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Experimental Analysis of Performance and Emission on Single Cylinder Di Diesel Engine Using Kharanja Biodiesel & Diesel Blends by Varying Injection Pressure

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Abstract

Bio-Diesel can be defined as fuel composed of monoesters of long chain fatty acids. Biodiesel is an ester of fatty acid derived from a range of organic sources such as edible andnon-edible or used vegetable oil and animal fats. It is considered as alternative to diesel oil which is non-toxic and renewable fuel.

Biodiesel is known as a clean burning alternative fuel, produced from domestic, renewable resources. The present work investigates oil in the form of karanja oil and is popularly known as Kharanja Pinnata or Honge oil and is extracted from the seeds of the karanja tree& also called the Honge tree. Karanja oil was selected for this investigation as an alternative fuel to diesel and was transesterified to obtain its biodiesel called karanja oil methyl ester (KOME). Performance analysis of single cylinder DI diesel engine using kharanja biodiesel& diesel blends by varying injection pressure.

Keywords: *Biodiesel,Karanja methyleaster*

1. Introduction

As the fossil fuels are depleting at a very faster rate, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Biodiesel is one of the best available sources to fulfill the energy demand of the world. The petroleum fuels play a very significant role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human requirements as shown in figure 1 general energy distributions. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society. Hence,

Available abundantly in India which can be there is a need of research for alternative fuels. There is a long list of trees, shrubs, and herbs exploited for the production of biodiesel [1]. India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations

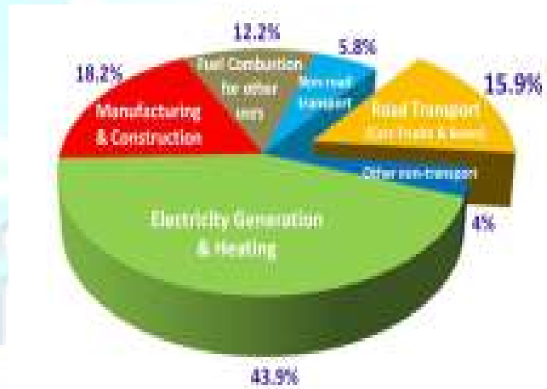

Fig 1: general energy distributions

In the figure 2 shows energy demand projection in India. India had approximately 5.6 billion barrels of proven oil reserves as of January 2010, the second-largest amount in the Asia-pacific region after China.

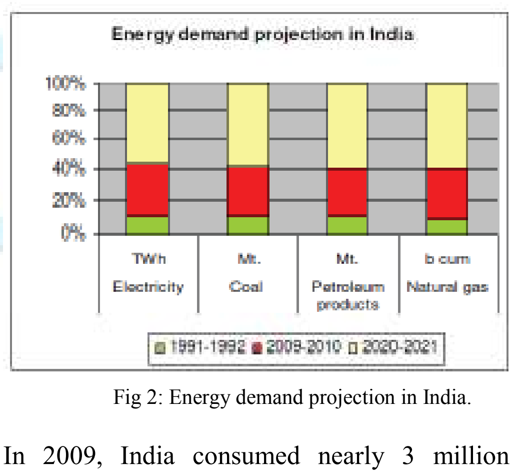

Fig 2: Energy demand projection in India.

In 2009, India consumed nearly 3 million bbl/d (figure 3), making it the fourth largest consumer of oil in the world. EIA (Energy Information Administration) expects approximately 100 thousand bbl/d annual consumption growth through 2011.

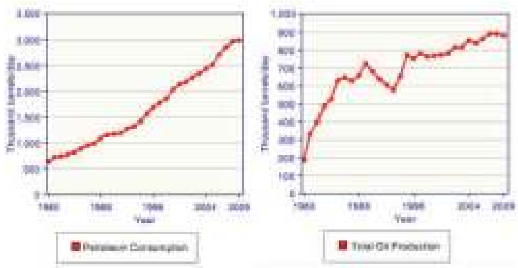

Fig 3: Petroleum consumption and production in India.

And it is also necessary for better economic growth for our country [2]. Dr. Rudolf Diesel invented the diesel engine to run on a host of fuels including coal dust suspended in water, heavy mineral oil, and, vegetable oils. Dr. Diesel's first engine experiments were catastrophic failures, but by the time he showed his engine at the world exhibition in Paris in 1900, his engine was running on 100% peanut oil. Research is still in progress in diesel engine for finding better ways of making good performance and less emissions emitting and fuel efficient engines for the reduction in emission of toxic gases while brining fuels. The research on internal combustion engine is of more than 150 years maturity. Due to various challenges faced in the use of petroleum fuel, researchers are working for the development of other fuel sources.

