

Comparison of Performance, Combustion and Emission Parameter for Copper Oxide Nano Particles Blended with used Vegetable oil Biodiesel in an IC Engine

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ABSTRACT: An experimental investigation is carried out to establish the performance and emission characteristics using Copper oxide (CuO) as nano additive in CSO blended with various proportions of nano additives 25ppm, 50ppm and 75ppm respectively. The biodiesel is produced from the CSO by standard transesterification process and subsequently, the nano particles are blended by means of an ultrasonicator to achieve stable suspension. It is observed that the blends are stable which are suitable for the performance test on the compression ignition engine. The characterization study of the nano particles such as SEM is carried out to analyze their morphology. The whole investigation is carried out in a single cylinder DI diesel engine using different proportions of nano additive blended biodiesel. The result shows a considerable enhancement in brake thermal efficiency and specific fuel consumption due to the influence of copper oxide nanoparticles addition in biodiesel blend.

KEYWORDS: Copper oxide nano particles, Diesel Engine, Ultrasonicator, CSO.

I. INTRODUCTION

The increase in energy consumption in precedent a number of decades has increased the awareness of exhausting natural resources. Swift industrialization and enormous growth of population have increased the hope and use of natural fuels. Around 90% of our energy requirements are met by fossil fuel. A study shows that if oppressed at the same rate, the coal depletes in next 200-300 years and petroleum will deplete in the next few decades. Diesel engines are mainly used in industrial, transport and agricultural applications due to their high efficiency and reliability. However, they suffer from high smoke and nitric oxide emissions. The increase in prices of diesel fuel, reduced availability, more stringent governmental regulations on exhaust emissions and the fast depletion of world-wide petroleum reserves provide a strong encouragement to the search for alternative fuels. It is commonly accepted that clean combustion in diesel engines can be achieved only if engine development with fuel reformulation and the use alternative fuels are implemented. In the name of energy security, regional air quality and greenhouse gas emissions reduction, use of oxygenated alternative fuels are advocated to reduce emissions in diesel engines. In this regard, vegetable oil have come across good choice to use as fuel in diesel engines. As a compression ignition engine fuel vegetable oil have cetane number and calorific value very close to diesel. Biodiesel fuels are measured as best alternative for diesel fuel as it is renewable, eco-friendly, non-hazardous. In recent year several kind of vegetable oil are working as fuel in engine. Various cooked oil such as peanut oil, corn oil, palm oil where used as alternative fuel for diesel engines. The cooked oils are increases the cost of food products they are not recommended to use directly. The oil after use is being wasted. Which can be used as alternative fuel. The burning of fossil fuel is connected with emission such as CO₂, CO, NO_x, SO_x and particulate matter. Nano oxides are reported to be successful in dropping diesel emissions. Then the metal based particles are to drop the diesel engine pollution and fuel consumption values. The cause for emission drop is that the metal reacting with water to create hydroxyl radicals. This is to get better soot oxidation. We have to conduct a number of experiments in direct injection diesel engine using copper oxide nano particles with biodiesel and diesel fuels. To observe a considerable increase in the brake thermal efficiency and drop in

