# INVESTIGATION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF COMPRESSION IGNITION ENGINE FUELLED WITH TWO BIODIESEL BLENDS

[1]Dr RAJU B.R, [2]Manjunath B,[3]Nischitha L, [4]Sathyadeep M K, [5]Vijay Kumar S

[1]Head and Professor,[2345]Students
[1]Automobile Engineering
[1]The Oxford College Of Engineering, Bengaluru,India

***Abstract:***Biodiesel fuel is an alternative fuel used extensively in diesel engines usually blended with petroleum diesel to overcome the ongoing fossil fuel depletion. Esterification process of organic resources such as vegetable oil or animal fats yields Biodiesel. This study has been carried out in a view to deal with biodiesel synthesis and its performance on a compression ignition engine fuelled with two biodiesel blends. It also deals with reducing macroscopic exhaust pollutants with a point of keeping emission level down. For the very purpose emission test series have been carried for all the biodiesel blends to know about the emission rate of individual blend. This paper investigates the scope of using biodiesel produced with methanol in the process of synthesizing biodiesel. Experiments were conducted on diesel engine with B15, B30, B45, B60 of methyl esters of Pongamia and Neem oil and standard diesel fuel separately. The performance and emission behaviors results were compared with diesel fuel.

*Index Terms* - **Biodiesel, transesterification, methyl esters, performance, emission characteristics**

## I. INTRODUCTION

With the everlasting greediness of humans who have kept their hands on every resources that are available in nature that has finally led to resource depletion. People are unaware about quagmires of resource depletion have been consuming the available resources at a faster rate than it can be replenished by nature. The world needs to change their habits to spare time for finding out new alternatives to fossil fuels. Due to the depletion of fossil fuels at an alarming rate there was a need to find a substitute which can used in place of petroleum fuel, this led to the innovation of synthesizing biodiesel from available resources of organic origin such as from plant oils, animal fats, microalgae lipids etc. Although biodiesel cannot be used as complete substitute for petroleum diesel, but can be used by blending biodiesel with petroleum diesel in certain optimum proportions, so that when biodiesel is used commercially can certainly decrease the amount of dependence on petroleum diesel to a smaller extent.

Biodiesel is an engine fuel that has alkyl esters produced by the transesterification process of triacylglycerol. As biodiesel is synthesized from organic origin hence, they are renewable sources of energy which are environment friendly, with calorific value close to that of petroleum based fuel. Transesterification has been recognized as the best method to synthesize biodiesel from edible and non-edible lipids. However, inefficiency in energy consumption during preparation of biodiesel results in higher production of biodiesel is still a matter of great concern. This is directly related to the heating method employed and slow settling of biodiesel in the process. Extensive research and development have been carried in finding an efficient method of producing biodiesel at lower cost than that of petroleum diesel. Many investigation have used microwave radiation in biodiesel production due to their specific advantages such as low reaction time and lesser energy consumption, faster heating complete numerous organic and inorganic reactions at a faster rate, they also increase the yield of biodiesel with the use of reduced amount of catalyst and alcohol used, further reducing the settling time.

This present study deals with synthesis of biodiesel from two non-edible oil, Pongamia pinnata and Azadirachtaindica by direct transesterification or in-situ, a process widely used as an analytical procedure. The traditional way of synthesizing biodiesel from two step method of solvent extraction is a time consuming process with less yield is totally replaced by direct transesterification process which yields more alkyl esters. The Biodiesel produced is later tested on compression ignition engine for recording performance and emission characteristics in order to analyze and compare the efficiency when run with biodiesel to that of petroleum diesel fuel.

The major positives about biodiesel is environment friendly, better combustion efficiency, being easily available, low sulphur content, biodegradable, higher cetane number, increased lubrication property. Researches have shown with the use of biodiesel nitrogen oxide emission (NOx) increases, on the other hand there is significant reduction in hydrocarbon (HC), carbon monoxide (CO), and particulate matter emissions (PM) when compared to the emission of diesel fuel. The present paper also focuses on the emissions by operating a diesel engine fuelled with biodiesel.