All the studies are mainly focus on the performance characteristic for the diesel engine operating with biodiesel and comparison to conventional diesel engine. Sejal narendra patel [3] et.al conducted an experimental analysis of diesel engine using bio-fuel at varying compression ratio using jatropha oil. It is found that when compression ratio increases brake thermal efficiency (BTHE) increases and brake specific fuel consumption (BSFC) decreases. M.Prabhahar; [4] et.al he conducted on performance and emission studies of a diesel engine with pongamia methyl ester at different load conditions using pongamia methyl ester the brake thermal efficiency obtained for B20 is closer to diesel fuel. The BSFC are slightly increases for biodiesel due to lower calorific value of biodiesel. Siddalingappa R. Hotti; Omprakash Hebbal [5] et.al conducted on the experiment on karanja biodiesel the variation of brake specific fuel consumption with brake power is, as the power developed increases the specific fuel consumption decreases for all the tested fuels. K. Arun Balasubramanian [6] et.al conducted with diesel, and blends of Jatropha oil biodiesel and neem oil biodiesel at different loads and constant speed (1500 rpm).On the whole it is seen that operation of the engine is smooth dual biodiesel blends. From the experimental results obtained, compared to neat diesel operation, dual biodiesel of jatropha oil and neem oil results in comparable engine performance and slightly higher emissions. Thepresent work investigates oil in the form of karanja oil and is popularly known as KharanjaPinnata or Honge oil and is extracted from the seeds of the karanja tree& also called the Honge tree. Karanja oil was selected for this investigation as an alternative fuel to diesel and wastransesterified to obtain its biodiesel called karanja oil methyl ester (KOME). Performance analysis of single cylinder DI diesel engine using kharanja biodiesel& diesel blends by varying injection pressure.

2. Materials and method

Based on the availability of biodiesel, the properties like calorific value, kinematic viscosity, flash point and fire point, density kharanja biodiesel is estimated in the table selected for bio-fuel preparation and experimental analysis. Various blending combinations of biodiesel i.e. K20 (kharanja biodiesel 20% & diesel 80% by volume), K40 (kharanja biodiesel 40% and diesel 60% by volume), K60 (kharanja biodiesel 60% & diesel 40% by volume), K80 (kharanja biodiesel 80% & diesel 20% by volume), K100 (kharanja biodiesel 100%), are prepared as shown in Table 1 and Table 2.

Table 1: Various blends of biodiesel prepared

Sl No	Fuel samples	Kharanja of	+ Pure diesel = Quantity biodiesel obtained
1	D100	800ml	
2	K20	160ml	+ 640ml = 800ml
3	K40	320ml	+ 480 ml =800ml
4	K60	480ml	+ 320 ml =800ml
5	K80	640ml	+ 160 ml =800ml
6	K100	800ml	

Table 2: Physical and chemical properties of Kharanja oil

Properties	Values
Density	$0.92 gm/cm^3$
Acid value	5.06mg KOH/gm
Sapnofication value	186KOH/gm
Unsapnofiablle matter	2.6w/w %
Iodine value	86.5 g
Oil content	27-40%

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3 Experimental Methods

The experiments of performance and combustion characteristics were conducted on a stationary single cylinder four-stroke diesel engine and compare it with baseline data of diesel fuel. The engine is coupled with an eddy current dynamometer. The eddy current dynamometer was used for loading the engine figure 4 shown the photograph of the experimental set up

