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Review of Nanocatalyst as Additive Fuel in Diesel Engine

Devaraj A*, Arul Prakasajothi M, Rajesh D, Anand P
Department of Mechanical Engineering, Veltech Dr.RR& Dr.SR University, Chennai-600062.
***Corresponding author: E-Mail: adevaraj@veltechuniv.edu.in**

ABSRACT

This study involves the performance and emission of diesel engine with addition of nanoparticles. Current research papers were showed there is a lot of scope for improvement in performance and reduction in emission by using nanoparticles as an additive with diesel and biodiesel blends. In this paper work, detailed report about nanoparticle as an catalytic agent with various biodiesel, alcohol and its blends has been discussed. By using nanoparticles as an additive in diesel improves high surface area to volume ratio, thermal conductivity, mass diffusivity, thermo physical properties when mixed with fluid medium. In this present work, the study of various research papers to improve performance and emission reduction by using nanoparticles as an additive with diesel, biodiesel, alcohol and its blends are reported.

KEY WORDS: Nanoparticles, catalytic agent, Surface to Volume ratio.

1. INTRODUCTION

Heat Transfer in Nanopaarticles: Arulprasajothi (2015), has investigated the heat transfer study of TiO_2/ water Nanofluids with different concentrations. They showed compared to conventional working fluids. Nanofluids showed increased heat exchanging capacity. TiO_2/water nanofluids is prepared by using two step method, with various volume concentrations of 0.1%, 0.25%, 0.5% and 0.75%. Thermal conductivity, stability and viscosity measurement was conducted using KD2 Pro, zeta potential and Brookfield Viscometer respectively. They showed nusselt number increases as particle size increases in volume fraction and nusselt number enhancement showed 13.2% over the base fluid for volume concentration of 0.75%.

Arulprasajothi (2015), has investigated the preparation, characterization and thermal behaviour of TiO_2/ water nanofluids. They showed compared to conventional heat transfer fluids, nanosized particles enhances its thermo physical behaviour. Using ultrasonic vibration continuously for 3hours, they maintained uniform dispersion and stable suspension. They showed thermal conductivity increases with particle volume to be 9.22% than the base fluid for volume concentration of 0.75.

Calorific valve of the liquid fuel has been considerably increased due to its higher energy density and gives evident to improve the performance of the engine by boosting power output. To get increased brake horse power and reduction in emission, the study of evaporation rate and ignition properties plays an important role. Two step method is commonly used for preparing nanofluids, first step is followed by physical and chemical process and then will be dispersed into second step with the help of ultrasonic agitation, magnetic force agitation and high shear mixing to form uniform distribution of nanoparticles.

Aluminium, boron and carbon nanoparticles mixing with base fluid results, ignition enhanced at lower temperature as compared to diesel (Lee, 1991; Turns, 1987). Water/ diesel emulsion fuel mixed with aluminium nano powder reacts with water at higher temperature and generates hydrogen which promotes combustion (Kao, 2008).

Fuel droplets (n-decane and ethanol) containing nano and micro-sized aluminium particles, burning characteristics were investigated. Distinctive stages such as preheating, ignition, classical combustion, micro-explosion, and surfactant flame and aluminium droplet flame has considered to get increased heat release rate. Generally nanoparticles have higher surface- to volume ratio, so that nano suspensions can remain stable for much longer time than micro suspensions. Microexplosion behaviour of the micron suspension occurred little later with much stronger intensity than nanoparticles.