## II. METHODOLOGY

### 2.1 Materials

Honge seeds and Neem seeds are purchased at Gandhi KrishiVignan Kendra, Bengaluru. The seeds were checked for their dryness by physically interpreting the colour, weight, seed skin texture. The seeds maintained upto 50% of moisture in kernels are collected and the oil is extracted either by solvent method or crushing method. The seeds are then poured into the hopper of mechanical expeller, where high pressure is employed to squeeze the seeds to obtain crude oil form the source.

The obtained oils are filtered by using 25 micron paper, which is later used for biodiesel synthesis. The left over seed product after extraction is stored in form of cakes can be later used as manure by agricultural industry. Thus, obtained Honge and Neem oil are mixed in equal proportion according to the requirement and used for biodiesel production.

### 2.2 Esterification process of Honge and Neem oil mixture

A known amount of Honge and Neem oil mixture (500 ml) and methanol in molar ratio 1:6 was taken into the one litre capacity three neck round bottom flask and 2% of conc.H2SO4 as a catalyst was added slowly to the reaction. The complete setup was placed on a hot plate with magnetic stirrer and temperature of about 60°C to 65°C was constantly maintained throughout the reaction process. A reflux condenser provided with circulating cooling water was also used to recover the methanol which was evaporating back to the reaction mixture. At every 18 minutes interval, a 5ml of reaction sample was pipette out from the flask and titration process was carried out and reduction in the FFA content was observed. Finally the Esterification process was carried out until the FFA value was complimentarily less than 1% and the reaction was stopped. The reaction process took nearly 1.75 hours, the product was then cooled first and poured into a separator and left for settling for a period of one day. After settling, two layers were observed. The bottom layer was residue along with the catalyst and the top layer contained the acid esters with the reduced FFA value.

### 2.3 Transesterification

The 500 ml of acid esters obtained from the Esterification process was once again taken into the three necked RB flask and known volume of methanol was added as per the volumetric ratio 3:1. The 4% of heterogeneous catalyst Calcium oxide was also added to mixture and similarly the setup was placed on hot plate and a reflux condenser was used. The standard reaction time maintained was about 4.5 hours. The temperature was kept constant to about 60°C to 65°C since the boiling point of methanol was found to be 62.5°C.

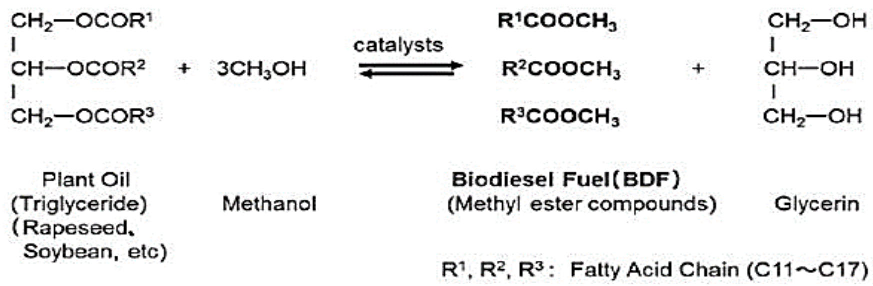



Fig 1 Reaction of biodiesel formation

### 2.4 Separation of Biodiesel

Upon reaching the predefined time of reaction, the reactor was taken out of the heating mantle and the products of the reaction were shifted to a 500 ml separating conical funnel.After the reaction time was completed, the products was cooled and then poured into the separator and was left it for 24-36 hours. At the end, three layers were significantly formed. The methyl esters having the lowest density compared to all was found to be floating at the top, the glycerol having the medium density acted as the layer floating above the catalyst and esters, the catalyst having the highest density had settled at bottom. Three layers were separately collected into a beaker. The catalyst was dehydrated back into powder form and was reused again for the next process, finally methyl esters were obtained.

Initially, biodiesel from the transesterification process was taken into a beaker. A weighed amount of EDTA crystals (about 10g) were taken in a separate beaker. Slowly the EDTA was added into the beaker containing the biodiesel and left it settle for about 2 days. After settling process, it was observed that the EDTA settled at the bottom hence by trapping the presence of catalyst and any other impurities.
Finally the biodiesel was heated around 120°C -140°C in order to remove any moisture content present in the diesel, finally purest form of biodiesel is obtained and is ready for blending with the petroleum diesel.