dangerous pollutants compared to that of neat biodiesel and neat diesel. [1] Biodiesel fuel is one of the alternate fuels for diesel fuel. Biodiesel can be used with diesel fuel at different proportions, as it has very similar characteristics but lower exhaust emissions. [2] Owing to the depletion of the fossil fuels day by day, there is a necessity to find out an alternative resolution to fulfil the energy requirement of the world. Petroleum fuels play a vital role in the fields of transportation, industrial development and agriculture. [3] Compression ignition engines play an important role in transportation, locomotives and industrial sectors due to their simplicity of operation, high reliability, durability and well-established design. On the other hand, the release of hazardous pollutants like smoke, carbon monoxide, unburned hydrocarbons and nitrogen oxides are a great threat to mankind, flora, fauna, ozone layer and the environment. Further, fossil fuels are being consumed rapidly and their existence is in question for future generations. [4] The compression ignition engines are widely used for transportation and agricultural sectors due to its reliable operation and fuel economy. Due to stringent emission norms and fast depletion of petroleum reserves, it is necessary to search for a renewable alternative fuel for diesel engines. Among the many alternative fuels, biomass and biodiesel (vegetable methyl esters) are considered as a desirable fuel and fuel additive due to its high oxygen content and renewable in nature. Dorado et al have tested the direct injection diesel engine with the use of olive oil methyl ester. It has been reported that the CO, CO₂, NO_x emissions were significantly reduced compared to diesel fuel. [5] The search for a variety of energy sources is nearly a sold as man-kind's need for energy. Increasing industrialization commencing in the 19th century, spurred by the development of machines converting the energy stored in a variety of resources to power, caused this search to intensify. The internal combustion engine, in its two major variations, the spark-ignition and compression-ignition (diesel) engines, is a prime example. While fuels obtained from fossil sources were investigated from the onset of these engines, biogenic materials also found some interest, primarily ethanol in the case of the spark-ignition engine [6] Researches on the field of improving fuel economy and exhaust emissions in internal combustion engines as well as renewable alternative fuels continues to increase as a challenge. Biodiesel fuel is preferred as a renewable diesel engine fuel with a less effect on greenhouse gases due to participation of CO₂ to photosynthesis and positive impacts on smoke emissions with absence of the aromatic and sulfur contents.

II. MATERIALS AND METHODS

2.1 Preparation of biodiesel

The CSO is collected from a hosur. The collected oil is clean to remove the impurity present in it. Then the viscosity of the oil is higher than that of the biodiesel standards. Use of high viscous oil leads to improper combustion. Hence, transesterification is done to reduce the viscosity.

Transesterification process of exchanging the organic group "R" of an ester with the organic group "R" of an alcohol. These reactions are often catalyzed by the addition of an acid and base and an alcohol in the presence of a catalyst. The transesterification process of biodiesel. Transesterification is basically a chronological reaction. Triglycerides are first reduced to diglycerides. The diglycerides are subsequently reduced to monoglycerides. The monoglycerides are finally reduced to fatty acid ester,

A 500 ml of the filtered CSO is taken in a flask. A mixture containing 125 ml of methanol and 3g of KOH is mixed with CSO and stirred in a magnetic stirrer for 60 min at a reaction temperature of 60^oc. The entire mixture is allowed to settle in a separating flask for 24 hrs. Glycerine, the heavier liquid, settled at the bottom is separated. After separation, the fatty acid methyl ester is washed with water. The process is repeated until the ester layer becomes clear.



A. Biodiesel



B.B20



C.CSO

The fuel flow rate was measured on a volume basis using burette and a stop watch. Thermocouple and a digital were used to note the exhaust gas temperature.

S. No	Properties	Raw Cotton Seed Oil	B0	B20	B100
1	Specific gravity	0.89	0.82	0.83	0.88
2	Kinematic viscosity at 40°C in cSt	10.85	2.69	3.62	6.13
3	Flash Point in °C	192	66	73	170
4	Fire Point in °C	234	71	81	183
5	Calorific Value in kJ/kg	39,648	46, 010	43, 987	41, 819
6	Cetane number	40	46.1	51.8	52.8

Based on several studies B20 (20% biodiesel + 80% Diesel) is found to be the optimum blend for the use in DI diesel engine, hence in this work B20 is taken for further studies.

