

**PERFORMANCE AND EMISSION CHARACTERISTICS OF COMPRESSION
IGNITION ENGINE FUELLED WITH CEIBA PENTANDRA AND
WATERMALON METHYL ESTERS**

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Abstract:

In the recent years, most commonly fossil fuels are more than 27% of the world's major consumption of energy. However, due to fluctuating price, environmental pollution and limited reserves. The development of alternative energy sources has become inevitable. In India, domestic demand of petroleum requirements is completed by importing of nearly 75% crude oil. In order to fulfill the requirements in the recent years, researchers have made various efforts for different energy sources for alternative fuels in diesel engine without any engine modification. The performance, emission and combustion test is conducted by three blend ratios likes B25, B50, B75 and B100 are prepared from CPME and WME to experimentally evaluate the performance and emission characteristics. The results proves that the brake thermal efficiency of B25 CPME and B25WME were 30.69% and 30.35% respectively. It is nearly close to diesel (31.88%). The emissions of CO, CO₂ HC, and smoke are reduced. The NO_x emissions are slightly higher compared to B100 CPME and B100 WME. From the experimental results, B25 CPME has proved to be best blend ratio when compared to other blends.

Introduction:

General:

In day to day life, the energy demands becomes increasing and fossil fuels are getting depleting, so we are in need to search renewable alternate fuels. At that time, the petroleum fuels acts an important role in the development of agricultural sector, transportation, industrial growth and to satisfy the primary necessities of humans. When the consumption is increasing rapidly these fuels are limited and depleting day by day. The utilization of fossil fuels is disturbing the environment and it makes so much of environmental problems in the society (i.e.) when the fossil fuel are burned it releases various smog –causing pollutant and greenhouse gases that lends to global warming. The conventional fossil fuels (diesel) used in a diesel engine, it releasing higher amounts of carbon dioxides (CO₂), oxide of sulphur (SO_x) particulate matter (PM), oxides of nitrogen (NO_x) and unburned hydrocarbon (HC). Moreover, CO₂ is the greenhouse gas but NO_x and SO_x causes "acid rain" (Altun and Lapuerta 2014). The particulate matter (PM) which emits from petroleum diesel engine causes several health hazards such as respiratory diseases, cardiovascular diseases and lung cancer. In addition to that, the fast depleting the petroleum fuels cause the threat of climatic change and fluctuating fuel cost. The expecting future populations about top ten countries are pointed out in Table 1 & 2. From the periods of 1950 to 2050 and 2100 to 2300 respectively. In a clear evident manner it shows that India will be the first position in terms of population with in the year 2050. (U.N. <http://www.un.org/esa/populations/longrange2/> world pop 2300 final. Pdf: 2004). While the population increases the usage of automobiles also increasing exponentially as well as the need of fossil fuel is also increasing rapidly.

Fuel Demand and Its Increase in Price:

