EasyChair Preprint

№ 9863

Impact of Nanocarbon Tubes Added Biodiesel on Diesel Engine Performance and Emission

Nivedita Nivedita and N Kapilan

March 12, 2023

IMPACT OF NANOCARBON TUBES ADDED BIODIESEL ON DIESEL ENGINE PERFORMANCE AND EMISSION

Nivedita*, Dr. N. Kapilan

* Department of Mechanical Engineering, ACEM, Pune, Maharashtra, India
Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bangalore, India
*Corresponding Author

Abstract

In recent years due to increased in population and globalization has created awareness among the people on the depletion of crude oil and its resources and various pollution related issues which created tension all around the globe to think on the alternate way.
Due to this Biofuel and various combination of Biodiesel are now a day's gaining popularity. The researcher all around the globe is doing research on this and trying to find the best possible output from Biofuel which can be alternate source for fossil fuel and can serve the need of the growing society. The fuel price also made researcher to find the alternate way to bring down the load on crude oil. In my research work I have carried out the Engine Experiment with Diesel however I added Carban Nano Tube (CNT) to enhance the performance. I even consider the different dosages for experimental studies; from that I observed that the CNT impact the performance and emission characteristic of the single cylinder Diesel engine. However the dosage level has to be optimized.

Keywords: Biodiesel, Biofuel, nano particles, Engine, performance, Carbon Nano Tube (CNT)

1. Introduction

From time of evolution till today we all, living organism need energy for number of purposes. The first start of civilization took place when human started to know the utilization of energy for its growth and development. Slowly people learnt the importance of energy and it contribution in every walk of life. The dependency level is so high that now we are facing the crises. To overcome the fuel or energy crises researchers are trying to find the alternate way to increase the production of Biofuel. This Biofuel the can be converted to biodiesel and be utilizes in automobile sector to reduce the dependency in crude oil. Petrol and diesel are the primitive source of energy provider. For sustainable development of the mankind one must and should opt the alternate way of fuel consumption. [1]
Transportation structures are the world's largest purchaser of fossil gasoline and if the diesel gasoline may be absolutely changed with any renewable reasserts which includes biodiesel fuels and, with inside the meantime, required no massive changes to the present day compression ignition (CI) engines, world dependency to the crude oil supply can be reduced. Biodiesel fuels may be constituted of diverse reasserts of vegetable oils through the chemical response known as transesterification process [2-3]

The energy from fossil production is nearly 80% [4]. China produces half of the total energy and other half is produced by Gulf country and United States. If we talk about the export of the total production then Russia and Gulf countries does the most. The export is largely done to the countries where not enough production of energy is done to meet the demand for actual satisfaction; the countries are China and European Union. 1 to 2% every year the production in energy can be seen [5].In 2010s the renewable energy like solar and wind energy gave the average per year production of 20% [6]

"Renewable energy is energy derived from natural processes that are replenished at a rate that is equal to or faster than the rate at which they are consumed there are diverse styles of renewable energy, deriving immediately or not directly from the sun, or from warmth generated deep in the earth. They include energy generated from solar, wind, geothermal, hydropower and ocean resources, biogas and liquid Biofuel" [7].

As the diesel being the petroleum product is limited on Earth but the efficiency and performance of the diesel fuelled vehicle is popular and in much demand. Diesel powered engine is found in every sectors of society; it can be transportation, locomotion, shipping, manufacturing industries, Aviation industries etc. Why is it so? Because of its fuel reliability, economy, rigidity, and sturdiness [8]

Diesel fuel not only has changed or brought a revolution in human life but also given lots of side effects. The effects can be seen directly on environment and habitation. The harmful exhaust emission like Carbon monoxide, carbon dioxide, Sulphur oxides, unburnt hydrocarbon, Nitrogen Oxides .[9]

Therefore, with so many pros and cons of diesel fuel has forced researcher to find the alternate fuel which not only be environmental friendly, economical and efficient but also be renewable and give good performance. From year's research have been carried out to come with an alternate fuel which can give best performance in terms of efficiency and emission.

Over years several researches have been carried out in the field of alternate resources among them the research in Biofuel is gaining lamplight. Biofuel is a type of fuel which is made up of living organisms or its by products. These fuels are sustainable and renewable as they are form from plants and organisms which are harvested again and again. Ethanol is a one of the common type of Biofuel which is derived from fruits, sugarcane, corn and many other type of grain. The fuel which is made after mixing ethanol and gasoline is less polluting and efficient.

The other type of known Biofuel is biodiesel, which is derived from vegetables oils, animal fats, non editable seeds etc. any diesel engine can used biodiesel with changing the engine design and specification. It can also be blended with diesel fuel to give more efficiency and be environmental friendly fuel.
Biodiesel has low carbon footprints then fossil fuels, which means they produce low green house gases when it is burned, adding to this Biofuel or biodiesel can be produced locally and helps in job opportunities in ruler area and the dependency in the fossil and foreign oil decreases.