## III. EXPERIMENTATION

The engine used for performance analysis is four stroke, single cylinder, water cooled compression ignition engine with Eddy current dynamometer. Experimental work were carried out by varying loads of 0, 10, 15, 20 and 100% diesel, biodiesel blends with diesel (HNME 15, HNME30, HNME45, HNME60) at 1300 rpm constant rated speed of the engine as shown in figure. The engine is coupled with thermocouples for temperature measurement, manometer, engine base to minimize vibrations, water cooling system etc. The specification of diesel engine in which test was performed is as follows:

Table 1 Engine Specifications

| | |
|---|---|
| Make | Kirloskar |
| Engine type | Single cylinder, 4-stroke, water-cooled, diesel type |
| Rated output | 5.2KW at 1500rpm |
| Compression ratio | 17.5:1 |
| Dynamometer | Eddy current dynamometer |
| Emission analyzer | Qrotech gas analyzer (QRO-401) |
| Measurables | CO, $CO_2$, HC, NOx, $O_2$ |

In this paper blending of biodiesel with diesel in different proportions are done which are as follows:
+B00 fuel (Pure diesel)
+B15 fuel (85% diesel + 15% biodiesel)
+B30 fuel (70% diesel + 30% biodiesel)
+B45 fuel (55% diesel + 45% biodiesel)
+B60 fuel (40% diesel + 60% biodiesel)

The tests are performed at unsteady state test the fuels are tested in random order and each test is repeated three times, and the results of three repetitions were averaged. An exhaust gas analyzer was used for measuring exhaust emissions. Before taking the measurement the gas analyzer instrument was calibrated and its probe sensor is inserted to the exit of muffler pipe. By mean of instrument exhaust temperature, CO, $CO_2$, HC, PM, NOx is measured and calculated.

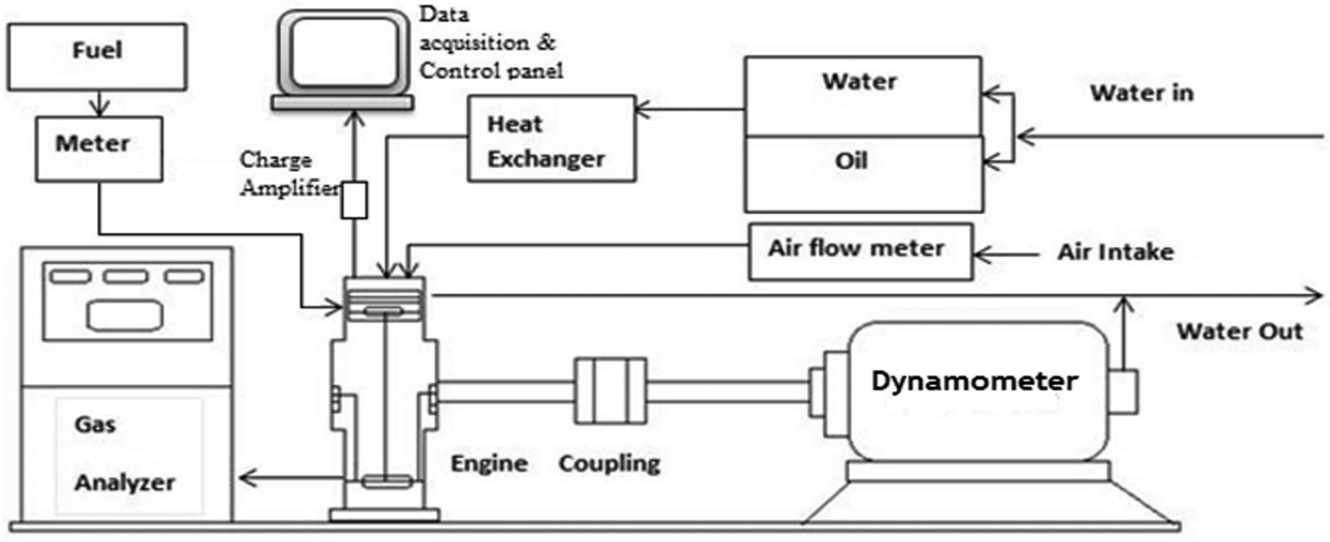
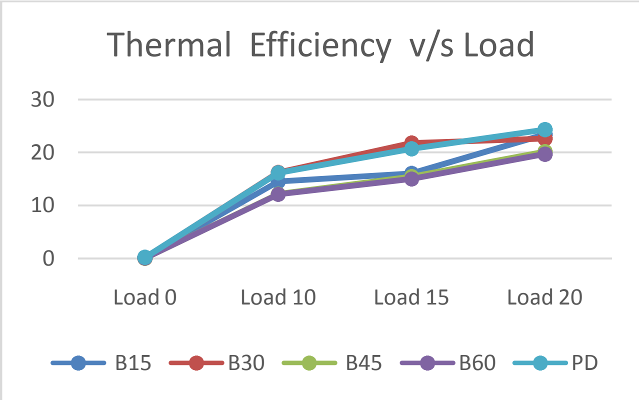