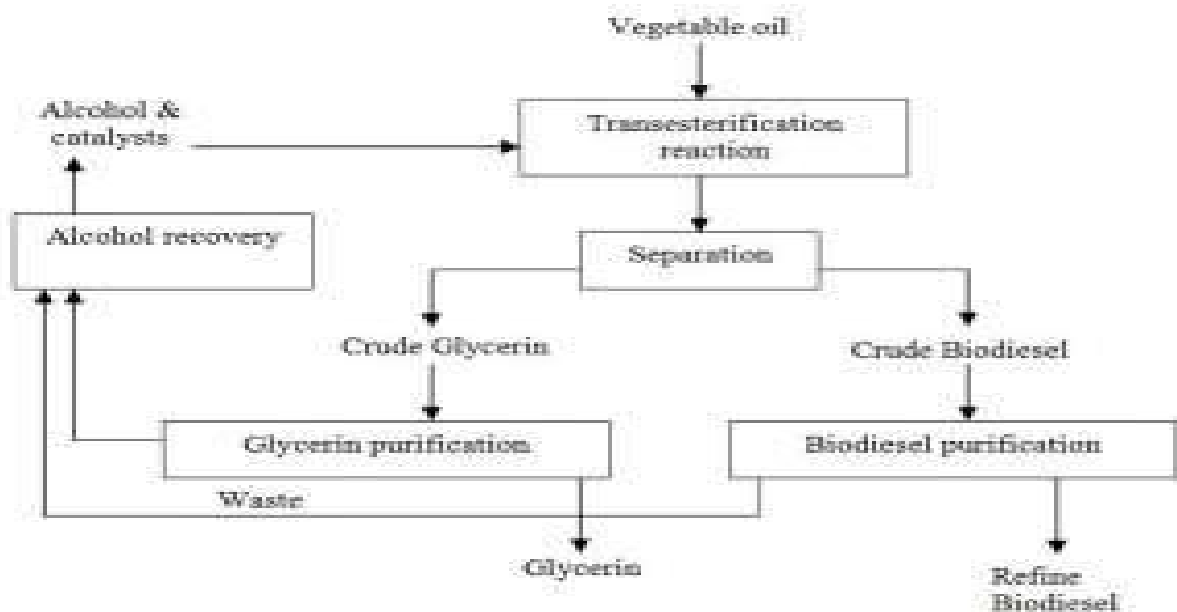
2.2 Preparation of nano blend

The Ultrasonicator for blending process of Nanoparticles. Copper oxide Cu_o alpha, 10-30 nm, purity 99% was purchased from Nano Wings Telangana, India. The ultrasonication is a best method for Nano blend for uniform suspension. One liter of B20 biodiesel and 25ppm of Cu_o nanoparticles are mixed in a ultrasonicator for 30min. Same procedure is followed to prepare the sample of with 50 ppm, 75 ppm respectively. These fuel blends are used to conduct test on diesel engine after preparation.

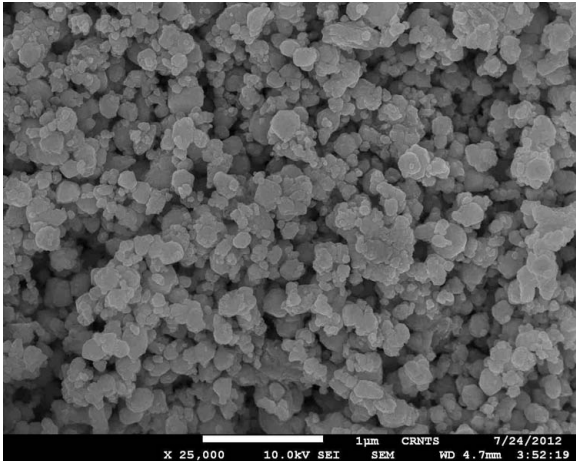


D. Ultrasonicator

The morphological characterization of Cuowas carried out using Scanning electron microscopy (SEM). Spherical shaped Cuo obtained were confirmed. SEM image of aluminum oxide. The fuel flow rate was measured on a volume basis using burette and a stop watch. Thermocouple and a digital were used to note the exhaust gas temperature. The Hartridge smoke meter was used for measuring of smoke density. The inner cylinder pressure was measured with the help on the legion brothers combustion analyzer.



