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Utilization of Aluminum Oxide Nano Particles in Dairy Scum Methyl Ester Biodiesel Engine

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Abstract: In response to the pressing need for sustainable energy solutions and environmental concerns, this study investigated the utilization of Waste Dairy scum methyl ester biodiesel blended with diesel and enhanced with Al_2O_3nanoparticles as an additive. Waste Dairy scum methyl ester biodiesel was prepared and blended with diesel and Al_2O_3 (100ppm) nanoparticles as additive. The performance and emission parameters of a single cylinder diesel engine were experimentally tested with use of neat diesel, biodiesel blends of B30 with (B30+ Al_2O_3) and without additive of Al_2O_3 nanoparticles. At peak load conditions B30+ Al_2O_3 resulted with lowest BSFC in comparison with neat Diesel and B30 biodiesel. The BTE with B30+Al_2O_3 was 2.31% higher than that of diesel and 2.06 % higher than B30. CO emission was reduced by 16.66% with use of B30 and B30+ Al_2O_3 compared to diesel. The Carbon dioxide emission was found reduced with use of Al_2O_3 Nano particles in comparison with diesel and B30 by 4.27% and 2% respectively. The HC emission was reduced by 7.69% and 13.46% with use of B30 and B30+ Al_2O_3 respectively. The addition of Nano particles has contributed for the improved performance and reduced emissions when compared to B30 Bio Diesel blend and Neat Diesel. This research addressed both the energy and environmental challenges.

Index Terms—*Al_2O_3 Nano additive, Dairy scum Methyl ester biodiesel, Diesel Engine Emissions*

1.**Introduction**

Emissions from engines in the transportation sector have a negative impact on air quality, the overall environment, and public health. A global study by Yaoxian Huang et al. Researchers found that the use of diesel engines in India increased premature deaths related to respiratory and cardiovascular diseases compared to other regions [2]. According to a report by APEDA, India's dairy exports reached a significant amount of 67,573.03 tonnes in 2022-2023 [24].

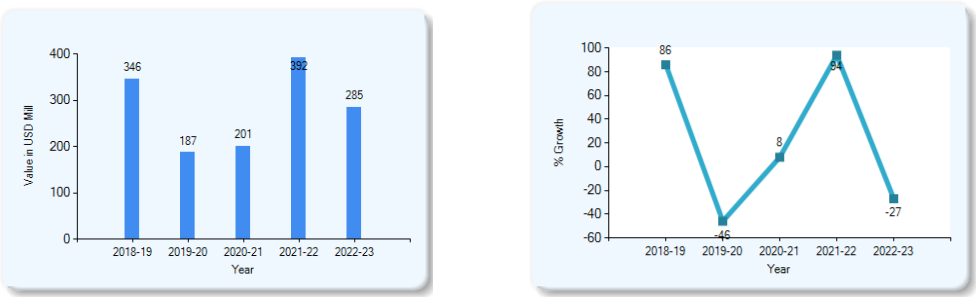

Fig.1:India's milk diary product export trend in last 5 years[25]

The milk dairy product export trend from India in last 5 years is represented visually in Figure 1. This confirms the high export potential for dairy products.

A study by Raghunath B.V et al. It has been shown that dairy farms produce an average of 2.5 liters of wastewater for every litre of milk processed. This milk waste decomposes rapidly, leading to a decrease in the oxygen content of water, which can lead to the spread of diseases such as dengue and chikungunya, and air pollution [1].Ashis Ranjan Behera et al. demonstrated that dairy wastewater can be successfully utilized as feedstock for biodiesel production, especially in combination with high fat accumulating bacteria [3]. Recent literature has investigated the use of milk waste to produce milk foam biodiesel and its incorporation into nanoparticles in compression ignition (CI) engines, providing solutions to address environmental and health.

Bashir Maleki et al. AC@ZnO/NiO nanocatalyst was used to achieve efficient biodiesel production from dairy waste in combination with optimized reaction conditions [13]. K.A. Satheesh etal ready 1 litre of DSME biodiesel with 20 ppm MWCNT nanoparticles.Its properties meet ASTM standards. Using an ultrasounddevicefor1hour at a test frequency of 40 kHz to obtain a homogeneous mixture is asuitable technique and is used. Oleic acid present in DSME biodiesel acts as a surfactant [14]. Telgan, Veerbhadrappa etal.have optimally blended B20 milkscum biodiesel with Al_2O_3nanoparticles,whichcould be a suitable replacement for pure diesel fuel from an emissions perspective [15,16]. Manjunath Channappagoudra etal. prepared a DSOME+CuO blendthatmet ASTM standards [17] Nanoparticles in DSME increased theviscosity,density,andheatingvalue of the mixture [14]. The productionof DSME biodiesel blendscontaining nanoparticles plays an important role in thestudy of CIengine performance and emissions.

Manjunath Channappagoudra etal DSMEB20 with 75ppm CuO nanoparticles showed the highest BTE of 31.26% and maintained BSFC comparable to diesel, due to higher CuOnanoparticle dosage [12]. K.A.Sateesh et.al quantitativelyoptimized,40ppmmulti-walledcarbonnanotube nanoparticles added to DSME biodiesel increased BTE by4.2%comparedto60ppm, especially when operatingonproduced gas [14]. Veerbhadrappa Telgane et.al showed that DSME B20 mixtureincreased BTE and BSFC with increasing compression ratio of CI engine [19]. Telgane Veerbhadrappa et.al The presence of Al_2O_3 nanoparticles in DSME biodiesel blendledtoasignificantimprovement in engine BTE [21]. Studies by Shaik Masthan Shareef et.al showed that BTE with DSME blends wasless than with diesel [20]. Manzoore Elahi et.al DSME B20 with 40ppm graphene oxide nanoparticle additive increased BTE by 11.56% comparedto B20. They found increased BSFC comparedto diesel [22].

