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EFFECTS OF COMBUSTION NANO PARTICLE CATALYST ON CASHEW NUT SHELL BIODIESEL (CARDANOL) OIL AND HABITUDE IN A COMPRESSION IGNITION ENGINE.

S.Vinodraj[1], Dr.R.Arularasan[2], S.Giridharan[3], C.Gnanaselvan[4], S.Gopinath[5]

[1]*Associate Professor Department of Mechanical Engineering, IFETcollege of engineering, Villupuram*
[2]*Associate Professor Department of Mechanical Engineering, University college of engineering, Arni*
[3,4,5]*U.GStudent Department of Mechanical Engineering, IFET college of engineering, Villupuram*

Abstract - *An experimental study has been carried out to establish the effects of combustion catalyst cupric oxide and Zirconium oxide nano particle on cashew nut shell biodiesel (cardanol) and habitude in diesel engine. The analysis includes two parts. In the first part of the analysis cashew nut shell biodiesel is refined by renowned transesterification process and Nano biodiesel fuels were prepared by adding cupric oxide and Zirconium oxide nanoparticles. These nanoparticles were blended with cashew nut shell biodiesel (cardanol) in the mass fractions of 25 ppm, 50 ppm, 75 ppm and 100 ppm with help of ultrasonicator. Physicochemical characteristics of Nano biodiesels were measured and correlated with diesel fuel. Engine tests have been conducted to get the equivalent measures of Specific Fuel Consumption (SFC), Brake Thermal Efficiency (ηTh) and Emission components like CO, HC, NO_x& O_2 are evaluated to study the behavior of B20 added with 25ppm, 50ppm, 75 ppm, 100 ppm Cupric oxide (CuO) nanoparticles and 25ppm, 50ppm, 75 ppm, 100 ppm Zirconium oxide nanoparticles at various loading conditions with standard diesel operation.*

It is noticed that there is slight rise in the specific fuel consumption for the fuel B20 with 100ppm cupric oxide(CuO) and Zirconium oxide (ZrO_2) at full load operation. The brake thermal efficiency is identical than that of diesel operation at full load condition. A convincing improvement in Emission components CO, CO_2& HC has been observed when the engine is fed with B20 with 100ppm CuO and ZrO_2 at both 3/4th Full Load and Full Load conditions. However, NO_X emissions had increased. Reckon with performance and emission analysis the fuel blend 20 with 100 ppm CuOand Zirconium oxide Nano particles is the best combination.

Keywords- *Combustion catalyst, Cashew nut shell, Cupric oxide, Zirconium oxide, Specific fuel consumption, Performance&Emission*

I INTRODUCTION

Compression ignition engines find wide spread use in locomotives, construction equipment, automobiles, and countless industrial applications. Degrade of fossil fuels and uncontrollable atmospheric pollution caused by diesel engines, we in need searchof alternate energy sources required for transportation and power generation across the planet. Impact ofnon-edibleoil biodiesel on engine performance and emissionbe used as alternative to diesel with or without engine modifications. [1]
Reduction in fossil fuels , rising fuels prices and environmental attention have renewedengineers and scientists to progress alternative fuels and improve the efficiencies of energy systems. Nano fluids are a new class of solid-liquid composite materials consisting of nano sized solid particles dispersed in any base fluid [2]
Metallic based and oxygen containing compounds, such as aluminum oxide (Al2 O3), titanium oxide (TiO2) and copper oxide (CuO) which acts as a combustion catalyst for hydrocarbon fuels. Therefore, nano diesel has a potential to improve the combustion efficiency and to reduce the air pollutants.[3]

II LITERATURE REVIEW

S.Vedharaj,R.Vallinayagam et.al has conducted an experiment in the performance emission and economic analysis of preheated CNSL biodiesel as an alternate fuel for a diesel engine.CNSL is trans-esterified in double stages due its high free fatty acid content and instead of using produced CNSL biodiesel it was directly used in a single cylinder diesel engine by preheating it. The high viscosity of biodiesel is reduced and the experimental investigation tends to show that performance and emission of preheated CNSLME has been improved. At an inlet fuel temperature of 80˚C, the CNSLME discerns a 20% increase in BTE, 66% and 52% decrease in CO and HC emission respectively, than unheated CNSLME. [4]

P.Dinesha, P.Mohanan et.alstudied on the evaluation of combustion, performance and emission of a diesel engine fueled with bio-fuel produced from cashew nut shell liquid.A non-edible plant based bio-fuel cardanol produced cashew nut shell liquid(CNSL) is used to study the combustion,performance and emission of single cylinder diesel engine. The test condition of the engine are 200 bar injection pressure and 27.5 degreebTDC injection timing.The bio-fuel blends B10M10 (10 % cardanol +80 % diesel+10 % methanol), B20M10 and B30M10 were tested at 25%, 50%, 75% and full load conditions. The results were compared with baseline diesel operation.From the experimental work, it was found that the brake thermal efficiency of B10M10 and B20M10 is comparatively similar to that of diesel fuel.The lower emissions of CO, HC, and smoke are decreased.[5]

Mallikappa D.N, RanaPratap Reddy, Ch.S.N.Murthy et.al conducted an experiment on the performance and emission characteristics of double cylinder CI engine operated with cardanol bio fuel blends.In this experiment the engine test were conducted on a double cylinder,direct injection,compression ignition engine,from the test it is observed that the brake power increases 70% as the load increases and emission levels were nominal up to 20% blends. [6]

T.Pushparaj, P.P.Shantharaman, D.JohnPanneerSelvam et.al conducted an experimental study on the effect of blending Nano additive with cashew nut shell liquid bio-oil on performance, combustion and emission characteristics of four stoke diesel engine and to investigate the impact of cerium oxide nanoparticles added at 20,40.60 ppm levels to CNSL bio-oil. The experiment results revealed a substantial enhancement in the performance of engine and reduction in harmful emission for cerium oxide nanoparticles blends compared to those of bio-oil blend and diesel. The 20% biodiesel with 40 ppm cerium oxide nanoparticle additive reduces 27% NO emission when compared with 20% bio-oil blends,CO emission is reduced by 37% and smoke opacity reduced by 29% at full load condition. [7]

S.Vedharaj, R.Vallinayagam et.al studied on the performance emission analysis of preheated CNSL biodiesel as an alternate fuel for a diesel engine.The CNSL oil is transesterifiedto remove the high free fatty acid by this the higher viscosity of biodiesel is reduced and the experimental investigation tends to show that both the performance and emission of preheated CNSLME has been improved.At inlet fuel temperature of 80˚C the CNSLME discerns a 20% increase in BTE, 66% and 52% decrease in CO and HC emission than unheated CNSLME.[8]

A.Prabu et.al conducted the experiment on the nanoparticles as additive in biodiesel on the working characteristics of a DI diesel engine by adding nanoparticles such as Alumina and Cerium oxide of each 30 ppm are mixed with the fuel blends by means of an ultrasonicator, to attain uniform suspension.The brake thermal efficiency has improved by 12% and 30% reduction in NO emission, 60% reduction in CO emission, 44% reduction in HC and 38% reduction in smoke emission. [9]

A.Prabu, R.B.Anandet.al studied on the Emission control strategy by adding alumina and cerium oxide nano particle inbiodiesel in order to evaluate the effect of nano particles such as Alumina (Al2O3) and Cerium oxide(CeO2) as additives in Jatropha biodiesel,. Alumina and Cerium oxide nano particles are added with Jatropha biodiesel at mixedproportions forming 10, 30 and 60 parts per million. Significant improvement in the brakethermal efficiency near to that of neat diesel is observed for the nano particle blended testfuels along with the reduction of nitric oxide, carbon monoxide, unburned hydrocarbon andsmoke emission by 13 %, 60 %, 33 % and 32 % respectively. [10]

V.ArulMozhiSelvan, R.B.Anand, M.Udayakumar et.al conducted an experimental investigation is carried out to establish the performance and emission characteristics of a compression ignition engine while using cerium oxide nanoparticles as additive in neat diesel and diesel-biodiesel-ethanol blends. After series of experiments, it is found that the blends subjected to high speed blending followed by ultrasonic bath stabilization improves the stability. The phase separation between diesel and ethanol is prevented using vegetable methyl ester (Biodiesel) prepared from the castor oil through transesterification process. In the second phase, performance characteristics where studied. The cerium oxide acts as an oxygen donating catalyst and provides oxygen for the oxidation of CO or absorbs oxygen for the reduction of NOx. The tests revealed that cerium oxide nanoparticles can be used as additive in diesel and diesel-biodiesel-ethanol blend to improve complete combustion of the fuel and reduce the exhaust emissions significantly [11].