E. Transesterification of Biodiesel



F. Blended Copper Oxide



G. Copper Oxide

III. EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, Multi-fuel, research engine connected to eddy current type dynamometer for loading. The operation mode of the engine can be changed from diesel to ECU Petrol or from ECU Petrol to Diesel mode by following some procedural steps. In both modes the compression ratio can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed *tilting cylinder block* arrangement. In Diesel mode fuel injection point and pressure can be manipulated for research tests. In Petrol mode fuel injection time, fuel injection angle, ignition angle can be programmed with open ECU at each operating point based on RPM and throttle position. It helps in optimizing engine performance throughout its operating range. Air temp, coolant temp, Throttle position and trigger sensor are connected to Open ECU which control ignition coil, fuel injector, fuel pump and idle air. Set up is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The setup has stand-alone panel box consisting of air box, two fuel tanks for dual fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and hardware interface. Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement.

Diesel fuel employed in the tests was obtained locally from commercial petroleum reserve. The Jatropha biodiesel was processed and obtained from Jatropha seeds. Jatropha biodiesel is prepared by a chemical process named transesterification where the glycerin is separated from the Jatropha oil. As a result, Jatropha oil methyl ester and glycerine is obtained.

The basic thermo physical fuel properties like density, calorific value, viscosity, flash point, cetane number along with carbon residue content, iodine value, oxidation stability, acid value, sulphur content and sulphated ash content were measured by standard test procedures.



A.ENGINE SETUP

Make	Kirloskar AVL model
Type	Single Acting High speed, 4S, vertical DI engine
Number of cylinder	One
Speed	1500 rpm
Power output	3.7 kw
Bore	80mm
Stroke Length	110mm
Compression ration	16:5:1