20 ppm and 40 ppm MWCNT in DSME+Producergasresultedin shorter combustion duration compared to higher concentrations [14]. The addition of Al_2O_3 nanoparticles, with a highersurface-to-volume ratio, stimulated the combustion process [15]. DSME mixture with CuO nanoparticles showed high cylinder pressure compared to DSMEB20 and diesel[17].DSME+Producer Gas +MWCNT nanoparticles exhibit reduced heatreleaserate (HRR) compared to Diesel+ProducerGas[14].40ppmgrapheneoxidenanoparticles with DSMEB20 increased theheatreleaserate (HRR) and peak pressure [18].

In a series of studies, researchers explored the impact of nanoparticle additives found in different biodiesel blends on emissions. KA Sateesh et al. demonstrated that adding 60 ppm multi-walledcarbonnanotubes(MWCNTs) to DSME results in significantemissionreductions. Specifically, they observed a 20.6% decrease in carbon monoxide (CO), a 21.6% decrease in hydrocarbons (HC), a 21.8% decrease in nitrogen oxides (NOx), and a decrease in smoke emissions compared to diesel combined with productiongas [14]. Similarly, Manzoore Elahi M et al. investigated the use of 40 ppm grapheneoxide nanoparticles in DSMEB20 and found a significant improvement in emissions. This nanoparticle mixtureshowed a significantreductionof 38.62% in CO, a 21.68% reduction in HC, and a significant 24.88% reduction in smoke emissions compared to DSMEB20 [22]. Additionally, Manjunath Channappagoudra et al. explored the impact of 50 ppm CuO nanoparticles in DSMEB20, showing that this blend produced lower CO, HC, and smoke emissions than conventional diesel [12]. Together,these studies highlight the potential of nanoparticle additives to significantly reduce toxic emissions, thereby contributing to cleaner and more environmentally friendly combustion in mixeddifferent biodiesel combinations. The literature review paves the way for further exploration and development of aluminium oxide nanoparticleenhanced DSME biodiesel as a sustainable solution to enhance the CI engine performance and alsotomitigate harmful emissions in the transportation sector. This research aims to study the performance of single cylinder diesel engine while reducing emissions through the use of DSME biodiesel blends withalumnium Oxide nanoparticle additives. The research objectivesincludepreparing a biodiesel mixture called Dairy Scum Biodiesel (DSME) at a concentrationof 30% (B30) and adding Al_2O_3 nanoparticles to this mixture. The study aimed to evaluate and compare the properties of biodieselmixtures Diesel, DSME, DSME B30 and B30+Al_2O_3.Additionally, research isinvestigating the impact of Al_2O_3 nanoparticles on the performance of compressionignition (CI) engine fuelled with these biodiesel blends. Inaddition, the study alsoexamined the effect of Al_2O_3 nanoparticles on emissions produced by CI engines running on biodiesel blends.

2. Materials And Research Methodology.

The research methodology employed in this study is visually illustrated through Figure 1.

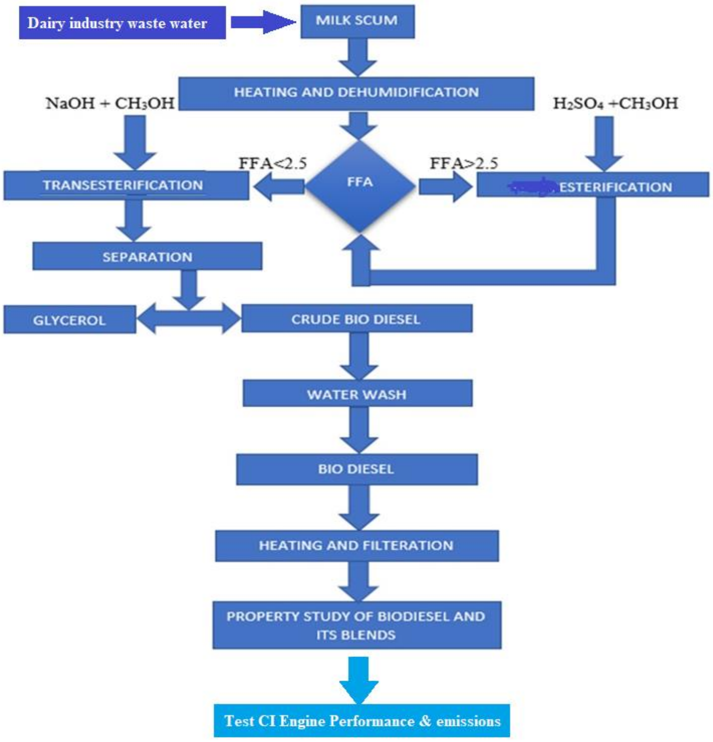

Fig.2: Flow chart of methodology

2.1: Diary Scum Collection.

Samarth Dairy and Agro Products Private Limited, located in Chikodi, Karnataka, India, has a processing potential of 10,000 kilograms in line with day. Their number onemerchandiseconsists of milk packets and ghee. During the processing of dairy merchandise, the dairy generates about 25,000 liters of wastewater daily, which incorporates scum because of the cleansing of process equipment. Additionally, they arecapable to separate 60 to70 kilograms of fatscontent material from this wastewater each day. This fatscontent materialaffords the capacityto supplyabout 45 to 50 liters of Dairy Scum oil in a day, imparting apossibility for sustainable biodiesel manufacturing from the dairy waste materials.A total of 6kg of Dairy Scum was collected.

2.2 : Milk Scum Oil Extraction.

The amassed dairy scum underwent heating process at temperature of 130°C, efficientlydisposing of all moisture content. Following this step, the milk scum oil become subjected to filtration to dispose of any coarse or floating impurities. As a end result of this procedure, about

Fig.3: Boiling of Waste Diary Scum

3.5litres of scum oil had beenefficaciously obtained. The heating and dehumidification procedure is visually represented in Figure 3.

2.3: Free Fatty Acid Test.

