Hindawi
Advances in Materials Science and Engineering
Volume 2024, Article ID 9828361, 1 page
https://doi.org/10.1155/2024/9828361

Retraction

Retracted: Influences of Aqueous Nanofluid Emulsion on Diesel Engine Performance, Combustion, and Emission: IoT (Emission Monitoring System)

Advances in Materials Science and Engineering

Received 8 January 2024; Accepted 8 January 2024; Published 9 January 2024

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] B. Venkatesh, J. C. Babu, S. K. Mathivanan, P. Jayagopal, S. Prasanna, and M. S. Uddin, "Influences of Aqueous Nanofluid Emulsion on Diesel Engine Performance, Combustion, and Emission: IoT (Emission Monitoring System)," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 8470743, 9 pages, 2022.

Hindawi
Advances in Materials Science and Engineering
Volume 2022, Article ID 8470743, 9 pages
https://doi.org/10.1155/2022/8470743

Research Article

Influences of Aqueous Nanofluid Emulsion on Diesel Engine Performance, Combustion, and Emission: IoT (Emission Monitoring System)

B. Venkatesh[1] **J. Chinna Babu**[2] **Sandeep Kumar Mathivanan,**[3] **Prabhu Jayagopal,**[3] **S. Prasanna,**[3] **and Md Salah Uddin**[4]

[1]*Department of Mechanical Engineering, Annamacharya Institute of Technology & Sciences, Rajampet, Kadapa, Andhra Pradesh, India*
[2]*Department of Electronics and Communication Engineering, Annamacharya Institute of Technology and Sciences, Rajampet 516126, Andhra Pradesh, India*
[3]*School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India*
[4]*Department of Multimedia and Creative Technology, Daffodil International University, Dhaka-1207, Bangladesh*

Correspondence should be addressed to B. Venkatesh; bvenkatesh.me.aits@annamacharyagroup.org and Md Salah Uddin; jahid.mct@diu.edu.bd

Received 15 July 2022; Accepted 16 August 2022; Published 28 September 2022

Academic Editor: Adel Mohamed

Pollution is the primary ecological threat to nature and it also raises the temperature of the Earth. The primary cause of air pollution is exhaust emissions from the combustion chamber. This study aims to focus on controlling emissions using an aqueous nanoemulsion method and to analyze positive vibrations for the reduction of pollutants in diesel engines. In this study 3% NWED (nano-based water emulsion diesel), 7% NWED, and 12% NWED emulsion blended diesel were mixed with Tween-20 as a solvent. In addition, this work was accomplished with a multiuser remote control system for the continuous monitoring of emissions with IoT technology applied to diesel engines. Experimental results have been measured with an IoT kit and five gas analyzers and reported that emission of oxides of nitrogen and hydrocarbons can be reduced by using a 7% NWED blend when compared with diesel. In addition, the experimental result also shows that the brake-specific fuel consumption is reduced with an improvement in thermal efficiency at 7% NWED when compared with other blends.

1. Introduction

As the rate of fossil fuel depletion is increasing daily, there is a need to fulfill the energy demand for alternative fuels [1]. Since the 1970s, the use of energy resources such as oil, gas, coal, nuclear and hydro, has increased tremendously to meet energy demand [2]. The transport, industry, non-composted, and building sectors depend mainly on petroleum fuels [3]. Combustion emissions such as CO, CO2, HC, NOx, and smoke are released into the atmosphere through exhaust pipes [4]. These emissions generate chemical reactions in the atmosphere, creating a greenhouse effect [5]. Controlling pollution mixture formation in diesel engines has been the prime objective of many researchers, who have found alternative fuels that have not shown any modifications to the engine, by reducing emissions and improving engine performance [6]. Biodiesel has been studied worldwide as the dominant diesel fuel. To achieve better performance and lower pollution, researchers have selected different biodiesel feedstocks or varying engine parameters such as injecting opening pressures (IOPs), fuel injection timings, compression ratio (CR), and additives, such as diethylether and antioxidants [7]. As a result that biodiesel blends produced lower CO, HC, and smoke emissions than diesel fuel, while combustion exhaust gas temperature, CO2, and NOx emissions were higher [8]. Researchers based on several studies on diesel engines using alternative fuels have claimed that NO_x emissions have increased owing to the high combustion and heat release rate inside the combustion chamber [9].

In addition, several scholars have found that additives such as nanoparticles and water emulsions in diesel offer useful performance improvements by reducing the emissions of a diesel engine. In most cases, additives such as metal oxide particles are added to the base fuels to achieve secondary atomization and improve thermal efficiency. Additionally, these particles reduce unburnt hydrocarbon and carbon monoxide emissions [10]. Graphene, carbon nanotubes, cerium oxide, manganese, nickel oxide, and other metal oxides have been studied extensively. The presence of these dissolved metal oxide nanoparticles enhances combustion by promoting cleaner combustion and reducing ignition delay. Consequently, the engine-specific consumption is reduced [11, 12].