Over all, Biofuel are the most promising alternative to fossil fuels. It has potential to reduce the dependency on fossil fuels and reduce the effect of climate change. To be more sustainable lots of research and development has to take place to address the social and environmental issues associated with Biofuel production. By enhancing the production and consumption of biofuels /biodiesel we are trying to reduce the dependency on the fossil fuels and in turn helping the environment to be clean and susceptible.

With base fuel various proportionate of biodiesel blends have been identified and these blends are used by various researchers in recent years to find the effect in internal combustion engine [10]. Many research have been carried out in recent years when the design of the internal combustion engine is kept content and various alternate fuel like Biofuel with ethanol or biodiesel with ethanol are used to run the engine and its performance is noted in terms of emission or fuel performance to find good alternate for fossil fuel and also see that the pollution level is decreased. Researchers have also found in their work that biodiesel fuelled engines produce less exhaust gases which contains less amount of un-burnt Hydrocarbon, Carbon monoxide, Sulphur oxides in comparison with fossil fuels. [11-13]
There are 3 everyday techniques of reducing pollutant emissions: engine modification, growing renewable opportunity fuels, and enhancing exhaust fuel line treatment [14]

With positive note we have moved forward, and thought to use nano-particles in biodiesel as additives to enhance the performance of the fuel as we know that the nano-particles mix with fuel in its molecular form and it nano size particle do not form any clogging. It possesses high surface area contact and good catalytic activities. The nano technology of the fuel improves as the nano-particles added to the fuel as additives improve the chemical properties of the fuel which not only modifies the fuel properties but also provide better output. [15-19]

2. MATERIALS AND METHODS

In my present work I have used single Walled Carbon Nano Tubes with Honge biodiesel. With this combination the fuel is used in Internal Combustion Engine to find its performance and emission characteristic. The main reason of using SWCNT (SinglewalledCarbonNanoTube) is its Thermal conductivity, Mechanical strength, and ultra light weight, electrochemical energy storage properties, large surface area which make it a good absorbents etc make the material unique.”One more important feature that distinguishes SWCNT is that the wall of the nanotubes consists of the only one Graphene layer”

2.1 Description of SWCNT

- Product Name – Single Walled Carbon Nanotubes (SWCNT)
- Product Series – SE-SWCNT
- Number of Layers – Less than 2
- Bulk Density - ~0.1g/cm3
- Surface Area - ~ 750 m2/g
- Purity - ~95%
- Material Form – Powder

- Colour – Black
- Packing Size –1gm
- Shape(TEM)-Tubular like shape

2.2 Specification of SWCNT

Table.1 Specification of SWCNT

Specification	Unit of measure	Value	Mode of Evaluation
Carbon Content	Wt%	>91	TGA, EDX
Single Wall CNT Content	Wt%	≥85	TEM, TGA
No. of layers CNT	unit	01-Feb	AFM,TEM
Outer mean dia CNT	nm	1.8±0.4	FM,TEM
Length of CNT	µm	~5	TEM, SEM, AFM
Metal Impurities	Wt.%	<5	EDX, TGA
Specific Surface Area	m2/g	~422	BET
Moisture content	Wt%	1	TEM

Table.2 Properties of Crude Honge oil [20]

Characteristics	value
Acid value (mg KOH/g)	5.06
Peroxide number	7.6
Iodine value(g/100 g)	86.5
Viscosity (40 _C) (mm2/s)	37
Saponification value(mg KOH/g)	187

