EXPERIMENTAL INVESTIGATIONS ON A VCR CI ENGINE FUELED WITH CORN OIL BLENDED WITH DIESEL AND CERIUM OXIDE NANO ADDITIVE

[1]Dr. Jasti Sudhir Kumar, [2]D.Satyanarayana, [3]M.N.V.Alekhya, [4]A.S.Ganapathi, [5]B.V.Subramanyam

[1]Professor, [2]Senior Assistant Professor, [3,4,5]Assistant Professor
Department of Mechanical Engineering,
Sir C.R. Reddy College of Engineering, Eluru, West Godavari District, Andhra Pradesh, INDIA.

***Abstract*: The fast depletion of fossil fuel resources and increase in fuel prices in recent years has led to focus towards alternate fuels used in diesel engines. The vegetable oil has become in favour and cost effective and used under a wider range of conditions among various fuel alternatives. The random extraction and consumption of fossil fuels have lead to reduction in petroleum reserves. A single cylinder computerized variable compression ratio engine was operated successfully using Corn Bio-diesel and its blends of Corn oil methyl ester with cerium oxide as nano additive. Pure diesel with different esterified Corn seed oil and its blends are tested for combustion, performance and emission characteristics and curves are drawn and compared with that of diesel. Exhaust emissions such as CO, CO2 and HC were determined and compared with that of diesel. Burning of fossil fuels has caused serious detrimental environment consequences. The application of biodiesel has shown a positive impact in partitioning these problems. It is concluded that the VCR Diesel engine works efficiently by giving lowest emission values of CO, CO2 and HC for Corn biodiesel blend B10 with cerium oxide as nano- additive at both the compression ratios 17.5:1 and 19:1.**

***Index Terms*: VCR engine, Emissions, Combustion, Corn bio-diesel and Neat diesel, Nano-Additive.**

I. INTRODUCTION

Fossil fuels have limited life and the ever increasing cost of these fuels has led to the search of alternate renewable fuels for ensuring energy security and environmental protection. Various sectors like transportation, agriculture and industries are consuming diesel fuel as a serious supply of power. As the stipulation of diesel fuel increases, the price of the fuel is also escalating. Biodiesel may be a cleaner burning replacement fuel for diesel drawn from natural sources such as virgin and used vegetable oil, algae and animal fats. India is not only a large importer of oil with the prospect of increased imports in the future, but also has significant potential for production of bio-fuels in the country. India actually has large areas of wasteland, which could be utilized for the production of bio-fuels. India and many countries in the world are on the verge of devising and implementing programs for production, conversion and use of bio-fuels. It is identified that more than 340 oil containing crops, among which only palm, jatropha, pongamia, cottonseed, soybean, rapeseed, sunflower, etc., are considered as potential substitute fuel for compression ignition engines. Rapeseed, soybean, sunflower, pongamia and jatropha are the most commonly used feedstock for biodiesel extraction.

Nano technology has already contributed to number of innovative products in various engineering disciplines because of their unique physical, chemical and mechanical properties. The present work studies the results of application of a Corn bio- diesel on a practical heavy-duty VCR diesel engine, with the aim of knowing their impact on exhaust emissions and performance. The goal of this experimental study is to analyze the new fuel contributions to potential performance and efficiency loss. An attempt is made to assess the combustion and performance phenomenon of Corn bio-diesel fuel. An investigation covering the performance, emissions is dealt with to evaluate the engine under various fuel blend implementations.

II. LITERATURE REVIEW

S. Bari et al., [1] 2002 makes a point that viscosity of Crude Palm Oil(CPO) is too high to allow smooth flow in fuel lines and thus needs to be heated to reduce viscosity. However, this heating of CPO offered no advantages in term of performance. In the performance test, it was found that the performance of CPO, as a fuel, was comparable with that of Diesel. Carbon monoxide emissions for CPO. Compared to Diesel, were higher. Y. He et al., [2] 2005 has done his investigation on cottonseed oil. This oil is a good alternate fuel source of Diesel engine because of its high gross heat content. Optimal combinations of four working parameters under two operating conditions were determined when the mixture of 30% cottonseed oil and 70% Diesel oil were used. The main factor effecting the SFC or thermal efficiency was found to be the fuel discharge angle and its appropriate values for two operating conditions was about 22CA that is 3CA to 5CA in advance of that which was appropriate for the engine fueled by pure Diesel oil. Murat karabektaset al.,[3] 2008 In this study " cottonseed oil methyl ester(COME) is use as fuel in Diesel engine to evaluate the performance and emission parameters. For this purpose single cylinder four-stroke, direct injection Diesel engine is taken. Before supplied to the engine, COME was preheated to four different temperatures. The results revealed that preheating COME up to 90Cleads to favorable effects on the BTE and CO emissions but causes higher NOx emissions. More over the brake power increases slightly with the preheating temperature up to 90̊ C. L.kallivroussis et al.,[4]2000 points out that one requirement for an oilseed crop to be considered for Bio-Diesel production is that it provides a positive energy return compared with the energy used to produce the fuel. Sunflower seed is a good source of Biomass, and a crop considered for Bio-Diesel production. The energy inputs and outputs were estimated to be 10.49and47.4 GJ ha-1, respectively, which translates into an energy ratio of 4.5:1. The possibilities to reduce the energy inputs are very limited. U Santhan Kumar et al.,[5] 2013 at el studied the Transesterification process adopted for the corn biodiesel and characteristics of corn biodiesel blends. In which different blends such as COME10, COME20, COME30, and COME100 taken for the experimentation. Nano-particles are added to the best blend to increase the performance and emission characteristics of C.I engine. Attia et al., [6] 2014 investigated the effect of B20-Jojoba methyl ester with addition of Aluminum oxide Nano-particle on properties of fuel, performance and emission characteristics of the diesel engine. The result showed that there was a considerable change in fuel properties. It was also noticed that the addition of Al2O3 reduced the kinematic viscosity of the fuel along with an increase in density and Cetane number. R.Senthi kumara et al., [7] 2014 at el studied the performance and emission characteristic of biodiesel engine with preheating corn oil methyl ester from thus paper we studied the performance & emission characteristics of corn biodiesel by using different preheating temperatures such as (50,70,and 900 c). PrabhuArockiasamyet al., [8] 2015 mentioned that the addition of 30 ppm Al2O3 and CeO2 with Jatropha methyl ester improved the kinematic viscosity, density and calorific value as 4.25 Cst, 875 kg/m3 and 38.9 MJ/kg for JBD30A blend. JBD30C blend was found to have similar fuel property values as 4.30 Cst, 876 kg/m3 and 38.7 MJ/kg respectively. The addition of alumina with Jatropha biodiesel improved the fuel properties. Syed Aalam and Saravanan et al., [9] 2015 also obtained similar improved fuel properties for B20- Mahua biodiesel by adding aluminum Nano-particles. Nithin Samuel at el., [10] 2015reported that the Specific fuel consumption is decreased by 0.5 kg/kw.hr for diesel mixed with cerium oxide at 30 ppm. Mechanical efficiency of the engine is increased by 20% while using fuel added with 30 ppm cerium oxide. However thermal efficiencies are higher for neat diesel than the fuel mixed with Nano-particle. There is a significant improvement in the exhaust emissions while using diesel mixed with cerium oxide Nano-particle. V.A. Markov et al.,[11] 2016 studied the mixing corn oil with diesel fuel in different percentages from this result optimized composition of bio fuel mixture is calculated.