The milkscum oil wassubjectedto a series of tests starting with a free fatty acid (FFA) evaluation using FFA test strips in a laboratory setting. The initial FFA content was determined to be 12.4%, whichwas significantly higherthan the allowed FFA content of 2.5%. To address thisissue, an acid-catalyzed esterification process was used to reduce the FFA content to a more acceptable 1.41%. Inthisprocess, the milkscum oil washeated to 50°Cwithstirring,

200ml of methanol and 10ml of H_2SO_4wereadded, and the mixture wasstirred for 3 hours. The reaction solution was then allowed to stand for oneday.Duringthistime, excess reactantsandimpurities such as methanol and acidformanother layer on top, making their removaleasier. The Dairy scum oil and Dairy scum methyl ester mixture is shown in Figure 4.

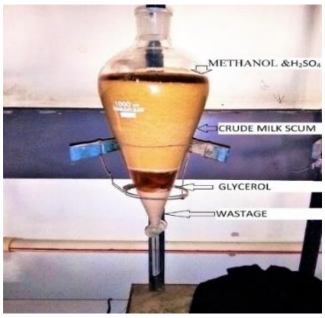

Fig 4: Dairy Scum Oil after Esterification.

2.4: Transesterification Process.

In the transesterification process, 1000 ml of scum is heated to 65°C and then transferred to the round-bottom flask of the esterification setup. A mixture consisting of 300 ml of methanol and 5 grams of NaOH pellets is prepared in a beaker within the setup and slowly introduced into the flask containing the scum. This combination of milk scum, methanol, and NaOH is continuously stirred until the Free Fatty Acids (FFA) form a distinct upper layer. Following this, the mixture is further stirred until glycerin separates into its own distinct layer. Once .

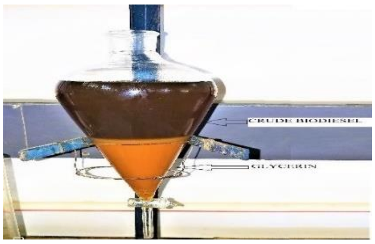

Fig.5: Crude biodiesel after transesterification process

glycerin has formed this separate layer, the mixture is left to settle for approximately 12 hours. During this period, the FFA and any impurities floating on the top surface are removed from the mixture.

The obtained biodiesel is washed 12 times with water at70°C to remove the catalyst. The heating processe vaporates the water present in the biodiesel. The complete process is shown in Figure6.

Fig 6: Biodiesel production process.

2.4: Biodiesel Blend Preparation

The diary scum biodiesel thus produced is named as DSME. The Blend B30 of biodiesel produced with of 30% DSME and 70% diesel was chosen to conduct the experiment. To produce B30 blend 30% DSME and 70% diesel were collected in a flask and continuously stirred with mechanical stirrer. The desirable properties of the diesel, DSME and the B30 blend were tested as per ASTM standards. The B30 blend thus produced is added with the 100ppm (0.10gm) Al_2O_3 nanoparticles. The Ultrasonicator maintained the uniform distribution of the nanoparticles.

2.2 Properties of diesel and DSME blends.

The desirable properties of the diesel, DSME and the B30 blend were tested as per ASTM standards. The flash point was determined using Pensky-Martens apparatus. Viscosity is determined using the Redwood Viscometer. The calorific value is determined using the bomb calorimeter. The properties obtained after the test are represented in the table1.

Table 1: Thermo Physical Properties of fuels

Parameter	Diesel	DSME	B30	B30+Al_2O_3	ASTM Standard
Flash point (°C)	54	90	60	58	ASTM D93
Viscosity (cSt)	2.8	3.2	3.0	3.1	ASTM D445
Density (kg/m^3)	830	836	835	835.01	ASTMD1298
Calorific value (kJ/kg)	42000	30963	39721	39780	ASTM D240

Effect Of Nanoparticles On Biodiesel Properties

2.1.1 KINEMATIC VISCOSITY:

The kinematic viscosity of DSMEB30+ $Al_2O_3$the nano additive fuel blend is greater than DSMEB30, it is also greater than that of diesel [23].

It indicates that the addition of aluminium oxide (Al_2O_3) nanoparticles, increased the fuel viscosity.

Al_2O_3, Nano particles have high surface area, which can interact with the fuel molecules, causing them to form clusters or agglomerates. These clusters contribute to increased viscosity by obstructing the flow of the fuel.

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Additionally, the surface chemistry of nanoparticles can influence interactions with the surrounding molecules, further affecting the viscosity.

The kinematic viscosity of DSMEB30+Al_2O_3 is greater than that of diesel, indicating that the biodiesel blend with nanoparticles is more viscous than pure diesel fuel.

Several factors contribute to the higher kinematic viscosity of DSMEB30+ Al_2O_3 compared to diesel:

a. Biodiesel chemical composition: Biodiesel, DSMEB30, is derived from animal fats and contains ester molecules with polar functional groups, which can lead to higher viscosity compared to the predominantly hydrocarbon-based structure of diesel fuel.

b. Nanoparticle effects: The addition of nanoparticles, such as Al_2O_3, can increase the viscosity of the fuel by forming nanoscale structures within the liquid, impeding fluid flow. These structures can create a more viscous and non-Newtonian behaviour.

c. Biodiesel-diesel blend effect: When blending biodiesel with diesel, as seen in DSMEB30+ Al_2O_3, the biodiesel component can contribute to increased viscosity. Biodiesel tends to have higher viscosity than pure diesel, and blending can amplify this effect.

2.1.2 **DENSITY**.

The density of DSMEB30+$Al_2O_3$is higher than that of diesel after the addition of nanoparticles, suggesting that the DSME biodiesel blend with Al_2O_3 nanoparticles is denser than pure diesel.