Fig 4: Experimental Set Up

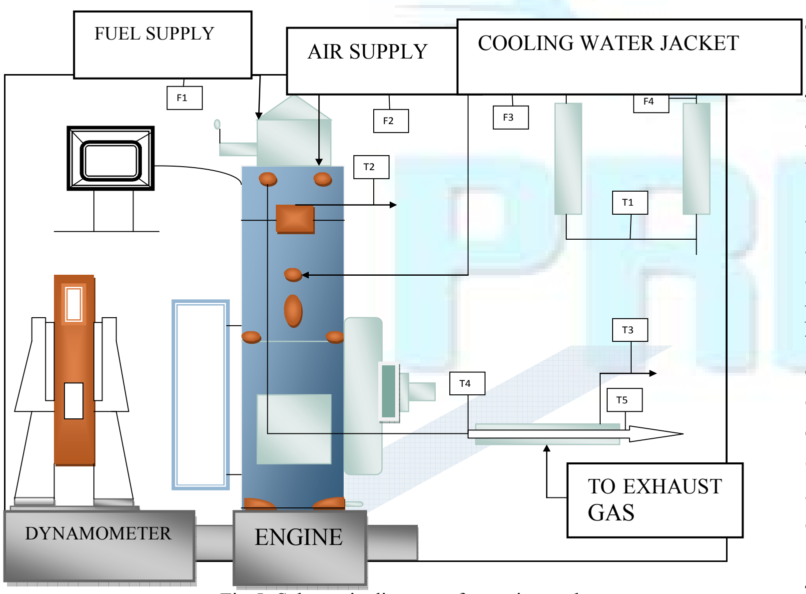

Fig 5: Schematic diagram of experimental setup.

Table 3: Engine specifications

1.	Name of Manufacturing company	Kirloskar oil and diesel engines limited. India
2.	Engine Model	Naturally aspirated TV-1.
3.	Design of engine	1-cylinder DI diesel engine.
4.	Diameter stroke length & CR	87.5mm 110mm & 17.5:1
5.	Rated power	5.2 KW
6.	Engine speed	Constant rpm of 1500
7.	Injection opening pressure & advance	190,205,220 bar & 23 degree before TDC
8.	Dynamometer	Eddy current
9.	Type of starting	Manually
10.	Flow measurement of air	'U' tube air box
11.	EGT	Thermocouple
12.	Flow measurement of fuel	Using burette with stop watch (digital)
13.	Governor	Mechanical governing (Centrifugal type)
14.	Sensor response	Piezo electric
15.	Time sampling	4 micro seconds
16.	Resolution crank	1^0 deg of crank angle
17.	Sensor angle	360^0 encoder with 1^0 of resolution

4. Result and discussions

4.1 Performance & their Emission analysis Characteristics of DI-CI Engine Fuelled with Kharanja Methyl Ester & Its Diesel Blends:

An attempt is made to study the performance and analysis of KME of K20, K40, K60, K80 and K100in a single cylinder DI diesel engine. Conventional diesel fuel & Kharanja methyl ester (KME) blends and injector pressures (190,205 and 220bar) are using for conducting the small term performance of engine test at varying different loads (0,3,6,9,12,15 and 18kg by maintaining engine speed (1500 rpm)constant. The Brake specific fuel consumption (BSFC, in Kg/kW-hr) and thermal efficiency ($\cap_{th}$ in %) are calculated from data is recorded. Other attempt is also made to find the emissions levels of diesel engine by selecting fuel test samples.

4.1.1 Load effect on BSFC:

Figure 4.1 to 4.3 shows the load effect on BSFC when engine runs on K100, K80, K60, K40, and K20 respectively. Below figures 6 to 8 indicates the increasing in the load (kg) of the engine BSFC is decreased. On the other hand the attentiveness of kharanja oil in the blend is more than 20%, the BSFC is found to be more than diesel at all loads. As the load increases in engine BSFC decreases for all other bio-fuel blends at all respective varying injection pressures. B100 has higher BSFC when compared with all blends and diesel at 205 bar pressure as compare to other pressures. The reason is lower heating value of kharanja bio-diesel.

As the density and calorific values blends are different as comparing with diesel fuel BSFC is not a reliable parameter. This because of they follow slightly different trend. Hence, in this work BSFC (Kg/kW-hr) was calculated and presented the variation of BSFC (Kg/kW-hr) with load (kg) for all selected test samples. Fig. 4.1 to 4.3 shows the variation of BSFC (Kg/kW-hr) with load (kg) at 190,205 and 220 bar pressures with blends of K20, K40, K60, K80 and K100 with conventional diesel oil. It was observed from the Figures.

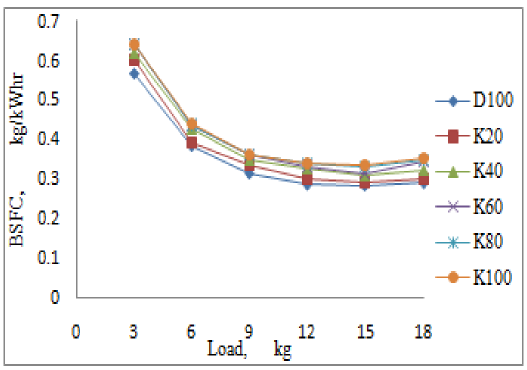

Fig 6: Load Effect on BSFC (Kg/kW-hr) for at 190bar Pressure.