III. EXPERIMENTATION

3.1 Experimental Set Up:

Direct Injection, VCR Diesel engine is utilized for the experimentation. Experimentation is done at various engine loads by using eddy current dynamometer. Engine performance data is important to study the performance and engine pollution parameters. The exhaust gas analysis of different components of exhaust gas are measured and compared and engine performance is analyzed for the parameters mentioned above with the implementation of blends of neat diesel with corn bio- diesel at different compression ratios. The engine setup is shown in figure 1.

Figure 1, Computerized VCR Engine Test Rig

Rated Horse power	6 kW
Rated Speed	1500rpm
No of Strokes	4
Mode of Injection	Direct Injection
Injection pressure	200 kg/cm^2
No of Cylinders	1
Stroke	116 mm
Bore	102 mm
Compression Ratio	17.5:1 and 19:1

Table1, Specification of the Diesel Engine

This experimental investigation was carried out on a Kirloskar made VCR engine. It was connected with the control panel unit with rotameter, water temperature indicator, loading switch, speed indicator and fuel flow transmitter etc. The engine performance and combustion parameters such as brake power (BP), brake specific fuel consumption (BSFC), brake thermal efficiency (BTE), mechanical efficiency (MEFF), heat balance, cylinder pressure and heat release rate were determined by engine performance analysis software.

The eddy current dynamometer coupled with the engine output shaft (Fig. 2) for measuring the power and torque. The dynamometer connected with a load cell and different load applied on an engine (0-12 kg) by load cell. These load cells joined with the load sensors which signaled the load on the load indicator.

Fig2. Dynamometer

Fig3. Smart Caps Multi Exhaust Gas Analyzer

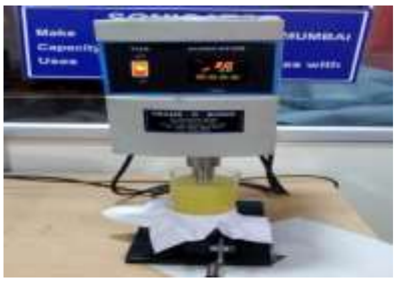

Fig 4. Ultra Probe Sonicator

A multi gas analyzer is a device used to detect combustible, flammable and toxic gases, and oxygen depletion. The gas analyzer measures the exhaust emissions such as Carbon Monoxide (CO), Carbon Dioxide (CO_2), Hydro Carbon (HC), and Oxygen (O_2) by means of Non-Dispersive infrared (NDIR) measurement as shown in fig3. The sonication is a method that uses sound energy for the aim of agitation particles during a sample for many functions like extraction compounds from plants, micro algae and seaweeds it is used to break up aggregates of micron-sized colloidal particles as shown in fig4

3.2 Production of Corn Oil Methylester

Transesterification requires the amount of catalyst KOH was dissolved in methanol and the rest amount of methanol along with the catalyst solution was added to the oil sample and placed in the water bath. The system was maintained airtight to stop the loss of alcohol. The reaction mix was maintained at temperature just above the boiling point of the alcohol i.e. around 60°C to speed up the reaction rate. Excess alcohol guarantees total conversion of the oil to its esters. After conforming of completion of methyl ester formation, the heating was stopped and the products were cooled and move to a separating funnel. The lower glycerol layer was separated. The oil was cleansed with water until it couldn't turn to pink beneath for further addition of acid-base indicator. To the bio diesel shaped anhydrous sulphate was added and left long for a night to remove moisture. The Bio diesel formed was then decanted.

1. Production of Corn oil Methylester

Corn oil is a bio-diesel produced by using raw Corn seed oil. Due to high content of FFA of Corn oil, the objective has been achieved in two steps namely

i) Acidesterification (ii) Alkaline esterification.

(i) Acid esterification

The acid esterification was carried out at 4:1-6:1 molar ratio with varied H2SO4 (0.5- 2.0%) at 50-60°C and 60-90 min reaction time. Preheated oil, methanol and acid H2SO4 were mixed together as per desired proportion and stirred at 200 rpm. After completing the acid esterification reaction, treated was taken into beaker Figure.5 and heated up to 60°C.

(ii) ***Alkaline esterification.***

After acid treatment, 50 g oil was taken in a 250 ml flask and preheated up to 100°C to eliminate dissolved moisture content in the Corn oil. Now required amount of methanol (4:1, 6:1, 8:1) were mixed with distinct percentage of KOH catalyst concentration (0.5, 1.0, 1.5). This homogeneous mixture of methanol and catalyst KOH was mixed with the Corn oil and stirred with 200 rpm at varied reaction temperature 50-60°C. The reaction was stopped after 60, 75 and 90 min. After completion of transesterification reaction, Corn oil methyl ester was separated from glycerol by separating funnel Figure.6 and then the separated methyl ester was washed with hot distilled water. At last biodiesel was heated in the hot air oven to remove excess water content, and collected in jar as shown in the Fig 7.

Fig5. Acid Esterification

Fig6. Alkaline Esterification

Fig7. Water Washing Corn oil

3.3 Blends Preparation

The series of exhaustive engine tests were carried out on a compression ignition diesel engine using diesel and Corn oil biodiesel blends. Several blends of varying concentration of Corn oil methyl ester (biodiesel) with diesel were prepared)Figure 9) as follows:

B10 : This is the blend containing 10% bio- diesel and 90% neat bio-diesel

B30 : This is the blend containing 30% bio- diesel and 70% neat bio-diesel

Fig9. Corn biodiesel BlendsB10 and B30 preparation

Properties	Diesel	Corn oil	B10	B30
Specific gravity	0.831	0.936	0.823	0.857
Viscosity at 40°c(centi poise)	4.3	5.3	3.1	3.8
Flash point ^{0}c	54	212	89	110
Fire point ^{0}c	65	224	119	118
Calorific value (kj/kg)	42,500	45,862	41,700	40,100

Table 3. Properties of Corn biodiesel and its blends

3.4 Cerium Oxide Nanoparticle as Additive

The use of nano-particles as additives to diesel fuel is a promising method for improving the efficiency and improving the exhaust emissions of a CI engine. The cerium oxide plays a role as an oxygen giving catalyst and provides oxygen for the oxidation of CO or absorbs oxygen for the lowering of NOx. The energy of activation of cerium oxide acts to burn off carbon deposits at intervals in the engine cylinder at the wall temperature and prevents the deposition of nonionic compounds on the cylinder wall leads to reduction in HC emissions. An experimental investigation is done to determine the performance characteristics of a compression ignition engine using nano-particles as additive in pure diesel and diesel-biodiesel blends. In the first part of the experiment, stability of pure diesel and diesel-biodiesel fuel blends with the addition of cerium oxide nano-particles is analyzed.