There are several factors contributing to the higher density of DSMEB30+Al_2O_3compared to diesel after the addition of nanoparticles:

a. Biodiesel's chemical composition: Biodiesel, such as DSMEB30, is typically derived from animal fats, which contain molecules with oxygenated functional groups, making them denser compared to the predominantly hydrocarbon-based composition of diesel fuel.

b. Nanoparticle effects: The addition of Al_2O_3nanoparticles, increases the overall mass and volume of the fuel, resulting in higher density. The nanoparticles occupy space within the fuel, increasing its overall mass without significantly affecting its volume. This contributes to the density increase.

c. Biodiesel-diesel blend effect: Blending biodiesel with diesel, as in DSMEB30+Al_2O_3, can also lead to a higher density. Biodiesel has a higher density compared to diesel, and blending biodiesel with diesel increases the overall density of the mixture.

2.1.3 FLASH POINT

The flash point of DSMEB30+ Al_2O_3 is lower than that of DSMEB30, indicating that the addition of aluminum oxide (Al_2O_3) nanoparticles results in a lower flash point for the biodiesel blend.

The lower flash point in DSMEB30+ Al_2O_3 can be attributed to several factors:

a. Presence of nanoparticles: The addition of nanoparticles, such as Al_2O_3can introduce catalytic effects, promoting the initiation of combustion at lower temperatures. These nanoparticles may facilitate the formation of flammable mixtures, reducing the flash point.

b. Enhanced surface area: Nanoparticles provide a high surface area for interactions with air and fuel, which can facilitate the release of volatile components and lower the flash point.

c. Alteration of fuel properties: Nanoparticles can modify the chemical and physical properties of the biodiesel blend, making it more prone to ignition at lower temperatures.

Lower Flash Point of DSMEB30+ Al_2O_3 Compared to Diesel.

The flash point of DSMEB30+ Al_2O_3 is lower than that of diesel, suggesting that the biodiesel blend with Al_2O_3 nanoparticles has a lower flash point than pure diesel fuel.

This phenomenon can be explained by the following factors:

a. Biodiesel's chemical composition: Biodiesel, including DSMEB30, typically contains ester molecules with polar functional groups that make it more susceptible to ignition at lower temperatures compared to the hydrocarbon-based structure of diesel.

b. Nanoparticle effects: The presence ofAl_2O nanoparticles, can enhance the flammability of the fuel blend by catalyzing combustion reactions, thereby lowering the flash point.

c. Biodiesel-diesel blend effect: Blending biodiesel with diesel, as in DSMEB30+ Al_2O_3, may contribute to a lower flash point due to the presence of biodiesel, which has a lower flash point than pure diesel.

2.1.4 CALORIFIC VALUE

The calorific value of DSMEB30+ Al_2O_3 is higher than DSMEB30, suggesting that the addition of nanoparticles, specifically aluminum oxide (Al_2O_3), enhances the energy content of the biodiesel blend.

The addition of nanoparticles, such as Al_2O_3, can improve the combustion efficiency of biodiesel. Nanoparticles enhance the fuel-air mixing, promote better atomization, and increase the surface area available for combustion. This results in more complete combustion and a higher calorific value.

DSME and its blends exhibit lower calorific values than diesel, indicating that they have lower energy content per unit mass.

There are several reasons for this difference:

a. Biodiesel's chemical composition: Biodiesel, including DSME, is typically made from animal fats. These feedstocks contain oxygen in their molecular structure, reducing the energy content compared to hydrocarbon-based diesel, which contains no oxygen. The presence of oxygen leads to lower energy content in biodiesel.

b. Lower energy density: Biodiesel has a lower energy density compared to petroleum diesel, resulting in a lower calorific value. This is due to the lower hydrogen-to-carbon ratio in biodiesel molecules.

c. Blending effect: Blending biodiesel with petrodiesel, as seen in DSMEB30, dilutes the energy content of the fuel, as biodiesel typically has a lower energy content than petrodiesel. Blending is done for various reasons, such as emissions reduction and using renewable resources, but it results in a lower calorific value compared to pure diesel.

2.3: Experimental Setup.

A single cylinder, four stroke, water cooled CI engine with, variable compression ratio was used in the present experimentation work. The engine and gas analyzer specifications are represented in the table 2.

Fig 7: Experimental set up

Figure 7 shows the computerized experimental setup for testing the engine; The crankshaft speed of 1500rpm was maintained constant. The compression ratio was set to 17.5:1. The load was applied through the Eddy current dynamometer. The engine was tested for the performance and emission with normal diesel fuel initially, then successively with B30 fuel and B30 Al_2O_3 fuels.

Table 2: Engine Specifications.

Parameter	Specifications
Engine	TV1 (Make: Kirloskar Ltd)
Software	Engine Soft.
Nozzle pressure	200-250 bar
Governor type	Mechanical centrifugal type
Cylinders	One cylinder
Strokes	4 strokes
Operating fuel	Diesel / Bio Diesel
Rated power	5.2 KW @ 1500 rpm
Cylinder Diameter (bore)	87.5 mm

Stroke length	110 mm
Compression ratio (variable)	12 to 18:1
Dynamometer Details	
Model/Type	AG-10/ Eddy current
Maximum power	7.5 KW at 1500-3000 RPM
Gas Analyzer	
Make	AVL
No.of Gases Analysed	5
Gases Analysed	CO, CO_2, O_2, HC, NOx

Performance parameters were measured in the software Enginesoft in computer. The accuracies of the different measurements are mentioned in table 3. The gas analyser was used to measure the emissions of DSME biodiesel engine.

Table 3: The accuracies of measurements.

Measured Variable	Accuracy
Load (Kg)	0.1
Engine speed (rpm)	1.98
Pressure transducer (bar)	0.1
Encoder reading, Crank angle (deg., CA)	0.1
Exhaust gas temperature (ºC)	1.5

3.Results And Discussions

3.1 Engine Performance.

The measured performance parameters are used to plot the graphs. The graphs are analysed to study the effect of aluminium oxide nanoparticles with dairy scum biodiesel on the CI engine performance parameters.

