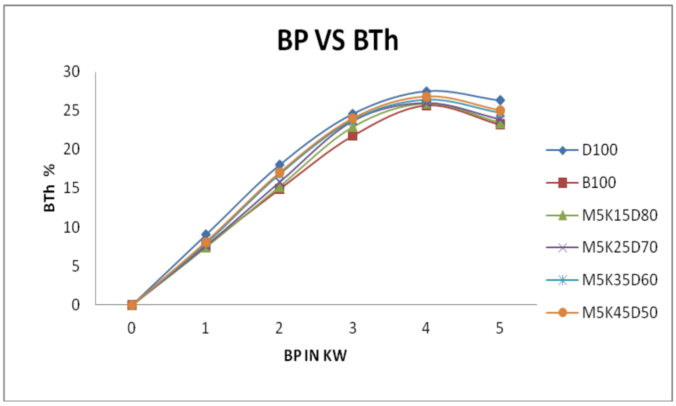

Fig-3.1: Variation of brake thermal efficiency with brake power

The fig 3.1 The variation of brake thermal efficiency with brake power for diesel and blends of kusum seed biodiesel are shown in fig.3.1. As the load on the engine increases, brake thermal efficiency increases because brake thermal efficiency is the function of brake power and brake power increases as the load on the engine increases. The maximum value of brake thermal efficiency for diesel & pure diesel is at 27.5 % and 32 %. The brake thermal efficiency is almost constant between range of 25 % to 30 %, brake thermal efficiency of all the blends are lower than that of diesel, this is attributed to more amount of fuel consumption for blends as compare to diesel. And pure biodiesel is 25.7% and against 27.5% for that of diesel on normal engine. At full load conditions, the brake thermal efficiency of diesel is more than all blends. Brake thermal efficiency of M5K45D50 blend is very close to diesel for entire range of operation.

3.2 Specific fuel consumption

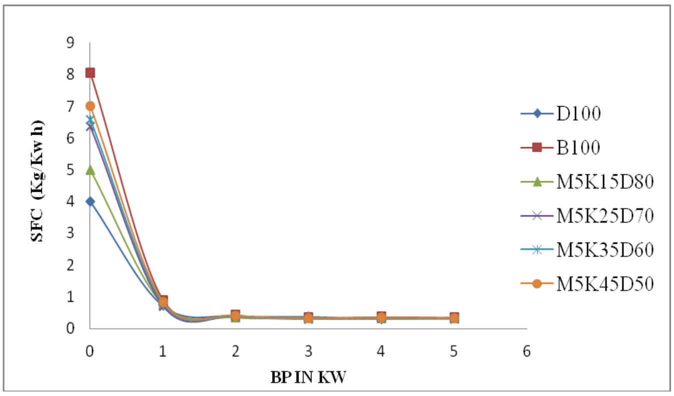

Fig-3.2:.Variation of specific fuel consumption with brake power

The variation of specific fuel consumption with brake power for diesel and blends kusum seed biodiesel are shown in figure 3.2, as the power developed increases the specific fuel consumption decreases for all the tested fuels. The specific fuel consumption of kusum seed biodiesel blends are higher than diesel because of lower calorific value and high density of biodiesel. From the graph it is clear that the specific fuel consumption is more for initial loads and further it is almost constant for remaining loads.

3.3 Exhaust Gas Temperature

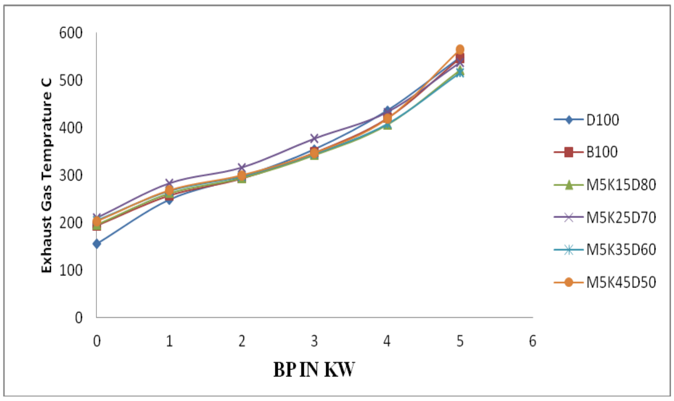

Fig-:3.3 Variation of Volumetric Efficiency with brake power

The variation of exhaust gas temperature (EGT) for diesel, pure biodiesel and different blends with respect to the brake power is indicated in fig .The exhaust gas temperature foe all the fuels tested increase with increase in the brake power .Exhaust gas temperature of pure biodiesel and all the blends is higher as compared to diesel .The Maximum EGT cccur at full load .Maximum EGT of pure biodiesel is 568 °C against 522 °C for that of diesel on normal engine .By increasing % of Methanol in biodiesel decreases the EGT .

