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Performance, Combustionand Emission characteristics of DI diesel engine fueled with Neem oil and Tyre oil blends

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ABSTRACT

The demand and price of petroleum based fuels are increasing at an alarming rate. If this situation continues there is every chance for the scarcity of petroleum products. A major solution to reduce this problem is to search for an alternative fuel. One of the best alternatives is Biodiesels obtained from different vegetable oils.

In this project, the biodiesel from non-edible neem oil (Azadirachta indica) and edible neem oil (Gossypium hirsutum) is prepared by the method of two-step 'acid-base' process. An experimental investigation has been carried out to analyze the performance, emission, and combustion characteristics of a diesel engine fueled with neem oil & neem oilmethyl ester and its blends.the blends will be prepared by the varying of 5% of biofuel with diesel with ***effect of using neem oil & neemoil and its diesel blends at different loads.***

The results will show that maximum cylinder pressure and maximum rate of heat release increased with the increase in bio diesel blends. The carbon monoxide (CO) and smoke emissions may found significantly lower when operating on biodiesel & diesel blends, Nitrogen Oxide (NOx) emissions will found at full load. This study will reveal that the performance of the engine with these biodiesel blends differ marginally from diesel and its blends. The performance of individual and mixture of both biofuels will be compared.

KEYWORDS:Engine, bio fuel, neem oil, Tyre oil, blends, performance, emissions

1. INTRODUCTION

Fossil fuel consumption is steadily rising in industrial as well as in transportation sector as a result of population growth in addition to improvements in the standard of living. The continually depleting resources of fossil fuel and the highly toxic emissions which are produced due to these fuels have largely hastened the need for alternate fuels for internal combustion (IC) engines. Several fuels have been tried for running internal combustion engines. These include straight vegetable oil, biodiesel, alcohol, natural gas and hydrogen. Hydrogen has been found to have several properties which are essential for a green alternate fuel to be used in IC engines. Its high auto ignition temperature and low ignition energy coupled with its various other combustive properties help in enhancing engine performance. The high diffusivity of hydrogen which is about four times that of gasoline improves the mixing process of fuel and air. As the burning velocity rises the actual indicator diagram is nearer to the ideal diagram and the thermodynamic efficiency increases.

1.1 SOURCES OF LIQUID BIOFUELS FOR AUTOMOBILES

The sources of liquid biofuels are summarized and depicted in the Figure-2, below:

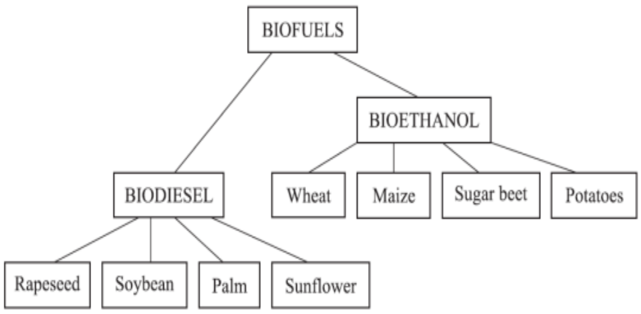


Figure-1: Sources of liquid biofuels for automobiles

1.2 BROAD CLASSIFICATION OF BIOFUELS

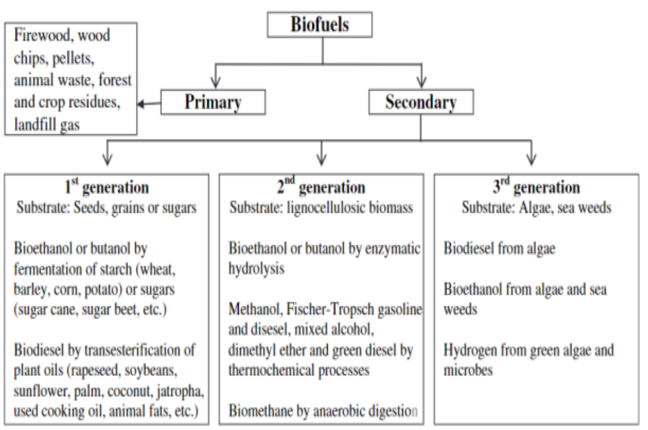


Figure-2: Broad classification of biofuels

1.3. HEAT ENGINE

Aheatengineisamachine,whichconvertsheatenergyin tomechanicalenergy.Thecombustion of fuel such as coal, petrol, diesel generates heat. This heat is supplied to aworking substance at high temperature. By the expansion of this substance in suitablemachines,heatenergyisconvertedintousefulw ork.Heatenginescanbefurtherdividedintotwotypes:

(i) Externalcombustionand
(ii) Internalcombustion.

Inasteamenginethecombustionoffueltakesplaceoutsi detheengineandthesteamthusformedisusedtorunthe engine.Thus,itisknownas*externalcombustionengine.*Int hecase of *internal combustion engine,* the combustion of fuel takes place inside the enginecylinderitself.

TheICenginecanbefurtherclassifiedas:(i)stationaryor mobile,(ii)horizontalorverti-cal and (iii) low, medium or high speed. The two distinct types of IC engines used for eithermobileorstationaryoperationsare:(i)dieseland(i i)carburettor.

