Effects of nano additives with biodiesel fuels in internal combustion engines – A Review

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Abstract. In our present world Internal Combustion Engines plays a vital role for transportations, in that engine fuels plays an vital role for transportations, but it causes more emissions. To reduce the emissions and increase the performance of CI engines, many experimental researches are done in alternate fuels in diesel engines and they were found that alternate fuel gives the better performance. Nano particles and nano additives with biodiesels, provide better performance and reduction in emissions. This Literature review reveals about the engines performance and its emissions in CI engines with the effects of addition of nano additives in biodiesels. Nano additives like Al₂O₃, CeO₂, CuO, ZnO, Ag, CNT, MWCNT, and their effects are summarized in this review under different load conditions. The addition of Al₂O₃ gives better performance. It reduces 7.66% of BSFC at maximum load, increases BTE by 1.58% . 35% of NOx emissions will be reduced with the addition of CNT with biodiesels.

Keywords- Nano Additives, Biodiesels, Engine Performance, Alternate Fuels, Reduction in emissions.

1. Introduction
For transportations we need high durability, reduces the consumption of fuel, to carry the heavy loads, for that purpose we are using diesel engines plays a vital role for transportations, but the main disadvantages we are facing from diesel engines are emission and to reduce the fuel consumption. The emissions from diesel engines like CO, NOx, CO₂, HC, Smoke, Soot are the emissions it will make pollutions for our world, It makes major health problems for human begins, lungs problem mainly asthma, skin diseases, causing irritation for respirations and for more hazards for young children also to reduce these problems the addition of nano additives with biodiesels will gives the reduction of these kind of emissions and it increases the performance parameters. The major pollutants are particulate matters are very small particles like soot and their metal tic substance that penetrates deep into lungs. It leads to major health problems. They are grouped as primary pollutants. Nitrogen Oxides(NOx) are includes NO, NO₂, N₂O, N₂O₃, N₂O₅ etc. In general, the oxides of nitrogen are called as NOx. The atmospheric air contains the atomic oxygen and it is the initiator of NOx formation. Carbon Monoxide(CO), It is a colourless and odorless, toxic gas formed due to insufficient availability of oxygen during combustion. Biodiesels contains maximum of oxygen atoms, hence contribute in reducing CO emissions. Hydrocarbons(HC), it causes irritation to respiratory system. It reacts with NOx in the presence of sunlight to form smog. CRDI systems reduces the fuel consumptions and it will provides the maximum output power and its produces a less noise under the conditions of performance parameters [1].
2. Effects of Nano Additives in Performance Parameters
Nan additives is used as catalyst with the blends of bio fuels to enhance the performance parameters, nan additives will increases BTE, BSFC and decreases the SFC, and to provides the better torque and to reduce cylinder temperature and friction power.

2.1. Aluminium Oxide (Al2O3)
Syed Aalam et al [1] found that Al2O3 contains high temperature at the time of reactions with oxygen. Al2O3 is unstable during the combustion in high temperature, methyl ester added to nano additives will improves the combustion, better performance of engines and the fuel suspensions stability will be increased in CRDI system, Al2O3 under the measure of ppm will added with biodiesel MME20D80 will reduces the SFC of 7.66% at the condition of maximum load. Al2O3 (100 ppm) with addition of MME20D80 will gives better fuel consumptions comparing with other biodiesels. MME20D80 with addition of Al2O3 (50 ppm) will increases the BTE of 1.58%, and MME20D80 with the addition of Al2O3 (100 ppm) will increases the BTE of 7.34%. MME20D80 added to Al2O3 will provides the extensive of high active surface, and it improves the activities of catalyst due to high dosage. Soner Gumus et al found that Al2O3 with diesel will increases the oxidation rate and decreases the ignition temperature [4].

2.2. Carbon Nano Tubes (CNT)
Najafi [2] found that Diesel-Biodiesel added to CNT will results better performance the output power is 3.67% and BTE is 5.57% little amount of SFC will decreased, CNT measured at the size of 5nm, CNT will increases the octane number and it is high reactive with many chemicals, In the case of Amino-functionalized CNT with the gasoline will increases the octane number. CNT blended with vegetable methyl ester prepared by using of used cooking oil with the base fuel of diesel will releases the high heat rate and with the improvement of engine power and output torque will increases.

2.3. Silver (Ag)
Najafi [2] found that Ag at the size of 50nm added with biodiesel will reduces the SFC and its increases the BTE at 5.58%, and SFC decreased up to 15% of BSFC, Ag also increases the engine power and output torque increases at the addition of Ag as an additives.

2.4. Multi Wall Carbon Nano Tubes (MWCNT)
Najafi [2] found that addition of MWCNT with JMED will results with maximum increase of BTE at 16% but there will be a decrease in BSFC 15%. MWCNT with some other B20D80 that results with 7% of CPP will increases. MWCNT at the dosage level of 40mg/l is the best level to increase the engine performance.