3.4 Emission characteristics

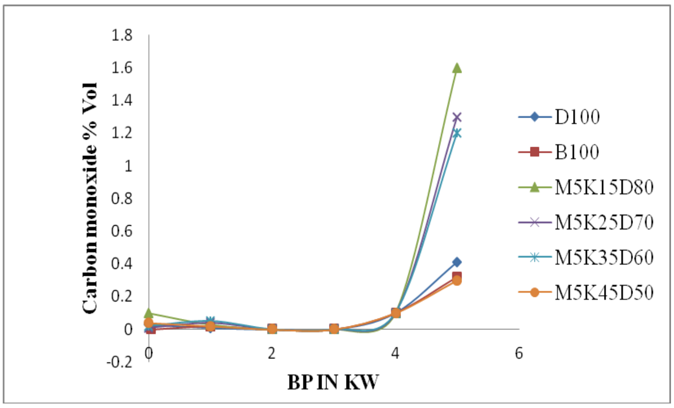

Fig-:3.4 Variation of carbon monoxide with brake power

The variation of carbon monoxide emission with brake power for diesel, pure biodiesel and blends of methanol –kusum biodiesel and diesel in test engine are show in Fig The CO emission depends upon the strength of the mixture ,availability of oxygen and viscosity of fuel .CO emission of pure biodiesel and all blends and blends is higher than that of diesel , except the blend M5K45D50 has lower CO emission that of diesel .The maximum CO emission occurs at full load .maximum CO of pure biodiesel 0.32 % vol against 0.41% vol for that of diesel on normal engine. M5K45D50 blends give lower emission with respect to other blends.

3.5 unburnt Hydrocarbon

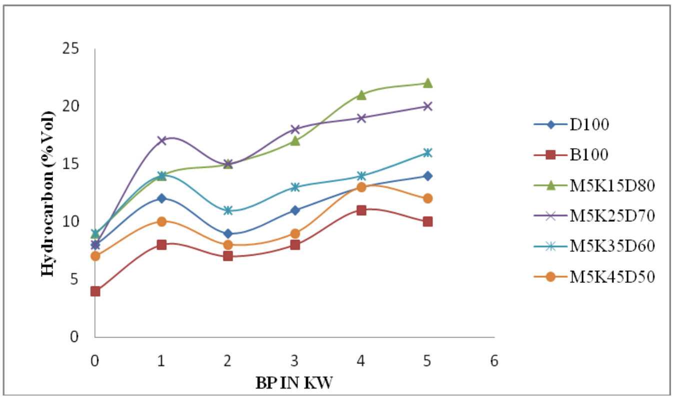

Fig-: 3.5 Variation of hydrocarbon with brake power

Show the variation in the quantity of unburnt hydrocarbon with change in brake power .it is observed that for kusum biodiesel 100% emission of HC is less than that of the diesel and methanol –kusum biodiesel blends the emission of HC is more than that of the biodiesel .the maximum HC emission occurs at full load .Maximum HC of pure biodiesel is 10 ppm against 14 ppm for that of diesel on normal engine by increasing % methanol in biodiesel .it increase the un burnt hydrocarbon emission .the M5K15D80 blends gives lower emission compared to other blends.