B.ENGINE SPECIFICATION

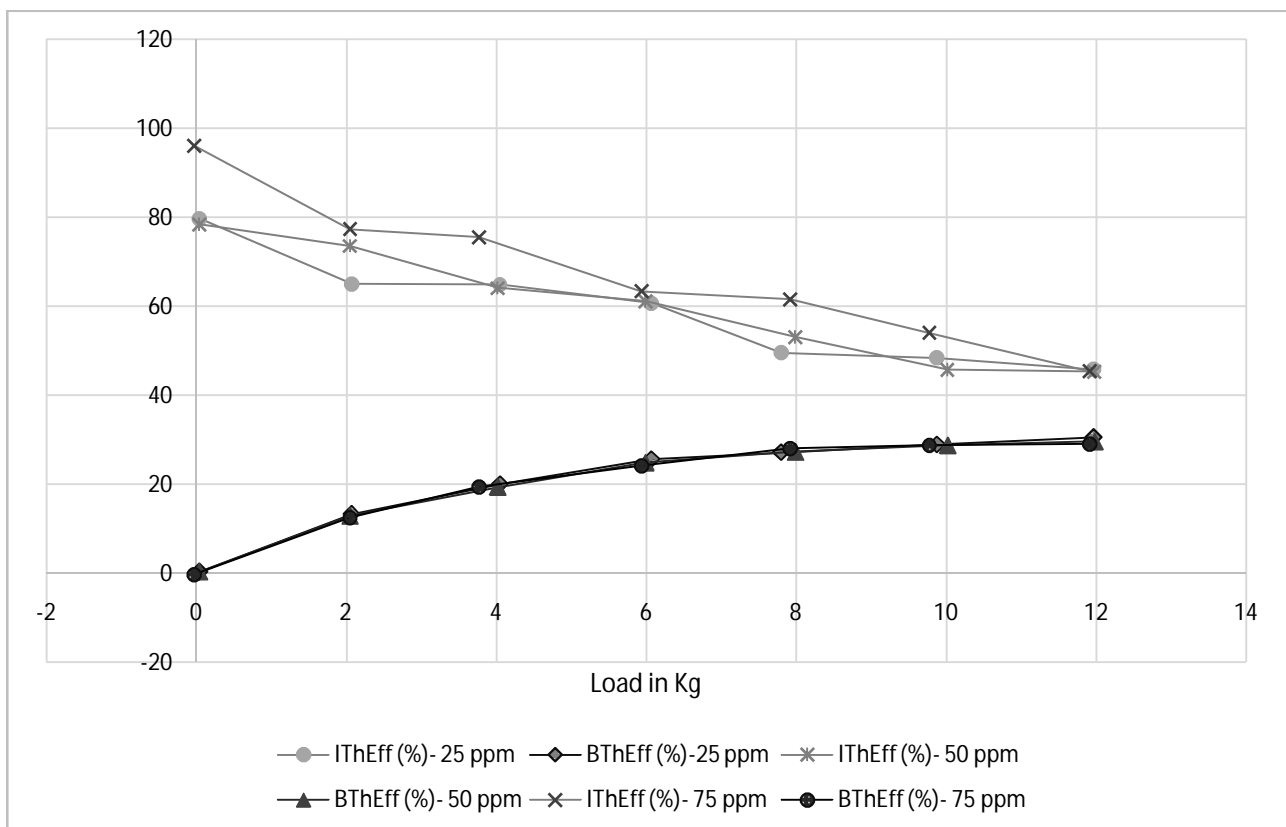
IV. RESULT AND DISCUSSION

It has been observed that the operation of the engine was very smooth throughout the rated load, without operational problem. The performance and emission characteristics of the engine fuelled with Copper oxide nano particles blended fuel blends were discussed and compared with the neat diesel fuel.

4.1 Engine performance parameters

4.1.1 Brake thermal efficiency

The Brake Power Vs brake thermal efficiency. The result shows that all the blends of Cu show higher value of BTE than diesel, even though the higher percentage of Cu shows improvement in BTE. The reason may be the copper oxide nanoparticles present in the blend promote longer and more complete combustion and also act an oxygen buffer, thus increasing the efficiency. The maximum brake thermal efficiency obtained for B20 with the addition of 75ppm of copper oxide nanoparticles as 24.95% at full load.