Cerium oxide nanoparticles (CERIA) and carbon nano tubes (CNT): Arul Mozhi Selvan (2009), has investigated the effect of Cerium oxide nanoparticles (CERIA) and carbon nano tubes (CNT) as fuel borne additives in dieseterol on the performance, combustion and emission characteristics of a variable compression engine. They have used castor oil biodiesel because diesel and ethanol are immiscible. They carried out experiment using CERIA and CNT ach 25, 50, 100 ppm in the diestrol blends by the high speed mechanical agitator followed by ultrasonic bath stabilization in VCR engine for various loading condition at an optimum compression ratio 19:1. When comparing with neat diesterol blends the addition of CERIA and CNT in diesterol blends shows increases in cylinder gas pressure. Due to the carbon nano tubes addition acting as a catalyst, it accelerates the burning rate, which gives decreased ignition delay and lower heat release rate. Cerium oxide nanoparticles act as a oxidation agent which provides oxygen for the carbon monoxide and absorbs oxygen for the reduction of nitrogen oxides. Carbon deposits within the engine cylinder tends to burn off due to activation energy of cerium oxide and also restrict the deposition of non-polar compounds in the engine cylinder wall for reduction of HC and Smoke emissions. Finally they have resulted combined effect of CERIA and CNT as fuel bore nano particle additive gives

cleaner combustion and reduces harmful exhaust engine emissions. They have noticed that brake thermal efficiency with addition of CERIA and CNT in diestrol blend increased upto 7.5% when comparing with diesetrol blend.

Arul Mozhi (2009), has investigated cerium oxide nano particle in addition with diesel and diesel-biodiesel-ethanol blends to find the performance and emission characteristics of CI engine. They have added caster-oil biodiesel to prevent the phase separation for diesel and ethanol blend and improves high speed blending with cerium oxide. Specific fuel consumption has noticed that higher for diesel-biodiesel-ethanol blends. Small improvement in brake thermal efficiency with addition of cerium oxide. Diesel, ethanol and cerium oxide blends shows increase in peak pressure. Ethanol with diesel gives increases in ignition delay were as the addition of cerium oxide results decrease in ignition delay. Carbon monoxide get decrease with help of cerium oxide nanoparticles. When comparing with neat diesel and diesel-biodiesel-ethanol blends cerium oxide gives decrease in HC and CO. In neat diesel NO emission is lower than oxygenated blends.

Alumina nanoparticle: Shaafi (2015), has investigated the alumina nanoparticle, ethanol and isopropanol blend as additive with diesel-soybean biodiesel blend fuel to improve the performance and emissions norms. They have used two modified fuel, B20 (diesel-soybean biodiesel) and diesel soybean biodiesel ethanol blends with alumina as a nano additive (D80SBD15E4SI + alumina) and the results are compared with neat diesel. Results shows that higher cylinder pressure during the combustion and heat release rate for D80SBD15E4SI + alumina fuel blend when compared to neat diesel. Exhaust gas temperature is also reduced by using nanoadditive, this indicates the higher pressure force acting on the expansion stroke to get increased brake thermal efficiency. Due to the presence of oxygen content soybean biodiesel it gives better mixing with nanoparticle to reduce CO and UBHC, by small increase in NOx at full load and they have noticed the BSFC is higher for B20 and D80SBD15E4SI + alumina full blends compared to neat diesel at 25% and 50% load, and also they said at higher loads of 75% and full load BSFC is minimum when compared with neat diesel. This is due to high viscosity in the case of B20 and D80SBD15E4SI + alumina fuel blends at lower load.

Rakhi Mehta (2014), has conducted experiment on the study of burning characteristics, engine performance and emission parameters of a single cylinder compression ignition (CI) engine using nanofuels (Aluminium (Al), iron (F1) and boron (B1)) in base diesel. From the experiments, they reported adding nano additives showed reduced ignition delay, longer flame substance and agglomerate ignition. Improved combustion rate has helped to raise exhaust gas temperature 8%, 7% and 5% leading to increase BTE by 9%, 4% and 2% for A1, F1, B1, respectively.