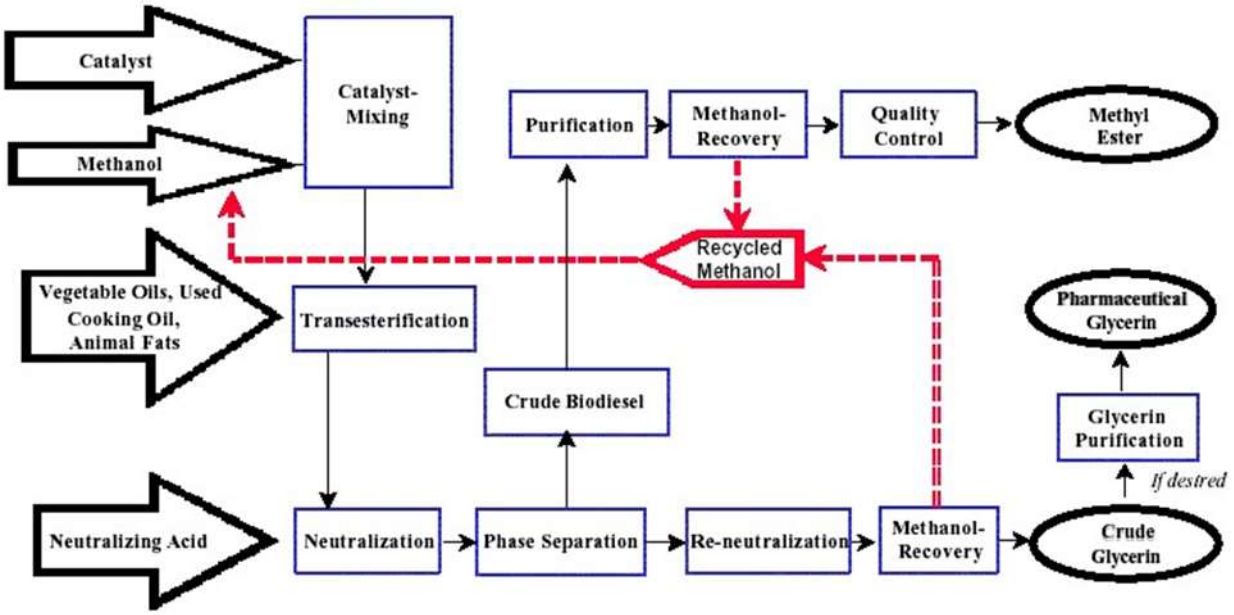


Figure1. Production Flow chart-1[21]

Transesterification is a chemical reaction where the triglycerides contained in oils are extracted to obtain the useful product. The biodiesel formed from transestification process makes a capable fuel which can replace the diesel in diesel engine.

The Honge oil FFA (wt %) is up to 20, pretreatment method is HSO4 and the catalyst for transestrification is KOH. The Methyl ester which we get is of maximum yield of 97(wt %) [22] To get the maximum yield (wt %) 97-98.Hongae oil uses catalyst (wt %) 1.0 KOH at temp 650C. The Methyl ester obtained 6:1 at rpm 360 and max time taken is 180min. [23]

Table3. Properties of Honge Biodiesel and Diesel Fuel [24]

Fuel name	Diesel	Honge Biodiesel
Viscosity 40oC (est)	2.87	4.37
Density (g/ml)	0.845	0.883
Calorific value	44	0.883
Cloud point	6.5	14.6
Flash point	76	163
Pour Point	3.1	5.1

Biodiesel of various concentration of Honge oil methyl easter (10, 20, 40, 80%) were taken as base fuel. Among these the blend chosen is B20, the Physical and Chemical properties of the blend B20 is near to Diesel fuel, so to conduct the further experiment, and we choose B20 fuel. The dosing levels of Carbon Nano tubes (by weight) in the base fuel were 25, 50, 75,100, 125ppm. The CNT is properly measured using electronic weighing machine. For making the dose of 25ppm, 0.025g of Carbon Nano tubes is added to Honge biodiesel fuel B20 to the volume of 1 liter. Same procedure is repeated to make other four solutions of doses50, 75,100,125 ppm (0.050g, 0.075g,0.1g,0.125g)/L. For testing the blends of biodiesel and CNT nano particles were prepared by mixing the CNT into biodiesel blends at concentration of 25, 50, 75, 100,125ppm, respectively and compared with diesel fuel. The test we carry out to find the performance parameter, exhaust gas emission percentage.

3. EXPERIMENTAL SETUP AND METHODOLOGY

The test is carried out in IC Engine set up under test is Research Diesel having power 3.50 kW @ 1500 rpm which is Single Cylinder, Four stroke, Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 18.00, Swept volume 661.45 (cc).Speed manometer is used to measured the crankshaft rotational, the fuel consumption was determined by measuring the time taken to consume the fixed fuel volume. The IC 'ENGINESOFT' software is used to acquire the high speed data and (NI-USB-6210) National instruments data acquisition system is used for further analysis. The smoke capacity is measured by using Gas Analyser and exhaust gas concentration also play vital role. The infrared measurement is used to measure CO, HC, CO2 and Electrochemical measurement is done to find the NO and O2. After study state condition, the gas analyser screen gives the digital readouts of CO and NOx, CO2, HC, CO. The experiment was carried without any change or modification in fuel injection system or engine. To warm up the engine the diesel fuel is used to run the engine for several minutes before the Biodiesel fuels are tested. The same process is also carried out with diesel fuel before it is shut down. The B20 fuel and its blends with CNT also blush out the nano-particle biodiesel fuels from the fuel line system. The detail specification is mentioned below along with performance and combustion parameters.

3.1 Engine Specifications

Product Engine take a look at setup 1 cylinder, four stroke, Diesel (Computerized) Engine Make Kirloskar, Model TV1, Type 1 cylinder, four stroke Diesel, water cooled, strength five.2 kW at 1500 rpm, stroke one hundred ten mm, bore 87.five mm. 661 cc, CR 17.five Dynamometer Type is eddy current, water cooled, Propeller shaft kind accepted joints Air container M S fabricated with orifice meter and manometer Fuel tank Capacity 15 lit, Type: Duel compartment, with gasoline metering pipe of glass Piezo sensor Combustion: Range 350Bar, Diesel line: Range 350 Bar, with low noise cable Crank attitude sensor Resolution is 1 Deg, Speed 5500 RPM with TDC pulse. Data acquisition tool NI USB-6210, 16-bit, 250kS/s.