Fig 2Schematic diagram of experimental setup

## IV. Results and Discussion



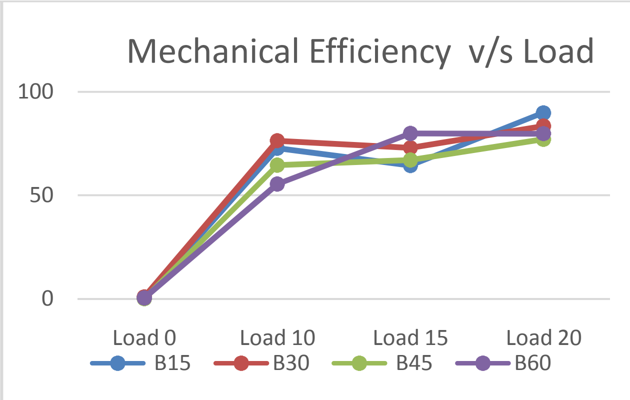




Fig 3 Variation in brake thermal efficiency with load Fig 4 Variation in mechanical efficiency with load

### 4.1.Thermal efficiency

Fig 3 shows the variation of thermal efficiency in case of diesel, B15, B30, B45, B60. It is clearly observed that BTE increases with increase in load. From the above results diesel has the highest brake thermal efficiency than that of other fuels which is mainly due to higher calorific value, less viscosity, lower density, in comparison to other biodiesel blends. However, increasing the amount of additive with biodiesel the BTE increases with respect to load and resembles very close very behavior to that of pure diesel.

### 4.2. Mechanical efficiency

Fig 4 shows the variation of mechanical efficiency with load for all biodiesel blends. It was observed that the mechanical efficiency was highest at maximum load for all the test fuels. From the above results it shows that B30 blend has maximum mechanical efficiency when compared to all other test fuels.

