International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

IJIEMR Transactions, online available on 28th Dec 2019. Link :http://www.ijiemr.org/downloads.php?vol=Volume-08&issue=Issue 12

10.48047/IJIEMR/V08/ISSUE 12/50

Title **Review the Nano Additives for Performance Improvement of Biodiesel and Ethanol in CI Engine**

Volume 08, ISSUE 12, Pages: 576-583

Paper Authors **Sumit K. Wagh, Dr. P. Ravikumar, Prashant S. Raut , Dr. M. K. Choprad**

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Review the Nano Additives for Performance Improvement of Biodiesel and Ethanol in CI Engine

Sumit K. Wagh[a], Dr. P. Ravikumar[b], Prashant S. Raut [c], Dr. M. K. Chopra[d]

[a]PhD Scholar, Department of Mechanical Engineering, RKDF IST, Bhopal, Madhya Pradesh, India

[b]Professor, Department of Mechanical Engineering, RKDF IST, Bhopal, Madhya Pradesh, India

[c]PhD Scholar, Department of Mechanical Engineering, RKDF IST, Bhopal, Madhya Pradesh, India

[d]Professor & Principal, RKDF IST, Bhopal, Madhya Pradesh, India

Abstract-People are developing environmentally friendly transportation solutions since fossil fuels are detrimental for the environment and there are concerns about future petroleum supplies. Biofuels must produce more energy than they use, be environmentally friendly, economically competitive, and produced in large quantities to be commercially successful. Without compromising food security or the environment. Life-cycle accounting allows us to compare biodiesel with maize ethanol using the above criteria. Biodiesel produces the same net energy as ethanol but less nitrogen, phosphate, and pesticide pollutants. Ethanol emits more per net energy gain than biodiesel. Biodiesel may be converted into fuel faster than ethanol and requires less land. The environment around biodiesel benefits greatly, hence the government should pay for it. If generated from waste biomass or low-input biomass grown on unsuitable farmland, synfuel hydrocarbons and cellulose ethanol may be more sustainable than food-based biofuels. Waste biomass requires fewer resources than non-arable land.

Keywords: CI Engine, Biodiesel, Nano Additives.

I. Introduction

Fossil fuels are important for the growth of industry, transportation, agriculture, and many other parts of daily life. Every day, the amount of oil that can be found in the world goes down. Because of this, a lot of scientists are looking for alternatives to traditional fuels. Fossil fuel reserves aren't as good as renewable energy sources. This is because the energy that comes from renewable sources can always be made more. There are problems with selling these products, getting enough feedstock, getting rid of the extra waste glycerol, and getting people to agree with the idea. Biodiesel will be used in the future as an alternative to diesel fuel to meet the growing need for energy, both now and in the future. Biodiesel is made from both edible and non-edible oils, which makes it safe for the environment, reliable, non-toxic, and biodegradable. Compared to diesel, biodiesel makes less smoke and less greenhouse gases. This is good for the world around us. In terms of density, pour point, viscosity, and molecular weight, biodiesel is better than diesel. Instead of oil, vegetable oils are used to make biodiesel. Some of the things that led to incomplete combustion were not enough fuel atomization, low volatility, injector coking, and piston rings getting stuck. These problems came about because of how thick and heavy the biodiesel was. Biodiesel is made up of long chains of fatty acids. It doesn't have any sulphur or aromatic compounds and has between 10 and 14 percent oxygen by weight. Biodiesel is a must-have if you want to improve the efficiency of combustion, lower particulate matter, carbon monoxide, and hydrocarbon emissions, and increase nitrogen oxide (NOx) emissions above diesel levels. Compared to diesel, it has a lower calorific value, or CV [1-9]. Mahmud et al. [10] say that biofuels like palm oil can be used in compression ignition (CI) engines. [Needs citation] It is the most effective oil crop in terms of output, availability, and use of land. It is also one of the most effective crops in general. It costs a lot less than other types of vegetable oil because it makes more of it. Because of these things, the researcher decided that palm biodiesel would be the best fuel for this study. Compared to diesel, biodiesel has a lower heating value, a lower oxidation stability, a higher brake specific fuel consumption (BSFC), and higher NOx emissions. Different kinds of additives were used to fix these problems. Nano-additives are good for diesel engines because they improve performance and reduce pollution. Nano-additives have a high number of calories, a high thermal conductivity, and a high ratio of surface area to volume. When antioxidants are added to biodiesel, they not only stop the production of free radicals, but they also make the fuel less likely to oxidise. TiO2 stands out from the other nano-additives that were talked about in the research because it is cheap, non-toxic, and safe for the environment. From a review of the relevant literature, it seems that adding the antioxidant N-phenyl-1,4-phenylenediamine (NPPD) is a good way to reduce NOx emissions and improve diesel engine performance at the same time. Review the Nano Additives for Performance Improvement of Biodiesel in CI Engine