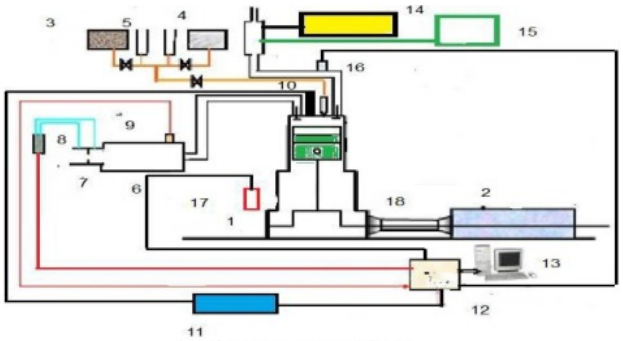
Temperature sensor Type RTD, PT100 and Thermocouple, Type K Temperature transmitter Type 2 wire, Input RTD PT100, Range 0–100 Deg C, Output 4–20 mA and Type 2 wire, Input Thermocouple, Range 0–1200 Deg C Load indicator Digital, Range 0-50 Kg, Supply 230VAC Load sensor Load cell, type strain gauge, range 0-50 Kg Fuel flow transmitter DP transmitter, Range 0-500 mm WC Air flow transmitter Pressure transmitter, Range (-) 250 mm WC Software "Enginesoft" Engine performance analysis software Rota
Meter Engine cooling 40-400 LPH; Calorimeter 25-250 LPH Pump Type Monoblock .Overall dimensions W 2000 x D 2500 x H 1500 mm

3.2 Combustion Parameters :

Specific Gas Const (kJ/kgK):1.00, Air Density (kg/m^3):1.17, Adiabatic Index: 1.41, Polytrophic Index: -6.56, Number Of Cycles: 25, Cylinder Pressure Reference : 9, Smoothing 2, TDC Reference : 0

3.3 Performance Parameters:

Orifice Diameter (mm): 20.00, Orifice Coeff. Of Discharge: 0.60, Dynamometer Arm Length (mm):185, Fuel Pipe dia (mm) : 12.40, Ambient Temp. (Deg C): 27, Pulses Per revolution: 360, Fuel Type: Diesel, Fuel Density (Kg/m^3): 830, Calorific Value of Fuel (kJ/kg): 42000



1. Diesel engine
2. AC generator
3. Diesel tank
4. Fuel tank
5. Burette
6. Air surge tank
7. Orifice
8. Pressure differential meter
9. Intake air temperature thermocouple
10. Piezo pressure transducer
11. Charge amplifier
12. Data acquisition card
13. Personal computer
14. Exhaust gas analyzer
15. Smoke meter
16. Exhaust gas temp. thermocouple
17. Proximity switch
18. Cardin shaft

Figure2.Schematic diagram of a Diesel test engine [27]

4. RESULT AND DISCUSSION

4.1 Specific Fuel Consumption

The graph shows the variation of Engine load with specific fuel consumption. B20 biodiesel has high specific fuel consumption then Diesel fuel due to lower volatility, lower calorific value and high viscosity. The addition of CNT additives lowers the specific fuel consumption for all kind of biodiesel blends compared to B20 .The decrease in specific fuel consumption can be due to better blending and better atomization process. The positive effect of nano-particles on physical properties of the fuel can be seen through better combustion and reduce in ignition delay time. [25]

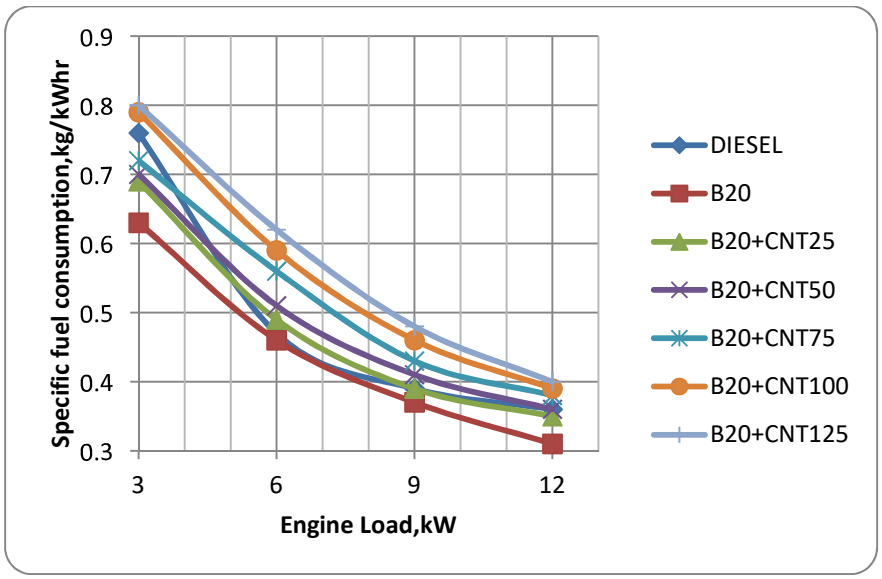


Figure3. Variation of specific fuel consumption vs. Engine load

4.2 Thermal Efficiency

The graph shows the variation of (B2O Honge Biofuel and Honge CNT blend fuel and diesel fuels) thermal efficiency. The B20 gives less thermal efficiency due to poor volatility and high density. But after the test the result shows that the thermal efficiency of the fuel which has CNT Nano-particles blended in Honge biodiesel increased. This can be due to nano-size particle has higher surface area good reactive surface that has nice chemical reactivity [25]. The max increase in thermal efficiency is due to increasing the dosing of CNT. 125PPM has shown high thermal efficiency.