After series of experiments, it is found that the blends subjected to high speed mixing followed by ultrasonic bath stabilization improves the steadiness. In the second part, performance characteristics are investigated using the fuel blends in a single cylinder four stroke engine and cconnected with an electrical dynamometer and a data acquisition system.

The cerium oxide, figure 10 acts as an oxygen donating catalyst and provides oxygen for combustion. The tests revealed that cerium oxide nano-particles can be used as additive in diesel and diesel-biodiesel blends to improve complete combustion of the fuel significantly. However thermal efficiencies are higher for neat diesel than the fuel mixed with nano-particle. There is a significant improvement in the exhaust emissions while using diesel mixed with cerium oxide nano-particle.

Molecular formula	CeO_2
Molecular weight	172.115 g/mol
Particle Size	30-50 nm

Table 4. Specifications of cerium oxide nano-particles

Fig10. Cerium Oxide Nano-particles

3.5. Experimental Procedure:

The experimentation is conducted on a single cylinder direct injection VCR diesel engine operated at normal room temperatures of 28^0C to 33^0C.

The series of exhaustive engine tests were carried out on a compression ignition diesel engine using diesel and Corn oil bio-diesel blends. Blends of varying concentration of Corn oil methyl ester (bio-diesel) with diesel were prepared as follows:

B10- Blend containing 10% bio-diesel and 90% neat diesel

B30- Blend containing 30% bio-diesel and 70% neat diesel

Performance and emission tests were conducted under different loading condition on these various diesel-bio-diesel blends. The optimum blend was found out from the graphs based on maximum thermal efficiency, minimum brake specific energy consumption and safe emission at all load.

IV. RESULTS & DISCUSSIONS

A series of exhaustive engine tests were carried out on a compression ignition diesel engine using diesel and Corn oil biodiesel blends. Several blends of varying concentration of Corn oil methyl ester(biodiesel) with diesel were prepared as follows

- B10 : This is the blend containing 10% bio-diesel and 90% neat bio-diesel
- B30 : This is the blend containing 30% bio-diesel and 70% neat bio-diesel

Performance and emission tests were conducted under different loading condition on these various diesel-biodiesel blends. The optimum blend was found out from the graphs based on the maximum thermal efficiency, minimum brake specific energy consumption and safe emission at all load.

4.1 Calorific Values for Diesel and Biodiesel Blends

Net Calorific value of diesel = 42,682 kJ/kg

Net Calorific value of B10 = 43,475 kJ/kg

Net Calorific value of B30 = 43,286 kJ/kg

4.2 Performance Analysis

Brake power, fuel consumption, brake specific fuel consumption (B.S.F.C), Brake thermal efficiency, Indicated thermal efficiency for both diesel and Corn biodiesel are calculated at different loads. The comparison graphs for diesel and biodiesel blends for Load Vs Mechanical efficiency, Load Vs brake thermal efficiency and Load Vs specific fuel consumption are shown below.

4.2.1 For Compression Ratio 17.5:1

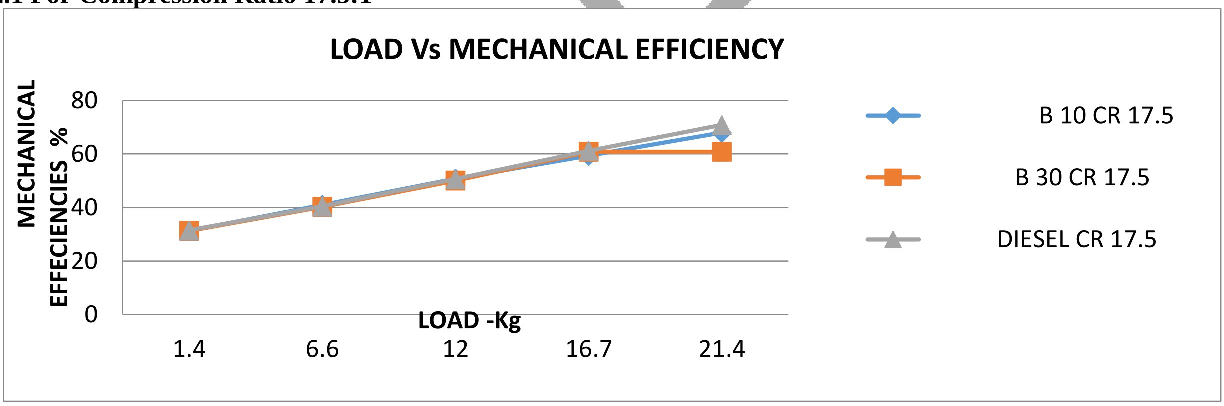

Fig 11. Load Vs Mechanical Efficiency

The maximum mechanical efficiency of the engine was 70.584% for diesel at 21.4 kg load.

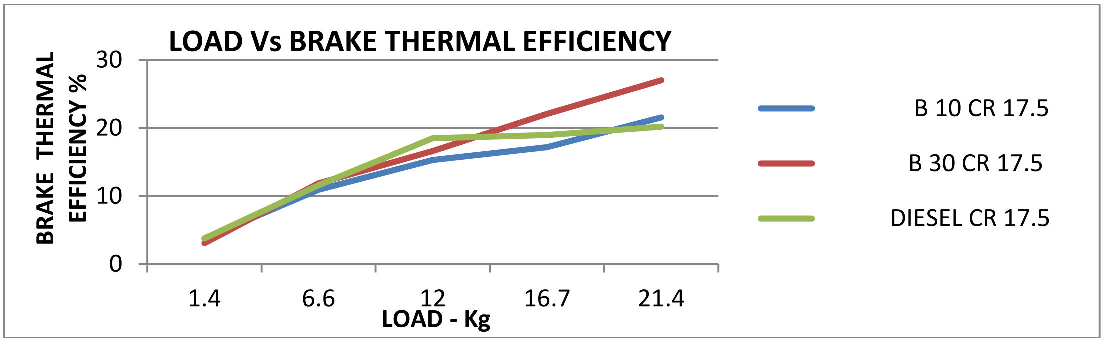

Fig12.Load Vs Brake Thermal Efficiency

The maximum brake thermal efficiency of the engine was 27.012% for corn biodiesel B30 at 21.4kg load.