II. Related work

Review the Nano Additives for Performance Improvement of Biodiesel in CI Engine J. Lv, et al. [1]This study gives a short summary of what is known about using nanoparticles as additives for diesel-biodiesel fuel mixes right now. First, the most interesting things about nanoparticles are looked at in detail. Then, the steps for making them are broken down and analysed before being summed up. In the second step of our study, we look at things like thermal efficiency, specific fuel consumption, carbon monoxide, unburned hydrocarbons, and nitrogen oxides. This is part of our research into how different nanoparticles used in diesel-biodiesel fuel blends affect how well combustion works and how much pollution is released. At last, we talk about how nano-additives affect ICEs as well as human and environmental health. The results of the research described in this paper could make a big difference in how nanomaterials are used in the fuel industry. Scientists will be able to quickly find the nano-additives that give internal combustion engines the best chance of being able to burn fuel in a way that makes the least amount of pollution because of what we found.

I. A., Tamilvanan, et al. [2] Biodiesel is the best alternative to regular diesel fuel made from oil, and it can be used in almost all engines with just a few simple changes. When used in a compression ignition (CI) engine, biodiesel's performance is just a little bit worse than that of diesel fuel. In terms of emissions, diesel is worse than its alternative, biodiesel, except for the amount of nitrogen oxides it gives off. By mixing nano metal particles into the fuel, the thermophysical properties of biodiesel are improved. This makes it possible to use fuels with nanoparticles in compression ignition engines in the future. Nanoparticles can raise both the operating pressure and the heat transfer rates because they have such a large surface area. This, in turn, makes the oxidation process work better, which speeds up the burning process.

Shiva Kumar Reddy Devasani, et al., [3] People think that biodiesel's physical properties, like density and viscosity, aren't as good as diesel's, which makes NOx emissions go up and the engine work less well. When biodiesels and other types of alcohol are added to the recipe, the bad things about blends are lessened. When added to fuel in tertiary or quaternary amounts, biodiesel works well in engines. To start, the performance and emissions of a number of binary mixtures are looked at in great detail. This is done to find the study gap that is caused by the use of binary mixtures. The study starts with a short summary of the relevant research. Then, it goes into a detailed analysis of ternary and quaternary mixtures in terms of performance, emissions, and how they burn.

S. K. R. Devasani et al.[4] In the last few decades, a lot of research has been done on whether or not biodiesel can be used as a source of renewable energy. People think that biodiesel's physical properties, like density and viscosity, aren't as good as diesel's, which makes NOx emissions go up and the engine work less well. When biodiesels and other types of alcohol are added to the recipe, the bad things about blends are lessened. When tertiary or quaternary amounts of biodiesel are added to diesel fuel, the engine's performance improves noticeably. To start, the research gap related to the use of binary mixtures is found through a thorough study of several different types of binary blends in terms of performance and emissions. This study was done to find out if binary mixtures work or not. The next part of this paper is an analysis of ternary and quaternary blends in terms of their performance, emissions, and how they burn. In this section, the author tries to highlight a number of different research conclusions.

Using a 7-hole fuel injector with nanofuel blends at injection timing and pressure of 10° BTDC and 900 bar showed that the air quality for mixing fuel and air was better. Several authors have said this, including M.E.M. Soudagar et al. [5] In the same way that the geometry of the cylinder bowl in the TRCC improved swirl and turbulence, which led to earlier ignition, the geometry of the cylinder bowl in the CRCC showed the same thing. When 30 ppm ZnO nanoparticles were added to Mahua biodiesel (MOME2030) and diesel (D10030) with diethyl ether, the CRDI engine characteristics were improved.