SundarrajChockalingam and SaravanakumarChowdry S et.al studied an experimental investigation of Cardanol Ethyl Ester as an alternative fuel for diesel engine.An experimental investigation to analyze the performance and emission characteristics of cardanol ethyl ester (CEE) and its blends with base fuel on a single cylinder water cooled four stroke diesel engine is presented. Engine performance and emission data were used to optimize the blends. Result shows improved level of performance with blends at high load. B25 (75% Diesel with 25% CEE by volume) blend recorded a higher level of brake thermal efficiency of 30.71% against 29.13% for the neat diesel at high load without significant changes in smoke density and NOx emissions. The HC emission for CEE blends at partial loading condition is arrived to be higher than that of base line diesel fuel however it is comparable in peak load. [12]

G.KASIRAMAN, M.BALAKRISHNANet.alconducted an experimental investigation on unattended methyl ester of cashew shell oil as fuel in direct injection diesel engine. In this work viscous vegetable oil from cashew shellhad been tested for feasibility as engine fuel. The oil was transesterified with Methyl Alcohol andvarious blends of Methyl Esters of Cashew Shell Oil (MECSO) were prepared. The blends were tested in a conventional Direct Injection Diesel Engine without any modification on the engine part.The performance, combustion and emission characteristics had been studied. The MECSOdeveloped up to 96% of indicated power that of diesel. The Brake Thermal Efficiency drooped by6 % with increase in Specific Fuel Consumption. The power output of the engine decreased with theincrease in percentage of biodiesel in the blend. The peak combustion pressure was slightly higherthan diesel. The maximum unburned hydro carbon emission ranges to 23 %. [13]

S.SaravanakumarChowdry and C. SundarRaj et.al conducted a study of physical and chemical properties of Cardanol Ethyl Ester for its suitability as petro-diesel. Experimental investigations were made to find out the physico-chemical properties of cardanol biofuel extracted from cashew nutshell and their ethyl esters produced through transesterification. The cardanol ethyl ester (CEE) was characterized as an alternative diesel fuel through series of ASTM standard fuel tests. A constant speed diesel engine, which develops 5.2 kW of power, was run with biodiesels and its performance was compared with diesel fuel. The CEE had 56% reduction of viscosity at 40°C and 9.2% heat value over its crude oil. Higher cetane number, specific gravity and lower flash and fire points were observed for CEE compared with neat diesel fuel. The fatty acid composition shows 10.8% increase in saturated and 23.4% decrease in unsaturated fat after tranesterification and their values were found to be within limits set by various international standards for biodiesel. [14]

Harish Venuand VenkataramananMadhavanet.al has conductedthe present work is dedicated to the comparative experimental study of biodiesel ethanol blends in a compression ignition engine using TiO2 (Titanium oxide) nanoparticle, ZrO2 (Zirconium oxide) nanoparticle and DEE (Diethyl ether) additives. The test fuels used are a blend of biodiesel (80%) - ethanol (20%) (denoted as BE), a blend of BE with 25 ppm Titanium oxide nanoparticle (denoted as BE-Ti), ablend of BE with 25 ppm Zirconium oxide nanoparticle (denoted as BE-Zr) and a blend of BE with 50 ml Diethyl ether (denoted as BEDEE).Addition of nanoparticles increases the oxidation rate, reduces the light-off temperature and creates large contact surface area with the base fuel thereby enhancing the combustion with minimal emissions. Experimental results shown that addition of Titanium nanoparticles increased NOx, HC and smoke with lowered BSFC and CO. Whereas addition of Zirconium nanoparticles increases BSFC and HC emissions with lowered CO, CO2 and smoke emissions in comparison with BE blends. DEE addition to BE blends improved the heatrelease rate and increased HC, CO emissions were observed with lowered BSFC, NOx and smoke. Simultaneous reduction of NOx and smoke indicates the effect of DEE on Low temperature combustion (LTC).[15]

III EXPERIMENTAL STUDY

The engine used for the study was a single cylinder, four stroke, speed,vertical, air cooled, and direct injection dieselengine that has a rated output of 4.4 kW at 1500 rpm. An electricaldynamometer was coupled to the engine was used as a loadingdevice. The load and speed can be increased or decreased on the engine by using dynamometer, by switching on or off theload resistances. Carbon monoxide (CO), carbon dioxide (CO_2), nitrous oxide (NO_x) and unburned hydrocarbon(UBHC) emissions were measured by AVL exhaust gasanalyzer. Fuel consumption was measured by a U-tubemanometer. Smoke number was measuredby smoke meter. The schematic diagram of the experimental set-upis shown in with all measuring points and measuringinstruments. The technical specifications of the engine are given below respectively.The engine was started with diesel fuel and warmed and thenfuel consumption and exhaust emissions NOx, HC, CO, CO2 andsmoke were measured. Similar procedure was repeated forbiodiesel (cardanol) and biodiesel (B20 cardanol) with nano fuel additives of CuO and ZrO_2 in various level ppm.

3.1 **Preparation of nanoparticles:**

The stabilization is the process of making the nanoparticles stable with the biodiesel without getting deposit at the bottom.The stability of fuel is very important, because by making the fuel stability it helps for good combustion inside the engine cylinder. The process of adding nanoparticles to the fuel is done with the aid of an ultrasonicator. The ultrasonicator technique is the best suited method to disperse the nanoparticles in the base fuel, as it facilitates possible agglomerate nanoparticles back to nanometer range. . It helps to maintain stability of nanoparticles with biodiesel for a period of time. In this experiment cupric oxide (CuO) and zirconium oxide (ZrO_2) nanoparticles are weighed to a predefined mass fraction say 25ppm, 50ppm, 75ppm and 100ppm dispersed in the biodiesel with the aid of ultrasonicator set at a frequency of 20 kHz for 60 minutes. The resulting nanoparticles blended biodiesel is named as B20+25ppm, 50ppm, 75ppm and 100ppm CuO and ZrO_2. For analyzing the stability characteristics of nanoparticles blended biodiesel, the blends were kept in conical flask under static conditions. The observation were done on the stability of the Nano fuel blend.

Procedure for stabilization process:

- First the nanoparticles of 25, 50, 75,100 ppm cupric oxide and zirconium oxide are measured and kept in the separate air tight container.
- The biodiesel (cardanol) obtained from the CNSL oil is poured into the conical flash of 500 ml.
- The distilled water is poured in to the ultrasonicator.
- In the conical flask the biodiesel (cardanol) are mixed with nanoparticles of 25 ppm of CuO and keep the conical flask inside the ultrasonicator.
- The stabilization time is set for 60 minutes in the ultrasonic bath so that the nanoparticles and biodiesel (cardanol) get stabilized.
- After 60 minutes the nanoparticles get stabilized in the biodiesel (cardanol).
- The same procedure is repeated is for all the levels of nanoparticles.

3.3 Engine performance and emission tests:

Table 1 Specifications of Test engine

Make	Kirloskar
No. of Cylinder	One
Stroke	Four Stroke
Type of Cooling	Air Cooled
Ignition	Compression Ignition
Fueling	Diesel
Bore	87.5 mm
Stroke	110 mm
Compression Ratio	17.5:1
Speed	1500 rpm
Brake Power	4.4 kW
Injection Pressure	200 bar
Static Fuel Injection Timing	23 bTDC

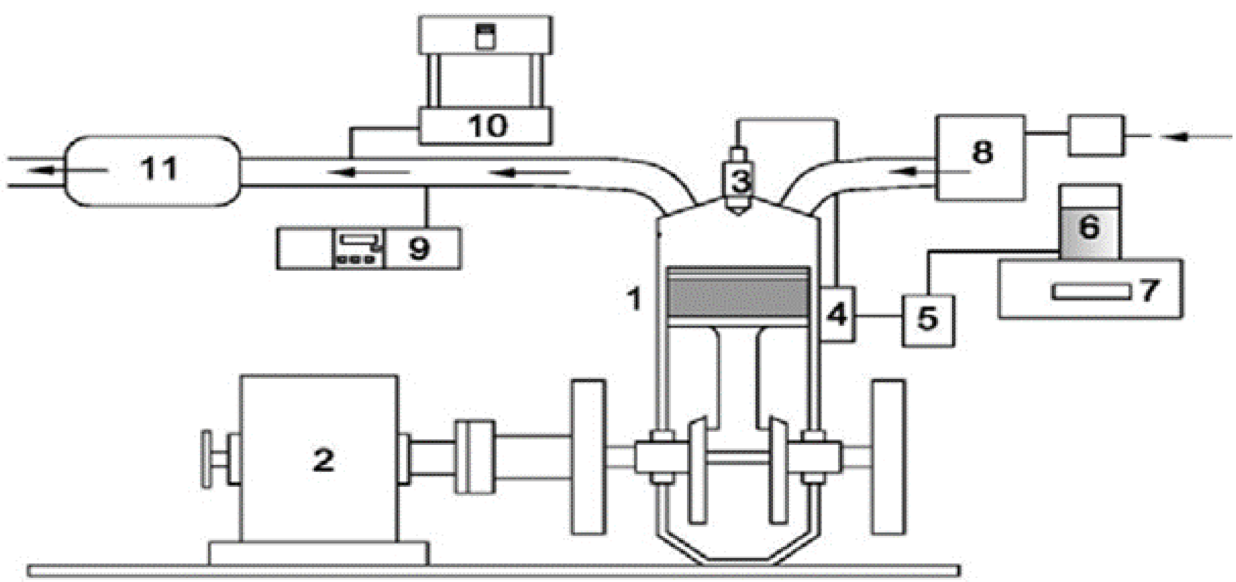

Fig 1 Experimental set-up

1. Kirloskar, 2. Eddy current dynamometer, 3. Fuel injector, 4. Fuel pump, 5. Fuel filter, 6. Fuel tank, 7. Weighing balance, 8. Air stabilizing tank, 9. AVL di-gas analyzer, 10. AVL smoke meter, 11. Exhaust silencer.

