Effect of Nanoparticle as Additive on Performance, Combustion and Emission Characteristics of a CI Engine Fueled with Diesel-Fish Biodiesel Blend

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Abstract: To estimate the performance, combustion with emissions characteristic of CI engine powered by diesel with biofuel blend formed from fish processing by-products, the experimental method was used to examine the impact of titanium oxide metal based additives on engine operation with varying titanium oxide concentrations in the biodiesel blends. The fish biofuel was obtained by the fish oil from transesterification method. The titanium oxide additives were combined with the fish biodiesel suspension fuel at changed concentration of 80ppm, 100ppm and 120ppm respectively. The whole experimental investigation was directed in diesel engine by means of 3 different fuels, viz., diesel, fish oil methyl ester and titanium oxide blended fish oil methyl esters. Experimental outcomes discovered that, the performance characteristics like BTE and BSEC. Marginal enhancement in the BTE for the titanium oxide blended fish oil methyl esters (FOME) compared with neat diesel and FOMEB20 with lower BSEC. The concentration of 75ppm of cerium oxide shows the improved combustion characteristics of HRR and peak pressure compare to diesel and FOMEB20. Substantial drop in CO, UBHC and reduction in NOx emission are accomplished with FOMEB20 biofuel blend. But there is a substantial drop in CO and UBHC emission for B20 biofuel blend with titanium oxide as an enhancer associated along FOMEB20 biofuels blends and diesel. The titanium oxide blended biodiesel fuel shows the lower NOx emission compare to FOMEB20 fuel. The smoke opacity also reduced for the blend with titanium oxide fuel compare to diesel and FOMEB20.

Index Terms **- Performance; Titanium oxide; Transesterification; CI Engine; Fish oil.**

1. INTRODUCTION

Substituting an alternative fuel like a biofuel by conventional fuel looks to be a viable choice as of inadequate resource of fossil fuel and unceasingly increasing stronger emissions regulation. Biofuel is always attentive as hopeful substitute in CI engine since, its having comparable properties with diesel and effective combustion regimes [1]. Between the numerous techniques existing to decrease exhaust emission, the use of metal based additive is presently attentive due to benefit in rise in fuel efficiency though lowering greenhouse emission. The impact of cerium oxides additives on ultra-fine diesel particles emission and kinetic of oxidations is deliberated through Jung, et al. [2]. It is noticed that adding of ceria to diesel cause substantial decrease in numbers biased scope dispersals and the oxidation degree was augmented suggestively. Impact of cerium oxide additive adding to diesel and diesel-biofuel-ethanol blend on different characteristics which will have impact of a compression ignition engine was investigated and consequences exhibited that cerium oxides work as oxygen molecules contributing substance and delivers oxygen to oxidations of CO or engrosses oxygen for decrease in NOx [3]. Carbon based nano tubes are act as beneficial enhancer to octane rating. Carbons nanotube comprising amide clusters take a higher responsiveness rate with those can respond through several substances. These substances can be more soluble in fuel to enhance the octane rating. In experimental examination, the ammonic carbon nano tube are combines with fuel. Investigation octane rating study exhibited that this enhancer improves octane rating of the chosen blends [4]. Preparation of advanced fuel by means of nanoparticles is widely examined by several investigators to decrease BSEC and after combustion exhaust and to rise fuel combustion effectiveness. The different nanoparticles like, Magnesium [5], Platinum [6] and Manganese, Nickel [7] are investigated with different biofuels. Karthikiyana et al. [8] exhibited an effect of the zinc oxides with diesel, with canola's biofuels exhibited improved BTE, heat value, Viscosity, lower CO with UBHC emissions related biofuel mixture (B20). Kao et al. [9] investigated the performance investigation of CI engine powered by diesel and aluminum metal based additives. Expressively enhanced BTE and lower opacity and NOx was detected. A substantial rise in HRR was too attained in the existence of metal based additives. Rao and Anand [10] studied about the outcome of aluminum oxide hydroxide metal based additives combined with Jatropha biodiesel water suspension fuel. Decrease in key contaminants like CO through 49%, HC through 37%, NOx through 36%, and smoke denseness through 24% was detected by constant engine performances. Decrease in carbon monoxides and nitrogen oxides emissions along by adding of titanium oxides metal based additives with biofuel experimentally studied by Fangsuwannarak and Triratanasirichai [11]. Sathiymoorthy et al. [12] studied the impact of CeO_2 along neam biofuel sample (B20) in the DI diesel engine and obtained healthier engine performance and combustions parameters with lower emission. The present study investigates the various concentration of titanium oxide in fish biofuel is diverse in the variation of 80–120 mg/l or ppm to assess the optimal concentration level depends on oxygen contented of the samples. These altered biofuels with optimal absorption of titanium oxide is then mixed with FOMEB20, and these samples are considered for the experimental study. The experimental results reveal that, metal oxide blended fuels show the better performance with reduced emission characteristics. Hence the possible usage of biofuel using fish oil methyl ester and titanium oxide nanoparticles added biofuel presented in this paper.