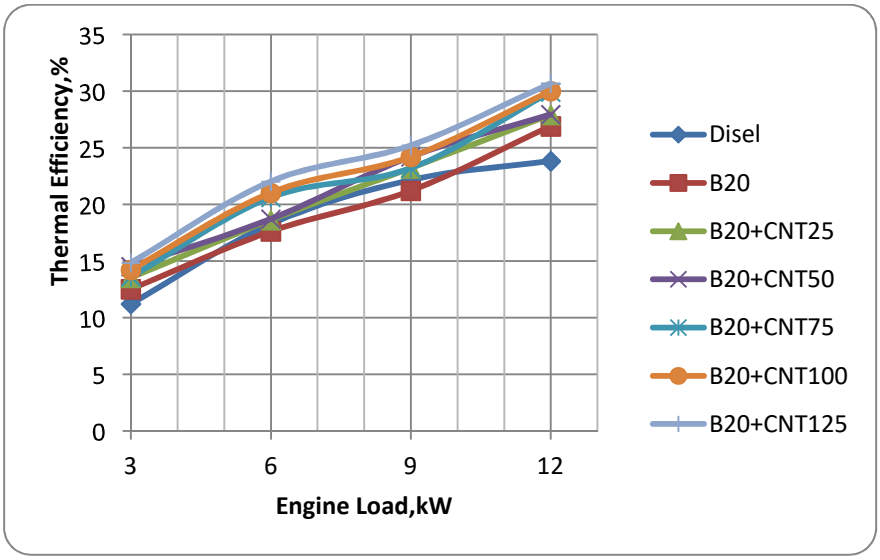


Figure4.Variation of thermal efficiency vs. Engine load

4.3 Exhaust Gas Temperature

The exhaust gas temperature gives the indication of heat loss of the fuel from the engine during the test [26].In all case break power increases with exhaust temperature increases. From the test the CNT blend fuel has less exhaust temperature for any break power. It is due to good combustion and high thermal efficiency. Heat loss decreased in exhaust content.

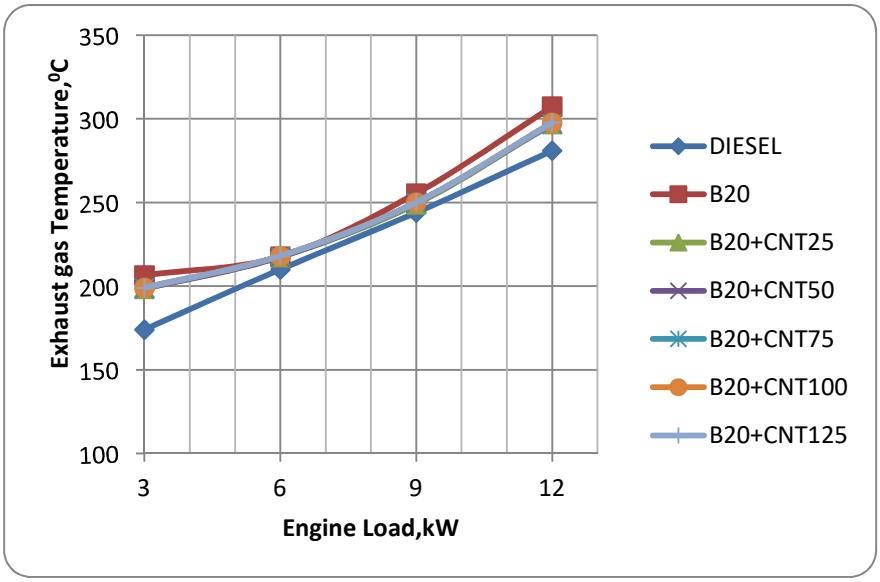


Figure5.Variation of Exhaust gas temperature vs. Engine load

4.4 Carbon Dioxide Emission

The graph shows the effect of CNT on carbon dioxide emission at different engine load. The carbon emission of Honge Biofuel of B20 blend was higher than diesel fuel; it may be due to oxygen content in biodiesel fuel. From the test it is observed that the carbon dioxide has reduced due to improved combustion and high catalytic activity. The increased CNT dosing in Honge biodiesel leads to increased of carbon emission.