IV RESULTS AND DISCUSSIONS

The following section illustrates the results obtained from the performance and emission characteristics of the CI engine for diesel and biodiesel blends B20, B60, B100,B20+25,50,75,100 ppm CuO and B20+25,50,75,100 ppm ZrO_2.

4.1 Performance characteristics of blend percentage of B20, B60, B100 of cardanol oil:

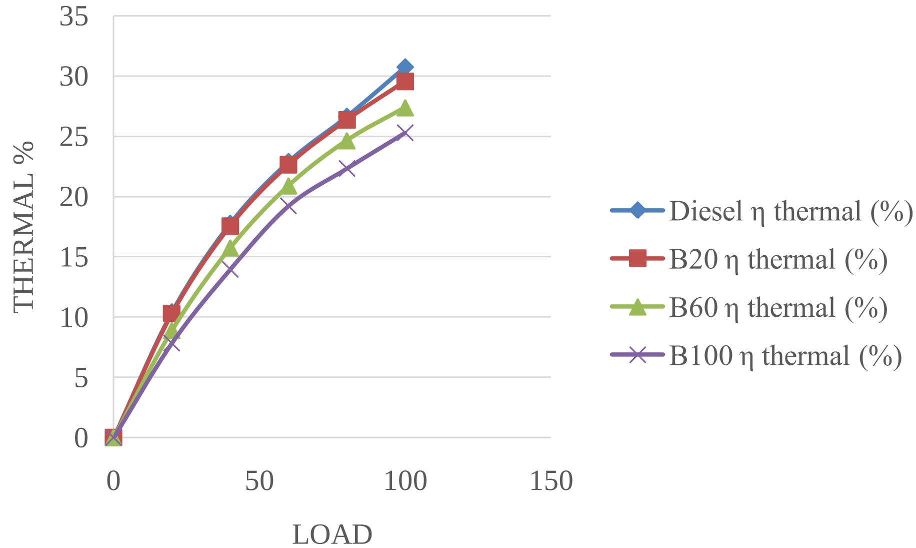

Fig: 2 Load vs Thermal η %

The variation of the thermal efficiency with respect to the load is shown in the Fig 2. The TE of the cardanol blends (B20, B60, and B100) was lower than the diesel due to the lower calorific value and also higher viscosity and density.

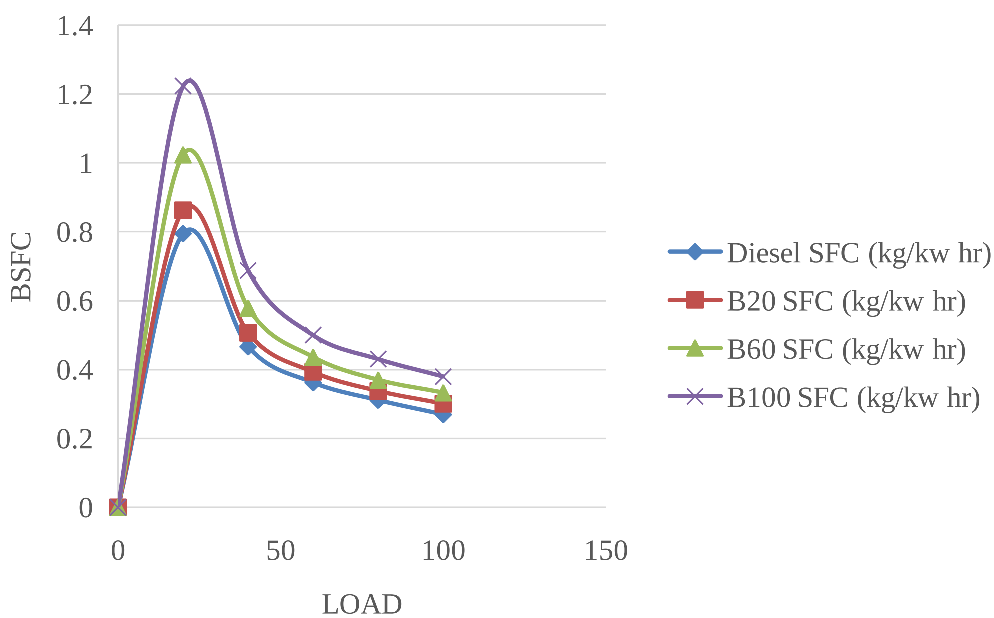

Fig: 3 Load vs SFC

The variation of the brake specific fuel consumption with engine loads, for different blends cardanol (B20, B60, and B100)) and diesel are shown in Figure 3. The specific fuel consumption decreases with an increase in the engine loads. Lower SFC is observed for B100 cardanol this occurs due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder.

Table 2 - Physico chemical properties of cardanol

Properties	Units	Diesel	Cardanol	ASTM standards
Specific gravity @ 20˚C	kg/m^3	0.835	0.9216	
Density @20˚C	Kg/m^3	0.85	0.9209	0.86-0.9
Flash point	˚C	80	171	>130
Cloud point	˚C	-	20	
Viscosity @40˚C	Cst	2.8	25.77	1.9-6
Fire point	˚C	88	210	
Calorific value	kj/kg	42000	42037	
Cetane number	-	50	57	Min 47
Iodine value	G12/110g	-	86.3	Max 120
Carbon residue	Mol/mol	-	0.07	Max 0.05

Emission Curve:
B20, B60, B100cardanol:
The major pollutants emitted at the exhaust of the engine are CO, CO2, NOx, HC, and Smoke. Among them, the most problematic gas emission is Nitric Oxide (NO).

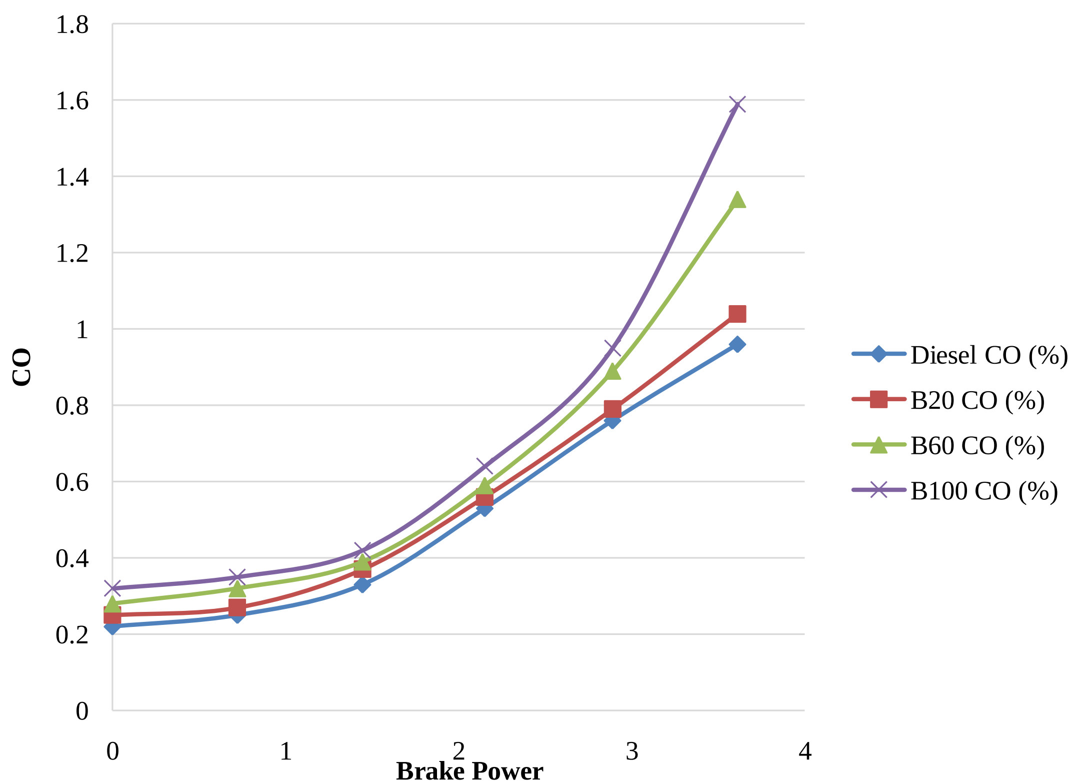

Fig: 4 Brake power vs CO

The graph plotted between brake power and CO% shown in Fig:4 indicates CO emission for cashew shell nut biodiesel (cardanol) are higher than that of diesel fuel for varying proportion (B20, B60, B100).This is due to the poor combustion of cardanol compared to diesel fuel and it also lowers the thermal efficiency of an engine and reduces the CO_2emission as shown in the fig: 5