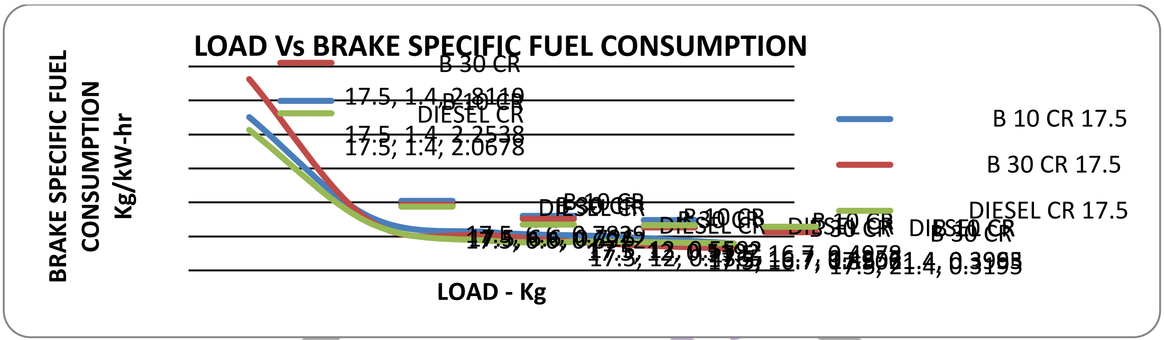

Fig13. Load Vs Specific Fuel Consumption

The minimum brake specific fuel consumption of the engine was 0.3195kg/kw-hr for B 30 at 21.4 kg load.

4.2.2 For Compression Ratio 19:1

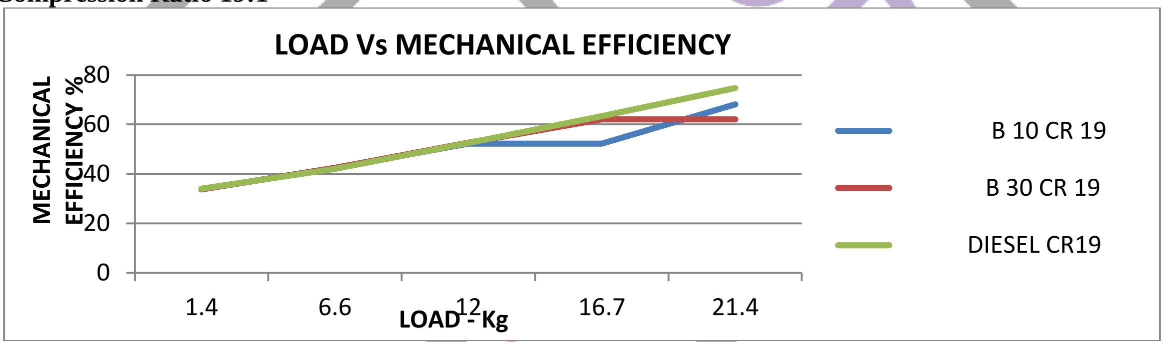

Fig14.Load Vs Mechanical Efficiency

The maximum mechanical efficiency of the engine was 74.7085% for diesel at 21.4kg load.

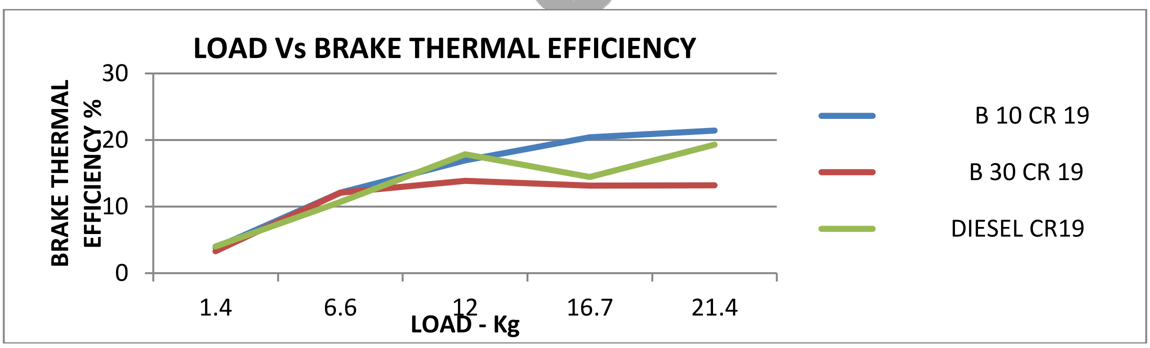

Fig15.Load Vs Brake Thermal Efficiency

The maximum brake thermal efficiency of the engine was 21.4135% for corn biodiesel B10 at 21.4 kg load

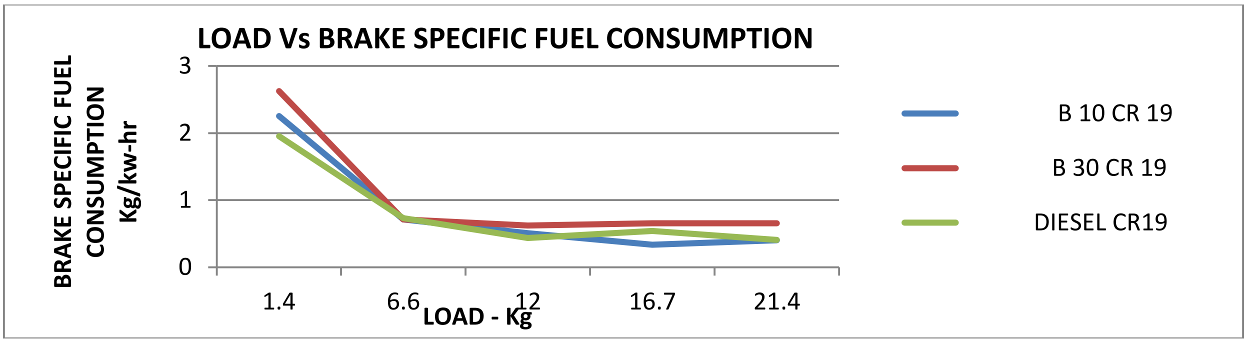

Fig16.Load Vs Specific Fuel Consumption

The minimum brake specific fuel consumption of the engine was 0.3362kg/kw-hr for B10 at 16.7 kg load.