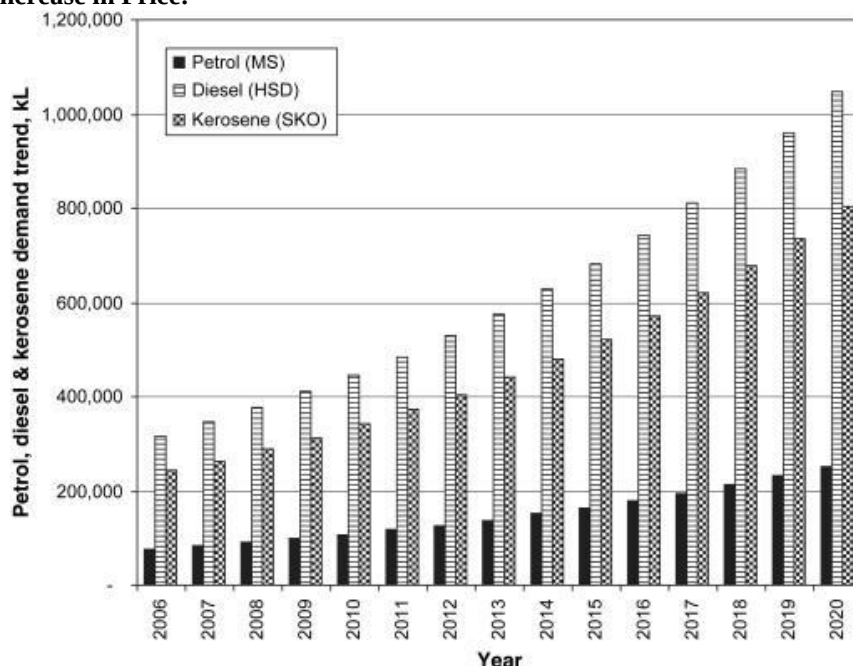


Figure1: Petrol, Diesel and Kerosene demand 2006 to 2020

Diesel fuel plays a major role in different sectors like agriculture industries, agriculture and transportation. Diesel fuel is also one of the unavailable and developing energy liquid fuel in India, due to the reason the diesel demand increasing, the fuel price also increasing. Since, we are importing approximately 75% of petroleum from other countries reported by Shukla et al., 2015. It becomes a great setback for the economy development of India against US dollars. Ale and Bade Shrestha (2008) reported that the year by year increased demand ratio of petrol, diesel and kerosene and it's evidently indicated that as compare with petrol and kerosene the usage and increasing the demand in diesel is higher as shown in Figure 1. So, the alternate source of energy research is a need of the day.

Mahuan Oil:

Puhan et al, (2005) reported that the performance and emission of a constant speed, direct injection, single cylinder, four stroke compression ignition diesel engine (Kirloskar) Using mahua biodiesel. The result exposed that diesel engine performance with biodiesel neither does not vary significantly. The brake thermal efficiency is 13% lower than that of diesel and brake specific fuel consumption is 20% higher than that of diesel. Exhaust emission pollutant are reduced when compared to diesel. Carbon monoxide, Hydro carbon, smoke and NOx are compared with diesel and it is decreased by 30%, 35%, 11% and 4% respectively. This experiment study observed by several researchers that NOx emission was increased with bio-diesel.

Karanja Oil:

Baiju et al. (2009) reported that the performance and exhaust emission characteristics using several blends of diesel and bio-diesel from karanja oil and by using base line fuel of petro diesel in a diesel engine. The result depicted that performance of engine does not vary greatly than diesel fuel. A little power loss, higher BSFC and lower BTE was observed due to lower calorific value of esters slightly produced higher power and emissions was lower than ethyl esters. They also found that at part loads when compare with conventional diesel fuel the emissions of NOx is increased by 10-25% when fuelled with diesel-biodiesel fuel blends. At maximum load, diesel emitted more NOx than esters and most of the major exhaust pollutants such as CO, HC and smoke were reduced with the use of neat bio-diesel and the blends. The study concluded that both methyl and ethyl ester of karanja oil can be used as a fuel in compression ignition engine without any engine modification.

Cotton Seed Oil:

Nabi et al. (2009) studied the effect of cotton seed oil bio-diesel on engine performance and emission. It was found that thermal efficiency of bio-diesel fuel was lower than that of diesel fuel due to the poor spray characteristics, higher density, viscosity and lower heating values of bio-diesel fuel. The emissions of CO, PM and smoke from biodiesel was lesser than that of neat diesel fuel. But, NOx emission with bio-diesel mixtures was higher compared to neat diesel fuel. For instance, with 10% bio-diesel mixtures (B10) PM and smoke emission reduced by 24% and 14% respectively. While bio-diesel mixture of 30% (B30) reduced CO emissions by 24% and NOx emissions increased by 10%. The authors attributed the reduction in PM, smoke and CO emissions and increased in NOx emission with biodiesel mixtures to the presence of oxygen in their molecular structure as well as low aromatics in the bio-diesel blend.

Jatropha Oil:

Chauhan et al. (2012) evaluated the performance and exhaust emissions using 5%, 10%, 20% and 30% jatropha bio-diesel blended with diesel fuel on an unmodified diesel engine. The experimental results showed the engine performance with bio-diesel of jatropha and its blends were comparable to the performance of diesel fuel. In case of all fuel blends, brake thermal efficiency, HC, CO, CO₂ and smoke density were lower while BSFC and NOx were higher than that of diesel. The authors concluded that biodiesel derived from jatropha and its blends could be used in a conventional diesel engine without any modification. However, there were various parameters which could be evaluated in future such as the prediction of best blend with respect to the various engine parameters by varying spray time of fuel using common rail fuel injection.