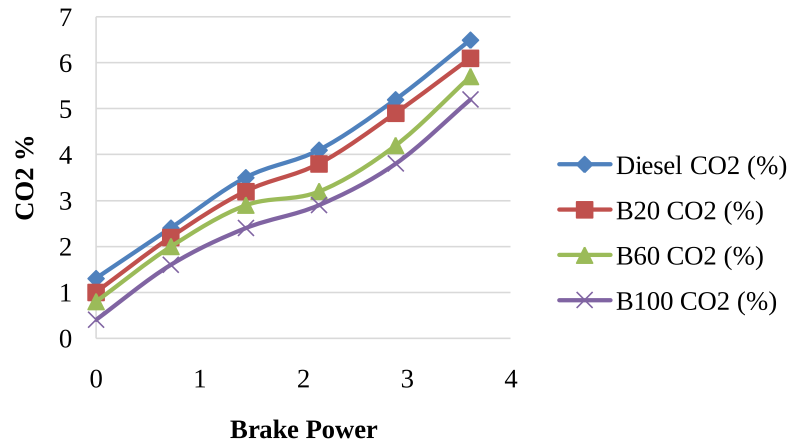

Fig: 5 Brake power vs CO_2

In fig:5 shows as CO% is higher than of diesel fuel it indicates the poor CO_2 emission comparable to diesel fuel and low CO_2 emission gives raise to higher unburnt hydrocarbon HC shown in fig:6

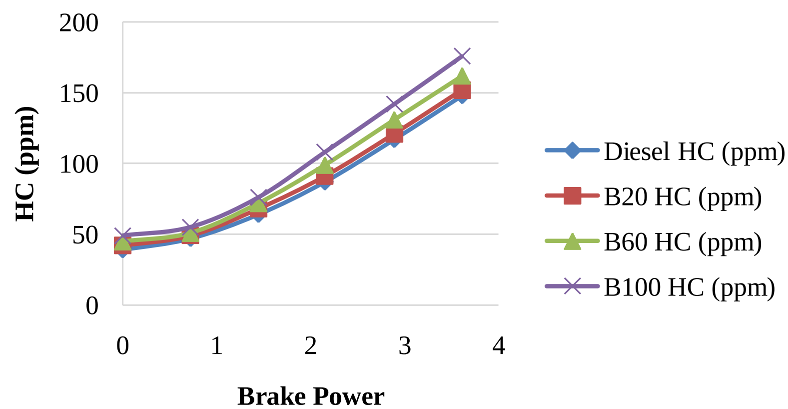

Fig:6 Brake Power vs HC(ppm)

The un-burnt HC emission variations for Diesel, cardanol blends of (B20, B60, and B100) B20 are shown in Fig 6. The HC emission for B20, B60, and B100operation was higher compared to diesel due to its lower thermal efficiency resulting from incomplete combustion.

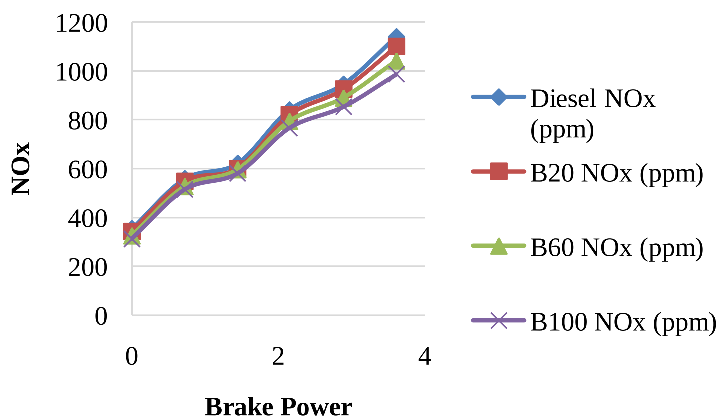

Fig: 7 Brake Power vsNO_x

The variations of NO_x emissions with respect to the load are shown in the Figure 7. The NO_x emissions found decreased with the increase in load. The NO emissions are decreased with the load due to the lower in-cylinder pressure and the corresponding combustion temperature for all the fuel blends.

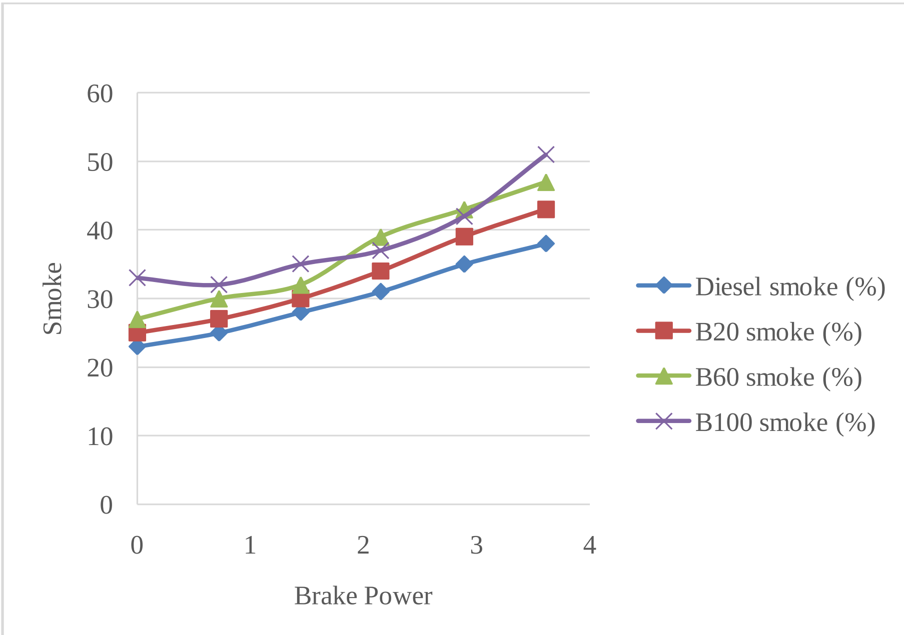

Fig: 8 Brake power vs Smoke

The smoke density variation for different blends is shown in Fig 8. Smoke density for cardanol (B20, B60, and B100) is noticed to be higher than the diesel fuel. This is due to the heavier molecular structure, poor atomization, presence of high carbon residue in the cardanol.

Performance characteristics curve:
Blend of B20 cardanol with 25, 50, 75, 100 ppm CuO:

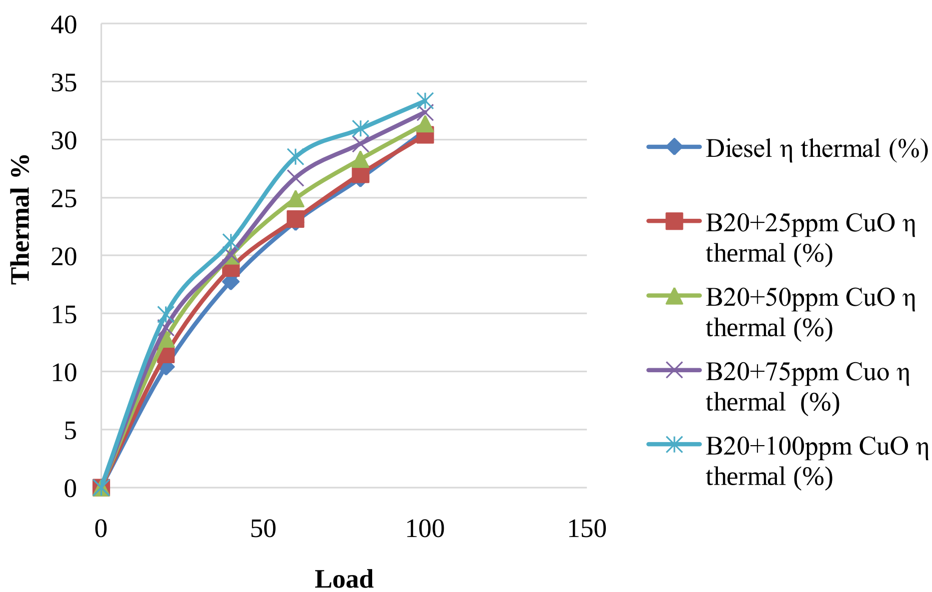

Fig: 9 Load vs Thermal

In the Fig: 9shows the variation of load with thermal efficiency. There is slight improvement inthe thermal efficiency than that of diesel fuel. This is due to the complete burning of fuel by adding combustion catalysts of cupric oxide in the biodiesel (B20 Cardanol).The blend B20+100 ppm CuO shows raise in thermal efficiency comparable to diesel fuel.

