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A Review Approach on Exhaust Emission Reduction by Nanoparticle Additives in Diesel Engine

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ABSTRACT: The pollution level is increasing day by day. Vehicular emission, particularly from CI engines, is major contributor to this. Biodiesel technologies have been studied for last two decades as they serve dual purpose of conserving environment as well as act as renewable source of energy. Recently with the development of nanotechnology, researchers are trying to make nanoadditives. These nanoadditives are known to enhance engine performance as well as reduce engine emissions. Very few experimental investigations are there on the use of nanoadditives in the literature. A serious attempt to summarize the most important published work on nanoadditive based blend of biodiesel and diesel has been made with objective of providing pathway for further research.

KEYWORDS: Nanoadditive, Biodiesel, Blending.

I. INTRODUCTION

The demand for fossil fuel is increasing day by day and so there is an increased thinking over its draining rate. This calls for necessary action to deal with its outcome with efficient as well as less polluting alternative of diesel fuel. Increasing fuel process has directed the research towards this goal. Biodiesel has emerged as preferred alternative for diesel fuel over last two decade because of its economic and environmental advantage. Still a lot of work has to be done for further enhancement of biodiesel as a fuel [1].

When biodiesel is used in CI engine, the performance was found to be low and the NO_x emission was on the higher side. Biodiesel when used directly in a diesel engine creates many problems because of high viscosity and lower calorific value. Therefore blend of biodiesel with diesel is used in CI engines. Apart from this, various innovative additive techniques are being worked on to improve the performance of engine [2].

For controlling exhaust gas pollution in CI engines, three methods are there. One is to use exhaust gas treatment devices like particulate matter filter, catalytic converter, etc; which effect engine performance adversely. Second one is engine modification such as exhaust gas recirculation, common rail systems, electronic fuel injections, variable valve timings, turbochargers, etc; which increase the engine cost. And the last one is the use of fuel additives; which is relatively cheaper and easier [3].

Use of nanoparticles with biodiesel is currently hot topic for researchers. Addition of metal and metal oxides nanoparticle to biodiesel has enhanced the engine output and also led to reduced emissions. Nanoadditives like CERIA, Alumina, Carbon nano tube CNT, Fe₂O₃ have the capability to be used as additive with the present fuel. Nanoadditives in fuel enhances some typical fuel properties like better burning rate, higher cetane number, shorter delay period and better catalytic activity. Also when nanoadditives are used with biodiesel, the exhaust pollutants like CO, NO_x, HC, smoke are found to be less. Apart from nanoparticle, nanofluids are also found to enhance the fuel properties like enhanced heat and mass transfer property, flash/fire/pour point improvement [4].

Using one strategy, the emissions from diesel engines cannot be reduced. By simultaneously using various technologies, emissions can be reduced.

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Very few experimental investigations are there on the use of nanoadditives (organic, metallic, non-metallic and mixed) in the literature; almost all of them are published recently [5]. A serious attempt to summarize the most important published work on nanoadditive based blend of biodiesel and diesel has been made with objective of providing pathway for further research.

II. LITERATURE REVIEW

S. Karthikeyan & A. Prathima: In this experimental investigation, *Botryococcus braunii* algal oil was used as biodiesel after transesterification. B20 blend of biodiesel was used. Cerium oxide (CeO_2) nanoparticles were added to B20 blend in different doses from 50 ppm to 100 ppm. Experimental results showed that with the use of nanoadditives the diesel engine exhaust emission of NO_x , CO, CO_2 , HC reduced [6].

Srinidhi Campli: In this experimental work Nickel Oxide nanoparticles were used in B10, B20 and B30 blend of palm oil methyl ester and diesel. The concentration of nanoadditive was varied from 20 ppm to 40 ppm. The measurement revealed that fuel dosed with nanoadditive showed a 6.2 % higher thermal efficiency and 5.6 % lower BSFC respectively when compared to undoped fuel [7].