4.2.3 Comparison Graphs For Mechanical Efficiency for Compression Ratios 17.5:1 & 19:1

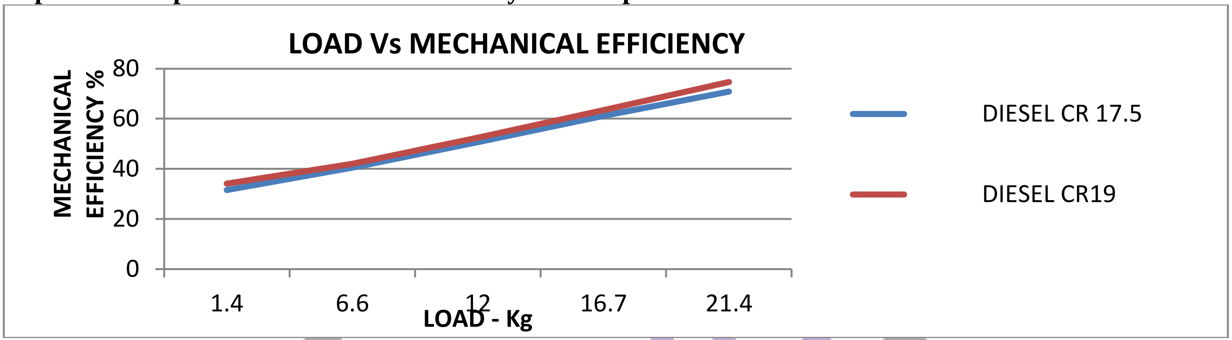

Fig17.Comparison for Diesel

The mechanical efficiency of the engine was increased with increase in the compression ratio and the maximum mechanical efficiency for diesel was found to be 74.7085 at 21.4 kg load.

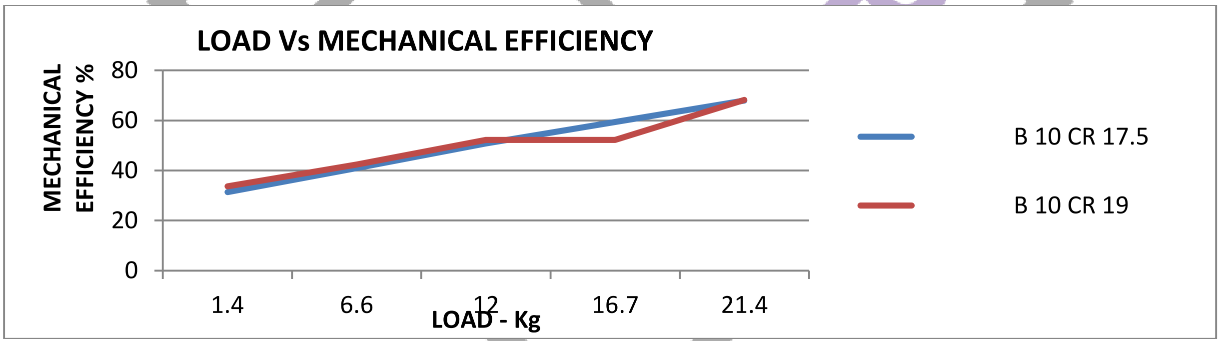

Fig18.Comparison for Blends (B10)

The mechanical efficiency of the engine was increased with increase in the compression ratio and the maximum mechanical efficiency for B10 was found to be 68.168 at 21.4 kg load.

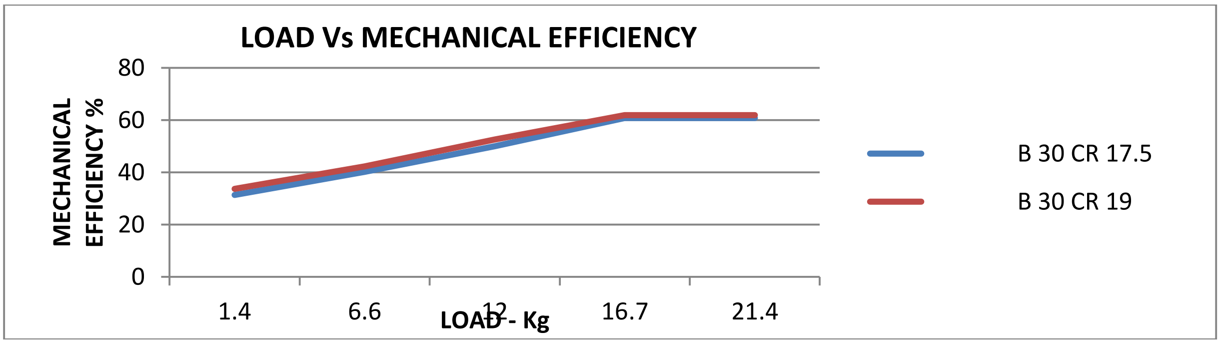

Fig19.Comparison for Blends (B30)

The maximum mechanical efficiency of the engine was increased with increase in the compression ratio and the maximum mechanical efficiency for B30 was found to be 61.9811 at 21.4 kg load.

4.2.4 Comparison Graphs for Brake Thermal Efficiency for Compression Ratios 17.5:1 & 19:1

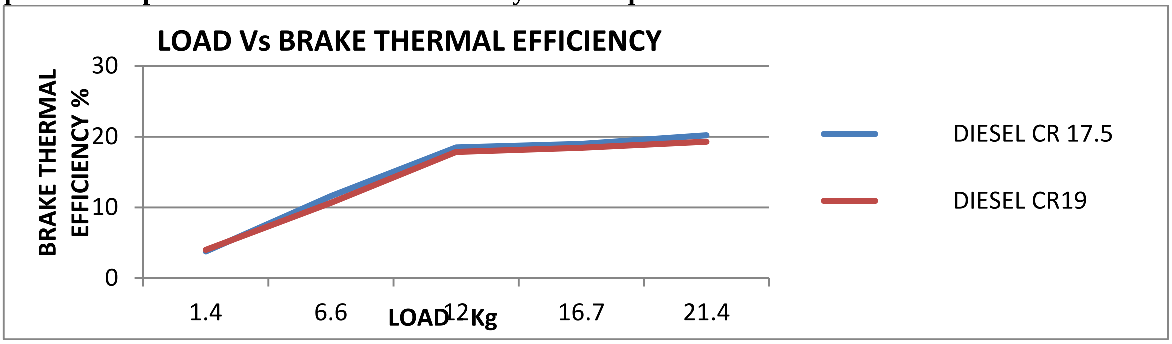

Fig20.Comparison graph for Diesel

The brake thermal efficiency of the engine was decreased with increase in the compression ratio and the maximum brake thermal efficiency for diesel was found to be 20.1822 at 21.4 kg load