Table 1. Abbreviations and Symbols

B20	20% Biodiesel & 80% Diesel
NOx	Oxides of Nitrogen
UBHC	Unburnt Hydrocarbons
BTE	Brake Thermal Efficiency
FOME	Fish Oil Methyl Ester
FOMEB20	20% FOME + 80% Diesel
FOMEB20+Ti100ppm	FOMEB20 + 100 mg TiO2

2. METHODOLOGY

2.1 Production of biofuel from Fish oil

The fish trade produces huge amounts of by-products, mainly due to fish processing and discards. The free fatty acid level test was carried out in the laboratory to choose the biodiesel conversion process. Transesterification process is chosen for biodiesel conversion process to meet industrial standards of biodiesel. Transesterification process will happen in a numerous reaction stages involving 3 rescindable stages in sequence, in first sequence triglycerides are renewed to diglyceride, in second sequence diglyceride are renewed to monoglyceride, and in third sequence monoglyceride are changed to ester and glycerol. Fig. 1 shows the complete transesterification process.

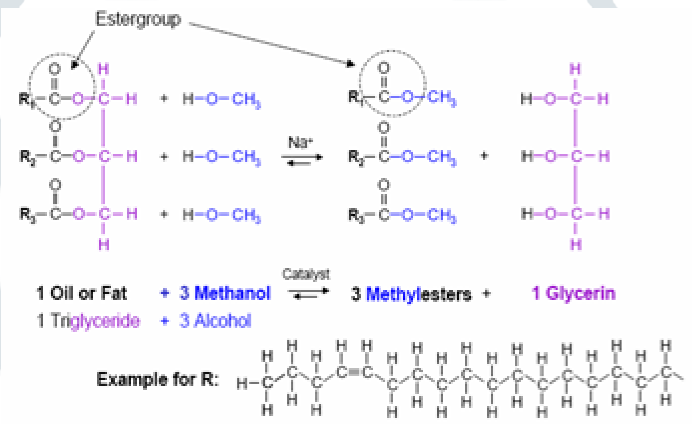

Figure 1. Schematic representation of Transesterification.

2.2 Evaluation of various Fuel Properties

Evaluation of numerous properties of oil like flash point, calorific value, kinematic viscosity and density, typical trial setups was implemented in departmental lab of AIT Chikmagalur to meet ASTM standards.
Heat value of fuel is resolved by means of Bomb's calorimeter, Kinematic viscosity is resolved by means of Capillary Tube Viscometers Test Method, flash point is measured by using open cup method and density is measured by using two separate measurements of mass & volume. The verified fuel properties are presented in the table 2.

Table 2. Properties of fuels used for testing

Properties	Diesel	FO	FOME	B20FOME
Kinematic Viscosity (40^0 C, Cst)	3.05	48	6.057	4.72
Heat Value (MJ/kg)	42.6	31	39.56	40.82
Density (Kg/m$^{3)}$	828	986	895	831
Flash Point ^{0}C	60	307	150	98
Cetane Number	40	53	51.48	51.48

2.3 Preparation of Nanofluids

Preparation of FOMEB20 is carried out by mixing 80% by volume diesel with 20% of biodiesel. In the present study three different concentration of titanium oxide (80 ppm, 100ppm and 120ppm) are mixed the FOMEB20. The ultrasonication method is used to dissolve the nanoparticles in a FOMEB20 to avoid the accumulation of titanium oxide.

Finally, three different nanofluids are prepared for the experimental study (FOMEB20+Ti80ppm, FOMEB20+Ti100ppm and FOMEB20+Ti120ppm).