Tobacco Seed Oil:

Usta et al (2005) evaluated the performance and exhaust emissions of a turbo charged indirect injection diesel engine using 10%, 17.5% and 25% tobacco seed oil methyl ester blend (TSOME). The authors found that the addition of up to 25% in volume TSOME did not cause any significant variation in the engine torque and power. Although the heating value of the TSOME is 10% less than that of the diesel fuel. Moreover, the blending of tobacco seed oil methyl ester to the diesel fuel reduced CO due to the fact that TSOME contained about 11.4% oxygen by weight and SO₂ emissions due to low sulphur content while causing slightly higher NOx emissions due to higher combustion temperature. The key points from the above discussion are, The four-stroke DI-CI engine are indispensable in major areas of transport, agriculture, etc. and it will be very difficult to replace it with any other type of power plant. The increased bio-diesel percentage of blends significantly reduced CO, HC and smoke due to the presence of oxygen in the fuel. However, slightly increased NOx emission due to the higher combustion chamber temperature and Exhaust Gas Temperature (EGT)

Objectives of the Study:

By under viewing the review of literature, the following objectives were outlined for the present work:

- To study the DI-CI engine performance characteristics fuelled with pine oil-CPME-WME and its diesel blends.
- To study the DI-CI engine emission characteristics fuelled with pine oil-CPME-WME and its diesel blends.

Performance and Emission Characteristics:

A series of experiments has been conducted on a single cylinder four stroke 3.7kW direct injection diesel engine fuelled with diesel, pine oil, bio-diesel from CPME, WME and diesel blends. The tests were carried out in the standard injection timing (23° BTDC). The important results of the experimental work are presented in the following sections. The configurations of different fuel blends are given in Table 3.

Table 3: Configuration of the different fuels

S.No	Description	Abbreviation
1	Diesel	DI
2	Ceibapentandra Oil Methyl Ester	CPME
3	Watermelon Oil Methyl Ester	WME

Brake Thermal Efficiency (Performance Parameters):

The following sections describe the disparity of brake thermal efficiency with respect to brake power for biodiesel-diesel blends of CPME, WME and diesel. Figure 2 and Figure 3 shows the variation of brake thermal efficiency with brake power for CPME, WME and its blends. The calorific value of bio-diesel is lower and the BSFC of biodiesel was much higher compared to base diesel operation condition. Since, the brake thermal efficiency is inversely proportional to its BSFC and heating value of fuel. For all the blends, the brake thermal efficiency has the propensity to increase with increase in applied brake power. At full load conditions, among the B25, B50, B75 and B100 bio-diesel blends up to B25 has a maximum brake thermal efficiency of 30.69%, 30.35% and 31.88% respectively, for CPME, WME and diesel. At full load conditions, the brake thermal efficiency up to B25 is almost closer to that of base diesel which is depicted in figure 5.14 and 5.15. As compared to B100 bio-diesel operation the brake thermal efficiency of B25 has increased by 3.76% and 3.28% for CPME and WME. It may be due to enhanced spray characteristics and dissolved oxygen molecule structure in bio-diesel of B25 blend of CPME and WME in the combustion chamber, which leads to effective utilization of air resulting in complete combustion of the fuel.

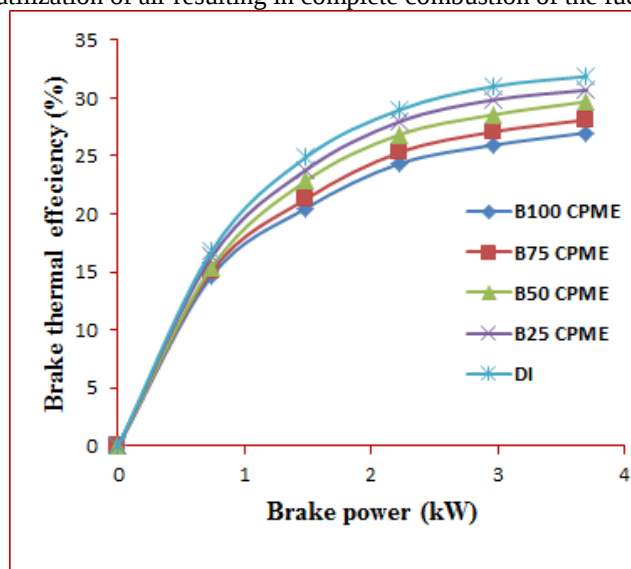


Figure 2: The variation of brake thermal efficiency for CPME

It is also evident from the plots that when the brake thermal efficiency is gradually decrease, the percentage of bio-diesel (CPME and WME) from B50 to B100 is gradually increase. The reason for that is the supply of biodiesel fuel to the engine is high as compare with base diesel, in order to maintain the equal energy input to the engine. The high viscous of the blended fuels inhibits the fuel vaporization, proper atomization and combustion. This trend is also due to the combined effect of lower heating value, higher viscosity and density of the blended fuel. In addition to this, studies conducted by pervious researchers Abedin et al (2016). From the experimental results proved that performance of ceibapentandra methyl ester (CPME) B25 blend is the best fuel compared to WME and other blends.