That K100 at 205 bar pressure of K20, K40, K60, K80 and K100 methyl esters has maximum BSFC (Kg/kW-hr) gradually higher than conventional diesel oil at different rated load. It also shows that K20 at 190bar pressure of K20, K40, K60, K80 and K100 methyl esters has minimum BSFC (Kg/kW-hr). This is 1.05 times greater than that of conventional diesel oil at different loads. For all the selected test fuel, BSFC decreased with increase in the load up to the pressure at 12kg rated load and then it has increased with increase in load.

4.1.2 Load effect on brake thermal efficiency (BTE)

Figure 7 to 9 shows variations of thermal efficiency (η_{th} in %) with load (kg) for varying injection pressure to 190,205 and 220 bar with KME blends for a diesel fuel engine. From figure 4.4 to 4.6 it is shows the K20 has matching thermal efficiency as diesel. K20 curve nearly merged with the diesel line. At maximum or full loading time in use for whole combustion of fuel is decreased therefore a slight drop in η_{th} is observed. Diesel has higher BTE because of higher heating value than all other blends at varying injection pressure. At 220 bar pressure we found higher thermal efficiency than other pressures.

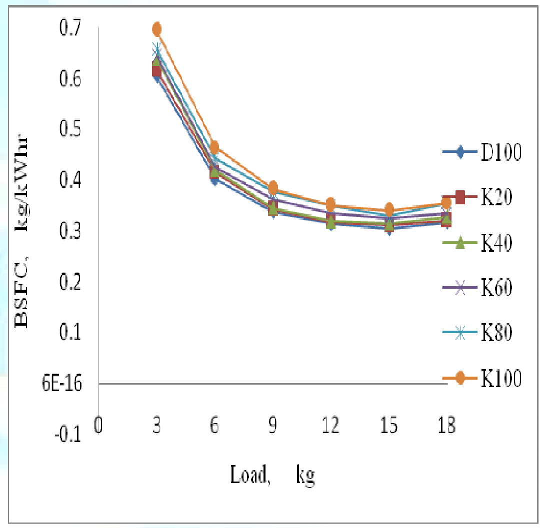

Fig 7: Load Effect on BSFC (Kg/kW-hr) for at 205bar Pressure.

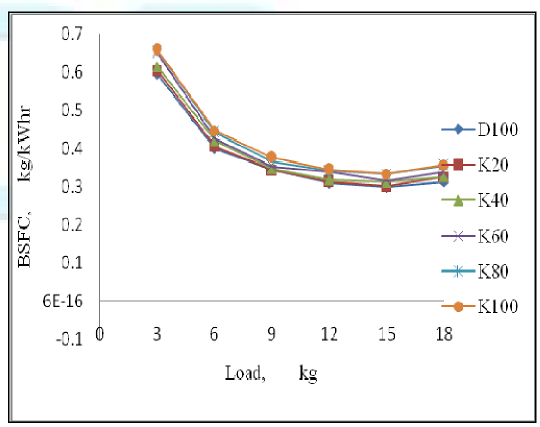

Fig. 8 Load effect on BSFC (Kg/kW-hr) at 220bar Pressure.

Fig. 7 to 9 shows variation of thermal efficiency ($\cap_{th\ in}$ %) with load (kg) with varying injection pressure to 190,205 and 220 bar with blends of K20, K40, K60, K80 and K100 with conventional fuel. $\cap_{th}$ (%) has increased with the increase in load (kg) and reached maximum value at rated load and given pressures. BTE (%) of conventional fuel is greater at all loading conditions.

BSFC fig 7 to 9 shows the increasing in the %tage of esters in their blends, the BTE is decreased. BTE of K20 of K20, K40, K60, K80 and K100 methyl esters has maximum at rated load. It also shows that K100 of K20, K40, K60, K80 and K100 methyl esters has minimum at full rated load. The efficiency is less due to the higher viscosity, low volatility & higher density. This effect the formation of fuel mixture & it leads to slower combustion. From these figures it was also observed that among the entire test samples, at B20 220 pressure has maximum thermal efficiency at rated load & at K100 190bar pressure of has minimum thermal efficiency on full load & given pressures.