Soner Gumus (2016), has investigated the effects of aluminium oxide and copper oxide added to diesel fuels. They have mixed nanoparticles with diesel fuel in varying mass fractions by means of ultrasonicator and mechanical homogenizer. They have concluded with addition of AL_2O_3 and CuO nanoparticles, torque and power increased slightly compared to neat diesel by adding 50ppm dosage. With addition of CuO to neat diesel CO, HC and NOx are reduced upto 5%, 8% and 2% respectively. At moderate engine speeds BSFC is reduced up to 1.5%.

Ferric Chloride: Kannan (2011), has conducted investigation on ferric chloride ($FeCl_3$) as a Fuel Borne Catalyst (FBC) for waste cooking palm oil based biodiesel in direct injection diesel operated at constant speed 1500rpm at different operating conditions. They have added metal based additive to biodiesel at a dosage of 20u.mol/l. The results showed that FBC added biodiesel is decreased in BSFC of 8.6% and the Brake Thermal Efficiency (BTE) increased by 6.3% and also reported lower nitric oxide (NO), slightly higher carbon dioxide (CO_2) emission as compared to diesel emission like carbon monoxide (CO), Hydro Carbon (HC) and smoke emission of FBC added biodiesel shows decreased by 52.6%, 26.6% and 6.9% respectively as compared to diesel without addition of FBC at 280 bar injection pressure and 25.5 degbTDC injection timing. Finally they have concluded that higher cylinder gas pressure and heat release rate tends to increase BTE and shorter ignition delay period with FBC added biodiesel in optimized operating condition.

Nano-Organic Additives: Yang (2013), has investigated nano-organic additives with emulsified fuel for the performance of diesel engine. They have taken 82.4% diesel, 5% water and 12.6% nano organic additives by volume. Due to nano organic, the emulsion which is formed is green in colour and very stable. They have obtained better brake thermal efficiency can be achieved with the emulsion fuel, by the way of micro explosion phenomenon. In this phenomenon, fuel is exposed to high temperature gas by the instantaneous and violent vaporization of the water droplets within the fuel and simultaneously large fuel droplets are broken into many smaller droplets. This results improving fuel vapourization and combustion process. Due to the presence of water in fuel reduced NOx emission is reported and slightly longer ignition delay period is obtained. At mid and high speed conditions using emulsion fuel high brake thermal is achieved. They showed BSFC has been increased and NOx, HC, smoke, CO has been decreased under various speeds when compared to diesel.

Mehrdad (2015), has investigated the synthesising a novel soluble hybrid nano catalyst to decrease emissions like Nitrogen Oxide compounds (NOx), Carbon monoxide (CO), Unburnt Hydrocarbon and soot. They

have used Cerium Oxide on amide functionalized multiwall carbon nanotubes (MWCN) with diesel –Biodiesel blends (B5 and B20) at three concentrations (30, 60 and 90ppm). They have obtained high surface area of the soluble nano sized catalyst particles and their proper mixing catalytic oxidation reaction gives overall improvement. The catalyst B20(90ppm) with B20 gives good improvement in pollutants like NOx, CO, HC and soot up to 18.9%, 39.8%, 71.4% and 26.3%. Performance parameters torque and fuel consumption also increased up to 7.81%, 4.91% and fuel consumption is decreased by 4.50%.

Table.1. Various Nanoadditive fuel and findings

Author	Engine Tested	Engine Speed	Loading Devise	Base Fluid
Arul MozhiSelvan (2009)	4-stroke Single Cylinder VCR 3.7KW water cooled	1500rpm	Eddy Current Dynamometer	Diesteral (Diesel+ Biodiesel+ Ethanol)
Shaafi (2015)	4Stoke single Cylinder 4.4KW Air Cooled	1500rpm	AC Generator	Diesel, Soybean Biodeisel, Ethanol, Isopropanol
Kannan (2011)	4Stoke single Cylinder 5.2 Kw Water Cooled	1500 rpm	Electrical Alternater	Diesel, Biodeisel
Rakhi Mehta (2014)	4Stroke Single Cylinder 5.2 KW Water Cooled	1500 rpm	Eddy Current Dynamometer	Diesel
Yang (2013)	4Stoke Four Cylinder 75KW Water Cooled	3600rpm	Eddy Current Dynamometer	Diesel, water
Mehrdad (2015)	4 Stroke 6cylinder	2200rpm	Engine Dynamometer	Diesel
Soner Gumus (2016)	4Strok, Single Cylinder 5.7KW	3600rpm	Water Brake Dynamometer	Diesel
Arul Mozhi (2009)	4-stroke Single Cylinder VCR 3.7KW	1500rpm	Eddy current Dynamometer	Diesel-Ethanol-Caster oil