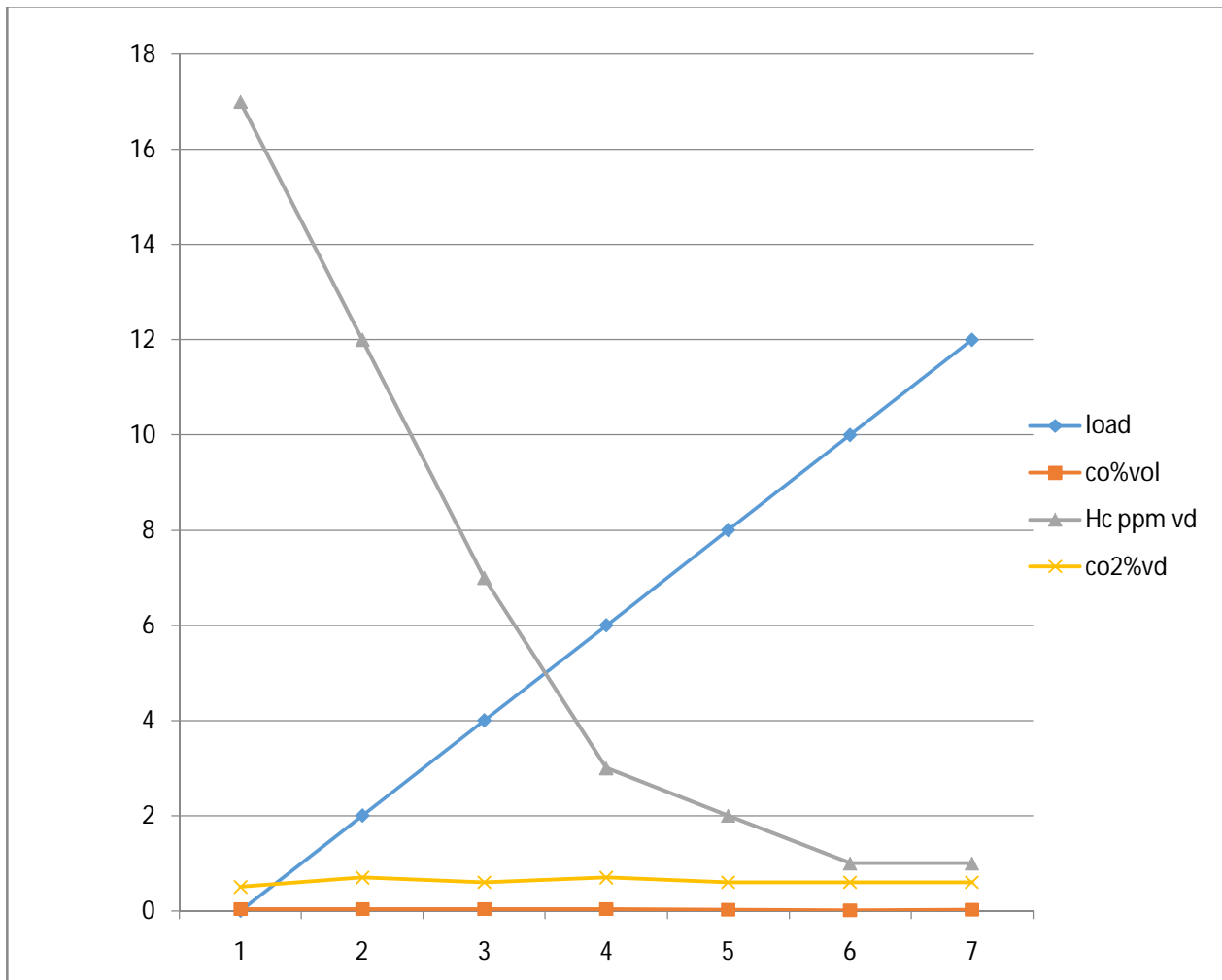


A. Brake power Vs Brake thermal efficiency

4.2 Emission parameters

The emission of NO_x Vs BP. The all values of nano blended biodiesel show a higher value than that of diesel. As the nanoparticles plays a major role in combustion which in turns increases in cylinder temperature the formation of NO_x. The NO_x emissions for B20 CuO 25ppm, B20CuO 50ppm, B20CuO 75ppm. The presence of oxygen in nanoparticles leads to better combustion there by reduction in carbon monoxide is recorded. Carbon monoxide emission for B20CuO 25ppm, B20 CuO 50ppm, B20 CuO 75ppm.

By adding of nanoparticles the oxygen level in the biodiesel tends to increases. Better combustion leads to less formation of HC . HC emission for B20 CuO 25ppm, B20 CuO 50ppm, B20 CuO 75ppm were respectively.