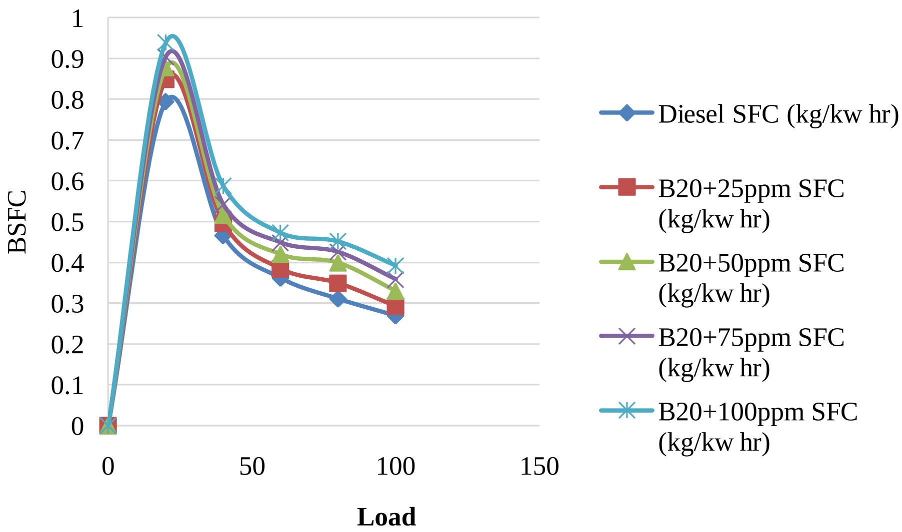

Fig: 10 Load vsBSFC

The variation of the specific fuel consumption with engine loads, for different nano additives blends of cardanol (B20) and diesel are shown in Fig: 10. Thebrake specific fuel consumption decreases with an increase in the engine loads. Lower SFC is observed for B20 blended nano additives this occurs due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder and also for B20 blends there is a slight increase in specific fuel consumption due to the decrease in the calorific value. From the above graphs it is concluded that B20+ 100 ppmCuO shows lesser specific fuel consumption than diesel due to the increase in calorific value and also catalytic effect.

Emission curve:

B20 (cardanol) blended with 25ppm,50ppm,75ppm,100ppm CuO:

The nanoparticle cupric oxide is added to the biodiesel (cardanol) at the levels of 25, 50, 75, 100 parts per million (ppm).The cupric oxide is added to reduce the exhaust gas emission. The below graph show the emission characteristics of the CuO added to the biodiesel (cardanol) B20.As the cardanol shows some unsteady combustion and increase in emission levels to avoid the toxic and to save the engine life an combustion catalysts is introduced in the form of nano particles to enhance the steady combustion in engine cylinder.

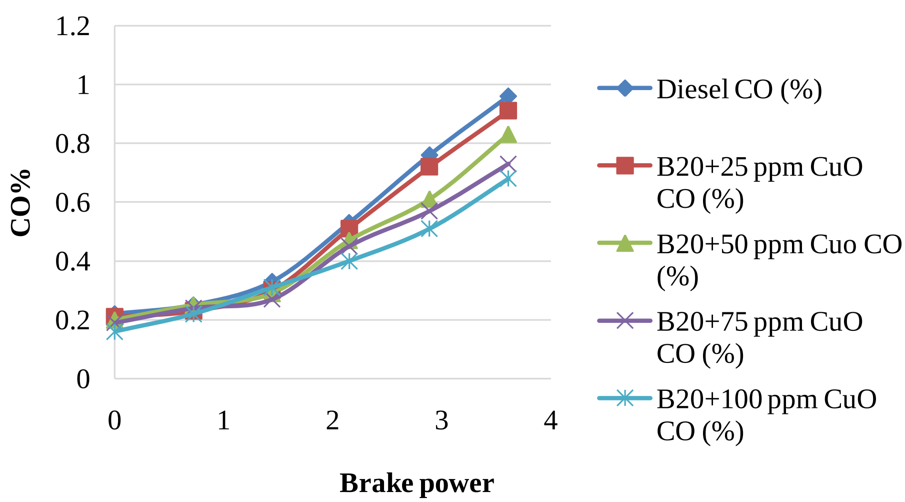

Fig: 11 Brake power vs CO%

The CO emissions for diesel, cardanol (B20) with nanoparticles blended fuel are shown in Figure 11. The CO emission for B20, B60, and B100 blends operation was higher compared to diesel due to its lower thermal efficiency resulting in incomplete combustion. However CO emissions were marginally lower for the nanoparticles blended fuels than diesel. The higher catalytic activity and improved combustion characteristics of copper oxide nanoparticles lead to improved combustion.

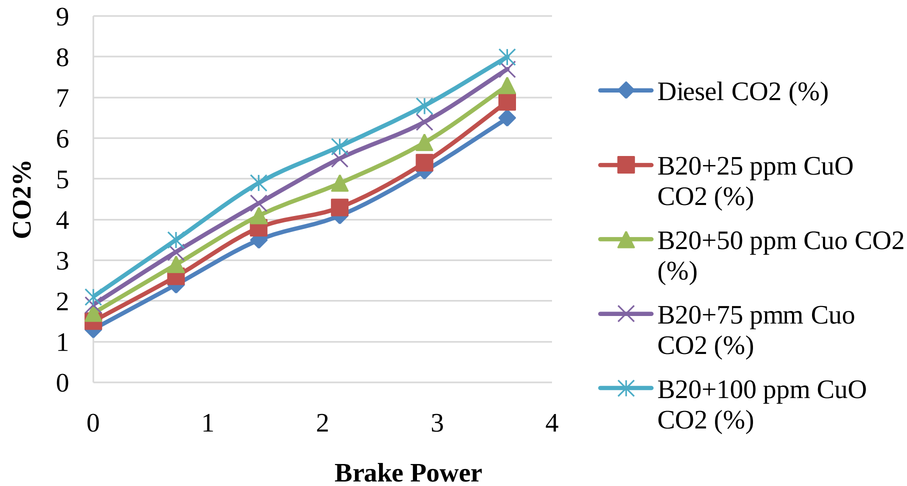

Fig: 12 Brake Power vs CO_2

The above fig 12 shows the variation of CO_2 with brake power. The CO_2 emission for cardanol (B20) blended with nanoparticles are comparatively higher than that of diesel fuel. This is due to the superior combustion fuel inside the engine. The increase in emission of CO_2 is good for the engine.

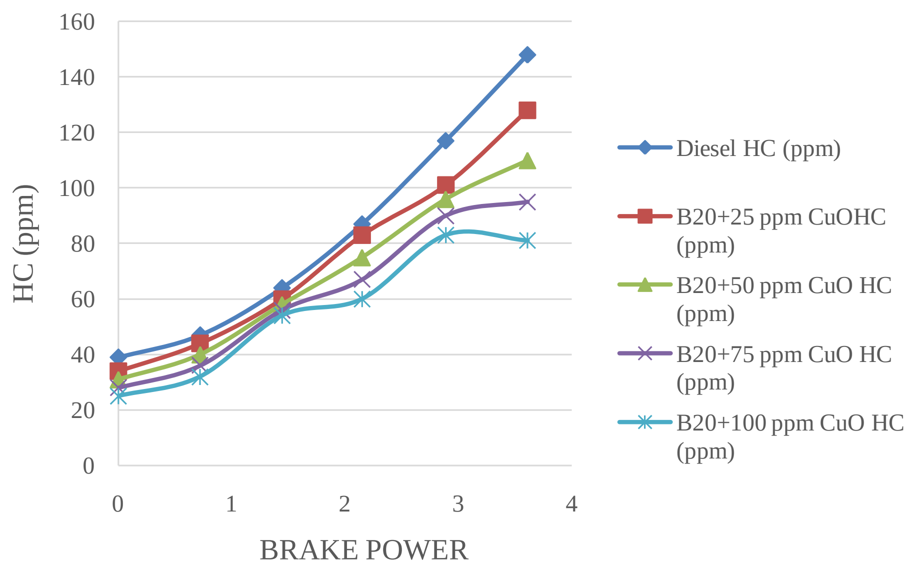

Fig: 13 Brake Power vs HC(ppm)

The un-burnt HC emission variations for Diesel, cardanol (B20) with cupric oxide nanoparticle blended fuels of B20 are shown in Figure 13. The HC emission for (B20, B60 and B100) operation was higher compared to diesel due to its lower thermal efficiency resulting from incomplete combustion. However HC emissions were marginally lower cupric oxide blended with (B20) cardanolcompared to B20. This could be due to increased catalytic activity and improved combustion characteristics of oxide, copper oxide nanoparticles which lead to improved combustion.