Table.1. Various Nanoadditive fuel and findings (Continution)

Fluid Nano Particle	Particle Size	Dosage	Preparation Method	Findings
Cerium Oxide and Carbon Nanotubes	32nm	25,50ppm	Two step	Nanoparticles Accelerate burning rate, Decresed ignition delay, Reduction of HC and Smoke, BTE increased upto 7.5%
Alumina	50nm	100mg/L	Two step	Higher cylinder Pressure during Combustion and heat release rate. Exhaust gas temperature is reduced, Increase in BTE, Decreased BSFC, Reduced CO and UBHC, Small increase in NO at full load
Ferric Chloride	-	20µmol/L	Two step	reduced BSFC upto 8.6%, increased BTE upto 6.3%, CO,HC and Smoke are decreased by 52.6%, 26.6%, 6.9% respectively,
Aluminium, Iron, Boron	5-150 nm, 30-60nm, 80-100nm	-	Two step	Reduced ignition delay,longer flame distance, Increased BTE by 9%,4%,2% for A1, F1,B1 respectively.
Nano-Organic Oxyganated additives (Glycerin- Polyethoxy-ester	100nm	12.60%	Two step	Better BTE, improved fuel Vapourization and combustion process, decreased Nox. At mid & High speed increased BTE obtained. Decreased Nox, HC and smoke.
cerium oxide on amide-functionalized Multiwall Carbon Nanotubes (MWCNT)	7 to 20nm	30,60,90 ppm	Two step	Decreased NOx, CO, HC and soot by 18.9%, 9.8%, 71.4% and 26%. Increased power and torque by 7.81% and 4.91% respectively. Decreased BSFC by 4.50%

aluminium Oxide	31.6 to 47.5 nm	25ppm, 50ppm	Two step	Reduced BSFC and Exhaust Emissions, of HC and smoke emission reduced to 8.599 g/KWh and 49 HSU respectively. BTE of the engine is increased by 2.5% while dosing 50ppm nano particle
aluminium Oxide Hydroxide	8-15nm	25,50 ppm	Two step	Increased BTE by 6%, reduction in NO by 42%, Smoke opacity by 18%
Aluminium oxide and Copper oxide	Copper oxide=30-50nm, Aluminium Oxide= 27-43nm	25-100ppm	Two step	Torque and Power increased slightly, CO, HC, Nox are reduced up to 5%, 8%, 2% respectively. At moderate engine speed BSFC decreased by 1.5%
Cerium Oxide	32nm	97ppm-225ppm	Two step	Decreases ignition delay, Small improvement in Brake thermal efficiency, CO and HC and smoke decreases, NO decreases for neat diesel.

2. CONCLUSION

In the present review, the use of various nano additives for the engine performance improvement and emission reduction are summarized below.

- Nano Catalyst as an additive in diesel, biodiesel and emulsified fuel shows improvement in engine performance. In the optimum dosage level the enhanced performance level is reached.
- Nano additives mixing with pure diesel results increase in Nox emission due to the peak temperature, and shows decrease in Nox when mixing with biodiesel because of low peak temperature.
- Emulsified fuel shows evident to reduce Nox. But, addition of water leads to reduce performance due to eat of evaporation.
- Due to complete combustion of fuel, CO emission is also get reduced.

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