2. LITERATURE REVIEW

An et al. [1] investigated the influence of the use of waste cooking oil biodiesel/blend fuels on performance, combustion and emission characteristics in a Euro IV diesel engine under low engine speed and partial load conditions. They found that engine performance, combustion and emission characteristics were improved with biodiesel addition.

Raman et al. [2] studied the performance characteristics of a single cylinder vertical cylinder direct injection diesel engine with rapeseed oil biodiesel blends. It was found that the CO and HC emission of the diesel engine fueled with biodiesel and its blends were lower than diesel fuel.

A ˘gbulut et al. [3] compared the effects of diesel-biodiesel and various metal-oxide based nanoparticles (TiO2, Al2O3, and SiO2) blends on combustion, performance, and exhaust emission characteristics of a single-cylinder diesel engine. The results showed that all metal-oxide based nanoparticles increased the cetane number, oxygen content, viscosity, and heating value of biodiesel.

Asokan et al. [4] investigated the performance, combustion and emission characteristics of a single cylinder diesel engine fueled with diesel-juliflora biodiesel blends (B20, B30, B40, B100). They reported that the CO, HC and smoke for biodiesel and its blends are smaller or equal compared to diesel; however, the brake thermal efficiency (BTE) for B100 is 31.11% and it is closer to diesel (32.05%) at full load. In summary, the biodiesel is oxygenated fuel, which has an oxygen self-supported effect in the combustion process, therefore, adding biodiesel to diesel can help to improve the mixture, especially to reduce soot and PM emissions from diesel engines.

3. EXPERIMENTAL SETUP AND METHODOLOGY

3.1 Production of Tyre Pyrolysis Oil

Since the number of automobiles used in India is less than the developed countries, the problems related to disposal of waste tyres is not seriously realized as on today. But it is supposed to become a serious problem in the near future. Hence, proper treatment methods for waste tyres have to be put in place in advance.

Table 1: Input Tyres to Finished Products Output Ratio

Input Material	Input Quantity	Output quantity
Waste mixed plastic scrap	10,000kgs	- 6,500 to 9,000 lit of Pyrolysis Oil - 500 to 1,000 Kg of Hydrocarbon Gas - 500 to 700 Kg of carbon Black
Nylon Scrap Tyres	10,000kgs	- 4,500 to 5,000 lit of Pyrolysis Oil - 1,000 to 1,200 Kg of Hydrocarbon Gas - 3,000 to 3,500 Kg of carbon Black
Radial Scrap Tyres	10,000kgs	- 4,000 to 4,500 lit of Pyrolysis Oil - 800 to 1,000 Kg of Hydrocarbon Gas - 2,750 to 3,250 Kg of carbon Black - 800 to 1,000 kgs of Mild steel wire scrap

A tyre is artificially engineered by the human mind. It contains chemicals, rubber, steel and fabric. Approximately 80% of the original constituents remain at the end of its service. The theory to reduce, reuse and recycle is difficult to implement with tyres owing to their complex nature, durability, varying size, numbers involved and different dimensions.

3.2 Pyrolysis of tyres

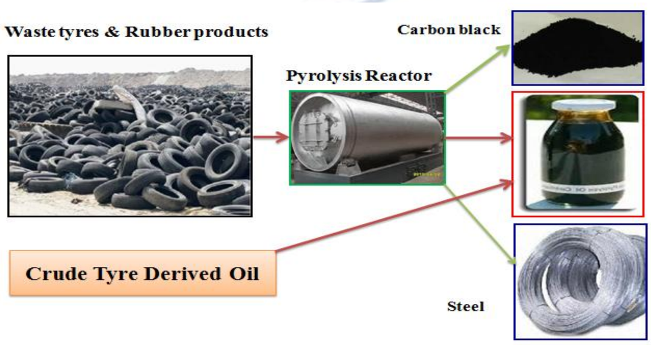


Figure 3 Products from Waste Tyres after Pyrolysis

A car tyre has a mass of about 8.5 kg, whereas the mass of a tyre of a passenger or light duty vehicle is around 11 kg. The constituents of truck tyre are given in Table .The various parts of an automobile tyre include bead, bundle, body, belt, cap sidewall and tread.

The raw materials used in tyres include synthetic and natural rubber, nylon, polyester cord, carbon black, sulphur, oil resin and other chemicals. These constituents provide the tyre with a good strength and flexibility to ensure adequate road holding properties under all conditions. About 80% of mass of car tyres and 75% of mass of truck tyres are rubber compounds. The components of tyre manufactured by different manufacturers are very similar. The tread portion of a tyre is primarily used for energy recovery to obtain TPO, pyro gas and carbon black.

Table 2: Components of truck Tyre

Component	Proportion (%)
Carbon Black	40
Oil	43.5
Steel Wire	16.5

3.3 Methods of Extraction of Oil

Neem essential oil is usually prepared from the seed kernels and is well known for its high insecticidal and medicinal value (Lokanadhan et al., 2012). The fruit, flower, and leaves are

minor sources of neem essential oil (Narsing Rao et al., 2014). According to a survey, only 20% of the seeds are being harvested due to scattered growth of neem trees in India.