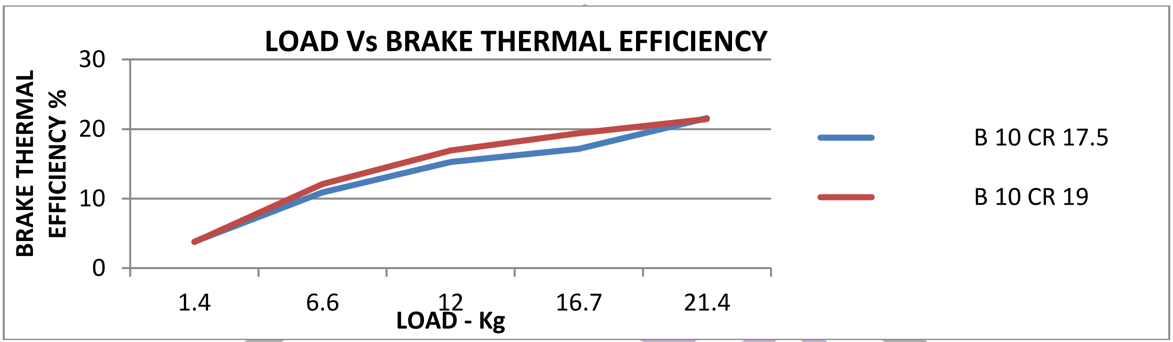

Fig21.Comparison graph for Diesel

The brake thermal efficiency of the engine was decreased with increase in the compression ratio and the maximum brake thermal efficiency for diesel was found to be 20.1822 at 21.4 kg load.

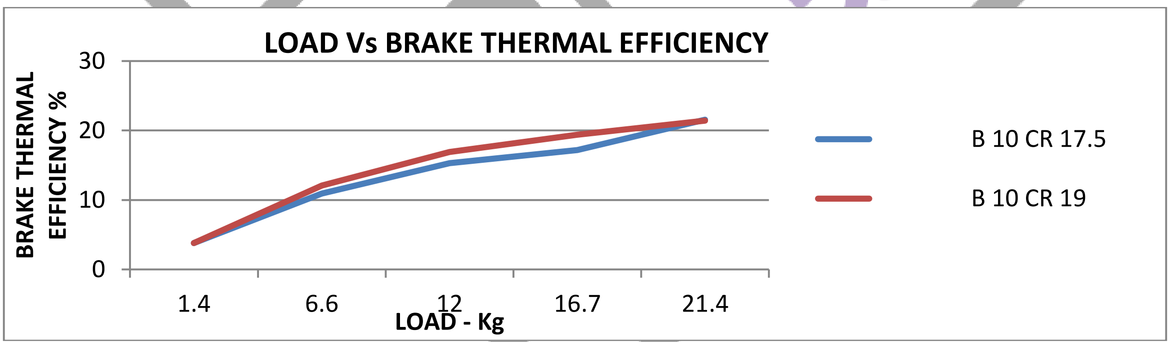

Fig22.Comparison graph for Blends (B10)

The brake thermal efficiency of the engine was increased with increase in the compression ratio and the maximum brake thermal efficiency for diesel was found to be 21.567 at 21.4 kg load

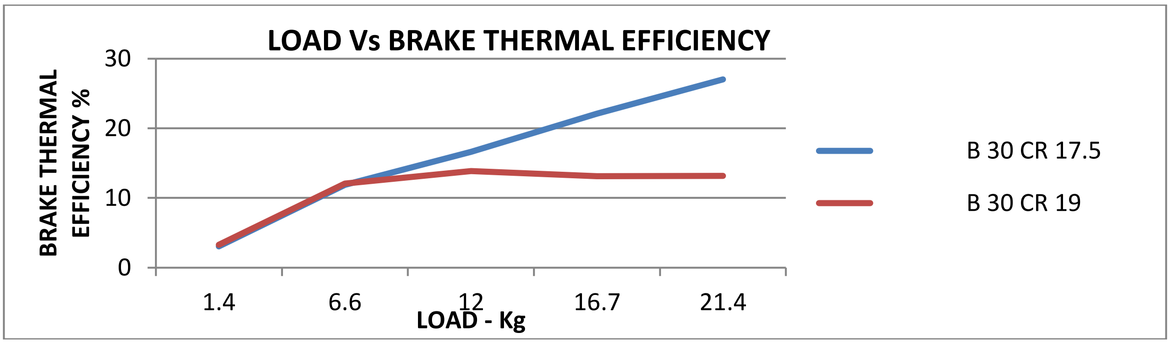

Fig23.Comparison for Blends (B30)

The maximum brake thermal efficiency of the engine was decreased with decrease in the compression ratio and the maximum brake thermal efficiency for diesel was found to be 27.0129 at 21.4 kg load.

4.2.5 Comparison Graphs for Brake Specific Fuel Consumption for Compression Ratios 17.5:1 & 19:1

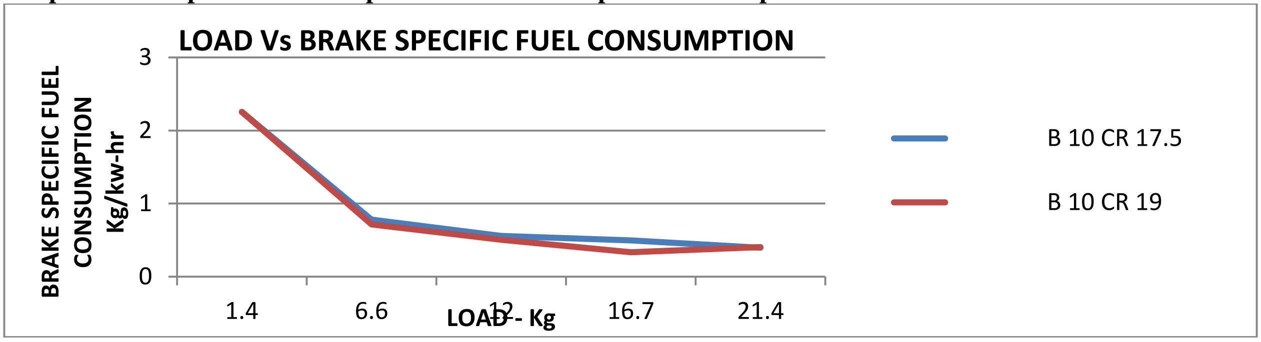

Fig 24.Comparison graph for Diesel

The brake fuel consumption of the engine was decreased with increase in the compression ratio and the minimum brake fuel consumption for diesel was found to be 0.03995 at 24 kg load.