3.1.1 Effect of Aluminium oxide nanoparticles on Brake Thermal Efficiency

The load was applied on the engine gradually and corresponding variation in brake thermal efficiency is shown in Figure 8. The results indicate that as engine load increases, brake thermal performance improves for all three fuels tested. This shows that the engine operates more efficiently under heavier workloads. The highest brake thermal efficiency observed in the study was 23.07%. This efficiency is achieved when the engine is running at full power,meaning it is operating at its highest capacity.The observation that brake thermal efficiency increases with higher engine loads has important implications. This suggests that under heavier workloads, theengine can operate more efficiently, resultinginbetter fuel economy and reduced emissions. This discoverycould influence engine design and operation, encouraging the use of higher loads to maximize efficiency. The obtained efficiency oftheB30+Al_2O_3 fuel mixture is 2.31% higher than thedieselfuelmixture.This shows that B30+Al_2O_3 is a more efficient fuel choice in terms of brake thermal performance compared to diesel. B30+Al_2O_3 also outperformed B30, another fuel used in the study, by 2.06% in brake thermal efficiency. This improvement is due to better combustion, showing that B30+Al_2O_3 has more efficient combustion than B30.

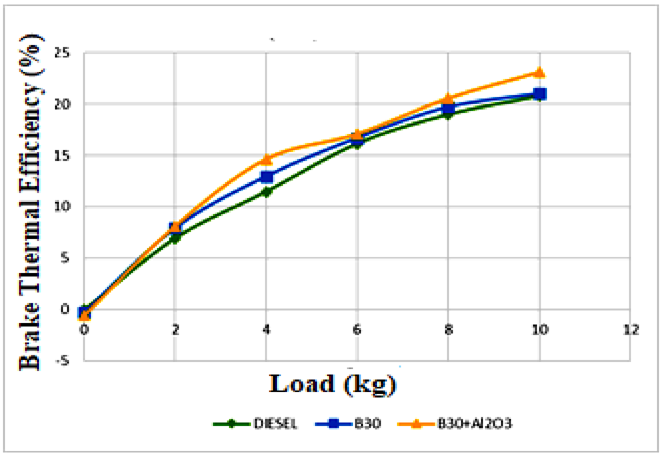

Fig.8: Variation of Brake thermal efficiency with load

The comparison between B30+$Al_2O_3$and B30, whereB30+Al_2O_3outperformsB30 by 2.06% in brake thermal efficiency, highlights the importance of combustion quality in engine performance. This finding has implications for fuel formulation and combustion optimization, highlighting the potential to improveperformance by improving combustion. The fact that B30+Al_2O_3has a 2.31% higher brake thermal efficiency thana diesel engine has important implications for the choice of fuel in theengine.Thisshows that B30+$Al_2O_3$is a good fuel choice, especially for applications where performance is important. This may lead to increased use of B30+Al_2O_3in engines seeking better performance and reduced fuel consumption. In summary, the study shows that increasing engine load improves brake thermal performance for all fueltypes tested. Among the fuels, B30+Al_2O_3stands out as the most efficient, with anefficiency 2.31% higher than diesel and 2.06% higher than B30 thanks to its superior combustion characteristics. These results highlight the potential benefits of using B30+Al_2O_3as anoptional fuel for this specific typeof engine, especially under highload conditions. In summary, the researchresults have broad implications for engine performance, load management, fuel selection and combustion optimization. They suggest opportunities toimproveengineperformance,reduce fuel consumption and minimize environmental impact, including considering B30+Al_2O_3as a more efficient fuel choice under loadconditionsHigh.These impactscould influence future research and engineering decisions in the field of internal combustion engines.

3.1.2 Effect of Aluminium oxide nanoparticleson Brake Specific Fuel Consumption.

The variation in BSFC with gradual loading on the engine is represented in Figure 9. The results show that as engine load increases, BSFC decreases for diesel fuel and its mixture [25]. Furthermore, at full load, the B30+Al_2O_3mixturehas the lowest fuel consumption, with a specific value of 0.39 kg/kW-h. This mixturehelpsreduceBSFCby 4.9% compared to pure diesel and significantly more than 9.30% compared to B30 mixture.The B30 blend showed improved fuel efficiency compared to pure diesel, possibly due to its higher biofuel content. Biofuels can have a positive impact on combustion efficiency and emissions.

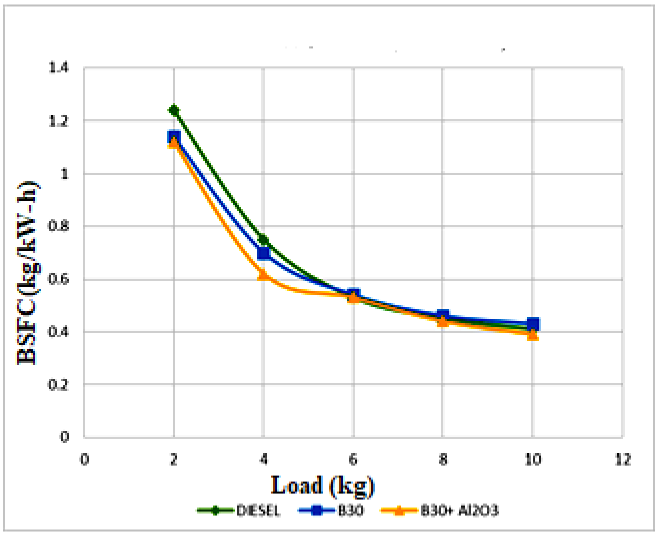

Fig.9.: Variation of BSFC with load.