### 4.3 Emission results

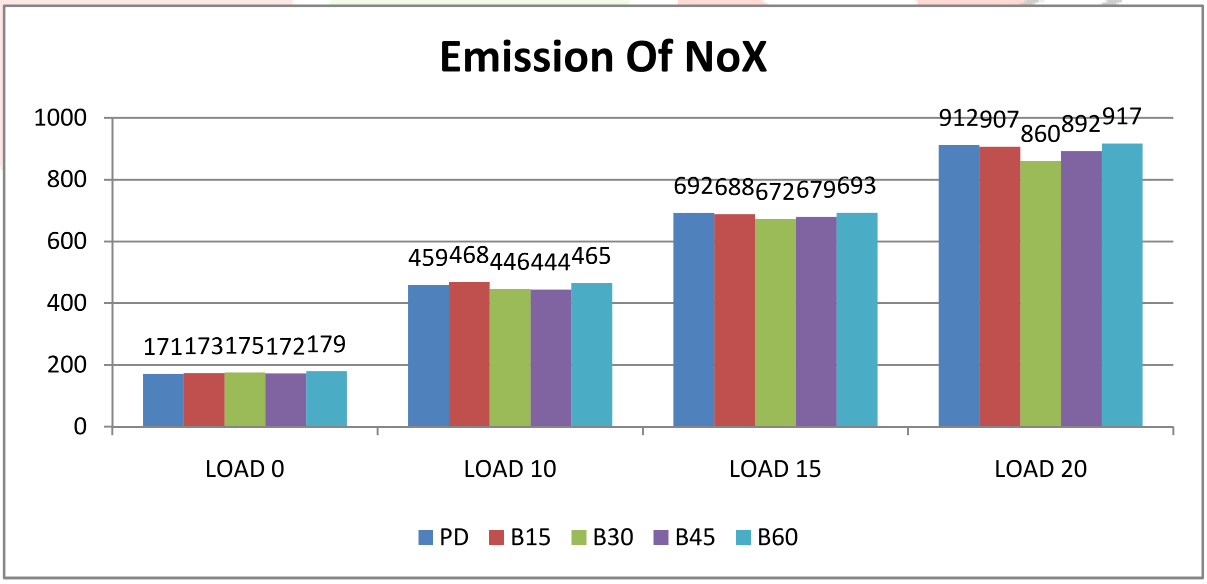



Fig 5 Variation of NOx emission with load

From the study of many papers it is known that NOx is directly proportional to power output of engine that is NOx emission increases with increases in exhaust and combustion temperature. The above test reveals that NOx emission increase linearly due to increase in load which leads to higher chamber pressure and temperature at high loads. NOx emission is high for B60 diesel because of complete combustion due to high oxygen content leading to high combustion temperature. With the use of biodiesel significant amount of NOx emission can be reduced. The above results interpret that B30 blend produces less NOx emission when compared to other fuels.

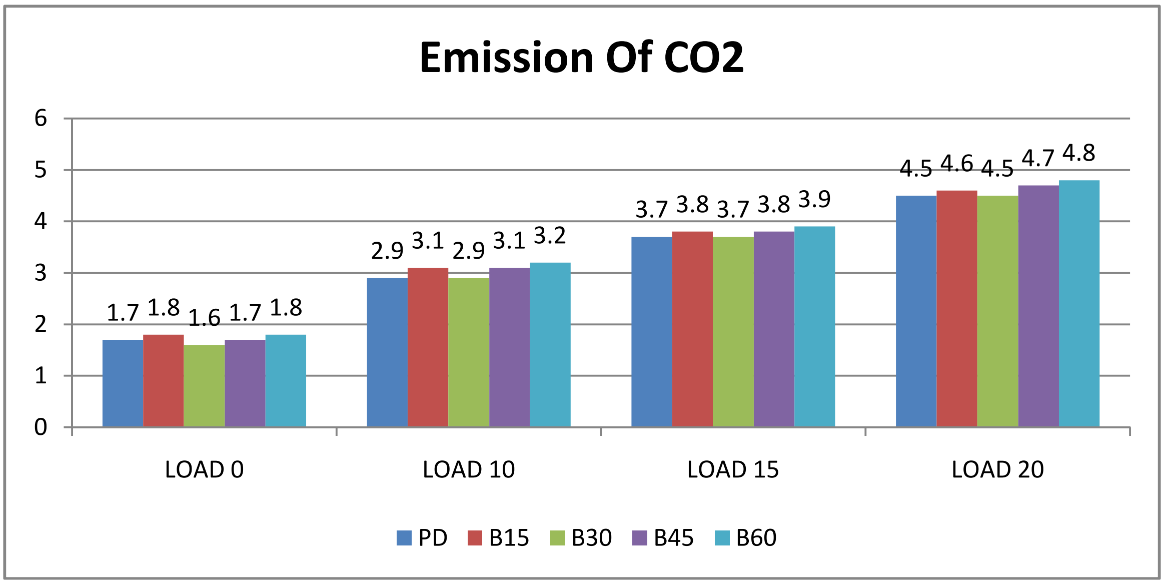



Fig 6 Variation of $CO_2$ emission with load

From the above figure, conclusion can be drawn that the CO2 emissions increases proportionally with load, biodiesel blends produce more CO2 emission than conventional diesel fuel. Increase in load leads to incomplete combustion when biodiesel blends are used. The above results signifies that B30 blend produces less CO2 emission when compared to other fuels.