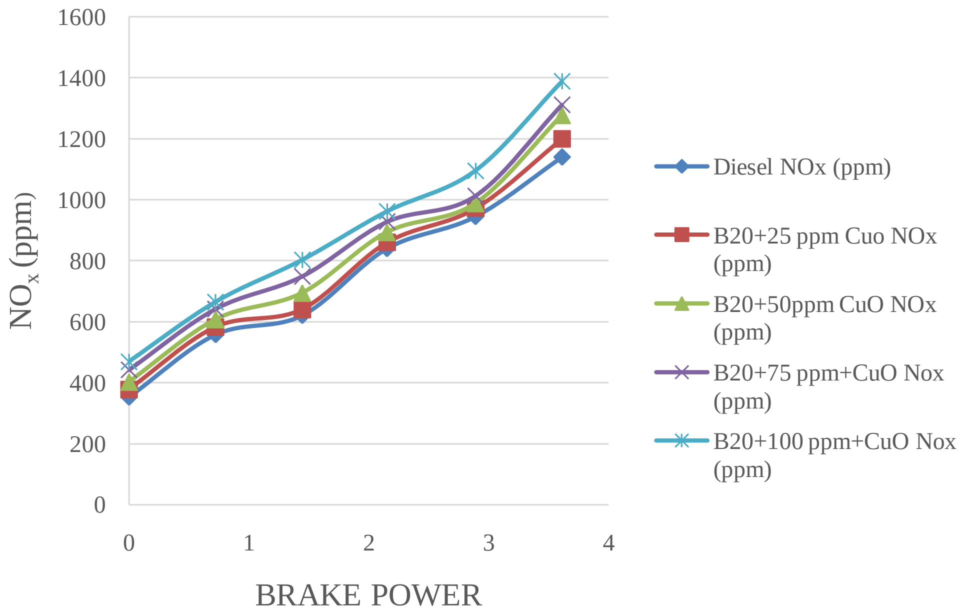

Fig: 14 Brake Power vsNO_x

The variations of NOx emissions with respect to the load are shown in the Figure 14. The NOx emissions found increased with the increase in load. The NO_x emissions are increasing with the load due to the more in-cylinder pressure and the corresponding combustion temperature for all the fuel blends. Similar trend was observed for diesel and B20 blended nano additives of cupric oxide at almost all loads. From the graph it is observed that addition of Nano-fuel additives resulted in an effective in NOx emission. This is due to that nanoparticles oxidize the nitrogen into nitric oxide at the elevated temperatures during the combustion process.

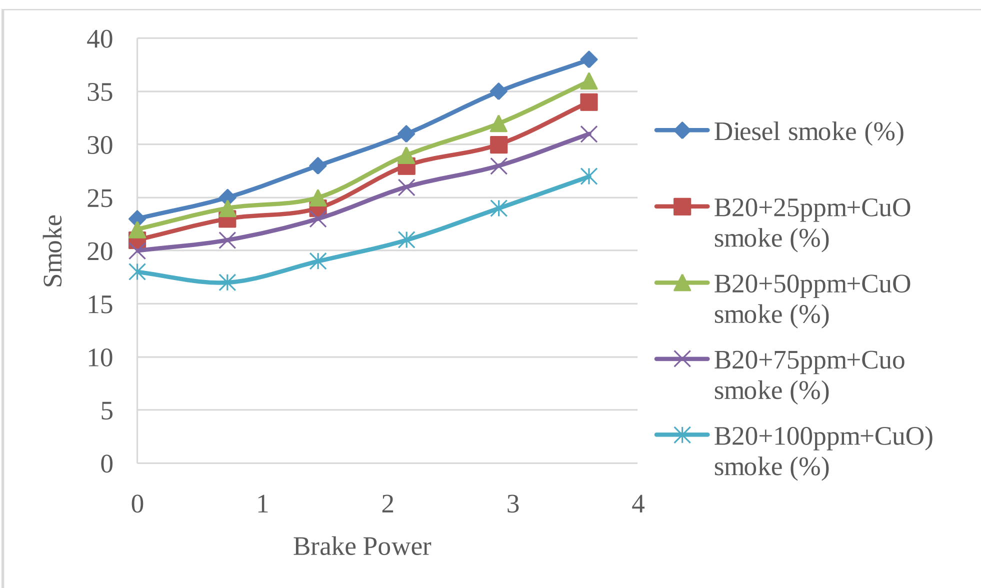

Fig: 15 Brake power vs Smoke

The smoke density variation with respect to brake power is shown Fig 15. Smoke density for cardanol blended with CuO nanoparticles is noticed to be lower than the diesel. This is due to the use of of oxygenate fuel (CuO) improves better combustion is the cause for reduction of smoke. It is observed the B20 cardanol with 100 ppm of CuO is very much lesser than diesel.

Performance curve:

B20 blended with 25,50, 75 and 100 ppm ZrO_2:

In this section we are adding the nanoparticles of zirconium (ZrO_2) at the levels of 25, 50, 75, 100 ppm. The below graphs shows the performance characteristics of the compression ignition engine by using the biodiesel (cardanol) with nanoparticles additives at various levels of proportion.

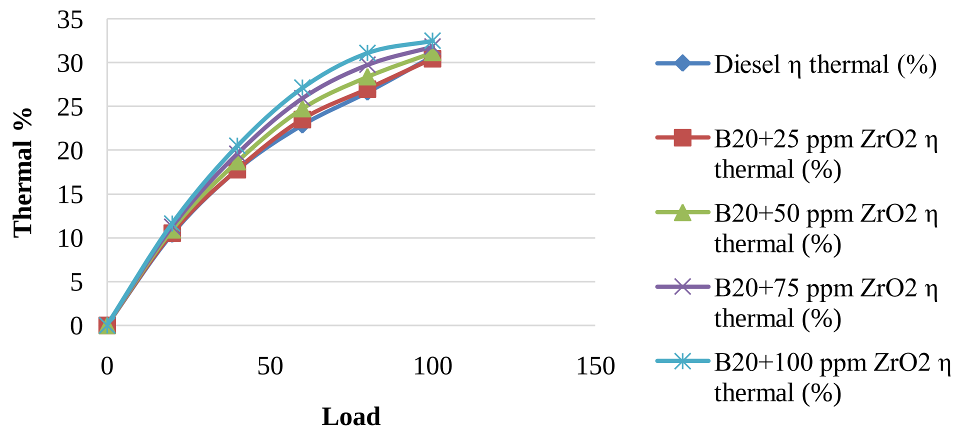

Fig: 16 Load vs η Thermal (%)

The variation of the thermal efficiency with respect to the load is shown in the Figure 16. The thermal efficiency of the cardanol was lower than the diesel due to the lower calorific value and also higher viscosity and density of the cardanol biodiesel fuel. However, a small improvement in thermal efficiency was found when addition of nano particles to the biofuel. From the above graphs it is observed that the B20 (cardanol) added with nanoadditives(ZrO_2) increase in thermal Efficiency

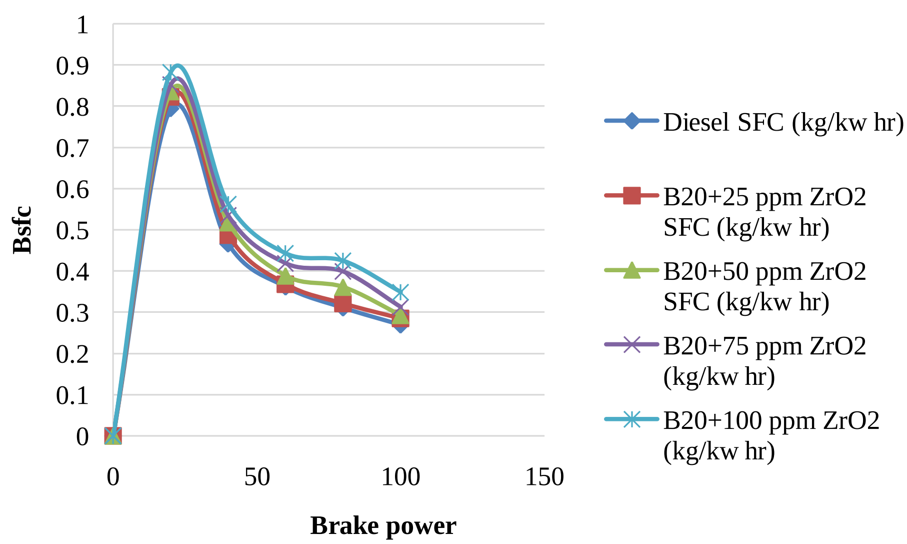

Fig: 17 Brake Power vs SFC

The variation of the specific fuel consumption with engine loads, for different nano additives blends of cardanol (B20) and diesel are shown in Figure 17. The specific fuel consumption decreases with an increase in the engine loads. . Lower SFC is observed for B20 blended with (ZrO_2)nano additives this occurs due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder and also due to the lower calorific value. From the above graphs it is concluded that B20+ 100 ppm ZrO_2 shows lesser specific fuel consumption than diesel due to the decrease in the calorific value.