2.4 Experimental Setup

The experiment was directed at the premeditated injection pressure of 200 bar, engine speed of 1500 rpm and power of 3.5 KW. It is a single cylinder engine, four stoke and water cooled along with eddy current dynamometer with essential arrangements as shown in Fig.2. the engine run was carried out in engine test bed along 0 load, 2.5 kg, 5.0 kg, 7.5 kg and 10 kg of maximum load. At the time of engine run all the required parameters of the engine were recorded. The engine was also equipped with smoke meter and gas analyzer with all the required instrumentation

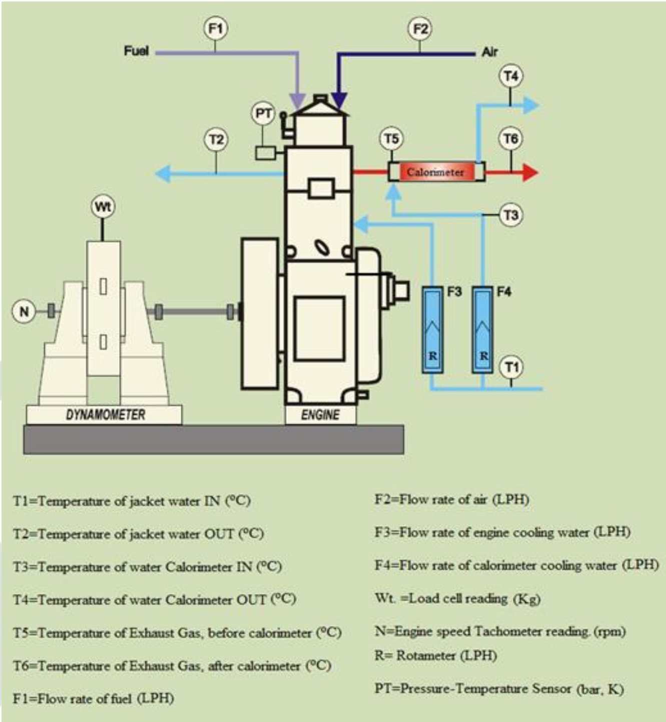

Figure 2. Schematic of Experimental setup.

Table 3. Uncertainties percentage

Parameters	Average uncertainties
Air flow rate	1.2%
LCV of fuel	1.0%
Engine speed	1.3%
Gas flow rate	2.1%
Engine load	0.2%
Liquid fuel flow rate	0.15%
Temperature	1.0%
Cylinder pressure	0.8%

3. RESULTS AND DISCUSSION

3.1 Performance parameters

3.1.1 BTE

Distinction of BTE along load for diesel, FOMEB20 and FOMEB20 with Titanium oxide with different Concentration are shown in Fig.3. with addition of titanium oxide metal based additives show the better BTE compare to diesel and FOMEB20. This might be attributed to collective accomplishment of micro detonation with secondary atomization through the existence of metal based additives Among all the blends FOMEB20+Ti100ppm shows the higher BTE compare to all blends. This could be due to advances combustions and provides supplementary surface energy for improved atomization

3.1.2 Brake specific fuel consumption

Fig. 4 demonstrate the distinction of BSEC along load for diesel, FOMEB20 and FOMEB20B with titanium oxide. This plot illustrates the increased trend for diesel and decreased trend for FOMEB20 and FOMEB20 with titanium oxide blends, due to the fine atomization property of titanium oxide resulting in better combustion. FOMEB20+ Ti100ppm shows the lower BSEC compare to diesel and all the blends. This is due to increase in power and improving the combustion, reduces the BSEC as well.

3.2 Combustion parameters

3.2.1 Heat release rate

The comparison of HRR along load for all verified samples is illustrate in Fig. 5. The effect of titanium oxide-based additives along diesel and biofuel fuel samples are initiate to provide higher HRR compare to diesel and biofuels. The enhancement is due to improvement in pre combustion stage. The metal based additives consequence delivers shorter ignition delay (ID) along improved ignition properties which roots an primary beginning of combustion progression associated to that of diesel fuel.