Fig 4: neem oil

Out of it, India produces approximately 8300 tonnes of neem oil annually. In general, the neem oil yield reported from seeds varies from 25% to 45% (Anya et al., 2012; Ismadji et al., 2012). Mechanical pressing, solvent extraction, and more recently, supercritical fluid extraction (SFE) are among the numerous methods to extract neem seed oil (NSO) (Liauw et al., 2008).

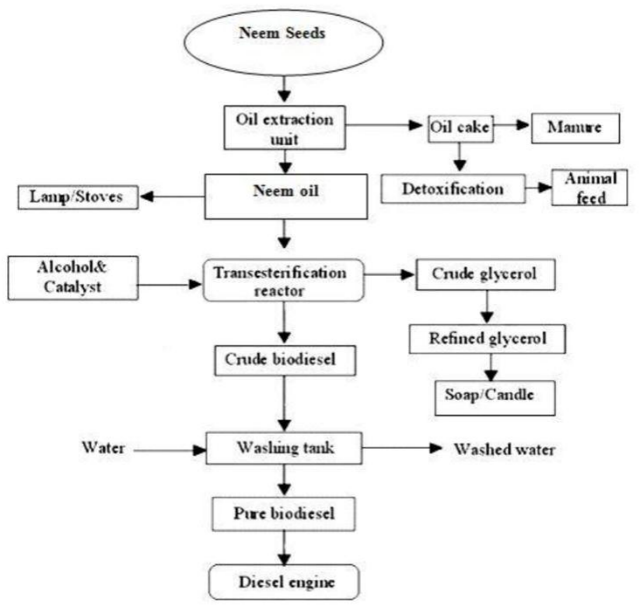


Fig 5: Neem oil extraction process

In the mechanical method, cold pressing or temperature-controlled pressing can be employed to procure oil from the neem seed kernel via physical crushing. Approximately 82% of the neem oil can be recovered by the mechanical extraction method. Although mechanical pressing is a frequently used technique, neem oil acquired with this process has poor quality due to it low azadirachtin content (1427 ± 51 ppm, 25.3%), suggesting nonselectivity of the extraction process. Moreover, oil produced by mechanical pressing is turbid, containing a considerable amount of water and metal content, and hence it has cheap market value (Adeeko and Ajibola, 1990; Lalea and Abdulrahman, 1999). According to a study conducted by Nitiema-Yefanova et al. (2012), the oil yield by cold pressing has a positive effect on increased kernel compression, reduced particle size, and decreased.

3.4 DIFFERENT TYPES OF BLENDS

The different types of blended bio fuels used in these projects are

1. DIESEL : 100% PURE DIESEL
2. D90T10N0 : 90%DIES 10%TYREOIL0%NEEM OIL
3. D80T20N0 : 80% DIESEL20%TYREOIL 0%NEEM OIL
4. C10T0D80 : 80% DIESEL0%TYREOIL 10%NEEM OIL
5. D80T0N20 : 80% DIESEL0%TYREOIL 20%NEEM OIL
6. D90T5N5 : 90% DIESEL5%TYREOIL 5%NEEM OIL
7. D80T10N10 : 80% DIESEL10%TYREOIL 10%NEEM OIL
8. D70T15N15 : 70% DIESEL15%TYREOIL 15%NEEM OIL

3.5 System requirements

We need following minimum hardware to use Engine Analysis Soft.

- **Personal computer**: PC Pentium 1V, 512 MB RAM ,a VGA card , 2 serial ports , parallel port , 40 GB hard disk space , key board and CD drive with an optical mouse and keyboard .
- **Monitor**: VGA Monitor /TFT Monitor.
- **RS -232Communication port:** COM port for interfacing data. Select one port, COM 1 or COM 2.
- **CD drive:** required for installing software.
- **Operating system:** Use Windows 98 and above.
- **Printer**: Windows compatible A 4-size printer.

Figure 6: Computer System

Engine : 4 - stroke 1- cylinder water cooled Diesel engine
Make : Kirloskar
Rated power : 3.7Kw (5 HP)
Bore dia : 80mm
Stroke length : 110mm
Connecting rod length : 234mm
Swept volume : 562cc
Compression ratio : 16.5: 1