Emission curve:

B20 blended with 25, 50, 75, 100 ppm ZrO_2:

The emission of the engine were recorded at the five different load condition by adding the nanoparticles of 25, 50, 75, 100 ppm of zirconium oxide. The nanoparticles are added to reduce the exhaust gas emission. The following graph shows emission from singles cylinder compression ignition engine by adding the zirconium oxide.

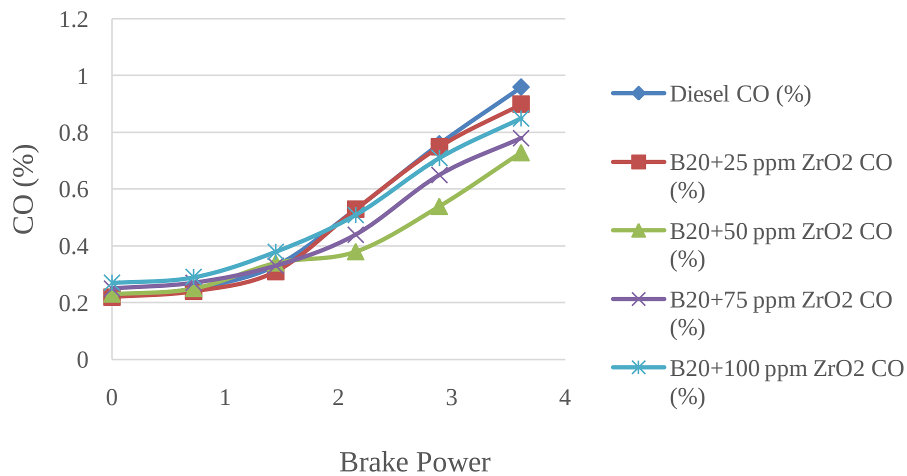

Fig: 18 Brake Power vs CO%

The CO emissions for diesel, cardanol (B20) with nanoparticles blended fuel are shown in Figure 18. The CO emission for B20, B60, and B100 blends operation was higher compared to diesel due to its lower thermal efficiency resulting in incomplete combustion. However CO emissions were marginally lower for the nanoparticles blended fuels than diesel. The higher catalytic activity and improved combustion characteristics of zirconium oxide nanoparticles lead to improved combustion.At B20cardanol with Nano additive of 100 ppm ZrO_2there is a reduction of CO emission.

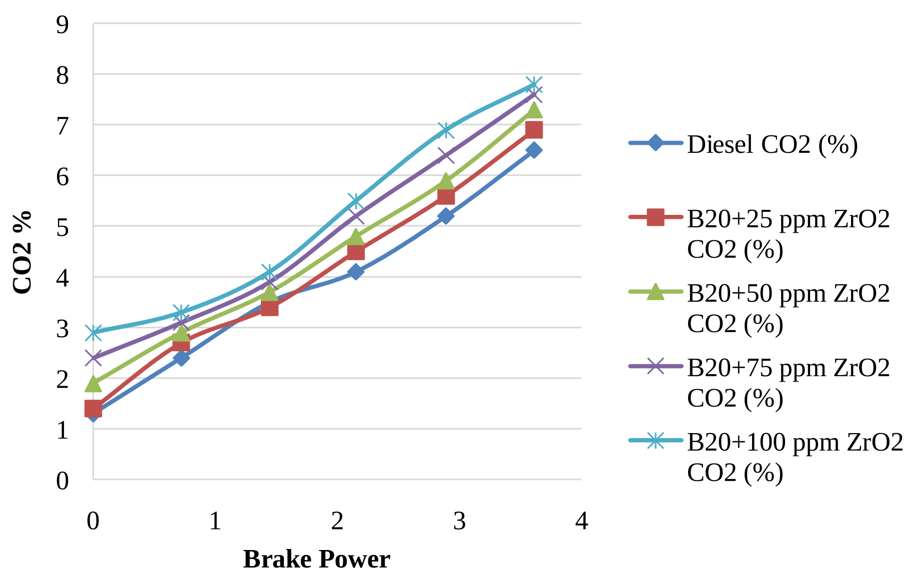

Fig: 19 Brake Power vs CO_2%

The CO_2 variation with brake power is shown in the above fig 19. The CO_2 emission for (cardanol) biodiesel with Nano fuel additive ZrO_2 are comparatively higher than that of diesel fuel. This is due to the complete reaction of carbon and hydrogen with oxygen. This leads to superior combustion of the engine

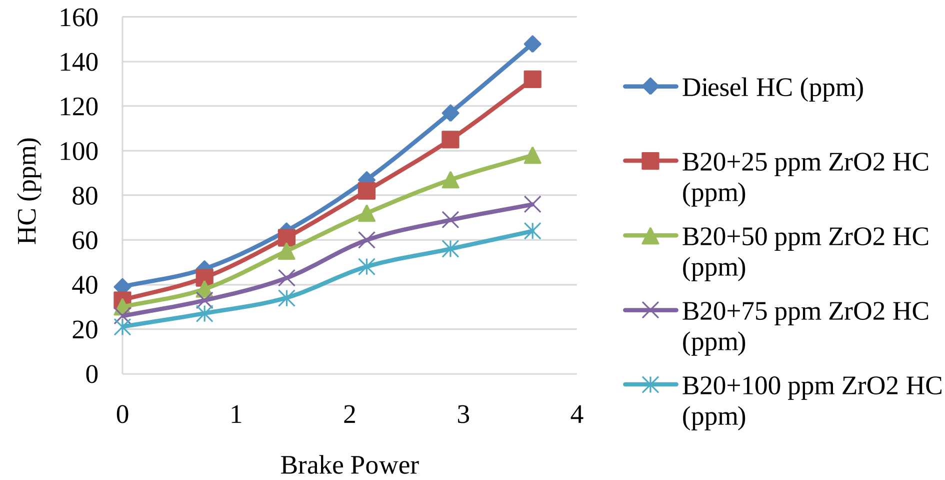

Fig: 20 Brake Power vs HC(ppm)

The un-burnt HC emission variations for Diesel, cardanol (B20) with zirconium oxide (ZrO_2) nanoparticle blend are shown in Figure 20. The HC emission for (B20, B60 and B100) operation was higher compared to diesel due to its lower brake thermal efficiency resulting from incomplete combustion. However HC emissions were marginally lower for the nano fuel zirconium oxide blended with (B20) cardanol compared to diesel. This could be due to increased catalytic activity and improved combustion characteristics of oxide, zirconium oxide nanoparticles which lead to improved combustion.

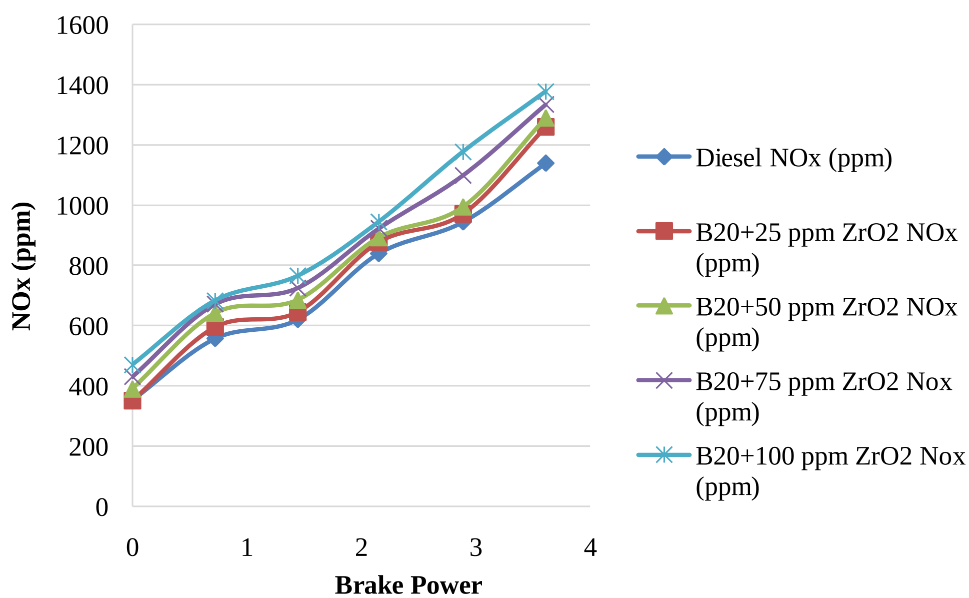

Fig: 21 Brake Power vsNO_x(ppm)

The variations of NOx emissions with respect to the load are shown in the Figure 21. The NOx emissions found increased with the increase in load. The NO emissions are increasing with the load due to the more in-cylinder pressure and the corresponding combustion temperature for all the fuel blends. Similar trend was observed for diesel and B20 blended nano additives of zirconium oxide almost all loads. From the graph it is observed that addition of Nano-fuel additives resulted in an effective in NOx emission. This is due to that nanoparticles oxidize the nitrogen into nitric oxide at the elevated temperatures during the combustion process.