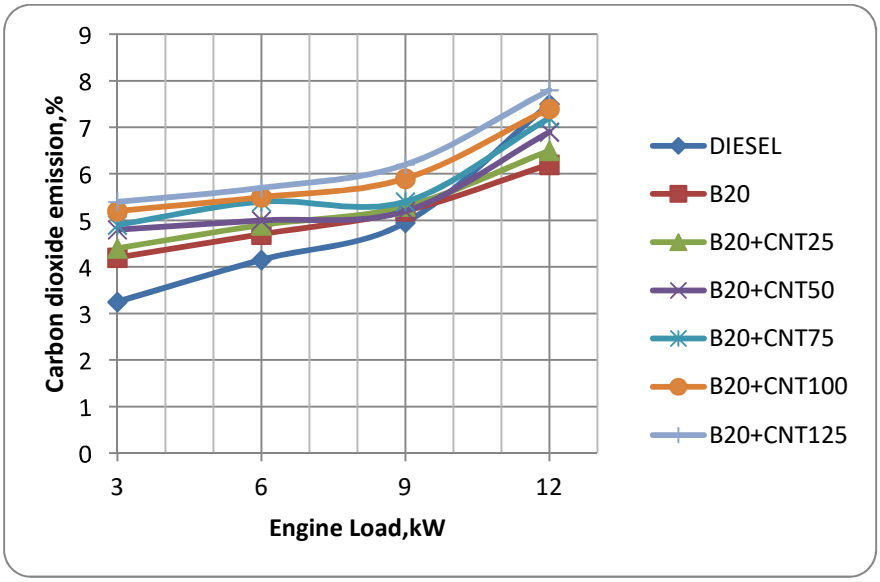


Figure6.Variation of carbon dioxide emission vs. Engine load

4.5 Hydrocarbon Emissions

The hydrocarbon emission is low for all fuels then Diesel fuels. From the test it is observed that the hydrocarbon emission is low for CNT blend fuels than biodiesel and Diesel fuels. This can be due to the secondary atomization and uniform fuel distribution in the combustion chamber of CNT fuel. It is observed that the increased dosing has decreased the hydrocarbon emission in compared with B20 Honge fuel and Diesel fuel.

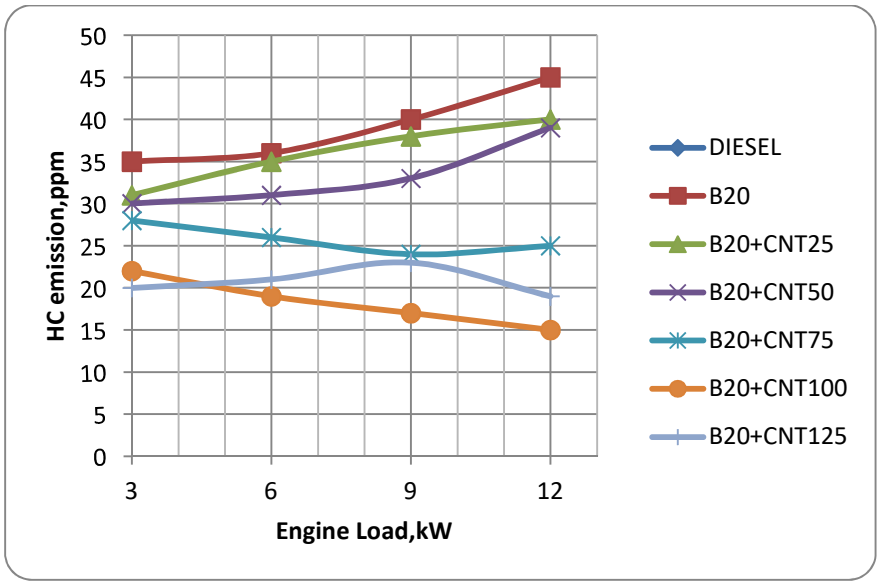


Figure7.Variation of Hydrocarbon (HC) emission vs. Engine load

4.6 Nitrogen Oxide Emissions

Normally Nitrogen oxides increased with increased engine load, fuel consumption and cylinder temperature. B20 OF Honge blends has recorded the high Nitrogen Oxide emission may be due

to shorter ignition delay or presence of oxygenated fuel. From the test it has observed that Nitrogen oxide has decreased with CNT addition and also with increase of dosing the Nitrogen oxide emission has decreased. This can be due to the catalytic effect of the CNT particle present in the combustion chamber which helps in heat promoting