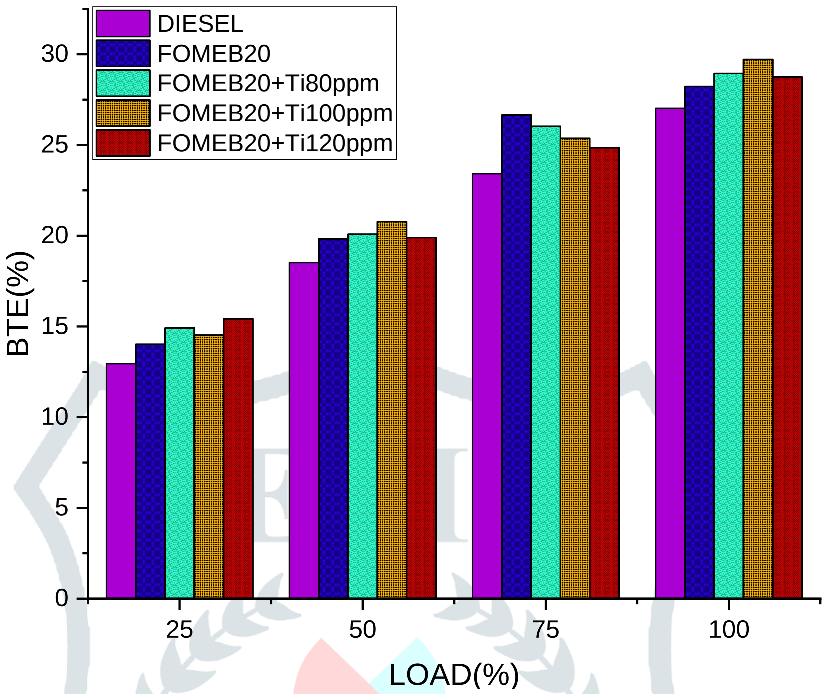

Fig 3. Distinction of BTE with load.

3.2.2 Peak pressure

Figure. 6 illustrate distinction of peak pressure along load for all verified samples. Here the peak pressure also rises with increase in load. Along with the titanium oxide metal based additives pressure of biofuels, the combustion development initiate priory which delivers shorter ignition delay could be the credible cause for peak pressure.

3.3 Emission parameters

3.3.1 Oxides of nitrogen

Figure. 7 illustrate the distinction of NOx along load for all the verified samples. From this plot its clear, the NOx increases along increase in load. The NOx emission is depending on so many constraints like, temperature of combustion chamber, cylinder pressure and ignition delay. It was apparent from the results that titanium oxide metal based nanoparticles exhibited considerable drop in NOx level compare to FOMEB20. The increased chemical reactivity of titanium oxide metal-based additives decreases the ignition delayed period which further reduces the NOx emissions.

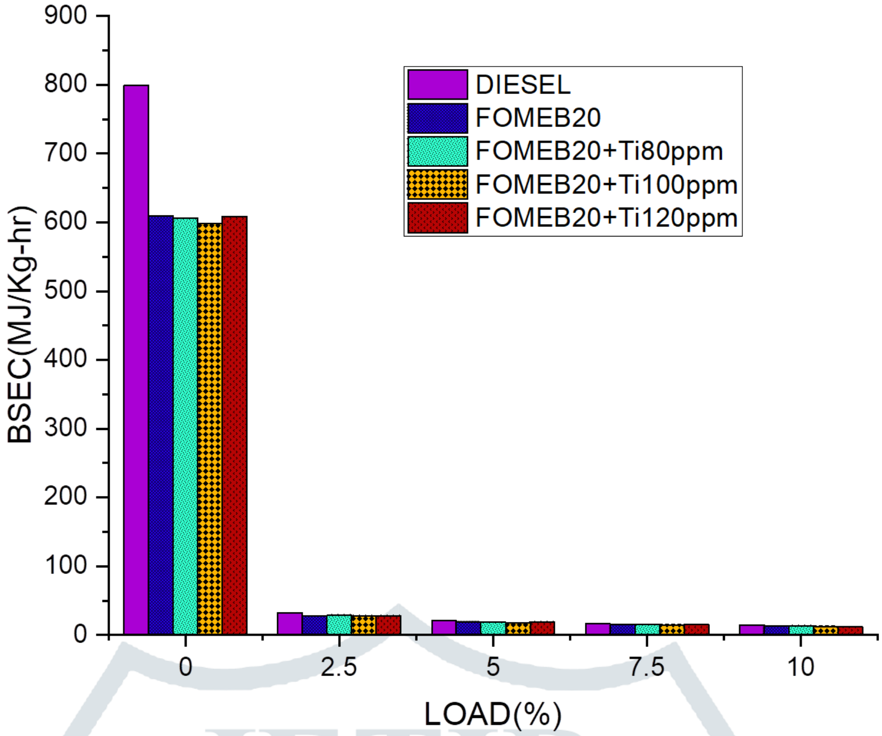

Fig. 4. Distinction of BSEC along load.