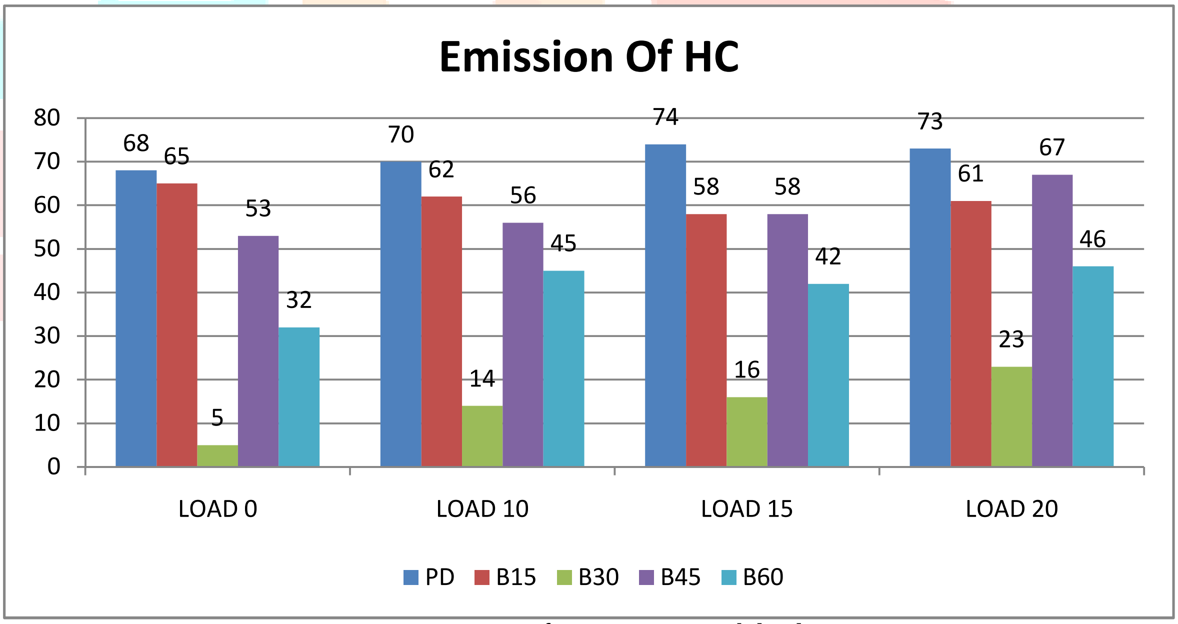



Fig 7 Variation of HC emission with load

Figure shows that HC emission of different fuels. It is observed that unburnt hydrocarbon emission increases with load for all the blends. From above results it is seen that biodiesel produces less HC emission when compared to diesel fuel because of better combustion due to presence of extra oxygen content than diesel. HC emissions increases with rise in load due to lower low cylinder pressure and temperature. From above contradictory results it is seen that B30 blend produces less HC emission.