3.6 Nitrogen oxide

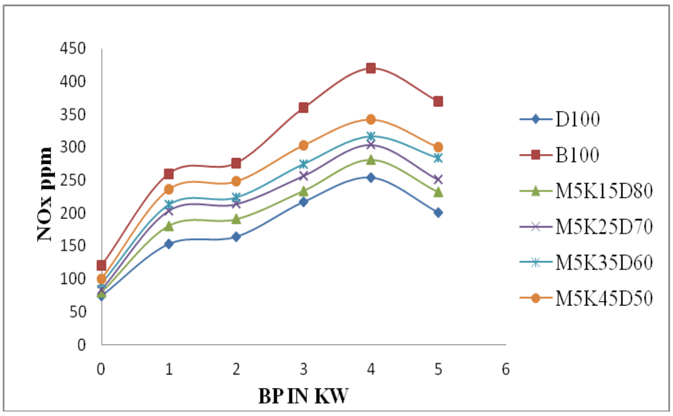

Fig-: 3.6 Variation of NOx with brake power

The variation of nitrogen oxides emission with brake power output for diesel ,neat biodiesel and blends of methanol –kusum bio diesel and diesel in the test engine are show in fig . The NOx emission occurs at full load. Maximum NO x of pure bio diesel is 430 ppm against 250 ppm for that of diesel on normal engine by increasing the % of methanol in bio diesel it decreases the NOx .The blends .M5K15D80 gives Lower emission compared to other blends .

3.7 Smoke

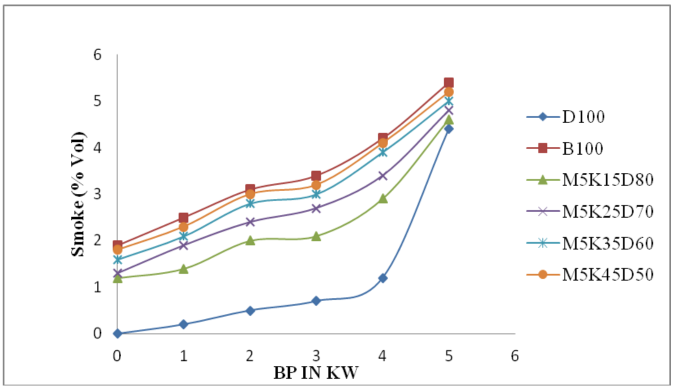

Fig-:3.7 Variation of exhaust smoke with brake power

The variation of exhaust smoke with brake poewer for diesel ,pure biodiesel and blends of methanol –kusum biodiesel and diesel in the test engine are show in Fig :3.7 it can be clear found that exhaust smoke of pure bio diesel and all blends is higher than that of diesel .The Maximum smoke emission occurs at full load Maximum smoke of pure bio diesel 5.6 % against 4.3% for that of diesel on normal engine .by increasing % of methanol in bio diesel it decreases the smoke. The M5K15D80 blends give better emission compared to other blends .

3.8 Combustion characteristics

Cylinder pressure with Crank angle

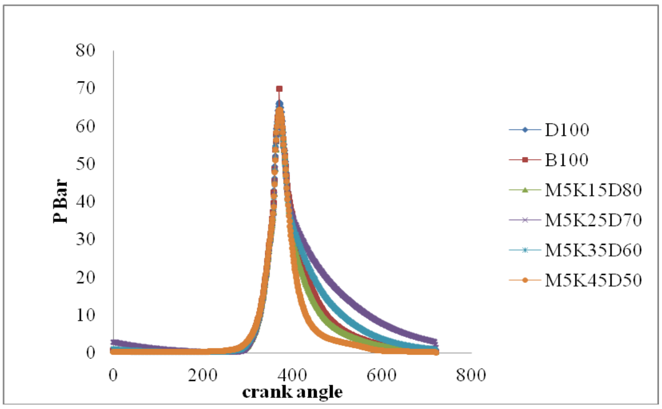

Fig-:3.8Variation of cylinder pressure with crank angle

In a CI engine the cylinder pressure is depends on the fuel burning rate during the premixed burning phase, which in turn leads better combustion and heat release. The variation of cylinder pressure with respect to crank angle for diesel ,pure biodiesel and different blends of methanol –kusum biodiesel and diesel are show Fig peak pressure of Neat kusum biodiesel and blends methanol is higher than diesel . Maximum pressure of pure bio diesel is 69.38 bar against 65.86 bar for that biodiesel diesel. On typical motor. By expanding level of methanol in biodiesel it decreases the pressures