The most significant reduction in BSFC was observed in the B30+Al_2O_3mixture. The presence of Al_2O_3 nanoparticles in fuel canhelpimprove combustion efficiency. Nanoparticles can improve combustion by promoting better fuel injection and mixing, leading to more complete and efficient combustion.In summary, the study shows that the addition of Al_2O_3 nanoparticles to the B30 diesel fuel mixture can significantly improve fuel efficiency, reduce BSFC, and improve combustion performance. These findings have importantimplications for the development of cleanerand more efficient combustion technologies.

3.2 : Emission Charecteristics

The measured emissionsfrom the gas analyser are used to plot the graphs. The graphs are analysed to study the effect of aluminium oxide nanoparticles with dairy scum biodiesel on the CI engine emission.

3.2.1 Effect of Aluminium oxide nanoparticles on CO emission.

The variation in Carbon Monoxide with gradual loading for all three fuel blends on the engine is represented in Figure 10. Comparative study of carbon monoxide (CO) emissions of Diesel fuel, B30 and B30+Al_2O_3 at full load. Diesel fuel had the highest CO emissions, measuring 0.18%, while the B30 blend and the B30+Al_2O_3 blend had lower CO emissions, both at 0.15%. This means that the CO emissions of B30 and B30+Al_2O_3 are 16.66% lower than diesel. Choosing B30 or B30+Al_2O_3 blends insteadof pure diesel can be anoption to minimize the impactof carbon monoxide on the environment. Themixtures B30 and B30+Al_2O_3 have a higher oxygen concentrationthan diesel. Oxygen is essential for combustion, and higher oxygen levelspromote more complete and efficient combustion.The presence of additional oxygen in the mixedfuel promotes better combustionkineticsand air-fuel mixing,resultingin a more thorough and cleaner combustion.Thisleadstoareduction in CO emissions. In summary, the study demonstrates that higher oxygen concentrations in B30 and B30+Al_2O_3mixturesleadto improved combustion efficiency andparadoxicallyreduced CO emissions compared to diesel fuel.

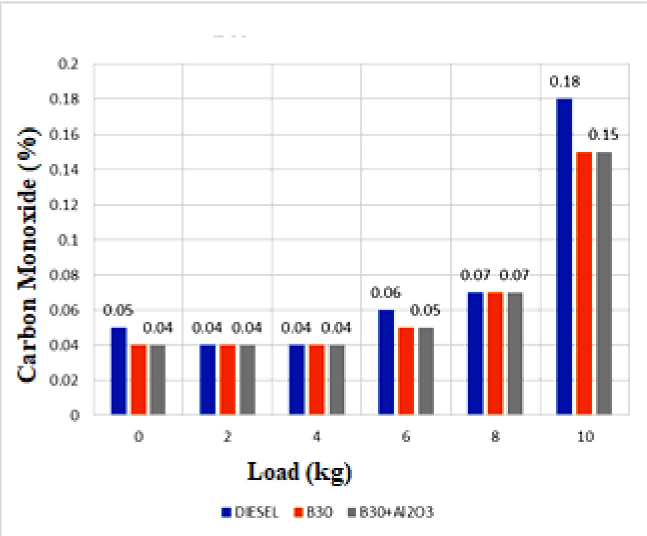

Fig.10: CO emission with load.

Implications of these findings include reduced environmental impact, the potential for emissions control strategies, and the importance of optimizing combustion technology tocreate cleaner energy and transportation systems.

3.2.3: Effect of Aluminium oxide nanoparticles on Hydro Carbon (HC) Emission

The variation in Hydrocarbon emissions with gradual loading for all three fuel blends on the CI engine is represented in Figure 11.

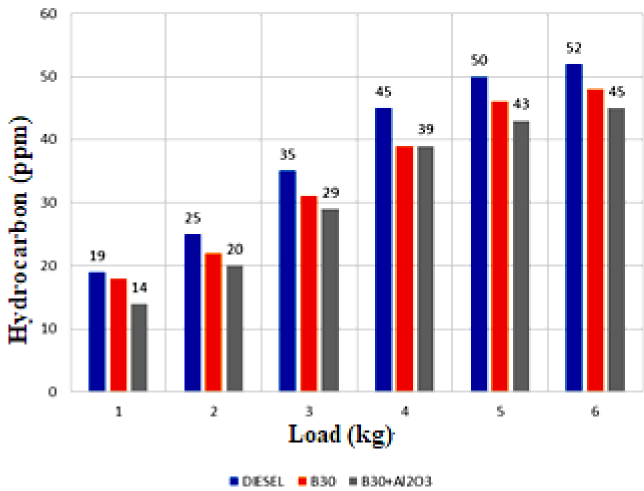

Fig.11.: HC emission with load.

The figure 11 compares the hydrocarbon (HC) emissions from all three fuels. It is observed that diesel fuel exhibited the highest HC emission at 52 parts per million (ppm), while the B30 blend and the B30+Al_2O_3 blend had lower HC emissions, reduced by 7.69% and 13.46%, respectively, compared to diesel. The reduction in HC emissions in B30 and B30+Al_2O_3 blends is likely due to better oxidation of hydrocarbons during combustion. The presence of additional oxygen in these blends can facilitate more complete combustion, leaving fewer unburned hydrocarbons in the exhaust. The reduction in HC emissions from B30 and B30+Al_2O_3 compared to diesel has significant implications for air quality, especially in areas with stringent emissions regulations. The implications of these findings include improved air quality, enhanced compliance with emissions regulations, and the importance of optimizing combustion efficiency for cleaner combustion in various applications.

3.2.4:Effect of Aluminium oxide nanoparticles onNitrogen Oxides Emissions

The variation in Nitrogen Oxide emissions with gradual loading for all three fuel blends on the CI engine is represented in Figure 12.