2.5. Zinc Oxide Nanoparticle (ZnO)
Prabakaran [3] found that the diesel with biodiesel ethanol blends at different temperatures and the addition of ZnO at 250ppm. The addition of blended fuel with ZnO metal oxide will increases the CV of fuel, and its increases the BSFC, Rate of heat releases and cylinder pressure also, but BTE increases at the full load, same way experimentally he found that palm oil added with of ZnO at 225 ppm will increases the BTE and increases the EGT at high load.

2.6. Cerium Oxide (CeO2)
Esmail Khalife [5] found that CeO2 (90 ppm) added with Biodiesel with 5% of emulsified H2O will increases the BTE, it will reduces the cylinder temperature, friction reduction occurs in engines, BSFC will increases slightly, and it's increases the overall combustion characters.

2.7. Copper Oxide (CuO)
Vijayakumar Chandrasekaran [6] found that CuO(50ppm) added with MME20D80 will reduces the lesser SFC, increases the thermal efficiency, 1.3% of BTE increases at maximum load, BTE decreases with increasing the blends percentage.

3. Effects Of Nano Additives With Emissions
Nan additives is used as catalyst with the blends of bio fuels to enhance the reduction of emissions like NOx, CO, CO2, Smoke and Shoot emissions.

3.1. Aluminium Oxide (Al2O3)
Syed Aalam [1] found that MME20D80 added with Al₂O₃ at 100ppm results in maximum 26.04% of HC emissions, CO emissions reduces when the engine works at minimum load, but at the full load CO emissions will increases slightly. MME20D80 added with Al₂O₃ (50 ppm) will decreases 26% of CO emissions but increases of 4.8% of NOx emissions and MME20D80 added with Al₂O₃ (100 ppm) will decreases 48% of CO emissions, but increases 7.95% of NOx emissions. At shorter ignition delay time NOx emission will increases. Smoke emission is reduced little.

3.2. Carbon Nano Tubes(CNT)
Najafi [2] found that CNT with diesel- biodiesel blends decreases the CO and Soot emissions, but it increases the NOx emissions. Biodiesel with CNT(5nm) results in increases of HC emissions, but decreases the CO emissions. CNT results with CO and HC emissions are reduced. CO₂ and NOx emissions are increased.

3.3. Silver(Ag)
Najifi [2] found that Ag(50nm) with biodiesel will decreases the CO and HC emissions, but CO₂ and NOx emissions are increased.

3.4. Multi Wall Carbon Nano Tubes(MWCNT)
Najifi [2] found that MWCNT with JMED will results in decreases with 35% of NOx emission, 50% of CO emission, 60% of Smoke emissions.

3.5. Zinc Oxide(ZnO)
Prabakaran [3] found that ZnO(250ppm) added with D40B30E30 will reduces the CO emissions, but higher in HC emissions at minimum loads. If at full load, complete combustion will occurs, so it reduces the HC emissions, It contains higher CV it increases NOx emissions, but it reduces smoke emissions.

3.6. Cerium Oxide(CeO₂)
Esmail Khalife [8] found that CeO₂ (90 ppm) added with Biodiesel with 5% of emulsified H₂O at the highest load it will reduces the NOx emissions, but it increases CO emissions because of insufficient oxygen.

3.7. Copper Oxide(CuO)
Dinesh Kumar Soni et al [7] found that CuO(50ppm) added with MME20D80 at part load CO emissions reduces up to 0.05%, in maximum load CO reduces up to 0.23%, overall it reduces emissions under the percentage of HC-5.33%, CO-33%, Smoke-12.5%.
4. Summary of performance parameters and emissions with additions of nano additives

Table 1. Summary of performance and Emission

| Nanoadditives                  | Performance Parameters                          | Emissions                          |
|--------------------------------|-------------------------------------------------|------------------------------------|
| Aluminium Oxide(Al₂O₃)         | Reduces SFC, Increases BTE                       | Reduces in Smoke and CO            |
| Carbon Nano Tubes(CNT)         | Better Output Power, Increases BTE, Reduces SFC | Reduces in CO, Smoke and Shoot     |
| Silver(Ag)                    | Reduces SFC and BSFC, Better Power Output and Torque | Reduces CO and HC                  |
| Multiwall Carbon Nano Tubes(MWCNT) | Reduces SFC, Increases CPP, Decreases in BSFC  | Reduces NOx, CO and Smoke          |
| Zinc Oxide(Zno)               | Increases in BSFC, BTE and EGT                  | Reduces HC and Smoke               |
| Cerium Oxide(CeO₂)            | Reduces Cylinder Temperature and Friction Force | Reduces NOx                        |
| Copper Oxide(CuO)             | Increases BTE and Thermal Efficiency            | Reduces HC, CO and Smoke           |

5. Conclusion
The summary of various research papers conclude that various types of Nano additives helps in reducing emissions from automobiles and they are providing better combustion because of their improved surface area to volume ratio and better catalytic action. Under the evaporation conditions HC and CO emissions are reduced, but MWCNT reduces NOx, CO and Smoke emissions and it gives better performance for engines. But MWCNT is costlier, minimization of production cost is the area where researchers should concentrate, since higher cost hinders wide usage of these nanofluids. In this scenario, biodiesel with nano additives reduces the emissions and provides a better performance for engines.

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