H. Venu et al. [6] According to the results of the tests, adding titanium nanoparticles caused NOx, HC, and smoke to be made more, while BSFC and CO were made less. When zirconium nanoparticles are added to a blend, BSFC and HC emissions can go up while CO, CO2, and smoke emissions go down. This is different from what happens when BE mixes are used. When DEE was added to BE mixtures, the rate of heat release went up. HC and CO emissions also went up, but BSFC, NOx, and smoke emissions went down. The fact that both NOx and smoke levels went down at the same time shows that DEE has an effect on low-temperature combustion (LTC).

The work Manzoore Elahi et. al. [7] When the results of the thorough review of the literature were looked at, they were confusing and contradictory. Since the results of the many experiments that were done by different researchers were not put together, there is no general agreement about the best way to change gasoline. This report gives an in-depth look at the most recent research findings on nanoparticles as fuel components. In this study, we look at how the spread of multiple nanoparticles can help improve the performance of a compression ignition (CI) engine that uses diesel-biodiesel blends and reduce the amount of pollution it makes. We pay special attention to how dispersion helps us reach these goals. Taking this idea one step further, we could think of making a nanoparticle additive that could be used in diesel and biodiesel fuel, would be possible, and wouldn't cost too much. But for them to be widely used in industrial settings, a number of the problems and limitations that were pointed out in this analysis need to be fixed.

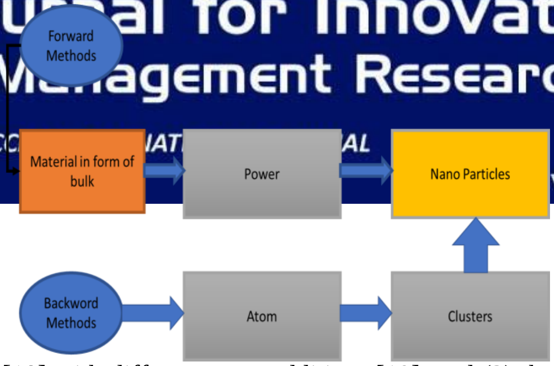
A. Vijayakumar, et al. [8] after that, the engine ran on 20MEOM blended fuel with 50 ppm of copper oxide nano additions. This was done with the solgel process. The results showed that when the addition was used, the thermal efficiency of the brakes went up by 2.19 percentage points compared to when the 20MEOM blend was used on its own. Emissions of smoke, carbon monoxide, and hydrocarbons were reduced to a significant extent. According to the findings of the most recent research, mahua oil biofuel that has been improved with nano additions makes for an outstanding diesel alternative.

III. Proposed Methodology

Because of what people do, the amount of fossil fuels, which are a resource that can't be replaced, is going down. Because the emissions from burning fossil fuels hurt plant and animal life and the ecosystem, a lot of people are pushing for ways to live that produce less carbon. The average temperature today is more than four degrees higher than it was before the industrial revolution, according to the Lancet Countdown [9] on health and climate change. These results show that climate change will have long-term effects on the health of people. It is therefore very important to find sustainable, environmentally friendly alternatives to fossil fuels that work as well as fossil fuels. There probably won't be a big change in the way cars are powered away from internal combustion engines in the near future. Because of this, diesel engines need to have both a high combustion efficiency and a low emission rate. We need to stop using traditional fuels and start using alternative energy sources. In the past few years, a lot of research has been done on a wide range of possible replacement fuels for diesel engines. However, biodiesel has become the clear frontrunner. Several different ways can be used to make a lot of biodiesel. Most of it is made by catalysing the esterification of different fats and oils, most of which come from animals or plants. This is what happens. The main benefit of using it as a motor fuel is that it can be used in most engines without making many changes. In terms of brake power, brake thermal efficiency (also called BTE), and brake specific fuel consumption [10], the engine's performance hasn't changed much (also known as BSFC). At the same time, the lack causes a big drop in the amount of hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM) that are released into the air (PM). After a lot of research on biodiesel fuels, it was found that some types of biodiesel, like rapeseed methyl ester, jatropha seeds methyl ester, and sunflower methyl ester, can be mixed with diesel in different amounts to make better emissions and combustion. This was found out after it was found that biodiesel can be used to run diesel engines. Studies of diesel-biodiesel fuel blends have also found some bad effects, such as lower cloud and pour points, poor atomization [11] of fuel injection, lower calorific value, and usually high levels of NOx emissions. [As an example] So, to improve engine performance and reduce emissions at the same time, the researchers have tried out cutting-edge methods like fuel additives and pretreatment mixes. The use of nanoparticles to improve a