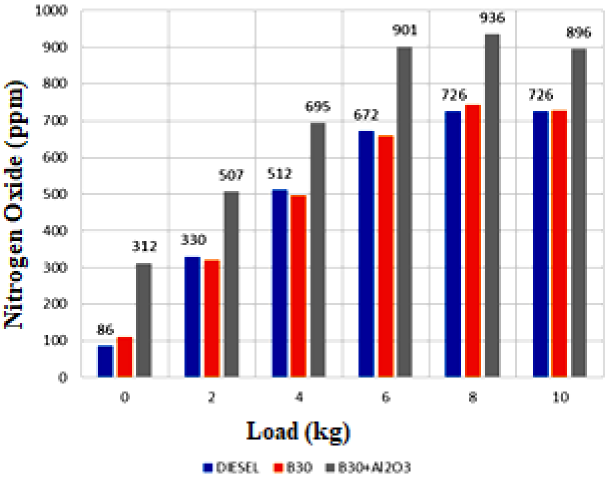

Fig.12: Variation of NO_x with load.

The results in figure 12 comparing emissions of nitrogen oxides (NOx) between all fuels. It is observed that the B30 and B30+Al_2O_3 blends showed higher NOx emissions, measuring 896 parts per million (ppm), compared to diesel fuel. Biodiesel blends like B30 and B30+Al_2O_3 typically contain higher levels of oxygen compared to diesel fuel. The presence of oxygen can lead to more complete combustion, which, in turn, raises the combustion temperature and results in increased NOx emissions. The addition of nanoparticles (Al_2O_3) to the fuel can enhance combustion efficiency. Nanoparticles can promote better fuel atomization, mixing, and combustion kinetics, resulting in higher combustion temperatures, which can further contribute to increased NOx emissions. The implications include the need for emission control technologies and strategies to address the increased NOx emissions associated with these fuels, particularly in compliance with emissions regulations and environmental standards.

Given the elevated NOx emissions associated with biodiesel blends and nanoparticle-enhanced combustion, the statement suggests the use of after-treatment devices such as catalytic converters and EGR to reduce NOx emissions. These technologies are effective in converting and mitigating NOx pollutants before they are released into the environment.

Conclusions

- The DSMEB30 with Al_2O_3 nanoparticles is a promotional fuel to enhance engine performance and emissions.
- The addition of Al_2O_3 nanoparticles to the fuel mixture (B30+Al_2O_3) significantly improves the engine's thermal efficiency.
- The improvement in BSFC is attributed to the presence of Al_2O_3 nanoparticles in B30+ Al_2O_3 which played a crucial role in achieving better combustion efficiency.

- B30+ Al_2O_3 showed significant improvements in HC emissions and brake thermal efficiency, it exhibited higher NOx emissions. The addition of Al_2O_3 nanoparticles played a critical role in these changes, acting as a catalyst to enhance combustion and reduce CO and HC emissions.
- This research offers valuable insights for optimizing fuel compositions and combustion processes to achieve better environmental and efficiency outcomes.
- The dairy scum usage for DSME biodiesel production is a sustainable and environment friendly option.
- The addition of Nano particles has contributed the better performance and emission when compared to Bio Diesel blend and Neat Diesel.

Future scope:

Overall, the use of nanoparticles in biodiesel blends is a complex and multifaceted area of research, and their effects on fuel properties have important implications for combustion, emissions, and fuel consumption. Further studies are essential to fully understand and optimize the use of nanoparticles in biodiesel production.

References

[1] Raghunath B.V., Punnagaiarasi A., Rajarajan G., Irshad A., Elango A., Mahesh kumar G. (2016) Impact of Dairy Effluent on Environment—A Review. In: Prashanthi M., Sundaram R. (eds) Integrated Waste Management in India. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-319-27228-3_22

[2] Yaoxian Huang, Nadine Unger , Kandice Harper , and Chris Heyes{2020) "Global Climate and Human Health Effects of the Gasoline and Diesel Vehicle Fleets" GeoHealth,20204,e2019GH000240. https://doi.org/10.1029/2019GH000240

[3] Ashis Ranjan BeheraaKasturi DuttaaPriyanka VermabAchleshDavereybDeepak KumarSahooc" High lipid accumulating bacteria isolated from dairy effluent scum grown on dairy wastewater as potential biodiesel feedstock; Journal of Environmental ManagementVolume 252, 15 December 2019, 109686

[4] Manzoore Elahi M. Soudagar , , Nik-Nazri Nik-Ghazali ,M.A. Kalam, Irfan Anjum Badruddin , N.R. Banapurmath "An investigation on the influence of aluminium oxide nano-additive and honge oil methyl ester on engine performance, combustion and emission characteristics" Renewable Energy 146 (2020) 2291e2307

[5] Shaik Masthan Shareef, Dillip Kumar Mohanty, "Experimental Investigations of dairy scum biodiesel in a diesel engine with variable injection timing for performance, emission and combustion", Fuel 280 (2020) 11864

[6] Manjunath Channappagoudra "*Influence of the aluminium oxide (Al2O3) Nano particle additive withbiodiesel on modified diesel engine performance"* Taylor & Francis & Informa UK Limited, trading as Taylor& Francis Group.2019,ISSN: 0143-0750 (Print) 2162-8246

[7] H.V. *Srikanth, J. Venkatesh, G. Sharanappa, M.Bhaskar, Acetone and diethyl ether: Improve Cold Flow Properties of Dairy Was ed Milk-Scum Biodiesel, RenewableEnergy(2018),doi:10.1016/j.renene.2018.06.051*

[8] Manjunath Channappagoudra (2018) Effect of copper oxide nanoadditive on diesel engine performance operated with dairy scum biodiesel, International Journal of Ambient Energy, DOI: 10.1080/01430750.2018.1557553

[9] Sudershan B Gadwal, NR Banapurmath, MA Kamoji, PB Rampure, SV Khandal "Performance and emission characteristic studies on CRDI diesel engine fuelled with plastic pyrolysis oil blended with ethanol and diesel, International Journal of Sustainable Engineering, 2019

[10] Manjunath Channappagoudra, K. Ramesh & G. Manavendra *"Bio-ethanol additive effect on directinjection diesel engine performance, emission and combustion characteristics – an experimental examination*"Taylor & Francis. 12 Sep.2018, ISSN: 0143-0750 (Print) 2162-8246