Rated Speed : 1500 rpm

3.6 Dynamometer

Dynamometer: Eddy current dynamometer

Make: POWER MAG

Rated torque: 24N-m

Arm length: 150mm

3.7 Test rig constants

Orifice dia: 20mm

Density of air: 1.193 kg/m^3

Density of water: 1000 kg / m^3

Density of petrol: 0.73 gram /cc

CV of diesel: 44500 kJ/kg

Value of cd: 0.62

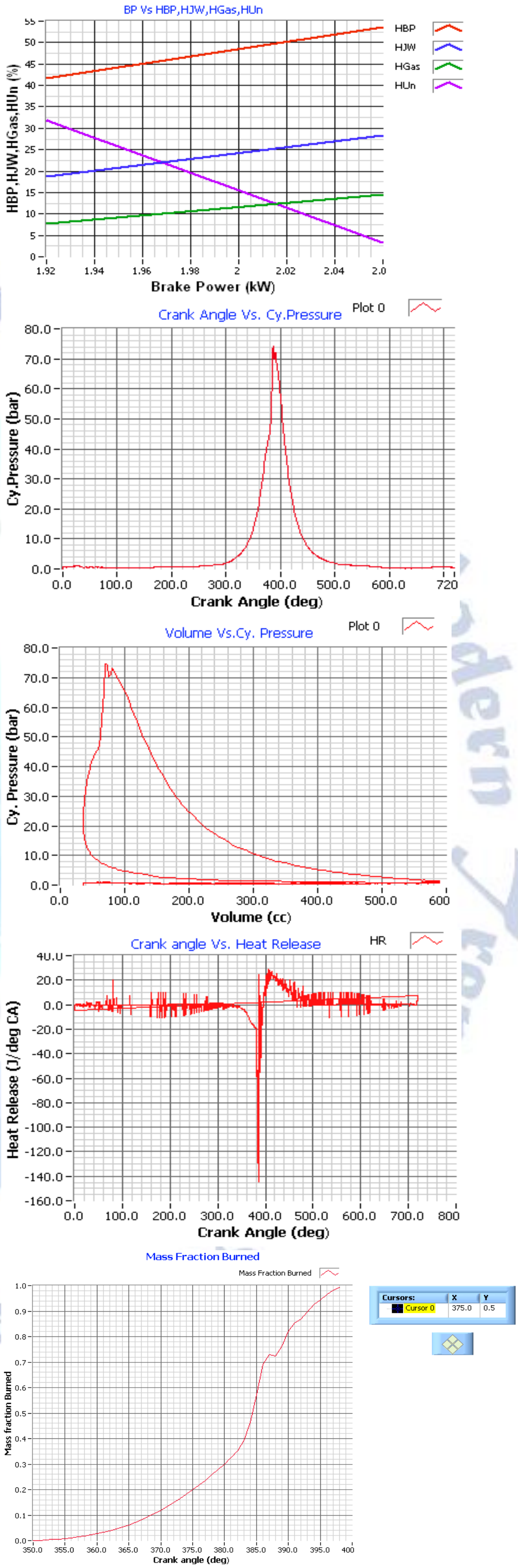
Value of '' Cp" for water: 4. 18 Kj /kg ^{0}K

4. RESULTS AND DISCUSSIONS

4.1 PERFORMANCE PARAMETERS

Table 3: blends properties

S. No	Blend	Viscosity (Stokes)	CV (kj/kg)	Flash Point t(^{0}C)	Fire Point (^{0}C)	Density 45 ^{0}C (Kg/m^3)
1	DIESEL	2.65	46000	55	61	640
2	D90T10N0	2.40	44230	54	59	650
3	D80T20N0	2.29	43250	52	57	660
4	D90T0N10	3.41	42120	57	65	640
5	D90T5N5	3.39	43630	51	59	660
6	D80T10N10	3.37	44860	55	69	670
7	D80T0N20	4.32	41750	61	71	650
8	D70T15N15	4.28	44120	64	70	60
9	TYRE OIL	1.64	41320	46	49	670
10	NEEM OIL	6.3	33240	146	158	670



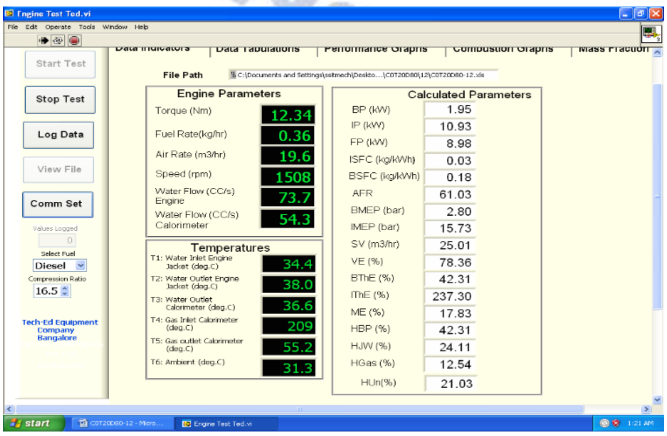
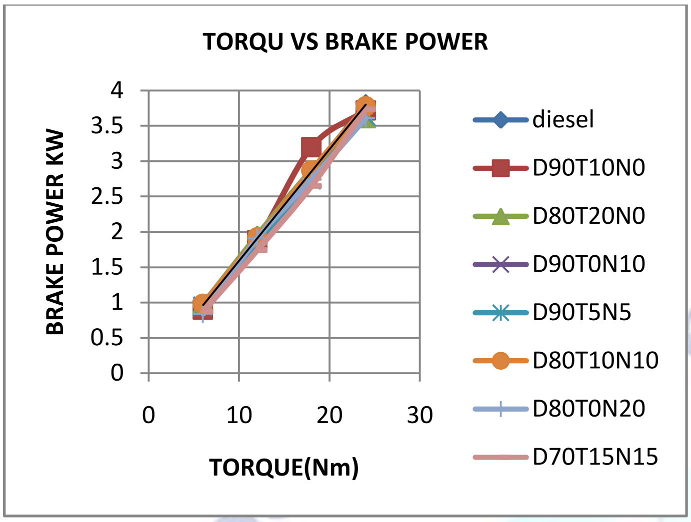
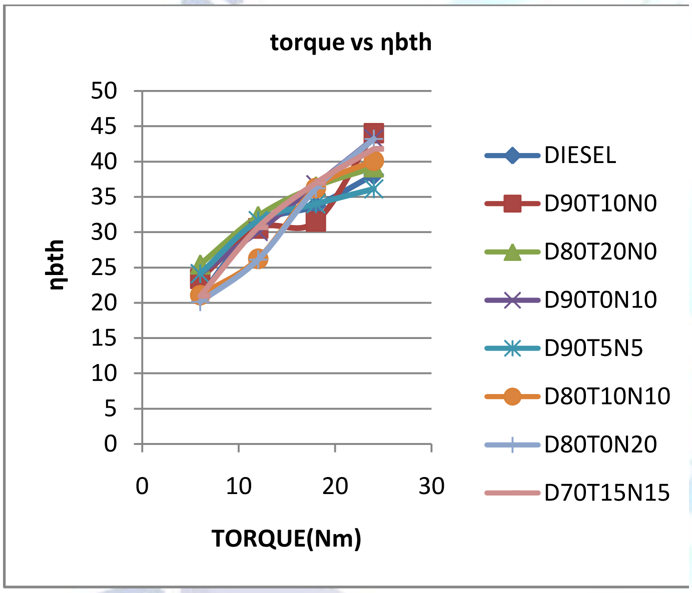