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

diesel-biodiesel hybrid fuel has made it one of the most successful and promising fuels. Nanoparticles may be more effective because they have a lot of good qualities, like high catalytic activity, fast reaction rates, a huge ratio of surface area to volume, and a large number of active centers that are needed for a wide range of reactions and processes. Because of these things, nanoparticles are a good choice for making things work better. It was found that increasing the amount of alumina in B20 (20% biodiesel and 80% diesel) greatly decreased the combustion time (CD) [12] and ignition delay (ID), increased the peak pressure, and only slightly increased the heat release rate (HRR) at maximum load and cylinder pressure. Even though HC production went down by 26.72% and CO production went down by 48.43%, NOx production went up by 11.27. CI single-cylinder engines were used to test diesel-biodiesel fuel mixes with 30, 60, and 90 parts per million (ppm) of carbon nanotubes. According to the data, diesel engines that ran on blend fuel had more power (3.67 percentage points), BTE (8.12 percentage points), and BSFC (7.12 percentage points) than diesel engines that ran on diesel fuel alone. On the other hand, the amount of NOx emissions went up by 27.51%. Experiments were done on compression-ignition engines with different amounts of biodiesel that had been changed (from 20 ppm to 80 ppm). Researchers looked at how adding nanoparticles of cerium oxide to a test engine changed both how well it worked and how much pollution [13] it made. The investigation found that adding cerium oxide nanoparticles to the fuel made the thermal efficiency of the brakes in diesel engines go up by 1.5 percentage points. When cerium oxide was used, NO emissions went down by 30% and HC emissions went down by 40%. This is because cerium oxide helped oxidise both of these pollutants. In a similar way, diesel-biodiesel fuel mixtures with nanoparticles of copper, iron, platinum, or graphene could improve combustion while lowering emissions. Researchers have been looking into a wide range of nano-additives [14] to improve how diesel and biodiesel fuel mixes burn and how much pollution they put out. Here is a summary of the most important things learned from the research: When deciding which nanoparticles [15] should be added to diesel-biodiesel, three things were taken into account: (1) a deep [16] understanding of how different nano-additives are made; (2) the performance and emission characteristics of combustion [17] and diesel-biodiesel fuel blends combustion engines



[18] with different nano-additives [19]; and (3) the nature of the nano-additive itself.

IV. Comparative Analysis

Getting nanoparticles that aren't stable out of a number of different mixtures Nanofluid is a type of fluid that is made by spreading nanoparticles evenly through a liquid. The word "nanofluid" is used to describe this type of fluid. Figure 1 shows the steps that need to be taken to make nanofluids. Because the nanoparticles that are used to make nanofluids have a big effect on how the nanofluids move and stay together, it is very important to make the nanomaterials and figure out what their properties are. In the past few years, a lot of research has been done on how nanoparticles can be used. Researchers have been able to change the nanoparticles' size, shape, and number of holes in order to improve their physical and chemical properties. Therefore,

One-Step Preparation

Method In the one-step method, the nanoparticles and the base solution are mixed together at the same time. Here are some of the most important benefits of taking a clear approach: Because (1) there is no need to dry, store, or spread the material, the cost of production is much lower than with other methods. (2) The one-step method makes a nanofluid that is very stable over time because the nanoparticles don't stick together too much during the process. Nanofluids can now be made using one-step processes like direct evaporation, vapour deposition, laser ablation, and submerged arc welding.

Prepare Yourself in Just Two Simple Steps

The nanoparticles are produced in a separate step, and then a number of technologies are used to incorporate them into the fundamental fluid. In a word, nanofluids that are produced through a method that consists of two steps are dependable and efficient in terms of dispersal. The most common approach to the production of nanofluids is described here. Techniques known as "bottom-up" and "top-down" are now the two that are utilised the most frequently in the production of nanomaterials.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Figure 1. Synthesis process