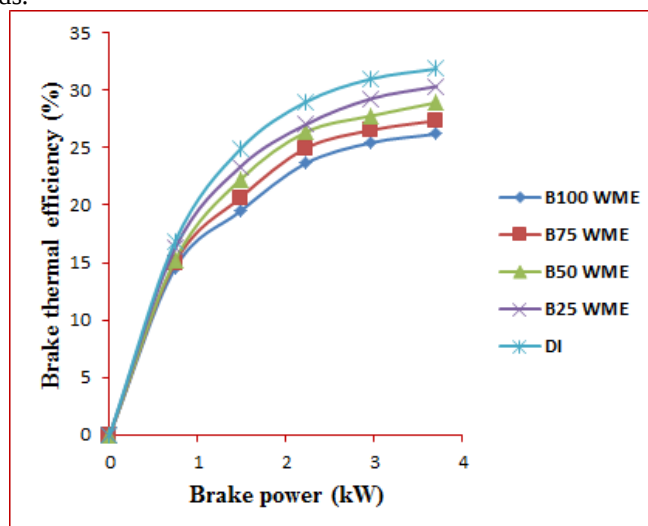


Figure 3: The variation of brake thermal efficiency for WME

Carbon Monoxide (CO):

The variation of carbon monoxide (CO) emissions with respect to brake power presented in Figure 4 and Figure 5 are discussed for CPME and WME and its blends with diesel. The characteristics of DI-CI engine shows when the load increases the air fuel ratio decreased. Usually, lower CO emissions emits CI engine due to excess air. CO is mainly dependent on the air-fuel ratio relatively to the chemically correct proportion and increase the air-fuel ratio becomes more than stoichiometric air-fuel requirements stated by (Kalam et al 2003). It could be seen from Figure 4 and Figure 5 that the CPME and WME fuelled engine emits less CO emission in compare with diesel fuelled. Because bio-diesel is an oxygenated fuel, which helps for complete combustion; reduction of CO emissions were observed in the experimental work. It is also clear from the plots the minimum CO emissions were observed with B100 for CPME and WME becomes maximum of 0.14 and 0.15 by % in vol. at full load condition. The combustion of biodiesel presence of extra oxygen molecule in the bio-diesel chain might have converted some of the CO in to CO₂ and reduced CO formation. Similar finding were noted with CO in the experimental work conducted by Datta and Mandal (2016).