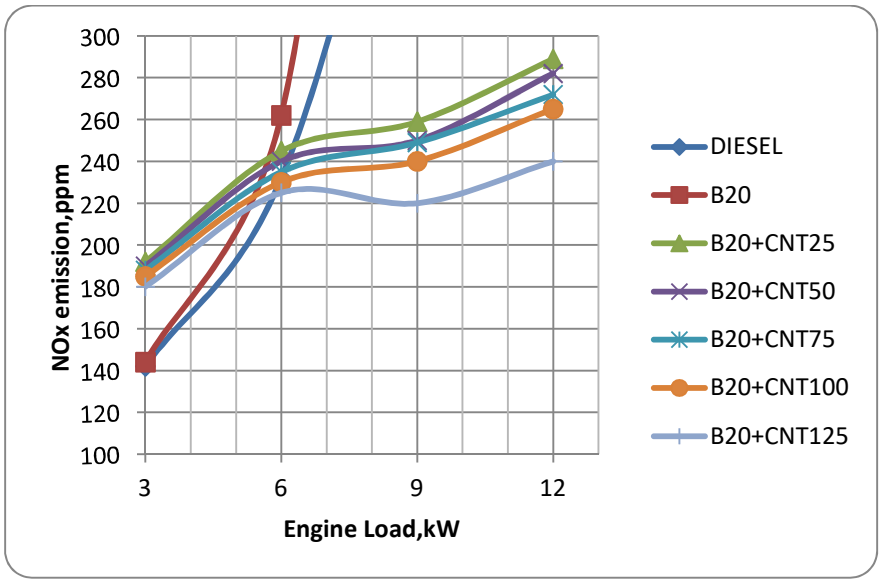


Figure7.Variation of Nox emission vs. Engine load

4.7 Smoke Capacity

The graph shows that the smoke capacity of the fuel is reduced due to the short ignition delay and good ignition characteristic of CNT. Nano particle leading to higher catalytic activity due to their higher surface to volume ratio and air fuel mixture in the chamber is good. it is also found that the decrease in the smoke density increase with the increase in the dosing of CNT in the fuel.

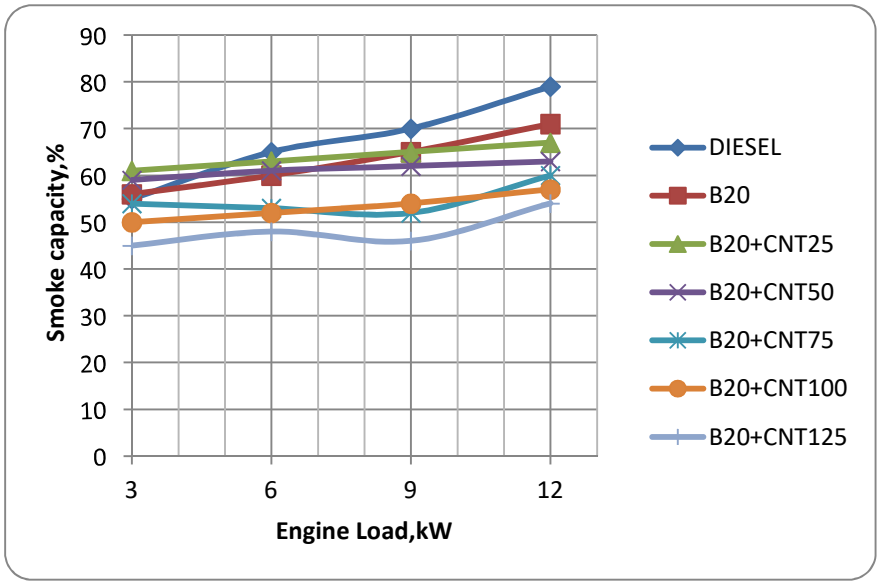


Figure8.Variation of Smoke capacity vs. Engine load

5. CONCLUSIONS

After all investigation like the emission of the exhaust and the performance characteristic of the Honge-CNT Blended fuel in single cylinder the following conclusion have been drawn.

a) At different dosing levels of 25,50,75,100,125 ppm in engine test with modified biodiesel shows that at optimized operating condition the thermal efficiency was better as compared to Honge Biodiesel fuel and neat diesel fuel
b) Due to lower viscosity, higher thermal efficiency, good combustion and less heat loss in the exhaust gases provided by the blends which increases better combustion has gas exhaust temperature for carbon nano-tubes blended Honge biodiesel B20 is less.
c) With the addition of CNT the exhaust emission level of NOX, HC are reduced .It is known that CNT being thermally stable and helps in oxidation of hydrocarbon and reduce in NOx, that makes as an effective catalyst in nano particle form.
d) Carbon nano-tubes blended fuel showed lower cylinder gas pressure and heat release rate at optimized conditions
e) Carbon nano tubes has decreased the smoke density of diesel that to 10-20%. Due to good air fuel mixing ratio in the combustion chamber and surface area high is also significant.
f) A dose level of carbon nano-tubes in the range of 100 and 125pp can be recommended to achieve the best engine performance and emission. It removes the disadvantages associated with biodiesel blends and diesel fuels.

REFERENCES

[1] Jackson RB, et al. (2022). "Global fossil carbon emissions rebound near pre-COVID-19 levels". Environmental Research
Letters. 17 arXiv:2111.02222. Bibcode:2022ERL....17c1001J. doi:10.1088/1748-9326/ac55b6. S2CID 241035429. Retrieved 22 May 2022.

[2] Halek, F., Kavousi, A. and Banifatemi, M. 2009. Biodiesel as an alternative fuel for diesel engines. World Academy of Science, Engineering and Technology. 57.