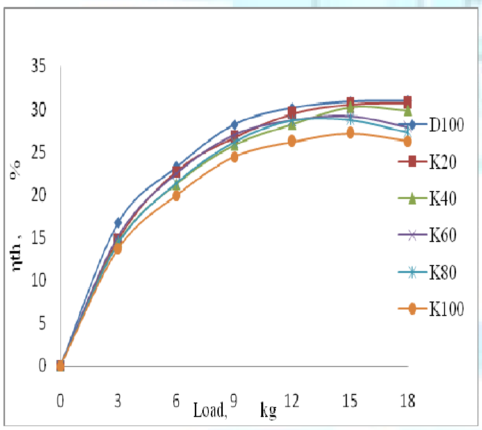

Fig. 7: Load effect on BTE in % at 190bar Pressure.

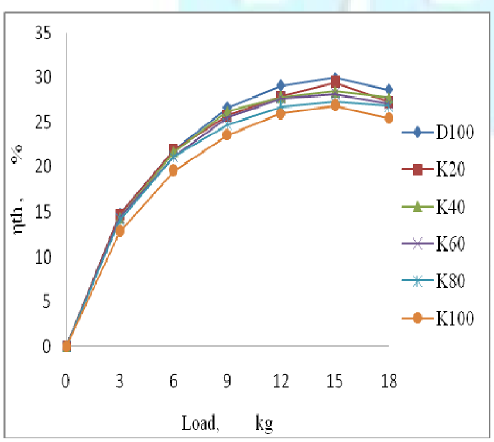

Fig 8: Load effect on BTE in % at 205bar Pressure

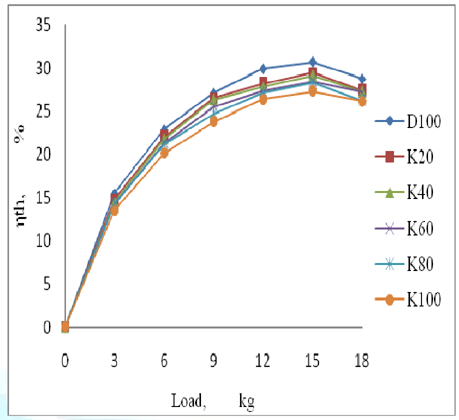

Fig 9: Load effect on BTE in % at 220bar Pressure.

4.2 Emission characteristics observations

4.2.1 Emission analysis:

Considerable research work is conducted on investigation of emission characteristics of diesel fuel engine using KME and their blends. Engine exhaust emission such as unburned hydrocarbon (UNBHC), oxides of nitrogen (NOX), carbon dioxide(CO_2), and carbon monoxide (CO_2) measured with five level gas analyzer (QROTECH QRO-401 Emission Analyzer) was carried out.

Fig 10 : Photographic view of Exhaust Gas Analyzer

The exhaust gas analyzer sensor is exposing the exhaust gas & readings are recorded & by varying injection opening pressure and respective loads on the engine. The engine is to kept constant speed at 1500rpm.

4.3 NO_X, CO, CO_2 and UNBHC emissions of diesel, blends of K20, K40, K60, K80 and K100 methyl esters at given load at 190,205 and 220 bar pressure respectively.

4.3.1 Oxides of nitrogen (NOX) emission characteristics

Figure 11 to 13 shows effect of load on NOx emission when engine is run on K20, K40, K60, K80, K100 & D100. Figure 11 to 13 indicating the NOx emissions are increasing with increase in the %tage of Bio-Diesel. 190 & 220 bars have minimum NOx emission (230 ppm, 236 ppm) at no load. K100 has maximum NOx emission at 205bar pressure. The reason of NOx emission of Kharanja oil biodiesel fuel is contributed towards inbuilt oxygen. 190 and 220 bar at no load fuel shows lower NOx emission compared to standard pressure. With changing in pressure in diesel engine & in kharanja methyl ester % in blend the oxygen content increase and hence higher blend shows higher NOx emission compared to standard pressure.

Fig. 11 to 13 shows variations of NO_X emissions with load (kg) at 190, 205, & 220 bar pressures of K20, K40, K60, K80 and K100 respectively. The results of NOx emissions are compared with convenrtional fuel used in engine. It is marked from the Fig. 11 to 13 as the load on the engine is increased; the emission of NOx is also increased slowly & reaches a maximum at part loads and 205bar pressures for all other type of test fuels.