Fig 7: System generated data

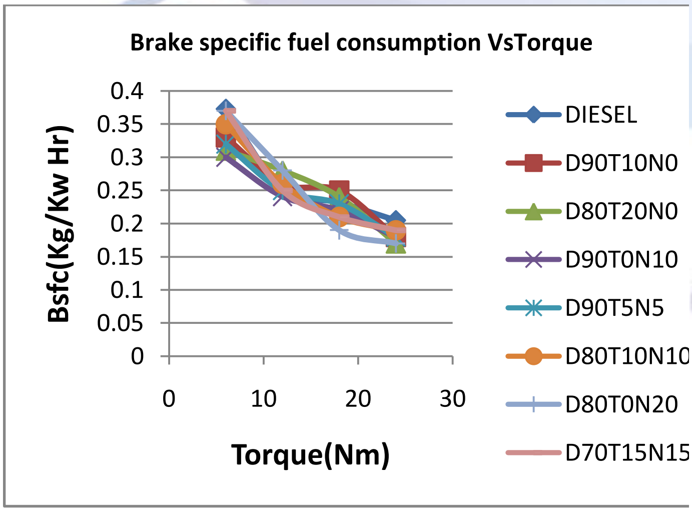
4.1.1 Brake power (kW) Vs Torque (Nm)



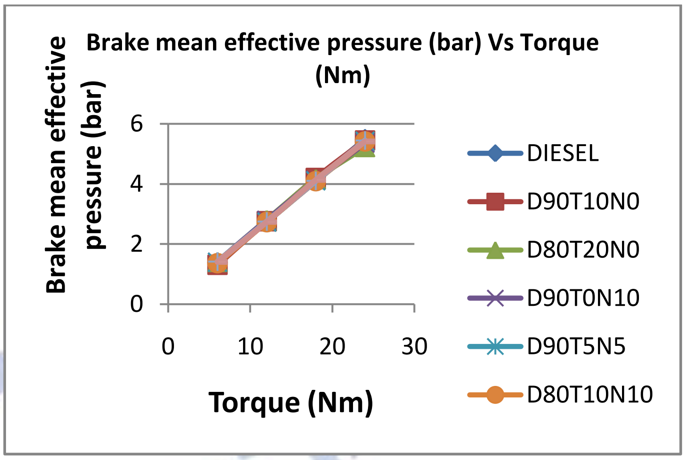
Graph 1: Variation of Brake power (kW) with



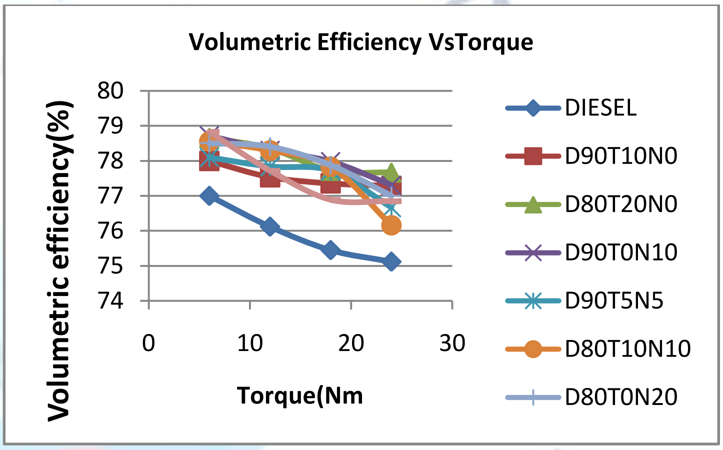
Graph 2: Variation of Brake Thermal Efficiency (%) with Torque (Nm)