3.9Heat Release Rate with Crank Angle

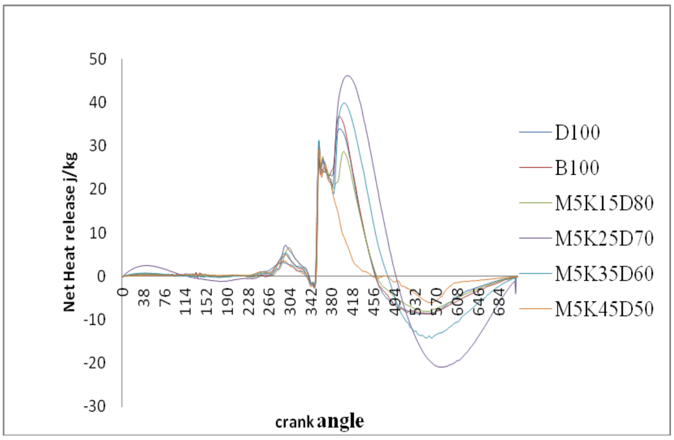

Fig-:3.9Variation of heat release rate with crank angle

The variation of cylinder net heat release rate with respect to crank angle for diesel, pure biodiesel and different blends of methanol –kusum biodiesel and diesel are show in Fig.3.9 The net heat release rate for all the tested fuel is more than that of diesel .Maximum net heat release rate of pure biodiesel is 36.82 j/deg against 34.02 j/deg for that of diesel on normal engine. by increasing % of methanol in biodiesel and it decreases the heat release rate .The M5K25D70 gives a 45.11 j/deg highest peak net heat release .

3.10 Commutative Heat Release Rate with Crank Angle

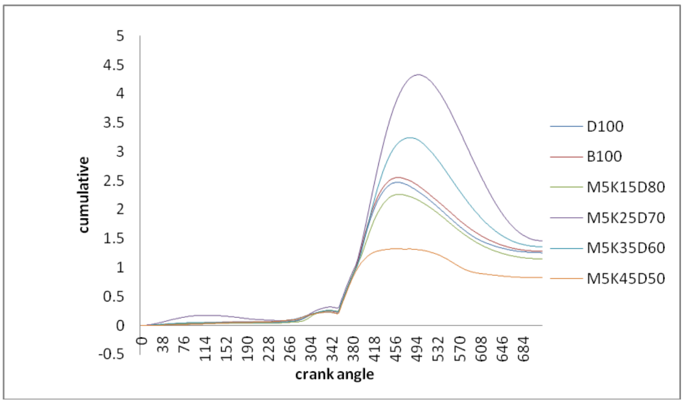

Fig-:3.10 Variation of cumulative heat release rate with crank angle

The variation of cumulative heat release rate with crank angle is show in fig:3.10SS The neat kusum biodiesel and blends methanol and diesel similar to diesel .The two main phase of the combustion process, premixed and diffusion are clearly seen in the rate of heat release curve .if all heat losses (due to heat transfer from the gases to the cylinder walls ,dissociation ,incomplete combustion ,gas leakage) are added to the apparent heat release characteristic ,the fuel burn characteristic are obtained . Maximum net heat release rate of is M5K25D70 blends 4.33 kj against 2.42 kj for that of diesel on normal engine.

CONCLUSION

From the present numerical investigation, it can be con-clouded that the addition of methanol as a supplementary fuel to diesel-biodiesel blends has a significant effect on the engine performance emission and combustion characteristics, an increase in brake thermal efficiency by 5% with methanol blended diesel-biodiesel blend has been observed. From the environmental point of view, emissions are greatly reduced with MKD blend. It is observed that blended fuels give significant reductions in the harmful emissions of CO2,CO, NOx, specific PM and smoke by an amount of CO Emission like 0.32%, 0.41%,. The fuel properties of neat kusum seed biodiesel and its blends, density, viscosity, flash point and fire point were found to be higher than that of diesel and calorific value is lower than that of diesel. Conclusions are as follows:

- Brake warm productivity of biodiesel is lower than diesel.

• Neat kusum oil is changed over into biodiesel utilizing transesterification prepare.

•Smoke, unburnt hydrocarbon, carbon monoxide, carbon dioxide outflows is a little lower than that of diesel because of low temperature of mean gas temperature.

• Brake thermal efficiency of M5K45D50 blend is very close to diesel for entire range of operation.

• CO emission of all blends is higher than that of diesel, except the blend has a lower CO emission that of diesel. CO emission of M5K45D50 blends at maximum load is 0.32% volume against 0.41% volume of diesel.

• The HC emission of biodiesel blends the emission of HC is less than that of the diesel. Unburnt hydrocarbon emission is the direct result of incomplete combustion and other blends, is about 22% and 25% respectively

• Smoke W better emission.

• NOx Lower emission.

• Cumulative warmth discharge rate and mean gas temperature has same pattern of biodiesel and diesel.

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