Increase in the emission level of NOx with increase in the load has been observed. Because the NOx formation depends on the CGT & the oxygen availaibility. The load of the engine increases the CGT also increases due to the amount of fuel burning is increased so for this reasonthe NOx emission also increased.

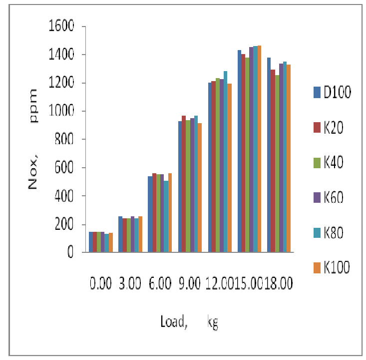

Fig. 11 Load effect on NOx emission (ppm) at 190bar Pressure.

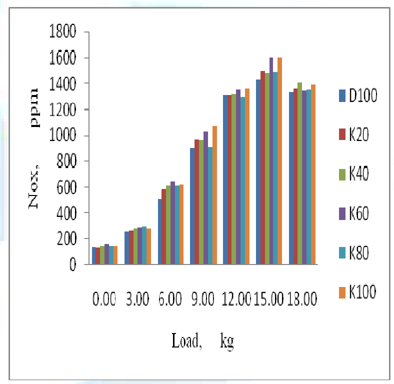

Fig. 12: Load effect on NOx emission (ppm) at 205bar Pressure.

Fig. 11 to 13 also indicates the gradually increasing in the NOx (PPM) emissions by increasing the %tage of the KME at any loading condition and given pressures.

Fig. 11 to 13 also shows that 190bar pressure of K20, K40, K60, K80 and K100 have minimum NOx emissions respectively at 0kg rated load. It also shows that 205bar pressure of K20, K40, K60, K80 and K100 has maximum NOx emissions at 100% full load. It is also observed among all the fuel samples 220bar pressure of B80 has maximum NOx emission at 15kg rated load.

4.3.2 Carbon monoxide (CO) emission

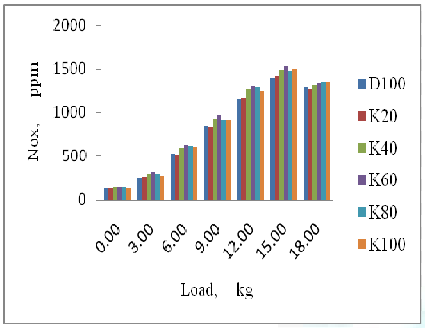

Fig. 13: Load effect on NOx emission (ppm) at 220bar Pressure.

characteristics

Fig 14 to 16 shows variations of carbon monoxide (CO) emission with varying load (kg) for 190bar, 205bar and 220bar pressures with blends of K20, K40, K60, K80 and K100 respectively. Obtained CO emissions results are compared with pure diesel. It is marked from Fig 14 to 16 shows as the load increase in the engine, CO emissions also increased step by step at low & part loads and also increased drastically at high loads for all other fuel blends. Fig 14 to 16 shows that CO emission for KME & their blends of fuels lower than that of base fuel diesel at all varying loads and pressure conditions.

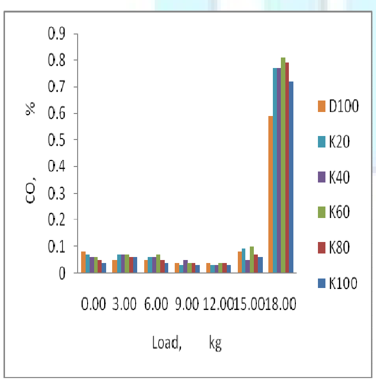

Fig. 14: Effect of Load on CO emission (ppm) at 190bar Pressure.

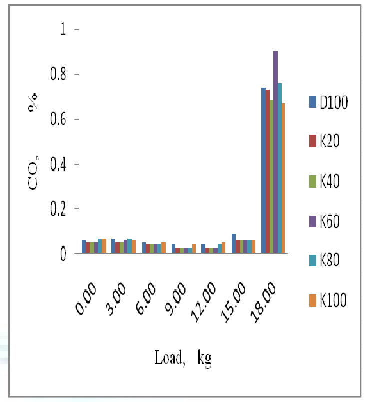

Fig. 15: Load effect on CO emission (%) at 205bar Pressure.