[11] Jyoti vij, Siraj Hussain, Abhinav Singh , Sakshi Saini , FICCI Paper on Development of Dairy Sector in India July 2020 http://ficci.in/spdocument/23304/Development-Dairy-Sector.pdf

[12] Manjunath Channappagoudra (2018): Effect of copper oxide nanoadditive ondiesel engine performance operated with dairy scum biodiesel, International Journal of Ambient Energy, DOI: 10.1080/01430750.2018.1557553

[13] Basir Maleki, Yatish Kalanakoppal Venkatesh, S. Siamak Ashraf Talesh, Hossein Esmaeili, Sakar Mohan, Geetha R. Balakrishna,"A novel biomass derived activated carbon mediated AC@ZnO/NiO bifunctional

nanocatalyst to produce high-quality biodiesel from dairy industry waste oil: CI engine performance and emission”,*Chemical Engineering Journal*,Volume 467,2023,143399,ISSN 1385-8947,https://doi.org/10.1016/j.cej.2023.143399.

[14] K.A. Sateesh, V.S. Yaliwal, N.R. Banapurmath, Manzoore Elahi M. Soudagar, T.M. Yunus Khan, P.A. Harari, A.S. El-Shafay, M.A. Mujtaba, Ashraf Elfaskhany, M.A. Kalam, " Effect of MWCNTs nano-additive on a dual-fuel engine characteristics utilizing dairy scum oil methyl ester and producer gas",*Case Studies in Thermal Engineering*, Volume 42,2023, 102661, ISSN 2214-157X,https://doi.org/10.1016/j.csite.2022.102661.

[15] **Telgane, Veerbhadrappa, Godiganur, Sharanappa, Srikanth, H.V, “performance study of compression ignition engine fueled with dairy scum biodiesel and Al_2O_3 nanoadditives”, International Journal of Energy for a Clean Environment, Volume 23, issue 7, 2022, ID 075791f41173212f**

[16] Shaik Masthan Shareef, Dillip Kumar Mohanty,“Experimental investigation of emission characteristics of compression ignition engines using dairy scum biodiesel”,*Materials Today: Proceedings,*Volume 56, Part 3,2022,Pages 1484-1489,ISSN 22147853,https://doi.org/10.1016/j.matpr.2021.12.367.

[17] Manjunath Channappagoudra (2021) Effect of copper oxide nanoadditive on diesel engine performance operated with dairy scum biodiesel, International Journal of Ambient Energy, 42:5, 530-539, DOI: 10.1080/01430750.2018.1557553

[18] Manzoore Elahi. M. Soudagar, Nik-Nazri Nik-Ghazali, M.A. Kalam, Irfan Anjum Badruddin, N.R. Banapurmath, T.M. Yunus Khan, M. Nasir Bashir, Naveed Akram, Rijavan Farade, Asif Afzal, The effects of graphene oxide nanoparticle additive stably dispersed in dairy scum oil biodiesel-diesel fuel blend on CI engine: performance, emission and combustion characteristics, Fuel, Volume 257, 2019, 116015, ISSN 0016-2361, https://doi.org/10.1016/j.fuel.2019.116015.

[19] Veerbhadrappa Telgane, N. Keerthi Kumar, Sharanappa Godiganur,“Dairy scum methyl ester production and its performance testing on a CI engine at different compression ratios”, Materials Today: Proceedings, Volume 54, Part 2,2022, Pages 270-273, ISSN 2214-7853,https://doi.org/10.1016/j.matpr.2021.09.155.

[20] Shaik Masthan Shareef, Dillip Kumar Mohanty,“Experimental investigations of dairy scum biodiesel in a diesel engine with variable injection timing for performance, emission and combustion”, Fuel,Volume 280,2020, 118647, ISSN 0016-2361, https://doi.org/10.1016/j.fuel.2020.118647.

[21] **Telgane, Veerbhadrappa, Godiganur, Sharanappa, Srikanth, H.V, “performance study of compression ignition engine fueled with dairy scum biodiesel and Al_2O_3 nanoadditives”, International Journal of Energy for a Clean Environment, Volume 23, issue 7, 2022, ID 075791f41173212f**

[22] Manzoore Elahi. M. Soudagar, Nik-Nazri Nik-Ghazali, M.A. Kalam, Irfan Anjum Badruddin, N.R. Banapurmath, T.M. Yunus Khan, M. Nasir Bashir, Naveed Akram, Rijavan Farade, Asif Afzal, The effects of graphene oxide nanoparticle additive stably dispersed in dairy scum oil biodiesel-diesel fuel blend on CI engine: performance, emission and combustion characteristics, Fuel, Volume 257, 2019, 116015, ISSN 0016-2361, https://doi.org/10.1016/j.fuel.2019.116015

[23] Cihan Bayindirli, Mehmet Celik, Recep Zan, “Optimizing the thermophysical properties and combustion performance of biodiesel by graphite and reduced graphene oxide nanoparticle fuel additive”,*Engineering Science and Technology, an International Journal*, Volume 37,2023,101295, ISSN 2215-0986, https://doi.org/10.1016/j.jestch.2022.101295.

[24] Rampure, PB, & Reddy, CV. "Performance Analysis of Rice Bran Oil [Non-Edible] as Alternative Fuel for D I Engines." *Proceedings of the ASME 2011 International Mechanical Engineering Congress and Exposition. Volume 4: Energy Systems Analysis, Thermodynamics and Sustainability; Combustion Science and Engineering; Nanoengineering for Energy, Parts A and B.* Denver, Colorado, USA. November 11–17, 2011. pp. 1323-1330. ASME. https://doi.org/10.1115/IMECE2011-62186

Websites

[25] https://agriexchange.apeda.gov.in/indexp/Product_description_32headChart.aspx?gcode=0407

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