Using the bottom-up method, material structures are built from the ground up, starting with atoms and going all the way up to nanoparticles. In this process, things like pyrolysis, biosynthesis, sol-gel, and chemical vapour deposition are often used. Researchers like the sol-gel method because it is easy to use, can be scaled up, and gives them a lot of control over the final product. Singh was able to make ZnO nanoparticles with a size of 81.28–84.98 nm by starting with zinc acetate (Zn(CH3COO)22H2O), using ethanol (CH2COOH) as a solvent, sodium hydroxide as a medium, and ethanol as a solvent. Using the same method, nanoparticles of nickel oxide (NiO) were also made. Researchers came up with a way to make single-walled carbon nanotubes using thermo chemical vapour deposition. They did this by using gold nanoparticles as a catalyst. Biosynthesis, which uses bacteria, plant extracts, fungus, and precursors, can be used to make nanoparticles that are safe and biodegradable. Using a top-down method, the process breaks up larger particles into pieces that are nanoscale in size. Most of the time, people use methods like mechanical grinding, nanolithography, thermal breakdown, and laser ablation. Mechanical grinding is a physical method that can be used to make nanoparticles. In this method, large pieces of material are broken up into smaller pieces by deforming them with plastic. Nanolithography is a more advanced form of photolithography that shrinks materials from a few microns down to the nanoscale range. This is done with the help of electron beams. Nanolithography is a term for a wide range of techniques, such as nanoimprinting, electron beam lithography, optical lithography, multiphoton lithography, scanning probe lithography, and others. Laser solution ablation is a better way to make nanoparticles from precious metals than chemical reduction because it works from the top down. This is because chemical reduction works from the bottom up. Biofuels made from food, like biodiesel made from soybeans, are better than ethanol made from corn grain in a number of ways. Compared to diesel, making biodiesel reduces greenhouse gas emissions by 41%, lowers the levels of several major air pollutants, and has little effect on human and environmental health from the release of nitrogen, phosphate, and pesticides. When corn grain is used to make ethanol, the amount of five air pollutants, as well as nitrate, nitrite, and pesticides, that are released into the air goes up. The net energy gain of 25% and the 12% decrease in GHG emissions are both good things, but they aren't as important as the increase in these pollutants.

Based on the results of our research on ethanol and biodiesel, we can say that the benefits of these types of biofuels would be higher if their biomass feedstocks required less agricultural input (less fertiliser, pesticide, and energy), if they could be grown on land with low agricultural value, and if the energy needed to turn the feedstocks into biofuel was also cheap. Due to the high amounts of fertiliser, phosphorus, and pesticides needed to grow corn and the need for equally fertile land to grow soybeans, corn grain ethanol and soybean biodiesel do not meet the first two requirements. Corn grain ethanol and soybean biodiesel, on the other hand, do not meet the requirements. Since soybean seeds make it easy to make long-chain triglycerides, the amount of energy needed to turn soybean biodiesel into biofuel is much less than the amount of energy needed to turn biomass into corn grain ethanol. Using low-input biomass or agricultural waste like maize stover instead of fossil fuels to power the biofuel conversion process could increase the net energy benefit (NEB) of both biofuels and maybe make them more economically competitive.

Nonfood feedstocks are good for three reasons: they save energy, are good for the environment, and can make money. Switchgrass (Panicum virgatum), different mixes of prairie grasses and forbs , and woody plants can all be grown in soils that aren't good for farming, and they can all be turned into synfuel hydrocarbons or cellulose ethanol. Switchgrass can be grown on soils that aren't good for farming. The energy needed to run biofuel processing systems that make cellulosic ethanol could come from the burning of waste biomass, such as lignin fractions made from biomass feedstocks. The NEB ratios could still be higher than 4.0, which would be a big step up from corn grain ethanol's NEB ratio of 1.25 and soybean biodiesel's NEB ratio of 1.93. Gains could be cut by a lot if more energy was needed for transportation, more energy was used to build bigger and more complicated ethanol plants, and maybe even more people were needed to work on them. If pretreatments, enzymes, and conversion factors get better, it's possible that the price of cellulosic ethanol will go down to the same level as the price of maize grain ethanol. Cellulosic ethanol should have a NEB ratio that is similar to that of

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

combined-cycle synfuel and electric cogeneration using biomass gasification, and combined-cycle synfuel and electric cogeneration using biomass gasification may be able to turn a higher percentage of biomass energy into synfuels and power than cellulose ethanol. In general, low-input biofuels may have far fewer negative effects on the environment for each unit of net energy gain while also delivering much higher NEB ratios.

A comparative analysis of the effects of nano additives on the performance of biodiesel and ethanol in CI engines based on the mentioned references in the form of a table. Please note that the data presented in the table is not exhaustive and should be taken as a summary of the major findings.