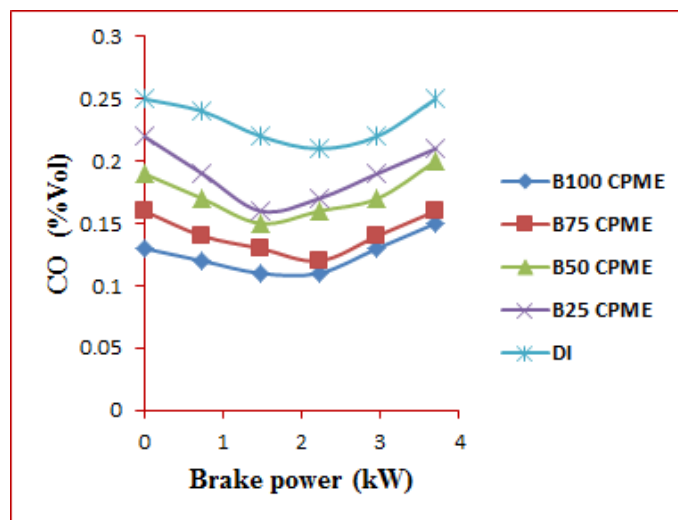


Figure 4: The Variation of COE mission for CPME

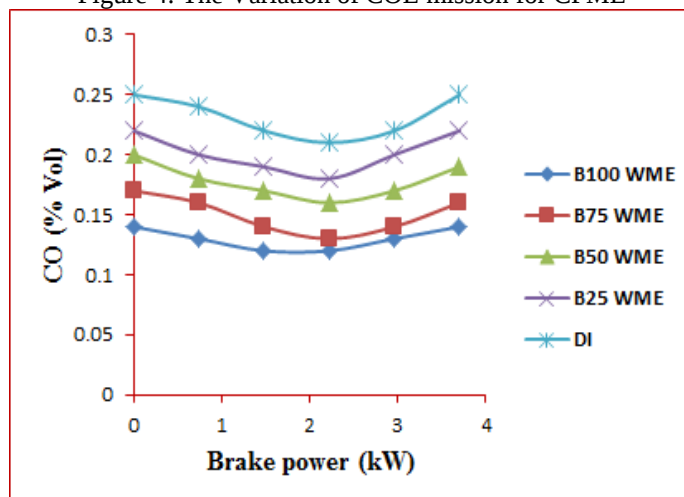
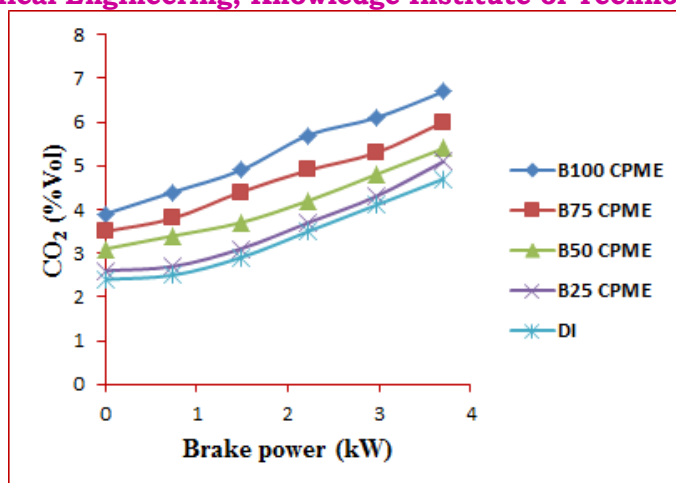
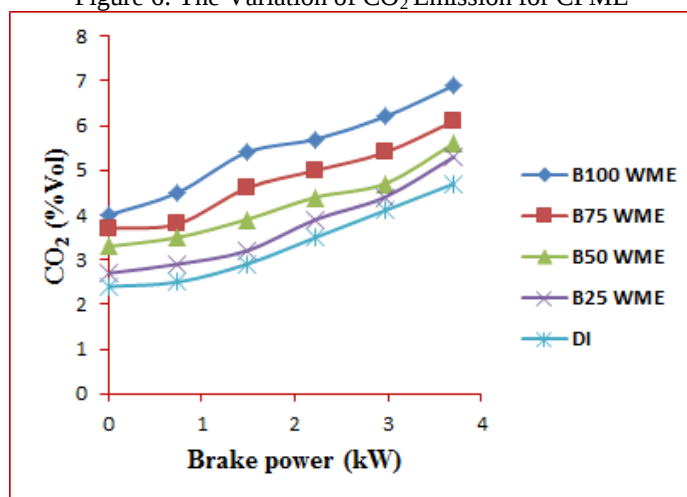


Figure 5: The Variation of COE mission for WME

Carbon Dioxide:

Figure 6 and Figure 7 show the variation of carbon dioxide (CO₂) emissions in percentage in volume with brake power for diesel, CPME, WME and its blends. This measurements reveals that the brake power increases with increases in CO₂ emissions; it indicates the combustion chamber efficiency, When compared with diesel the B25 percentage of blends emit almost same amount of CO₂ emission. This is because bio-diesel is generally a lower elemental carbon to hydrogen ratio and has a low carbon fuel than base diesel fuel. The ratio of the blends increases from B50 to B100, there is a slight increase in CO₂ emission which is due to more oxygen content of methyl esters. In B100, the value of CO₂ for CPME and WME were emits 6.7% and 6.9 % by vol. respectively and more CO₂ emissions in compression with base diesel. The insignificant differences were observed between bio-diesel blends and diesel from B25 to B100. In general, bio diesel themselves are considered carbon neutral because, all the CO₂ released during combustion has been sequestered from the atmosphere during the process of photosynthesis for the growth of vegetable oil crops, which are later processed into fuel. Hence, bio diesel also helps to mitigate global warming, as carbon dioxide levels are kept in balance. These results are in accordance with experimental work done by Suresh Kumar et al (2008).

Figure 6: The Variation of CO₂ Emission for CPMEFigure 7: The Variation of CO₂ Emission for WME**Conclusions:**

The following conclusions were drawn in the present experimental work

- The trans-esterification process improved the fuel properties of the oil with respect to relative density, viscosity, flash point, cloud point, pour point and calorific value. The methyl esters properties of ceibapentandra with pine oil blends physic-chemical characteristics are near to ASTM standards.
- Biodiesel is produced from ceibapentandra seed oil and watermelon seed oil. The catalyst KOH is found to be superior than NaOH, So, KOH is the best suitable catalyst of methanolysis process.
- The engine performance of B25 blend (30.69%) is nearly similar to that of diesel (31.88%) at the same time not affected the engine performance.
- Compared with diesel, bio-diesel-diesel blends emit lower CO, HC, smoke and slightly increased CO₂ emission. From the experimental results proved that performance of ceibapentandra methyl ester B25 best blended fuel compared to WME and other blends.

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