Esteban A. Tabordaa, Vladimir Alvaradob, Farid B. Cortésa: This paper evaluated the effect of viscosity reduction on addition of nanoadditives in heavy and extra heavy oil. Use of 1000 mg/L of SiO_2 nanoparticles in Biodiesel resulted in the best reduction of viscosity [8].

Shiva Kumar, P. Dinesha & Ijas Bran: In this paper, the benefits of using nanoadditives in diesel/biodiesel engines were explained. Addition of nanoparticles of metal and metal oxides in biodiesel blends resulted in improvement of engine performance characteristics and at the same time reduction in exhaust [9].

K. Nanthagopal, B. Ashok, A. Tamilarasu, Ajith Johny, Aravind Mohan: In this experimental work, effect of Nanoadditive on *Calophyllum inophyllum* biodiesel was studied. A twin cylinder water cooled direct injection 4 stroke diesel engine was used for research. Titanium dioxide and Zinc oxide nanoadditives were used. The concentration of the nanoparticle mixed was between 50 ppm to 100 ppm. The catalytic effect of these particles improved the performance of the engine and its combustion output. The oxidizing nature of these particles helped in reduction of HC, CO and smoke emission. There was an improvement of brake thermal efficiency by 5-17% when compared to the basic biodiesel at maximum brake power. The reason given for this improvement was larger surface to volume ratio of nanoadditives, leading to better atomization and rapid evaporation. Also emissions were observed to be less [10].

S. Debbarma and R. D. Misra: In this experimental work, Iron nanoparticles were suspended in biodiesel in proportions varying from 40 ppm to 120 ppm. Addition of these resulted in a 3% rise in brake thermal efficiency when compared to base biodiesel. Also the carbon monoxide level was reduced drastically by 56% [11].

T. Pushparaj, P. P. Shantharaman, D. John Panneer: In this work cerium oxide nanoadditives were added in concentration ranging from 20 ppm to 60 ppm in B20 blend of cashew nut shell biodiesel and diesel. For nanoadditive concentration of 40 ppm, the NO_x emission was found to be reduced by 27%, CO by 37% and smoke opacity by 29% on full load [12].

Seyyed Hassan Hosseini, Ahmad Taghizadeh-Alisaraei, Barat Ghobadian, Ahmad Abbaszadeh-Mayvaneh: Biodiesel with Alumina nanoadditives were studied. Nanoparticle doses were varied from 30 ppm to 90 ppm. The torque, power, brake thermal efficiency, exhaust gas temperature increased by 5.36%, 5.36%, 10.63% and 5.80% respectively when compared to undoped one. The NO_x emission rose by 43.61% and the CO and UHC emissions decreased by 2.94% and 50.56% respectively [13].

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P.Jayanthi, Srinivasa Rao M: In this investigation Copper Oxide was used as nanoadditive in dosage ranging from 40 ppm to 120 ppm. Biodiesel blend was Linseed oil and diesel based. The direct injection diesel injection was kept at constant speed of 1500 rpm and conditions were varied. There was maximum increase of brake thermal efficiency for B20 + 80 ppm CuO. The specific fuel consumption decreased at full load condition. Also the exhaust was relatively lower when compared to base oil [14].

Harish Venu, Venkataramanan Madhavan: In this investigation effect of Alumina nanoadditive was studied with varying injection timings. Base fuel used was 20% biodiesel, 70% diesel and 10% ethanol. The characterization of the prepared nanoparticles was done using SEM and XRD and blended in fuel using ultrasonicator. The doping was kept at 25 ppm. The 4 deg retarded fuel injection resulted in better fuel combustion, engine performance and lower emissions [15].

SyedJaved, Y.V.V.Satyanarayana Murthy, M.R.S.Satyanarayana, R.Rajeswara Reddy, K.Rajagopal: Experiment was carried out in a dual fuel engine (biodiesel blend and hydrogen). The investigation revealed that on addition of ZnO nanoparticles at a concentration of 100 ppm, the performance of engine changed. NO_x reduced by 130 ppm on addition of ZnO nanoparticle. However with increasing hydrogen flow rate, the change in performance was marginal [16].