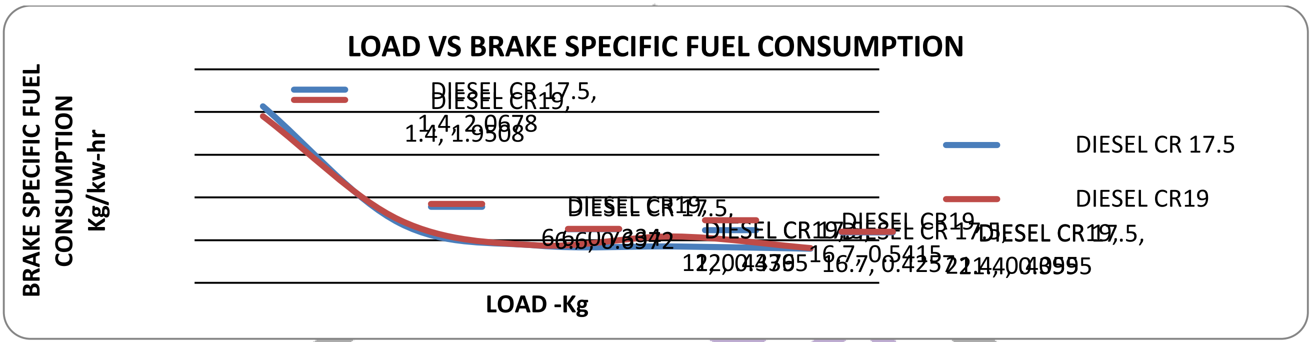

Fig 25.Comparison graph for Blends (B10)

The minimum brake fuel consumption of the engine was decreased with increase in the compression ratio and the minimum brake fuel consumption for diesel was found to be 0.3362 kg/kw-hr at 16.7 kg load.

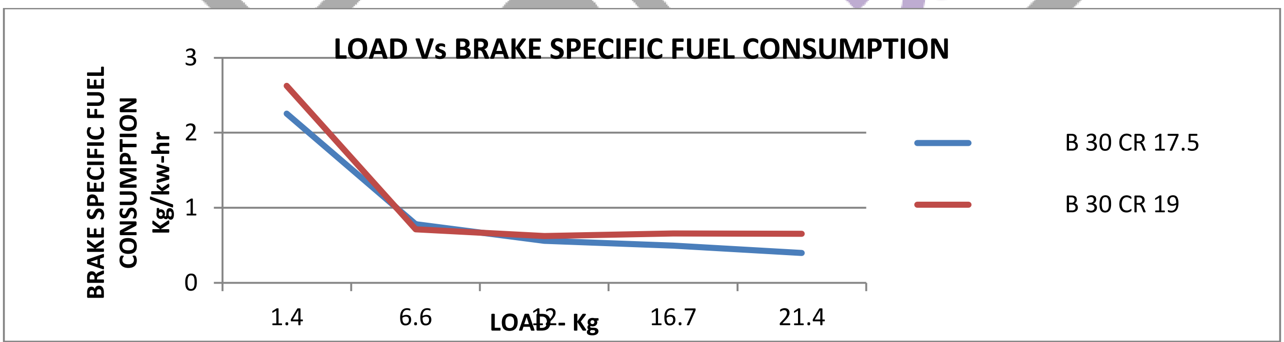

Fig 26.Comparison graph for Blends (B30)

The brake fuel consumption of the engine was decreased with increase in the compression ratio and the minimum brake fuel consumption was found to be 0.3963 at B30 24 kg load.

4.3 Effect of Compression Ratiofor Diesel and Corn Oil Blends B10 And B30 With Cerium Oxide as Nano Additive

In a CI engine, cylinder pressure depends on the burnt fuel fraction during the premixed burning phase, which is the begininig phase of combustion. Cylinder pressure characterizes the capacity of the fuel to mix properly with air and burn condition. The comparison of cylinder pressures with crank angle for the fuels tested are done at all compression ratios under the 75% of rated load. The results show that the peak cylinder pressure of the engine running with ester blends is marginally greater than the engine running with diesel at 75% of rated load and compression ratios.

There were some reasons for this behavior .Due to higher viscosity, low volatility, and higher cetane number of biodiesel blends, there is occurrence of a short ignition delay and advanced injection timing for esters blend than diesel fuel. As a result, combustion starts later for diesel fuel and the peak cylinder pressure attains a lower value as it is further away from the TDC in the expansion stroke.Due to the presence of oxygen molecule in biodiesel, the hydrocarbons achieve better combustion resulting in higher cylinder pressure. These increased values of cylinder pressure with compression ratio were observed at 75% of rated load for all blends. This shows that increasing the compression ratio had more benefits with ester blends than with pure diesel. Due to their low volatility and higher viscosity and cetane number, biodiesel might be performing relatively better at higher compression ratios. Also the oxygen content of biodiesel may be a cause for this better performance.

4.4 Comparison Graphs Between Pressure And Crank Angle

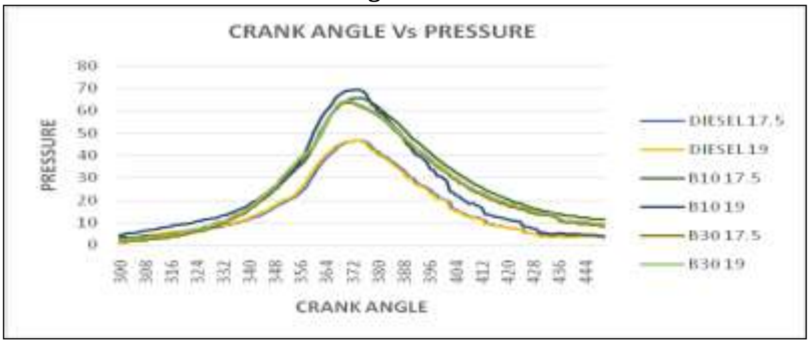

Fig 27. Crank angle Vs Pressure

From the above graph the peak pressure is obtained for Corn bio diesel blend B10 with cerium oxide as Nano additive when compared to other blends.

4.5 Emission Analysis

The emissions obtained during the experimentation at different loads are obtained by using a 5-Gas analyzer. The experimentation is done by diesel, Corn bio diesel blends. The emission analysis for CO, CO_2, and HC are shown in figure 27 to 29 for diesel and bio diesel blends.