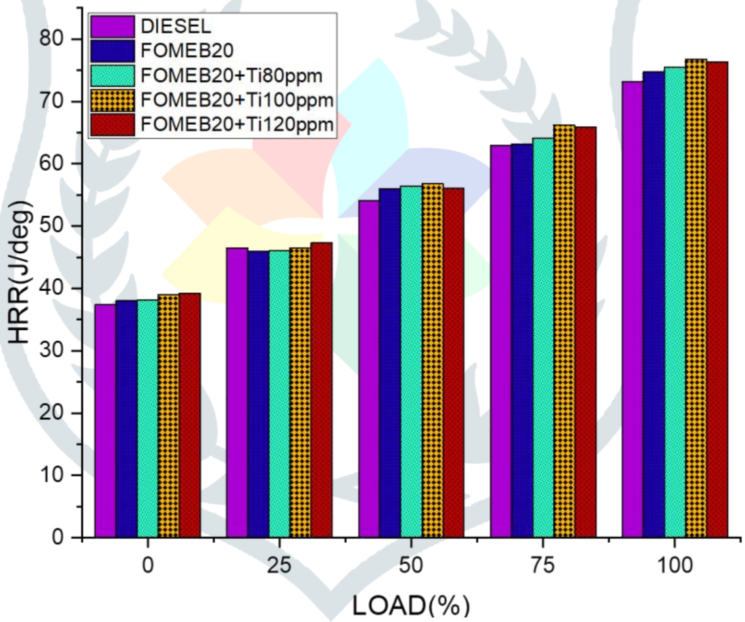

Fig. 5. Distinction of HRR with crank angle.

3.3.2 Carbon monoxide

Fig. 8 illustrate the distinction of carbon monoxide along with the load. FOMEB20 shows a lower CO associated to diesel at higher load. This can be due to, biofuels which behaves as a oxygen buffers, provides supplementary oxygen for comprehensive combustion. Along with the titanium oxide metal based additives further reduction in CO emission. This drop in CO emissions rate could be ascribed owing to rich oxygen contented obtained in the particles of biofuels and the catalyst influence of metal based additives which cumulatively progresses the combustion effectiveness of altered fuel.

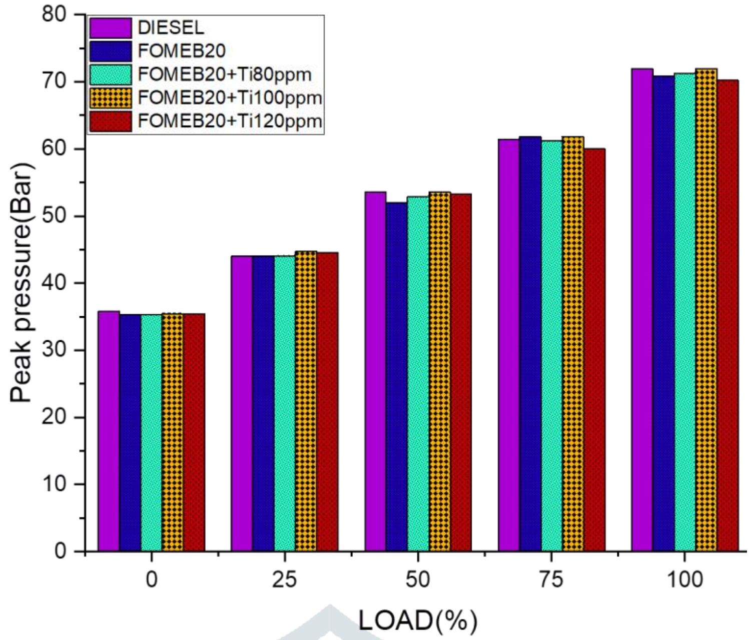

Fig. 6. Distinction of Peak pressure with crank angle.

3.3.3 Unburnt hydrocarbon

Figure. 9 illustrate distinction of UBHC along with the load. FOMEB20 shows a lower UBHC associated to diesel at higher load. The amount of oxygen existing in biofuels directs to comprehensive combustion and the advanced cetane rating decreases the ignition delay, as shorter the ignition delay reductions the unburnt hydrocarbons. Further reduction in UBHC with titanium oxide metal based additives due to, secondary atomizations and improved catalytic consequence triggered by the metal based additives combined BD emulsions fuel.