Water and diesel are framed into emulsion mixtures by using surfactants [13, 14]. O/W, W/O, and multiple (O/W/O and W/O/W) emulsion methods are used to stabilize water and diesel [15]. W/O emulsion is a strong bonding for the stabilization of water emulsions [16]. During the combustion process, these suspended water particles absorb heat from the cylinder walls and reduce the cylinder temperature, resulting in a reduction in the oxides of nitrogen and particulate matter [17]. Water emulsion leads to a longer delay, resulting in potholed engine operation and a longer ignition delay [18, 19].

Nanoparticles and Nanofluids act as a fuel additive to enrich the combustion rate and reduce emissions [20]. The addition of a nanocatalyst to diesel fuel improves fuel oxidation and reduces the ignition delay period time [21]. The doping of nanoparticles and the thermal brake efficiency of engine performance can be improved by reducing the emissions of CO, HC, and NO_x [22]. In diesel engines, improved events in the heat transfer rate, and thermal conductivity of nano fluid and diesel blends are helpful and the blend preposition helps to form long-term stability and good dielectric property. When using nanofluids, NO_x rates increase because of the high latent heat of vaporization [23].

The Internet of Things technology is the most efficient system for continuous monitoring of emissions, but there have been many techniques and precautions implemented in order to control emissions. Internet of Things (IoT) technology is a revolutionary, wireless health monitoring tool that integrates embedded sensors, actuators, and RFID tags to improve operations, enhance daily activities, and monitor health care [24]. A wireless communication system is well suited to measure and interpret urban environmental indicators and natural resources. In the European Union, smart IoT technology is currently being used to monitor and update emission standards. Smart IoT systems continuously collect and transmit data to detect natural threats. Using web applications, it reports back to the user whether they are threats. Intelligent mobility (e.g., route stability, smart metro traffic, vehicle tracking, and Internet of vehicles), smart living (e.g., healthcare, tourism, education, buildings, and public safety), smart environment (e.g., monitoring of city air quality, air pollution, trees, water quality, green spaces, weather, waste collection, vehicles parking emission monitoring, management, and energy efficiency), smart citizens, smart government, smart economy, and smart architecture and technologies all benefit from it [25]. IoT can be used in various applications, such as monitoring and controlling press shop assembly, weather forecasting, prediction of plant leaf diseases, and food processing units [26, 27].

The aforementioned literature concludes that a reduction of NOx for diesel engines has different methodologies. Among that nanofluid was used as a fuel additive because very rarely implemented in the engine literature studies for the reduction of NOx. Furthermore, this study was carried out to reduce emissions and continuously monitor the emissions with IoT as a future scope in a different way.

The main objective of this work is to focus on controlling the emissions of oxides of nitrogen, hydrocarbons, and carbon monoxide as well as improving combustion by blending nanofluids in a diesel engine. The secondary objective of this work is to develop specific IoT technology aids for the continuous monitoring of emissions in diesel engines at regular intervals of time.

2. Experimental Setup and Process

2.1. Emulsion Fuel Preparation. Water is a polar substance, whereas diesel is nonpolar in nature. Both polar and nonpolar molecules are unbondable in nature. To obtain a homogenous mixture, a process called emulsification was implemented. Al_2O_3 nanoparticles dispersed in water emulsions significantly improve the properties of thermophysical combustion. The incorporation of nanoparticles into a base fluid is a vital process. Therefore, special care was required. The prepared nanofluid must be an agglomerate-free stable suspension for extended periods without sedimentation.

Generally, for the preparation of nanofluids, the two-step method is optimistic, easy, and less expensive. The steps involved in preparing the nanofluid were as follows: a specific amount of γ-Al_2O_3 nanoparticles, Tween-20, and distilled water. Distilled water was poured into a beaker and nanoparticles and Tween-20 were slowly poured and stirred with a magnetic stirrer. Water and Al_2O_3 were thoroughly mixed using an ultrasonicator for at least one hour to obtain a nanofluid. Figure 1 shows a flow diagram for the preparation of the nano-fluid using a two-step method. Figure 2 shows SEM and TEM Images of the aluminum nanoparticles.

After the preparation of the nanofluid based on the blending ratio, the aqueous nanofluids were titrated with diesel fuel. A 3% NWED, 7% NWED, and 12% NWED emulsion blended ratio was prepared for experimentation. The properties of the diesel and emulsion blend are shown in Table 1.