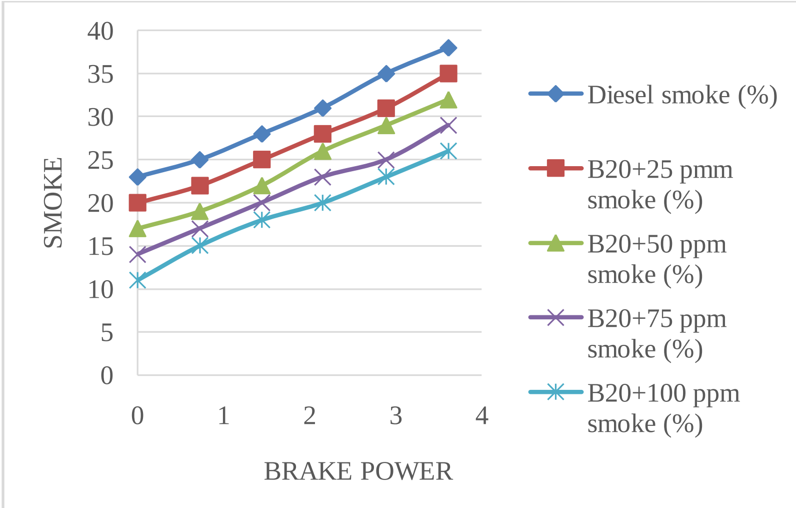

Fig: 22 Brake Power vs Smoke

The smoke density variation with respect to brake power is shown Fig 22. Smoke density for cardanol blended with ZrO_2 nanoparticles is noticed to be lower than the diesel. This is due to the use of oxygenate fuel (ZrO_2) improves better combustion is the cause for reduction of smoke. It is observed the B20 cardanol with 100 ppm of ZrO_2 is very much lesser than diesel.

Conclusion:

The influence of the performance variables, TFC,SFC,Thermal efficiency and emission variables NOx, Smoke, CO, CO_2, HC of a direct injection single cylinder diesel engine was investigated by using combustion catalysts like cupric oxide and zirconium oxide.

The following conclusions are made about the potential of on selected CI engine.

- Physiochemical properties and combustion characteristics ofcardanol are examined and compared with ASTM standard.
- B20, B60 and B100 is having lower efficiency and higher energy consumption due to the poor combustion in the engine.
- Addition of nanoparticle in biodiesel decrease the ignition delay and accelerates earlier initiation of the combustion which results lower heat release rate and cylinder pressure at full load condition.
- The addition of nano fuel additives CuO and ZrO_2 in the B20 cardanol there is a significant increase in the thermal efficiency compare to the cardanol without nano additives.
- The CO emission for B20, B60, and B100 blends operation was higher compared to diesel due to its lower thermal efficiency resulting in incomplete combustion. However CO emissions were marginally lower for the nanoparticles blended fuels than diesel due to the higher catalytic activity and improved combustion characteristics of CuO and ZrO_2 nanoparticles lead to improved combustion of the engine.
- The CO_2 emission for (cardanol) biodiesel with Nano fuel additive ZrO_2 are comparatively higher than that of diesel fuel. This is due to the complete reaction of carbon and hydrogen with oxygen. This leads to superior combustion of the engine
- The HC emission for B20, B60 and B100 operation was higher compared to diesel due to its lower brake thermal efficiency resulting from incomplete combustion. However HC emissions were marginally lower for the nano fuel blended with cardanol (B20) compared to diesel. This could be due to increased catalytic activity and improved combustion characteristics of oxide, zirconium oxide nanoparticles which lead to improved combustion.
- The NOx emissions found decrease with the increase in load for (B20, B60 and B100) due to the lower in-cylinder pressure and the corresponding combustion temperature for all the fuel blends. Similar trend was observed for diesel and B20cardanol blended withnano additives of cupric oxide and zirconium oxide almost all loads. It is observed that addition of Nano-fuel additives resulted in an effective in NOx emission. This is due to that nanoparticles oxidize the nitrogen into nitric oxide at the elevated temperatures during the combustion process.
- Smoke density for cardanol blend (B20, B60, B100) were noticed to be higher than that of diesel because due to the heavier molecular structure, poor atomization and high carbon resdiue.Smoke density for cardanol blended with CuO and ZrO_2 nanoparticles is noticed to be lower than the diesel. This is due to the use of oxygenate fuel (CuO and ZrO_2) improves better combustion is the cause for reduction of smoke. It is observed the B20 cardanol with 100 ppm of CuO and ZrO_2 is very much lesser than diesel.

- Finally we concluded that the addition of nano fuel additives cupric oxide (CuO) and zirconium oxide (ZrO_2) to the cardanol biodiesel improves the combustion characteristics and reduction in the emission

Reference:

[1]Abhisheksodhi, Ravi BishnoiSai,2017 Effects of Biodiesel from Non Edible Oils on Engine Performance and Exhaust Emission: A Review, IJAERD Volume 4, Issue 9, September -2017

[2] Patel PraveshRajendrakumar, Parth.H.Patel, Dr.Tushar .M. Patel 2018 Effect Of Compression Ratio On Emission Of Ci Engine Fuelled With Diesel-Palm Seed Oil Blends Using Taguchi's Doe Approach. IJAERD Volume 5, Issue 03, March -2018

[3] SonerGumus, HakanOzcan, Mustafa Ozbey, BahattinTopaloglu, 2016, Aluminum oxide and Copper oxide nanodiesel fuel properties and usage in a compression ignitonengine. Elsevier, Fuel,Page no: 80-87

[4] S. Vedharaj, R. Vallinayagam, W. M. Yang, S. K. Chou, K. J. E. Chua, P. S. Lee. 2015. Performance emission and economic analysis of preheated CNSL biodiesel as an alternate fuel for a diesel engine.

[5] P. Dinesha and P. Mohanan 2014 september. A study of the effect of injection pressure on the combustion, performance, and emission characteristics of cardanol biofuel blend fuelled compression ignition engine.

[6] Mallikappa D.N, RanaPratap Reddy, Ch.S.N.Murthy Performance and emission characteristics of double cylinder CI engine operated with cardanol bio fuel blends.

[7] T.Pushparaj, P.P.Shantharaman, D.JohnPanneerSelvam. March 2017. Effect of blending Nano additive with cashew nut shell liquid bio-oil on performance, combustion and emission characteristics of four stoke diesel engine.

[8] S.Vedharaj, R.Vallinayagam. March 2016. Performance emission analysis of preheated CNSL biodiesel as an alternate fuel for a diesel engine.

[9] A.Prabu.2017. Nanoparticles as additive in biodiesel on the working characteristics of a DI diesel engine.

[10] A.Prabu, R.B.Anand.2015.Emission control strategy by adding alumina and cerium oxide nano particle in biodiesel.

[11] V.ArulMozhiSelvan, R.B.Anand, M.Udayakumar. 2009. An experimental investigation is carried out to establish the performance and emission characteristics of a compression ignition engine while using cerium oxide nanoparticles as additive in neat diesel and diesel-biodiesel-ethanol blends.

[12] Sundar Raj Chockalingam and SaravanakumarChowdry S.2017 Feburay. An experimental investigation of Cardanol Ethyl Ester as an alternative fuel for diesel engine.

[13] G.KASIRAMAN, M.BALAKRISHNAN.2011.Experimental investigation on unattended methyl ester of cashew shell oil as fuel in direct injection diesel engine.

[14] S.SaravanakumarChowdry and C. SundarRaj. March 2017. A study of physical and chemical properties of Cardanol Ethyl Ester for its suitability as petro-diesel.

[15] Harish VenuandVenkataramananMadhavan. December 2015.Effect of nano additives (titanium and zirconium oxides) and diethyl ether on biodiesel-ethanol fuelled CI engine.