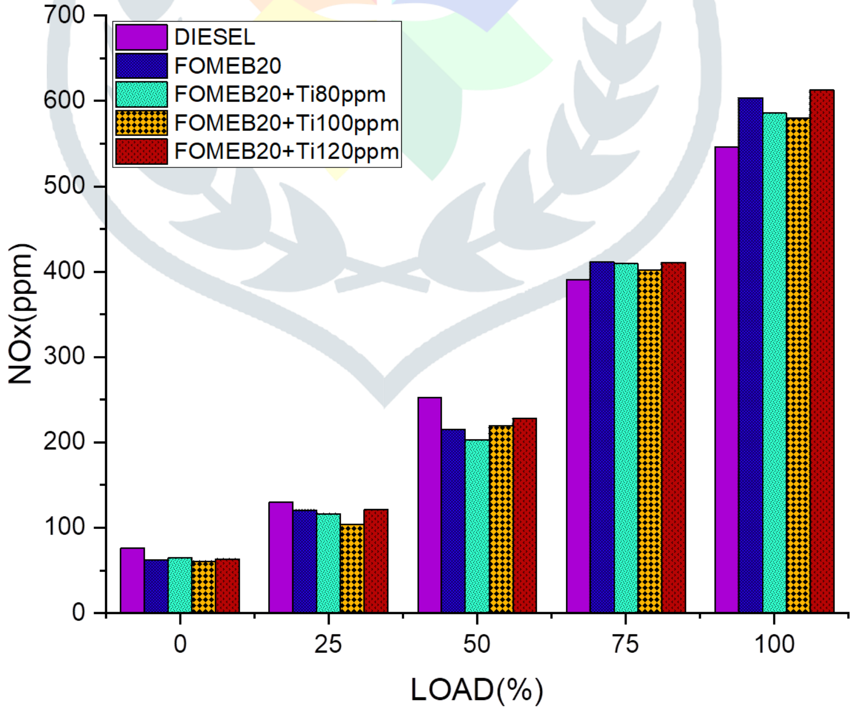

Fig. 7. Distinction of NOx with load.

3.3.4 Smoke opacity

Figure.10 illustrate the distinction of smoke (exhaust gas) denseness along load. FOMEB20 are showing higher smoke opacity compare to diesel. This could be owing to deprived volatility and mixing of the blend precipitations with air due to higher viscosity of the verified samples. It has been detected that there was a substantial drop in the smoke emission for the FOMEB20 with titanium oxide metal based additives emulsion fuels compared to FOMEB20 due to better combustion characteristics of meatal based additives.

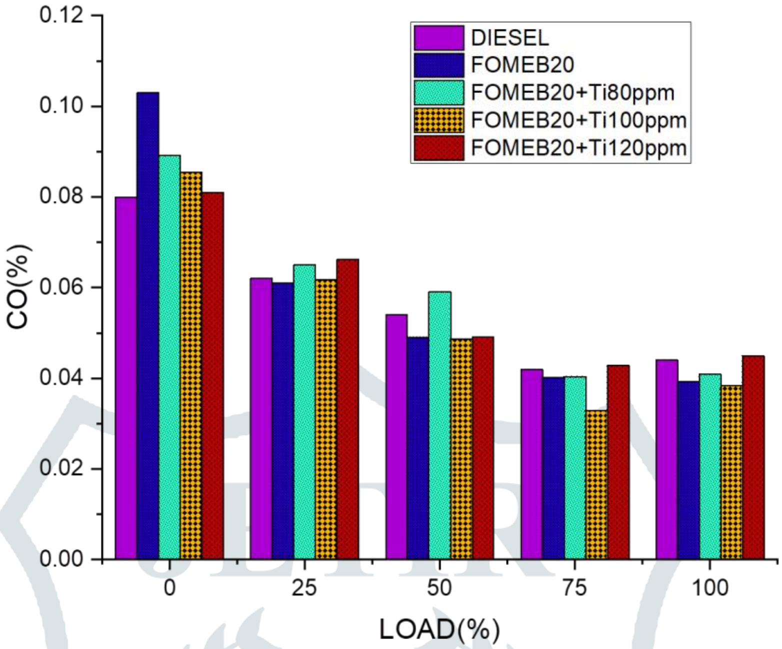

Fig. 8. Distinction of CO along load.