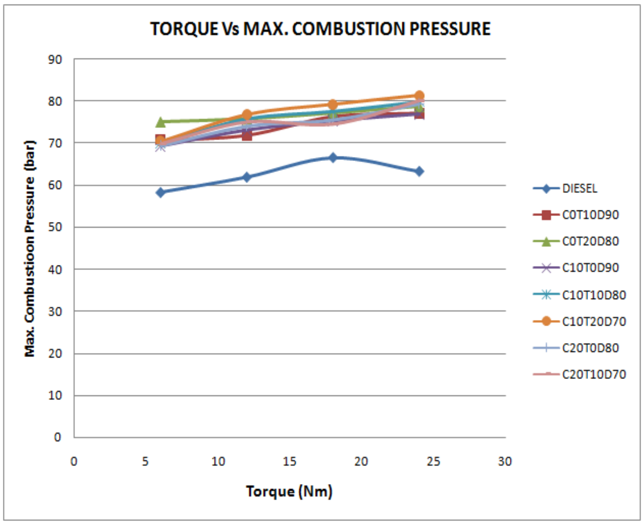
Graph 3: Variation of Brake Specific fuel consumption (Kg/Kw Hr) with Torque (Nm)



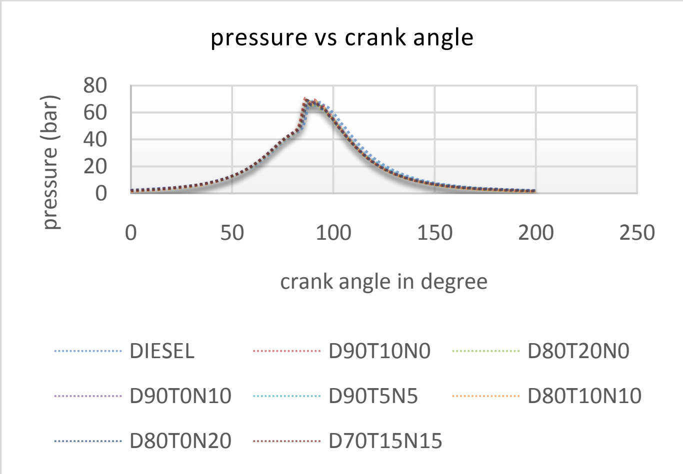
Graph 4: Variation of Brake mean effective pressure (bar) with Torque (Nm)



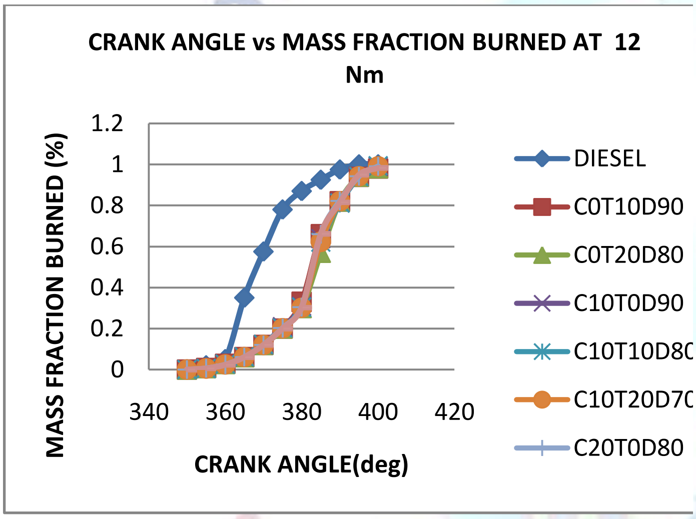
Graph 5: Variation of Volumetric efficiency (%) with Torque (Nm)



Graph 6: Variation of Maximum combustion pressure (bar) with Torque (Nm)



Graph 7: Variation of pressure with crank angle at torque of 6Nm for different blends



Graph 8: Variation of Mass fraction burnt (%) with crank angle at torque of 12Nm for different blends