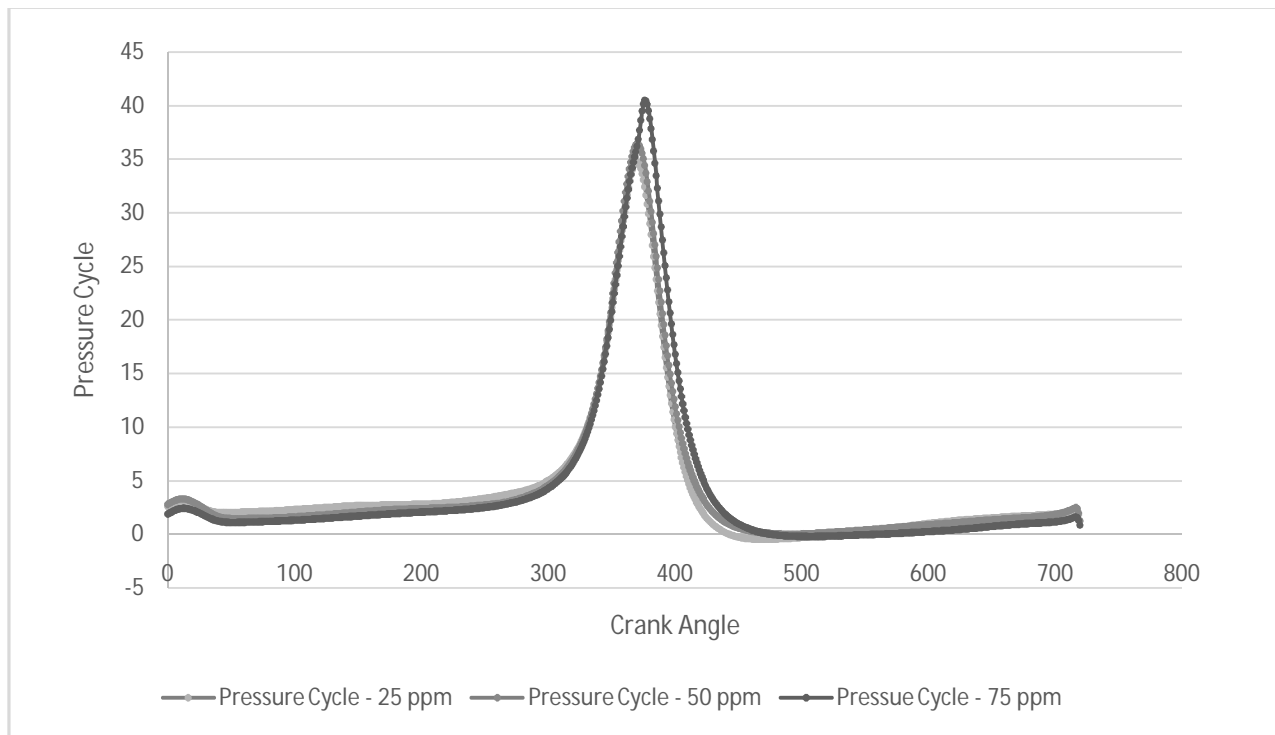
B. Emmission performance

4.3 Combustion characteristics

The Crank angle Vs Cylinder pressure. The increase in addition of nanoparticles leads higher cylinder pressure. This may be due to reduction in ignition delay and improves the combustion. The cylinder pressure for B20 CuO 25ppm, B20 CuO 50ppm, B20 CuO 75ppm was 66.76, 73.45 and 75.34 respectively. The increase of nanoparticles tends to increase of cylinder pressure. The crank angle Vs cylinder pressure bar were 73.80642 bar, 75.16402 bar and 76.55651 bar.

The Crank angle Vs Heat release rate. The increases of higher carbon combustion activation and hence promotes the complete combustion by addition of nanoparticles [15, 19 & 20]. The addition of nanoparticles increased the combustion process. Due to higher calorific value of nanoparticles blended biodiesel trends to the behavior. The heat release rate for B20 CuO 25ppm, B20CuO50ppm, B20CuO 75ppm was 26.03557 kJ/deg, 27.35283 kJ/deg and 29.5592 kJ/deg.

Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m³) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.28, Number Of Cycles : 10, Cylinder Pressure Reference : 4, Smoothing 2, TDC Reference



C. Pressure Angle

V. CONCLUSION

The performance and emission characteristics of DI diesel engine with diesel-blended biodiesel with the addition of copper oxide nanoparticles were investigated. The following conclusion were drawn the experimental result.

- The brake thermal efficiency was increased in B20CuO75ppm at all loads than neat diesel.
- The specific fuel consumption is higher for the B20CuO75ppm than neat diesel at the entire load comparing with the different dosing level of blends.

- The CO emission decreases by addition of B20CuO75ppm.
- The HC emission level was decreased at B20CuO 75ppm.
- The NO_x emission is lower for the diesel than the addition of B20CuO. By addition of CuO slightly increased compared with diesel.

The overall performance and emission characteristics were clearly obtained that the addition of copper oxide nanoparticles (CuO) is efficient in improving the properties of biodiesel blend.