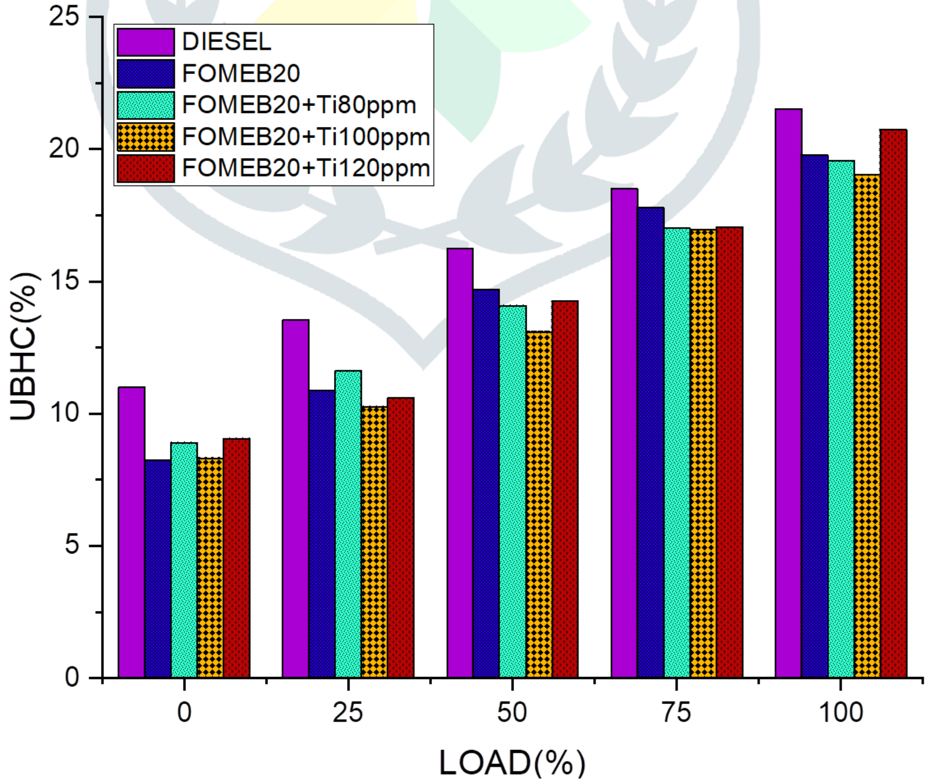

Fig. 9. Distinction of UBHC along load.

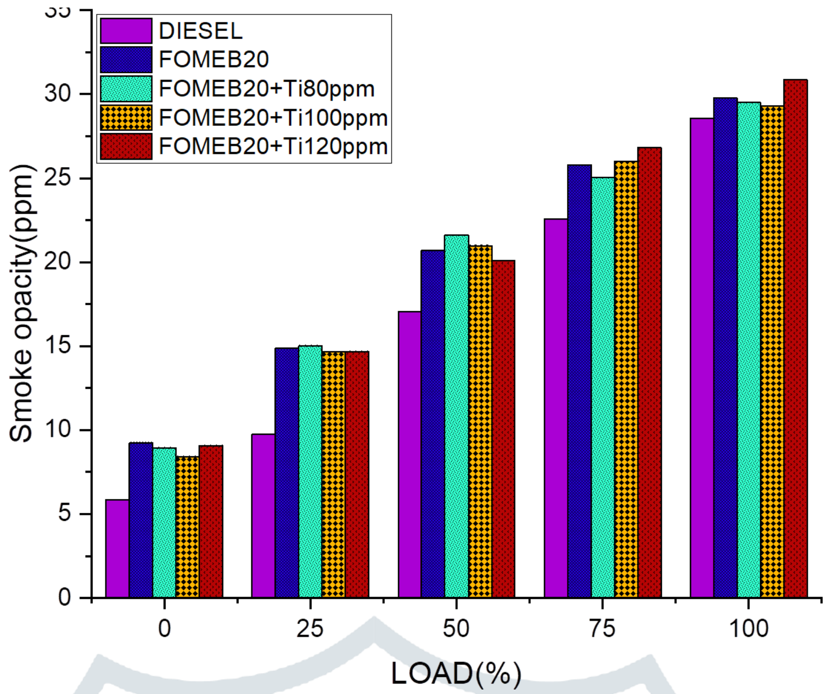

Fig.10. Distinction of Smoke opacity along load.

4. Conclusion:

This experimental investigation shows that, it's clear that the metal based additives show the very significant part to enhance engines performance and emission drop in diesel engine. The characteristics of performance, combustion and emission of CI engines fueled along fish biofuels combined with titanium oxide nanoparticles were studied and associated with those fueled with diesel fuel. On the basis of above stated conditions, results and discussion the conclusions drawn are condensed as takes after:

1. After transesterification process, the properties fish oil was improved. The obtained biodiesel after transesterification process is blended with Titanium oxide with different concentration.

2. Engine test was conducted by using, neat diesel, FOMEB20, FOMEB20+Ti80ppm, FOMEB20+Ti100ppm and FOMEB20+Ti120ppm.

3. The blend FOMEB20+Ti100ppm shows the better BTE and reduced BSEC compare to diesel and FOMEB20. Titanium oxide metal based additives enhance the combustion characteristics due to, shorter ignition delay.