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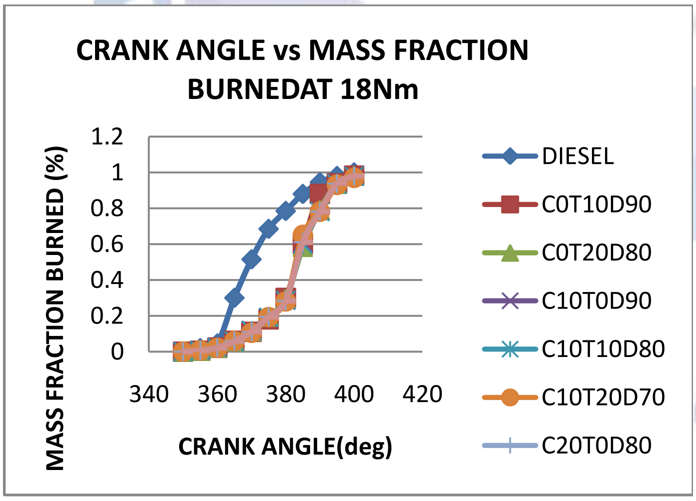
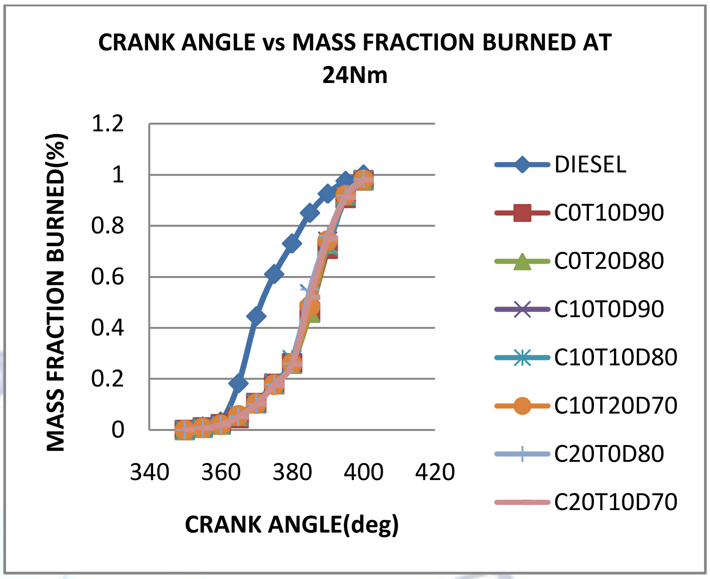
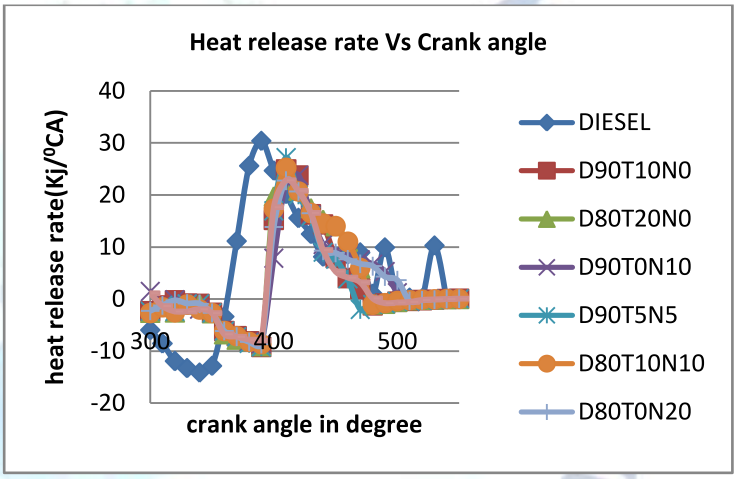


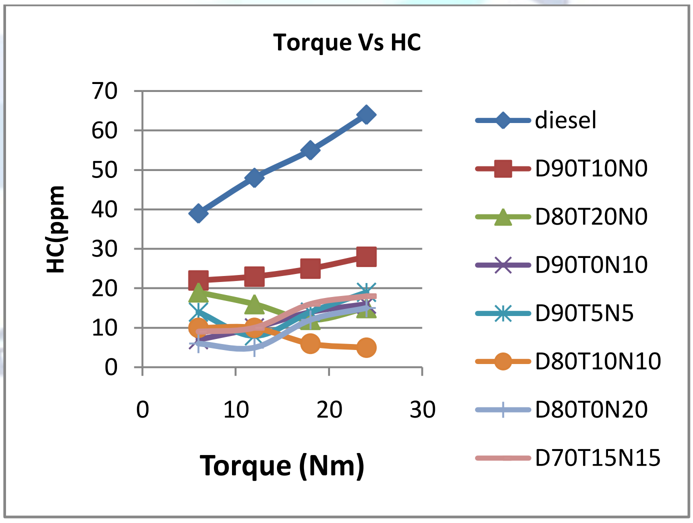
Graph 9: Variation of Mass fraction burnt (%) with crank angle at torque of 18Nm for different blends



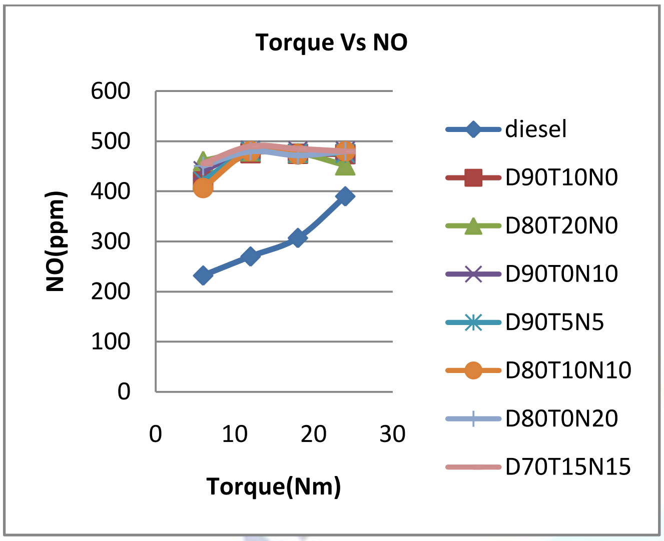
Graph 10: Variation of Mass fraction burnt (%) with crank angle at torque of 24Nm for different blends