REFERENCES

- [1] C. Syed Aalam *, C.G. Saravanan, M. Kannan Experimental investigations on a CRDI system assisted diesel engine fuelled with aluminium oxide nanoparticles blended biodiesel. Alexandria Engineering Journal (2015) 54, 351–358.
- [2] C. Syed Aalam *, C.G. Saravanan Effects of nano metal oxide blended Mahua biodiesel on CRDI diesel engine. 2015
- [3] Srinivasa Rao, M. and Anand, R. B. Performance and emission characteristics improvement studies on a biodiesel fuelled DIC I engine using water and AlO(OH) nanoparticles.
- [4] Prabhu L1, S. Satish Kumar2 A. Anderson3 K. Rajan4 investigation on performance and emission analysis of TiO₂ nanoparticle as an additive for bio-diesel blends. ISSN: 0974-2115.
- [5] Gerhard Knothe a,*, Luis F. Razon b Biodiesel fuels.
- [6] Özer Can Combustion characteristics, performance and exhaust emissions of a diesel engine fueled with a waste cooking oil biodiesel mixture
- [7] Syed Javed, Y.V.V. Satyanarayana Murthy, M.R.S. Satyanarayana, R. Rajeswara Reddy, K. Rajagopal Effect of a zinc oxide nanoparticle fuel additive on the emission reduction of an hydrogen dual-fuelled engine with jatropha methyl ester biodiesel blends.
- [8] Harish Venu, Venkataraman Madhavan Effect of Al₂O₃ nanoparticles in biodiesel-diesel-ethanol blends at various injection strategies: Performance, combustion and emission characteristics.
- [9] Vivek W. Khond, V.M. Kriplani Effect of nano fluid additives on performances and emissions of emulsified diesel and biodiesel fuelled stationary CI engine
- [10] A. Prabu, R.B. Anand Emission control strategy by adding alumina and cerium oxide nano particle in biodiesel.
- [11] G. Vairamuthu, S. Sundarapandian, C. Kailasanathan, B. Thangagiri Experimental investigation on the effects of Cerium oxide nanoparticle on Calophyllum inophyllum (PUNNAI) biodiesel blended with diesel fuel in DI diesel engine modified by nozzle geometry.
- [12] M. Boopalan, M. Niranjanaa, M.J. Umopathy. Study on the mechanical properties and thermal properties of jute and banana fiber reinforced epoxy hybrid composites. Composites: Part B 2013; 51: 54–57.
- [13] Sreenivasan VS, Somasundaram S, Ravindran D, Manikandan V and Narayanasamy R. Microstructural, physico-chemical and mechanical characterisation of Sansevieria cylindrica fibres – an exploratory investigation. Materials and Design 2011; 32: 453–61.
- [14] V.S. Sreenivasan, D. Ravindran, V. Manikandan, R. Narayanasamy. Mechanical properties of randomly oriented short Sansevieria cylindrical fibre/polyester composites. Materials and Design 2011; 32: 2444–2455.
- [15] Chen JK, Sun G. Dynamic large deflection response of composite laminate subject to impact. Composite structure 1985; 4(1): 59-73.
- [16] Khoshbakhit M, Choudhury SJ, Seif MA, Khashaba UA. Failure of woven composites under combined tension-bending. Composite structure 2009; 90: 279-86.
- [17] K. Murali Mohan Rao, K. Mohana Rao, A.V. Ratna Prasad. Fabrication and testing of natural fiber composites: Vakka, sisal, bamboo and banana. Materials and Design 2010; 31: 508–513.
- [18] N. Venkateshwaran, A. Elaya Perumal, A. Alavudeen, M. Thiruchitrambalam. Mechanical and water absorption behaviour of banana/sisal reinforced hybrid composites. Materials and Design 2011; 32: 4017–4021.
- [19] Kasama Jarukumjorn, Nitinat Suppakarn. Effect of glass fiber hybridization on properties of sisal fiber – polypropylene composites. Composite: Part B 2009; 623–7.
- [20] SM Luz, A. R. Goncalves, A. P. Del Arco Jr. Mechanical properties and microstructural analysis of sugarcane bagasse fibers reinforced polypropylene composites. Composite: Part B 2007; 38: 1455-1461.
- [21] Khalil HPSA, Ismail H, Rozman HD, Ahmad MN. The Effect of acetylation on interfacial shear strength between plant fibers and various matrices. European Polymer Journals 2001; 37: 1037-45.
- [22] Ahmed Syed, Syed Azam Pasha Quadri, G. Amba Prasad Rao, Mohd Wajid Experimental investigations on DI (Direct injection) diesel engine operated on dual fuel mode with hydrogen and Mahua oil methyl ester (MOME) as injected fuels and effects of injection opening