4. Emission characteristics like, NOx, CO and UBHC are showing less emission compare to diesel and FOMEB20.

5. The blend FOMEB20+Ti100ppm shows the reduced smoke opacity compare to FOMEB20.

References

[1] Ayatallah Gharehghani.2017. Effects of waste fish oil biodiesel on diesel engine combustion characteristics and emission. Renewable Energy 101 (2017) 930-936.
[2] Jung H, Kittelson DB, Zachariah MR. The influence of a cerium additive on ultrafine diesel particulate emissions and kinetic of oxidation. Combust Flame 2005; 142:276–88.
[3] Arul Mozhi Selvan V, Anand RB, Udayakumar M. Effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a CI engine. ARPN J Eng Appl Sci 2009;4(7):1–6.
[4] Safari Kish S, Rashidi A, Aghabozorg HR, Moradi L. Increasing the octane number of gasoline using functionalized carbon nanotubes. Appl Surf Sci 2010;256:3472–7..
[5] Guru, M., Koca, A., Can, O., Cinar, C., and Sahin, F., 2010, "Biodiesel Production From Waste Chicken Fat Based Sources and Evaluation With Mg Based Additive in a Diesel Engine," Renewable Energy, 35(3), pp. 637–643..
[6] Kelso, D., Epperly, W. R., and Hart, M. L., 1990, "Effects of Platinum Fuel Additive on Diesel Emissions and Efficiency," SAE Paper No. 901492.
[7] Keskin, A., Guru, M., and Altiparmak, D., 2007, "Biodiesel Production From Tall Oil With Synthesized Mn and Ni Based Additives: Effects of the Additives on Fuel Consumption and Emissions," Fuel, 86(7–8), pp. 1139–1143.
[8] Karthikeyan, S., Elango, A., and Prathima, A., 2013, "Diesel Engine Performance and Emission Analysis Using Canola oil Methyl Ester With the Nano Sized Zinc Oxide Particles," J. Sci. Ind. Res., 21(1), pp. 83–87.
[9] Kao, M. J., Ting, C. C., Lin, B. F., and Tsung, T. T., 2008, "Aqueous Aluminium Nanofluid Combustion in Diesel Fuel," J. Test. Eval., 36(2), pp. 1–5.
[10] Rao, M. S., and Anand, R. B., 2016, "Performance and Emission Characteristics Improvement Studies on a Biodiesel Fuelled

DICI Engine Using Water and AlO(OH) Nanoparticles," Appl. Therm. Eng., 98, pp. 636–645.

[11] Fangsuwannarak, K., and Triratanasirichai, K., 2013, "Improvements of Palm Biodiesel Properties by Using Nano-TiO2 additive, Exhaust Emission and Engine Performance," Rom. Rev. Precis. Mech. Opt. Mechatron, 43, pp. 111–118.

[12] Sathiyamoorthi, R., Puviyarasan, M., Bhuvanesh, B. K., and Joshua, D. B.,2016, "Effect of CeO2 Nano Additive on Performance and Emission Characteristics of Diesel Engine Fuelled by Neem Oil-Biodiesel," Int. J. Chem. Sci., 14,pp. 473–484..

[13] Arvind Kumar Madheshiyaa., Ajitanshu Vedrtnama.: Energy-exergy analysis of bio-diesel fuels produced from waste cooking oil and mustard oil. vol. 214, pp. 386–408. Fuel (2018).

[14] Chiranjeeva Rao Seela, B. Ravi Sankar, D. Kishore & M. V. S. Babu, "Experimental analysis on a DI diesel engine with cerium oxide added Mahua Methyl Ester blends", International Journal of Ambient Energy, DOI: 10.1080/01430750.2017.1360203.

[15] Mohamed Musthafa, M., Ashok Kumar, T., Mohanraj, T., Chandramouli, R.: A com-parative study on performance, combustion and emission characteristics of diesel en-gine fuelled by biodiesel blends with and without an additive. vol. 225, pp. 343–348. Fuel (2018).

[16] K. Kara. 2017. Biodiesel production from waste fish oil with high free fatty acid content from Moroccan fish-processing Industries. Egyptian Petroleum Research Institute. Production and hosting by Elsevier B.V, 1110-0621 2017.

[17] M. Anand, M. Gobalakrishnan, M. Maruthupandy, S. Suresh, Energy and environment, Focus 4 (2015) 47–53.

[18] R. Yahyaee, B. Ghobadian, G. Najafi, Renewable Sustainable Energy Rev. 17 (2013) 312–319.

[19] Sarvestany SN, Farzad A, Bajestan EE, Mir M. Effects of magnetic nanofluid fuel combustion on the performance and . emission characteristics. J Dispers Sci Technol 2014;08:1745–50.

[20] Basha JS, Anand RB. Pefrofmance, emission and combustion characterists of a diesel engine using carbon nano tubes blended Jatropha methyl ester emulsion Alex Eng J 2014;53:259–73.