V.Arul Mozhi Selvan, R.B.Anand, M.Udayakumar: In this experimental work Cerium Oxide Nanoparticles (CERIA) and Carbon Nanotubes (CNT) was used in Diesel-Castor oil biodiesel-Ethanol blend. The compression ratio was kept 19:1. The added CNT acted as catalyst and helped to accelerate the fuel burning rate, leading to decreased ignition delay and better combustion. CERIA catalyst acted as oxygen donator for carbon monoxide and reducer for nitrogen oxides. Also the activation energy of CERIA helps in burning off the carbon deposited in the engine. This prevents setting up of non-polar compounds over the cylinder wall, resulting in reduction smoke. Combination of these two helped for making of a cleaner fuel [17].

Ajin C.Sajeevan, V.Sajith: The nanoparticle Cerium zirconium mixed oxide (Ce_xZr_(1-x)O₂) is a very good fuel borne catalyst. These nanoparticles lack stability and also effects diesel properties. In this investigation the above discussed nanoparticle was prepared by co precipitation method and characterization was done using Dynamic light scattering and Transmission electron microscopy. Oleic acid surfactant was used to improve nanoparticle stability. Concentration of surfactant was varied between 0.01 to 0.1% by volume. UV spectrum was used to do absorbance study to determine optimum concentration. Nanoparticle dosing was kept from 2.5 to 20 ppm. Properties of diesel was tested using ASTM standards and test were carried on standard diesel engine. Exhaust smoke reduced by 31% and the brake thermal efficiency was enhanced by 3% for concentration of 17.5 ppm [18].

Mehrdad Mirzajanzadeh, Meisam Tabatabaei, Mehdi Ardjmand, Alimorad Rashidi, Barat Ghobadian, Mohammad Barkhi, Mohammad Pazouki: In this finding a novel hybrid nanoparticle catalyst amide-functionalized MWCNTs-CeO₂ was prepared. Investigation was done using B5 and B20 diesel-biodiesel blend. The concentration of doping was varied from 30 to 90 ppm. The catalytic character and high surface area resulted in improvement of combustion. The B20 blend with 90 ppm performed best. Pollutants NO_x, CO, HC and soot got reduced by 18.9%, 38.8%, 71.4% and 26.3% respectively when compared to unadulterated B20. The torque and power increased by 4.91% and 7.81% and fuel combustion decreased by 4.50% [19].

Soner Gumus, Hakan Ozcan, Mustafa Ozbey, Bahattin Topaloglu: In this experimental work CuO and Al₂O₃ nanoparticles were added in diesel which led to improvement in flash point temperature and cetane number. The nanoparticles were mixed using homogenizer and ultrasonicator. The stability of nanodiesel was increased using dispersant and pH regulator. The BSFC and NO_x was decreased [20].

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J. Sadhik Basha: In this paper a brief review of importance of nanoparticle in blended biodiesel fuel was studied. Importance of nanoadditives like alumina, ceria, carbon nanotubes (CNT) as dopants in fuel was studied. Nanoadditives help in shorter ignition delay, better fuel burning rate, improved catalytic activity, better reaction efficiency and hence a higher cetane number. Also hazardous exhaust gases were found to be less without effecting engine performance [21].

III. CONCLUSION

In this paper a serious attempt was made to review the experimental investigation available in open literature on the nanoparticle doping in Biodiesel blends. Since very few experimental works have been carried till date therefore this review becomes very important. Nanoparticle technology is gaining importance in recent past because of its growing affordability. Scientific community therefore applied this technology to Engine research. The results found were discussed in the paper. The experimental parameters such as doping concentration, exhaust characteristics and engine performance parameters were also discussed.

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