TABLE I
Comparative Summary of Performance & Emission

Reference	**Additives**	**Fuel**	**Performance**	**Emission**
[19]	Palladium, Acetylferrocene	Diesel Fuel Biodiesel Blend	Improved Engine Performance and Emission Characteristics	Reduced CO, UBHC, Smoke, and NOx emissions
[5]	Nanosized Zinc Oxide, Diethyl Ether	Mahua Biodiesel-Diesel Blend	Improved Brake Thermal Efficiency, Indicated Mean Effective Pressure, and reduced Specific Fuel Consumption	Reduced CO, UBHC, Smoke, and NOx emissions
[6]	Titanium Oxide, Zirconium Oxide, Diethyl Ether	Biodiesel-Ethanol Blend	Improved Brake Thermal Efficiency, Indicated Mean Effective Pressure, and reduced Specific Fuel Consumption	Reduced CO, UBHC, Smoke, and NOx emissions
[7]	Various Nano Additives	Diesel-Biodiesel Blend	Improved Engine Performance, Stability, and reduced Emissions	Reduced CO, UBHC, Smoke, and NOx emissions
[8]	Nano Additives	Biodiesel-Diesel Blend	Improved Engine Performance and Emission Characteristics	Reduced CO, UBHC, Smoke, and NOx emissions
[17]	Nanoparticles	Biodiesel	Improved Evaporation Characteristics	-
[18]	Nano Particles	Biodiesel-Diesel Blend	Improved Engine Performance and Emission Characteristics	Reduced CO, UBHC, Smoke, and NOx emissions

Overall, the use of nano additives in biodiesel and ethanol fuels has been shown to improve engine performance and reduce emissions in CI engines. The specific types of nano additives used and their concentrations vary between studies, and more research is needed to fully understand the effects of nano additives on engine performance and emissions.

In the next fifty years, the amount of food people eat is expected to increase by a factor of two, while the demand for fuels to run cars is expected to grow even faster . We need energy sources that can be replenished naturally, don't hurt the environment, and don't affect food supplies. Biofuels made from food sources can only meet a small part of the energy needs of the transportation industry. Over a longer period of time, energy efficiency and biofuels that don't come from food are expected to become more important. The environmental benefits of biofuels like synfuel hydrocarbons and cellulosic ethanol, which can be made on land that isn't good for farming and doesn't need much fertiliser, pesticide, or fossil energy to make, could make our fuel supply much more stable than it is now with oil and food-based biofuels.

V. Conclusion

Because they have a higher ratio of surface area to volume and work better as catalysts, different types of Nano additives help reduce the emissions that vehicles put out. As a result, a number of research studies have found that combustion is getting better. MWCNT has the opposite effect of evaporation conditions. It reduces NOx, CO, and smoke emissions while also making the engine run better. HC and CO emissions tend to go down when conditions are right for evaporation. Since the higher cost of MWCNT prevents these nanofluids from being widely used, researchers should focus on lowering production costs to get the most out of their funding. In this situation, adding nanoparticles to biodiesel makes the engine run better and reduces pollution at the same time.

References

[1]. Lv J, Wang S, Meng B. The Effects of Nano-Additives Added to Diesel-Biodiesel Fuel Blends on Combustion and Emission Characteristics of Diesel Engine: A Review. Energies. 2022; 15(3):1032. https://doi.org/10.3390/en15031032.

[2]. A., Tamilvanan., K., Balamurugan., Thangamuthu, Mohanraj., P., Selvakumar., B., Ashok., R., Sakthivel. (2020). Influence of nano-particle additives on bio-diesel-fuelled CI engines: a review. 85-104. doi: 10.4018/978-1-7998-2539-5.CH005.

[3]. Shiva Kumar Reddy Devasani, Sudeshna Vodnala, Dharmasai Singarapu, Jayashri N. Nair. (2021) A comprehensive review on performance, combustion and emissions of ternary and quaternary biodiesel/diesel blends. Environmental Science and Pollution Research 59.Online publication date: 22-Nov-2021.

[4]. Devasani, S.K.R., Vodnala, S., Singarapu, D. *et al.* A comprehensive review on performance, combustion and emissions of ternary and quaternary biodiesel/diesel blends. *Environ SciPollut Res* **29**, 51083–51094 (2022).https://doi.org/10.1007/s11356-021-17504-4.

[5]. Soudagar, M.E.M., Banapurmath, N.R., Afzal, A. et al. Study of diesel engine characteristics by adding nanosized zinc oxide and diethyl ether additives in Mahua biodiesel–diesel fuel blend. Sci Rep 10,15326 (2020).