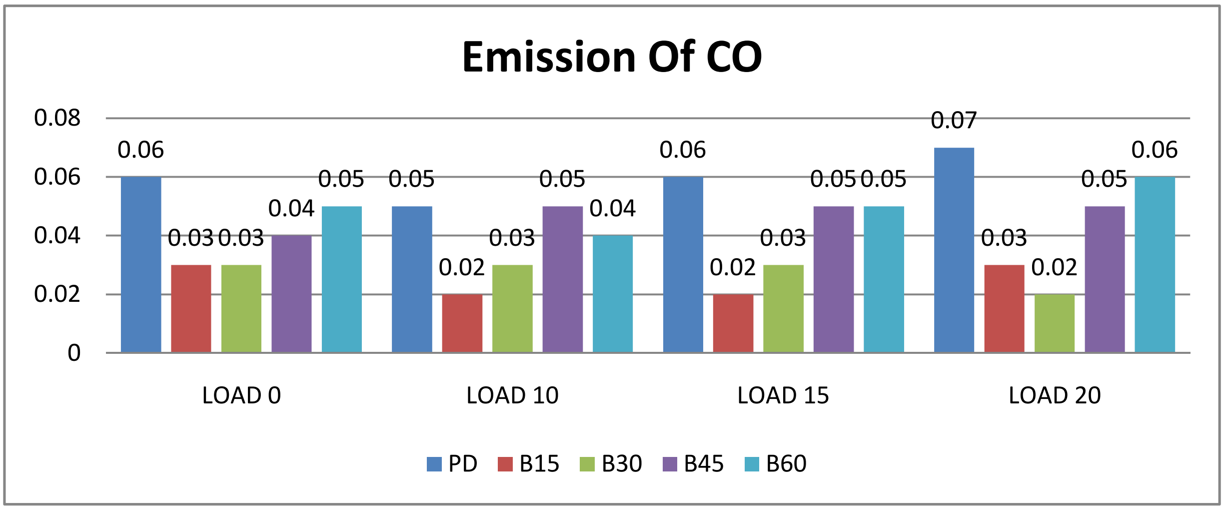



Fig 8 Variation of CO emission with load

From the above figure it can be seen there is decrease in CO emission initially at loads upto 15% and increases sharply, CO emission is highest for B60 blend due to poor combustion rate at higher loads which leads to formation of CO and CO2 compounds. From the above figure we can interpret that B30 blend produces less CO emission when compared to all other fuels.

## CONCLUSION

Several tests were carried out in this present investigation on single cylinder four stroke, vertical water cooled diesel engine using diesel and biodiesel synthesized from Honge and Neem oil mixture at different volumes with diesel. From the experiment the below points can be concluded.

1. Temperature of exhaust gas was found to be highest for B60 blend due to high combustion temperature of biodiesel which is a result of high oxygen content.
2. Brake thermal efficiency increases with rise in additives percentage in biodiesel and is lower with the pure diesel
3. NOx emission and smoke emissions were found to be more in case of biodiesel due to higher density and viscosity and low calorific value when compared to diesel.
4. HC and CO emissions were found to be highest for pure diesel and less in case of biodiesel because of increased oxygen content.
5. From above emissions tests conducted B30 blend was found to be the best which produced less emissions when compared to all other blends.
6. The HC emission mainly depends on exhaust gas temperature of any fuel, B30 blend has lower HC emission.

Biodiesel is an eco-friendly renewable engine fuel alternative used alongside with petroleum diesel. From the results obtained, it is understood that the thermal efficiency is slightly less with biodiesel to that of conventional diesel fuel. This is due to increase in oxygen content while blending and specific fuel consumption is slightly higher in case of biodiesel due to low calorific value than diesel. The main conclusion that can obtained is by using biodiesel dependence on diesel can be reduced to certain extent, which plays a major role in reducing the depletion of petroleum fuels.

## REFERENCES

1. Narinder Singh ,Narinder kumar and skMahla(2013),"experimental studies on single cylinder CI engine using Mahua oil and ethanol blends", international journal of emerging science and engineering, vol. 1,

2. Ajay Kumar, I S Singh. (1991), "Chemical evaluation of Mahua (MadhucaIndica) seed." Journal of food Chemistry, 40(2), 221-228.

3. Shashikant Vilas Ghadge and HifjurRaheman, (2006), "Process optimization for biodiesel production from Mahua (Madhucaindica) oil using response surface methodology", Bio resource Technology, Vol. 97, pp. 379–384.

4. Ashish Jawalkar , KalyanMahantesh , M Jagadish , MadhusudhanMerawade, M C Navindgi (2012), "Performance and Emission Characteristics of Mahua and Linseed Biodiesel Operated at Varying Injection Pressures on CI Engine" , vol.2, Issue.3,pp1142-1149,ISSN:2249-6645.

5. Lokanadharao M and Apparao B.V., (2012), "Experimental studies on combustion characteristics of di-diesel engine with Mahua oil methyl ester (mome) and dimethyl carbonate (dmc) as additive", International journal of engineering, science and metallurgy, Vol. 2, pp. 2249–8974.

6. Swarup Kumar Nayak and BhabaniPrasannaPattanaik (2014), "Experimental Investigation on Performance and Emission Characteristics of a Diesel Engine Fuelled with Mahua Biodiesel Using Additive", Energy Procedia, vol. 54, pp. 569 – 579.