Due to high oxygen content in the esters & their blends. During engine exhaust process it will promotes the CO oxidations. Fig 14 to 16 also shows there is a slowly decrease in the emissions (CO) with increasing the %tage of KME and their blends at all loads and all varying pressures. Fig 14 to 16 also shows that K100 of K20, K40, K60, K80 and K100 has minimum CO emissions respectively at maximum loads and all varying pressures. It also shows that among all the test samples K100 at 190bar has minimum carbon monoxide emission at full load.

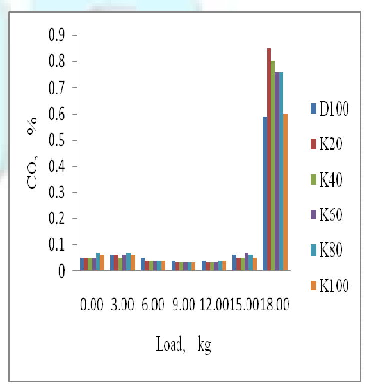

Fig. 16: Load effect on CO emission (%) at 220bar Pressure.

4.3.3Unburned hydrocarbon (UNBHC) emission characteristics.

Figure 17 to 19 shows the Load effect on HC emission when engine runs on K20, K40, K60, K80, K100 and D100 at varying injection pressure at 190, 205 and 220 bar respectively. Figure 17 to 19 shows HC emission increasing with increase of respective load and decreasing with increase in the %tage of blends. K100 has minimum HC emission at all loads and pressures. K20 is maximum HC emission on all loads and pressures.

UNBHC is a key factor in determining the emission of the engines because its results in incomplete combustion of engine. Fig 17 to 19 shows variation of UNBHC (PPM) emission with load (kg) for 190bar, 205bar, and 220bar pressures with blends of K20, K40, K60, K80 and K100 respectively. The results of UNBHC (PPM) emission compared to that of conventional diesel. Fig 17 to 19 shows as the load on the engine increased the UNBHC emissions increased at Zero & Part Loads. The emissions increased gradually at maximum load for all tested fuels.

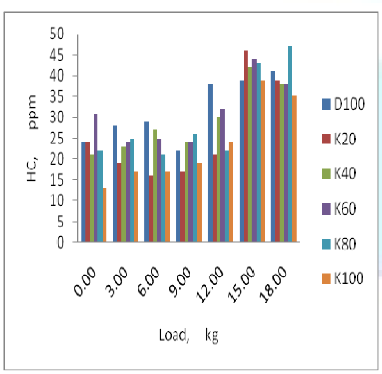

Fig. 17: Load effect on HC emission (ppm) at 190bar Pressure.

At maximum load on the engine, the quantity of the oxygen is less for the reaction. The more fuel is injected into the engine cylinder. Fig 17 to 19 shows UNBHC (PPM) emissions for KME & their blends of at all loading ranges is less compare with conventional fuel engine at 205bar pressure. The lower UNBHC emissions for KME and their blends also are due to their greater cetane number.

Fig 17 to 19 also indicates that there is an increase in the percentage reduction of UNBHC emissions with increase in the %tage of KME & blends at all loads.

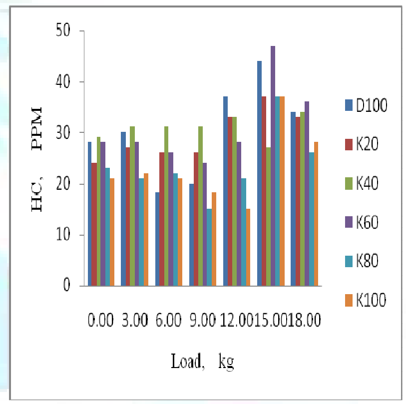

Fig 18: Load effect on HC emission (ppm) at 205bar Pressure.

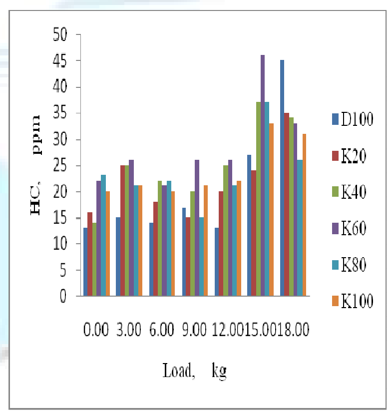

Fig 19: Load effect on HC emission (ppm) at 220bar Pressure.