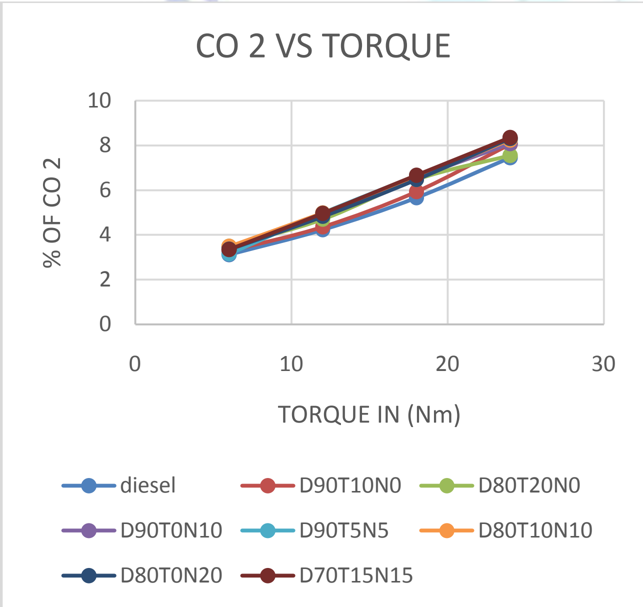
Graph 11: Variation ofHeat release rate (Kj/ºCA) with crank angle at torque of 6Nm for different blends



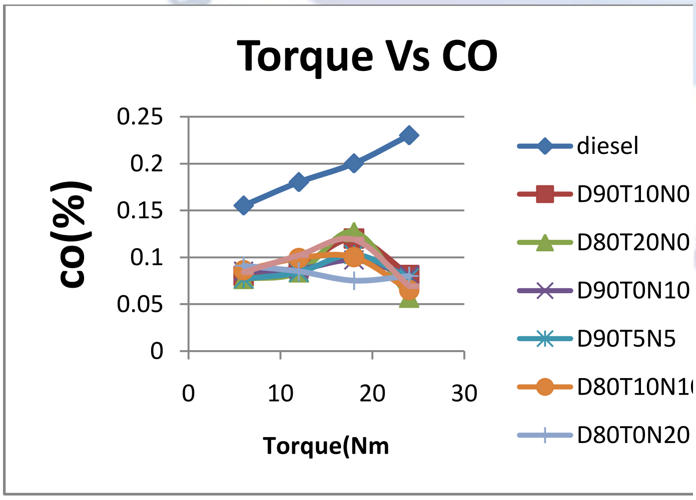
Graph 12: Variation of hydro carbon with torque for different blends



Graph 13: Variation of NO_x with torque for different blends



Graph 14: Variation of CO_2 with torque for different blends



Graph 15: Variation of CO (%) with torque for different blends

5. CONCLUSION

The experimental results shown in this paper that engine performance and emissions of all blends where run on the diesel engine and compared with standard diesel fuel

- The brake power for D70T15N15 is 1.183% more than the diesel and for D80T20N0 is 5.125 % less than diesel. The highest is recorded with and D70T15N15 lowest with D80T20N0
- As the applied torque is increases, the brake thermal efficiency of the fuel blends also increases. The maximum brake thermal efficiency at full torque of 24Nm is 45.36% for D90T0N10
- The brake specific fuel consumption for D80T20N0, D90T0N10 and D80T0N20 is 0.17 Kg/Kw Hr and diesel has 0.205 Kg/Kw Hr the specific fuel consumption only increases for higher percentages of blends
- A little variation of mean effective pressure has been observed during the experiment for each blend
- The volumetric efficiency was increases for blend. The increase in volumetric efficiency is due to increase in amount of intake air.
- The increasing in Torque the exhaust gas temperature is also increases. The exhaust temperature is highest for D80T10N10 and lowest for D90T5N5.
- At crank angle 350^0-360^0, the mass fraction burnt for the fuel blend is same as diesel. But the crank angle 360^0 – 398^0, the mass fraction burnt is away from diesel but at crank angle 398^0-400^0, the mass fraction slightly closer to each other
- It has been confirmed that the heat release rate decrease at the start of combustion and increase further. While comparing the results obtained the heat release rate for D80T10N10 blends quite near to that of standard diesel
- At higher load condition the hydrocarbon emission of various blends are higher except the blends D80T20N0 and D80T10N10. In this work for blends D90T10N0, D90T0N10, D90T5N5, D80T0N20 and D70T15N15 increase in load increase the hydrocarbon

emission and produce lesser hydrocarbon emission at 50% and above while comparing with standard diesel.

- It can be observed from the figure that there was a gradual increase in NOx emission with increase in the blend concentration but lesser than that of diesel fuel. Due to higher heat release rates there is an increase in cylinder temperature resulting in increase in NOx emissions

- Due to incomplete combustion and inadequate supply of oxygen carbon dioxide emission of the fuel blends D90T10N0 low at full load decreases.

- The carbon monoxide emission of the blend D90T5N5 is found to be higher for low and medium torque and closer to that of standard diesel at high Torque. For the blends of D80T10N10and D80T0N20 are having he carbon monoxide lower than that of the diesel

Neem oil and tyre oil promising as a best alternative fuel source of diesel engine because of its high heat content. It can be directly used as diesel fuel but having a major problem was neem oil having high viscosity. From this investigation, test results showed that 20% neem oil 10% tyre oil and 70% diesel (D70T15N15) and for suitable it to be used as diesel fuel without any modification of engine

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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