[3] Hoekman, S.K., Broch, A., Robbins, C., Ceniceros, E. and Natarajan, M. 2012. Review of biodiesel composition, properties, and specifications. Renewable and Sustainable Energy Reviews, 16: 143–169.

[4] "World Energy Statistics | Enerdata". Yearbook.enerdata.net. Retrieved 26 August 2022.

[5] Ritchie, Hannah; Roser, Max; Rosado, Pablo (28 November 2020). "Energy". Our World in Data. Global energy consumption continues to grow, but it does seem to be slowing – averaging around 1% to 2% per year.

[6] "Global Electricity Review 2022". Ember. 29 March 2022. Retrieved 16 September 2022.

[7] https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/about-renewable-energy/7295

[8] Basha, J. S, and R. B. Anand. 2014. Performance,emission and combustion characteristics of a dieselengine using carbon nanotubes blended jatropha methylester emulsion. Alexandria Engineering Journal, 53(2):259-273.

[9] Choi, S. H, and O. H. Younhtaig. 2006. The emissioneffects by the use of biodiesel fuel. International Journalof Modern Physics, 20(25n27): 4481–4486.

[10] Hasheminejad, M., Tabatabaei, M., Mansourpanah, Y,and A. Javani. 2011. Upstream and downstream strategies to economize biodiesel production. Bioresource Technology, 102(2):461-468.

[11] Hameed Hussain J., Anbazhgan G., Improve of the cop of vapour compression refrigeration system by using thermoelectric cooler, International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-585-589, 2017

[12] Nakkeeran S., Hussain J.H., Innovative technique for running a petrol engine with diesel as a fuel, International Journal of Pure and Applied Mathematics, V-116, I-18 Special Issue, PP-41-44, 2017

[13] Naveenchandran P., Vijayaragavan S.P., A sensor less control of SPM using fuzzy and ANFIS technique, International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-43-50, 2017

[14] Shaafi T, Velraj R. Influence of alumina nanoparticles, ethanol and isopropanol blend as additive with diesel–soybean biodiesel blend fuel:

Combustion, engine performance and emissions. Renewable Energy 2015; 80: 655-663.

[15] Hameed Hussain J., Nakkeeran S., Design and development of pepper plucking equipment,International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-573-576, 2017

[16] Naveenchandran P., Vijayaragavan S.P., A high performance inverter fed energy efficient cum compact microcontroller based power conditioned distributed photo voltaic system, International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-165-169, 2017

[17] Golden RenjithNimal R.J., Hussain J.H., Stress analysis of gear tooth using metal, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-317-322, 2017

[18] Hameed Hussain J., Hariharan R., Development of temperature-time and pressure-time diagrams for diffusion bonding ti-aa7075 dissimilar materials, International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-493-499, 2017

[19] Udayakumar R., Khanaa V., Saravanan T., Saritha G., Cross layer optimization for wireless network (WIMAX), Middle - East Journal of Scientific Research, V-16, I-12, PP-1786-1789, 2013

[20] Bora DK. Studies on storage stability of bio-diesel and its utilisation in a diesel engine. PhD Thesis, Centre for Energy Studies, Indian Institute of Technology Delhi; 2008.

[21] Meher, L.C., Naik, S.N. and Das, L.M., Methanolysis of Pongamia pinnata (Karanja) oil for production of biodiesel, Journal of Scientific & Industrial Research, 2004; 63:913- 918.

[22] Naik M.; Meher L. C.; Naik S. N.; Das L. M. Production of biodiesel from high free fatty acid Karanja (Pongamia pinnata) oil. Biomass. Bioenerg. 32: 354–357; 2008. doi:10.1016/j.biombioe. 2007.10.006.

[23] Meher L. C.; Dharmagadda V. S. S.; Naik S. N. Optimization of alkali-catalyzed transesterification of Pongamia pinnata oil for production of biodiesel. Bioresource. Technol. 97: 1392–1397;2006b. doi:10.1016/j.biortech.2005.07.003.

[24] Bora DK. Studies on storage stability of bio-diesel and its utilisation in a diesel engine. PhD Thesis, Centre for Energy Studies, Indian Institute of Technology Delhi; 2008.

[25] Karthikeyan, S., A. Elango and A. Prathima, 2014," Diesel engine performance and emission analysis using oil methyl ester with the nano sized zinc oxide particles", Ind. J. Sci. Indus. Res., 21: 83-87

[26] Sadhik Basha, J. and Anand, R. B.," Role of nanoadditive blended biodiesel emulsion fuel on the working characteristics of a diesel engine", Journal of Renewable and Sustainable Energy, 2011, 3, 1-17.

[27] S.M. Abdel Razek, M. S. Gad, Mohamed Abd El Hakeem “Experimental Investigation using CNTS as an Additive to Palm Biodiesel Blend on a DI Diesel Engine Performance, Emission and Combustion Characteristics” International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; Volume 5 Issue VII, July 2017-