Fig 17 to 19 also shows that K100 of K20, K40, K60, K80 and K100 have minimum UNBHC emission respectively at no load condition. It was also observed that among all the test samples K100 at 190bar pressure has minimum UNBHC emission at no load.

4.4 Comparisons & Variations of performance & emissions of different blends with different loads and at varying pressure:

4.4.1 Brake Specific Fuel Cosumption At 9kg and 15kg:

Fig 20 to 21 shows variation of BSFC with respect to varying injection pressures at 9 & 15 kg load. As compare to the both graphs the B100 is shows maximum fuel consumption in the both loads.

As compare to these loads the 9kg load at 190bar shows maximum fuel consumption and at 15kg load shows minimum fuel consumption. At higher load at higher pressure fuel consumption is comparatively less. And B20 near to pure diesel shows minimum fuel consumption in both loads.

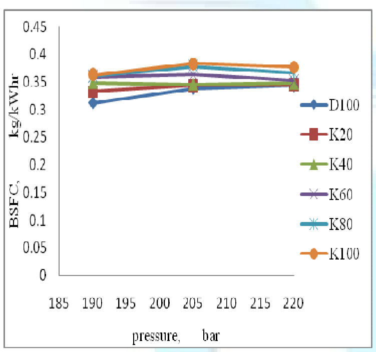

Fig 20: Pressure effect on BSFC (Kg/kW-hr) at 9kg load.

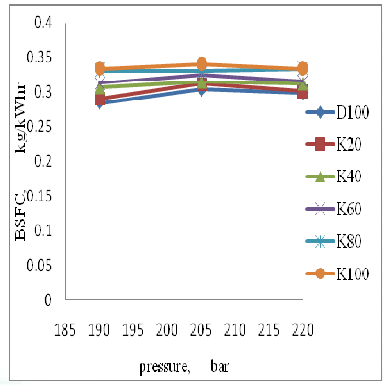

Fig 21: Pressure effect on BSFC (Kg/kW-hr) at 15kg load.

Fig 22 to 23 shows variations of $\cap_{th}$ efficiency of engine with different loads at varying pressures. At 9kg of 190bar pressure shows the greater thermal efficiency of engine compare to 15kg.

B100 shows the minimum thermal; efficiency at 220bar lower load lower pressure efficiency is more in both loads. The variation shows lower load lower pressure efficiency is more. Pure diesel shows the maximum thermal efficiency as compare to higher load B20 is almost near to the pure diesel.

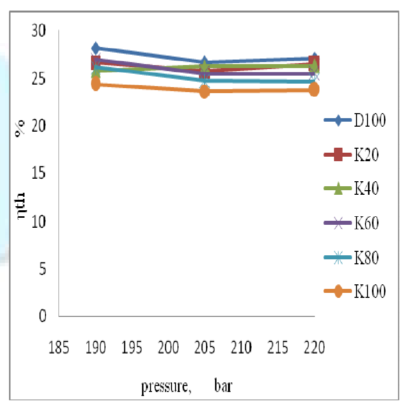

Fig 22: Pressure effect on BTE (%) at 9kg load.

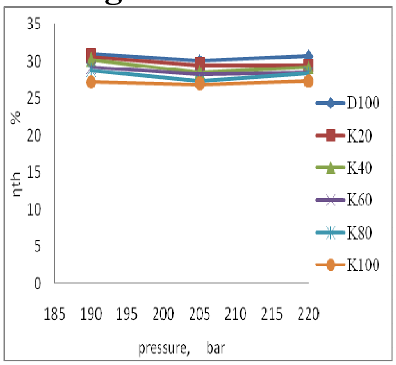

Fig. 23: Pressure effect on BTE (%) at 15kg load.

The present work is to improvise the diesel engine performance by varying fuel injection pressure of K20 biodiesel from 190bar, 205bar and 220bar through experimental investigation in the single cylinder DI-CI engine. The result mentioned in following steps:

The BTE at 15kg of load rises by 1.5% for K20 blend at 205 bar and 3.1% for K20 blend at 220bar, when equated to K20 blend at 190bar at 15kg of load due to the fuel sprayed diffuses with air entirely in combustion chamber and progresses the Characteristics of burning. The BSFC at maximum load decreases by 3.15% for K20 blend at 205 bar and 12.36% for K20 blend at 220bar, when equated to K20 blend at 205bar maximum load.

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