[6]. Venu, H., Madhavan, V. Effect of nano additives (titanium and zirconium oxides) and diethyl ether on biodiesel-ethanol fuelled CI engine. J Mech Sci Technol 30, 2361–2368 (2016). https://doi.org/10.1007/s12206-016-0446-5

[7]. Manzoore Elahi M.Soudagara Nik-Nazri Nik-Ghazalia,Md.Abul Kalama I.A.Badruddinb N.R.Banapurmathc Naveed Akrama , The effect of nano-additives in diesel-biodiesel fuel blends: A comprehensive review on stability, engine performance and emission characteristics, Energy Conversion and Management Volume 178, 15 December 2018, Pages 146-177.

[8]. Vijayakumar, handrasekarana Murugesan Arthanarisamyb Panneerselvam Nachiappanc Subramaniam Dhanakottib Bharathiraja Moorthya, The role of nano additives for biodiesel and diesel blended transportation fuels, Transportation Research Part D: Transport and Environment Volume 46, July 2016, Pages 145-156

[9]. Cai, T.; Becker, S.M.; Cao, F.; Wang, B.; Tang, A.; Fu, J.; Han, L.; Sun, Y.; Zhao, D. NOx Emission Performance Assessment on a Perforated Plate-Implemented Premixed Ammonia-Oxygen Micro-Combustion System. Chem. Eng. J. 2021, 417, 128033.

[10]. Li, Y.; Tang, W.; Chen, Y.; Liu, J.; Lee, C. Potential of acetone-butanol-ethanol (ABE) as a biofuel. Fuel 2019, 242, 673–686

[11]. Cai, T.; Zhao, D.; Sun, Y.; Ni, S.; Li, W.; Guan, D.; Wang, B. Evaluation of NO Emissions Characteristics in a CO2-Free MicroPower System by Implementing a Perforated Plate. Renew. Sustain. Energy Rev. 2021, 145, 111150.

[12]. Tan, D.; Chen, Z.; Li, J.; Luo, J.; Yang, D.; Cui, S.; Zhang, Z. Effects of swirl and boiling heat transfer on the performance enhancement and emission reduction for a medium diesel engine fueled with biodiesel. Processes 2021, 9, 568.

[13]. E, J.; Pham, M.; Deng, Y.; Nguyen, T.; Duy, V.; Le, D.; Zuo, W.; Peng, Q.; Zhang, Z. Effects of Injection Timing and Injection Pressure on Performance and Exhaust Emissions of a Common Rail Diesel Engine Fueled by Various Concentrations of FishOil Biodiesel Blends. Energy 2018, 149, 979–989.

[14]. Cai, T.; Zhao, D. Temperature Dependence of Laminar Burning Velocity in Ammonia / Dimethyl Ether-Air Premixed Flames. J. Therm. Sci. 2022, 31, 189–197.

[15]. Huang, Z.; Huang, J.; Luo, J.; Hu, D.; Yin, Z. Performance enhancement and emission reduction of a diesel engine fueled with different biodiesel-diesel blending fuel based on the multi-parameter optimization theory. Fuel2021,122753.https://doi.org/10.1016/j.fuel.2021.122753.

[16]. Adewale, P.; Dumont, M.-J.; Ngadi, M. Recent Trends of Biodiesel Production from Animal Fat Wastes and Associated Production Techniques. Renew. Sustain. Energy Rev. 2015, 45, 574–588.

[17]. Jiang, G.; Yan, J.; Wang, G.; Dai, M.; Xu, C.; Wang, J. Effect of Nanoparticles Concentration on the Evaporation Characteristics of Biodiesel. Appl. Surf. Sci. 2019, 492, 150–156.

[18]. Ghanbari, M.; Najafi, G.; Ghobadian, B.; Yusaf, T.; Carlucci, A.P.; Kiani DehKiani, M. Performance and Emission Characteristics of a CI Engine Using Nano Particles Additives in Biodiesel-Diesel Blends and Modeling with GP Approach. Fuel 2017, 202, 699–716.

[19]. Keskin, A.; Yaşar, A.; Yıldızhan, Ş.; Uludamar, E.; Emen, F.M.; Külcü, N. Evaluation of Diesel Fuel-Biodiesel Blends with Palladium and Acetyl ferrocene Based Additives in a Diesel Engine. Fuel 2018, 216, 349–355.