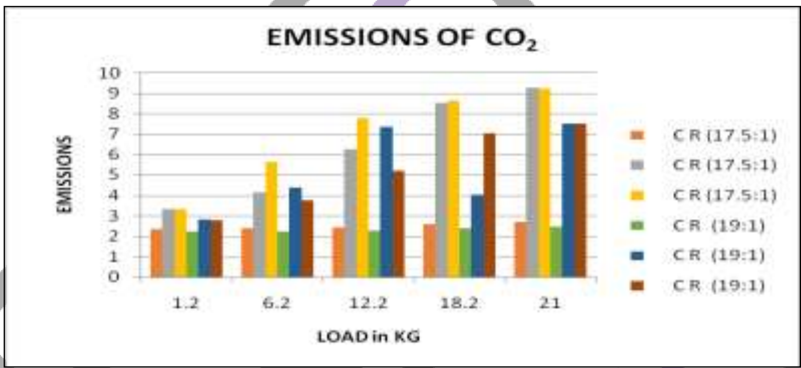

Fig28 Load Vs CO_2 comparison graph

The emisssion of carbon dioxide varies for various blends at varying loads. The carbon dioxide emission for the blends is higher than diesel for all loads and blends and decreases with increase in compression ratio. Carbon dioxide is formed on complete combustion of the fuel in oxygen. As the calorific value of the fuel is low, more fuel needs to be burnt to get equivalent power output. So combustion of more carbon compounds leads to higher carbon dioxide emissions.

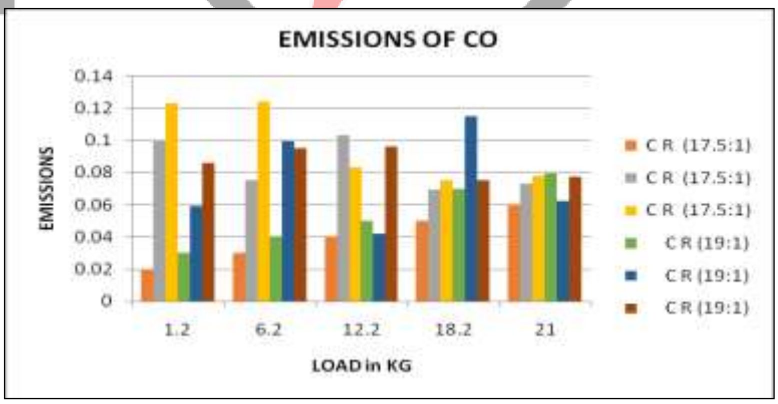

Fig29. Load Vs CO comparison graph

The variation of carbon monoxide with load and compression ratio of the engine is shown in figure 28. It is observed that carbon monoxide emission decreases when comes to diesel. It means that proper combustion has not carried out for biodiesel. The minimum carbon monoxide emissions were obtained for diesel.

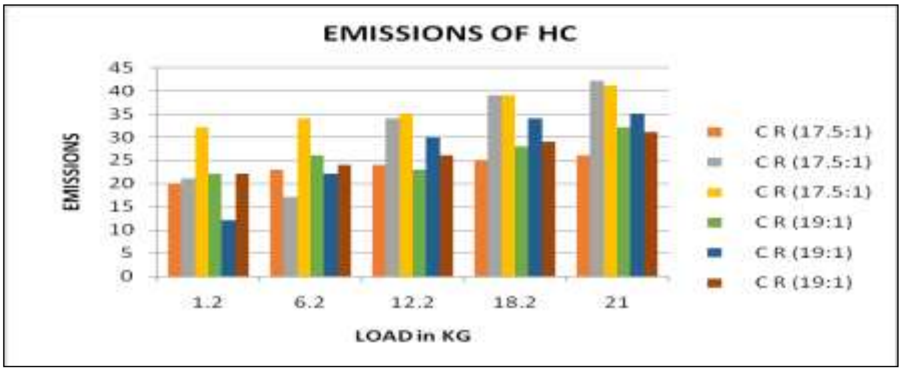

Fig30. Load Vs HC Comparison Graph

The hydro carbons variation with load for the Corn biodiesel and diesel are shown in figure 29. The hydro carbons are higher for all the blends for the Corn biodiesel compared with diesel. The results depend on oxygen quantity and fuel viscosity and uniform vaporization during combustion.

4.6 Emission Characteristics:

The variation of carbon monoxide with load on the engine is shown in Figure 28. It is observed that carbon monoxide emission decreases when comes to diesel. It means that proper combustion has not carried out for biodiesel. The minimum carbon monoxide emissions were obtained for B10 blend. The variation of carbon dioxide with load on the engine is shown in Figure 27. It is observed that carbon dioxide emission increase with increase of load. The Minimum carbon dioxide emission was obtained for the diesel is 2.23% at 1.2 kg load. This is a result of low accessibility of gas throughout combustion.

The hydro carbons variation with load for the Corn biodiesel and diesel are shown Figure 29. It is observed that hydro carbon emissions increase with increase of load. The hydro carbons are greater for all the blends for the Corn biodiesel compared with diesel. The lowest value of HC was 12 at load 1.2 Kg and it was 42 at 22 kg for B10. This result depends on oxygen quantity and fuel viscosity and uniform vaporization during combustion.

V. CONCLUSIONS

A single cylinder computerized variable compression ratio engine was operated successfully using Corn biodiesel and its blends of Corn oil methyl ester in addition with cerium oxide nano-particles. The following conclusions are made based on experimental results. Engine works smoothly on Corn oil with performance comparable to diesel operation. Mechanical efficiency of engine is increased by the blends of Corn oil with diesel. The brake thermal efficiency of the engine with Corn methyl ester-diesel blend was marginally better than with neat diesel fuel. Brake specific energy consumption is lower for Corn methyl ester-diesel blends than diesel at all loading. With the increase in load, mechanical efficiency of B30 increased in 17.5:1 compression ratio. With the increase in load, specific fuel consumption of B10 decreases in 17.5:1 compression ratio. With the increase in load, brake thermal efficiency of B10 increases in 17.5:1 compression ratio. With the increase in load, mechanical efficiency of B30 increases in 19:1 compression ratio. With the increase in load, break thermal efficiency of B30 increases in 19:1 compression ratio. With the increase in load, specific fuel consumption of B30 decreases in 19:1 compression ratio. For 17.5:1 compression ratio with B10, a better mechanical efficiency, brake thermal efficiency is observed when compared to diesel and other blends and brake specific fuel consumption for B10 was less. For 19:1 compression ratio with B30, better mechanical efficiency, brake thermal efficiency is observed when compared to diesel and other blends and brake specific fuel consumption for B30 was less. Hence it is concluded that the VCR Diesel engine works efficiently by giving lowest emission values of CO, CO_2 and HC for Corn biodiesel blend B10 with cerium oxide as nano- additive at both the compression ratios 17.5:1 and 19:1.

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