2.2. Experimental Equipment Specification. The investigation was conducted on a single cylinder naturally aspirated vertical water-cooled diesel engine with a rated power of 5.12 kW at 1500 rpm and a compression ratio of 17.5 : 1. Figure 3 shows a

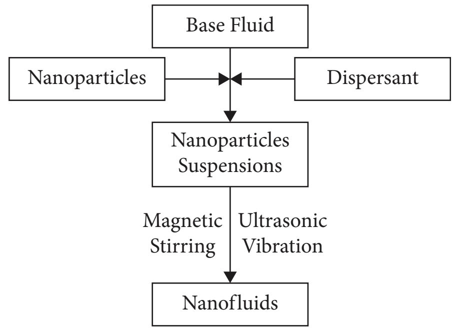
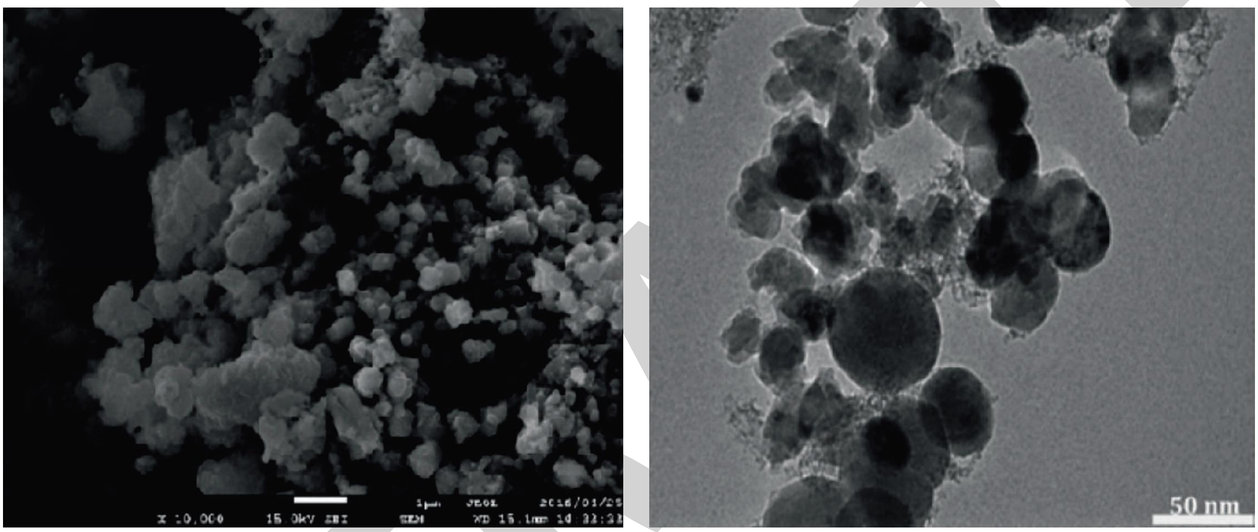


Figure 1: Procedure to prepare nanofluids using the two-step method.



(a) (b)

Figure 2: SEM and TEM image of Alumina nanoparticle.

Table 1: Properties of fuel.

Test description	Reference		Diesel	Al_2O_3 water emulsion blend		
	Unit	Limit	B0	3% NWED	7% NWED	12% NWED
Density	Gm/cc	0.800–0.900	0.832	0.833	0.846	0.854
Calorific value	MJ/kg	34–45	42.70	41.85	39.33	38.89

Figure 3: Photographic views of diesel engine.

detailed view of the diesel engine and explains the details of the engine that had been used for experimentation. The specifications and model names of the emission analyzers are also mentioned in detail in Tables 2 and 3.

(i) Diesel engine specification

(ii) Five gas analyzers

2.3. Statistical Analysis

(a) Brake-specific fuel consumption

$$\text{Bsfc} = \frac{\text{Fuel flow in (kg/Hr)}}{\text{Brake power (kW)}} \text{X } 100. \quad (1)$$

Table 2: Engine model: Kirloskar engine TV 1.

Type	Four stroke, single cylinder vertical water-cooled diesel engine
Rated power	5.12 kW
Rated speed	1500 rpm
Bore dia (D)	87.5 mm
Stroke (L)	110 mm
Compression ratio	17.5 : 1
Dynamometer	Eddy current dynamometer make: Techno mech Model: TMEC-10

Table 3: Details of five gas analyzer.

Model	AVL DI GAS 444 N
Measurement data	Resolution
Co-0–15% vol	0.0001% vol
HC-0-20000 ppm vol	1 ppm/10 ppm
NOx 0–6000 ppm vol	1 ppm vol

(b) Brake thermal efficiency

$$\text{BTE} = \frac{\text{Brake Power (kW)} X\ 3600}{\text{FuelFlow (Kg/Hr)X CalorificValue (KJ/Kg)}} \text{X } 100. \quad (2)$$

The aforementioned equations were used for statistical analysis of brake-specific fuel consumption and brake thermal efficiency.

2.4. IoT Emission Setup. The Internet of Things is the ability to transmit data over a network, without the need for a computer, for humans or a human, provided by interconnected computing devices, mechanical and digital machines, objects, animals, or unique identifiers to each other. Initial deigning of the IoT kit used, Thinker CAD helps in executing the weather the algorithm suits the program. Figure 4 shows the circuit diagram for multiple gas sensors connected to the emission monitoring device layout. Finally, using the Arduino board all emission sensors are connected, and the code is uploaded to the board which executes the program easily. Figure 5 shows the IoT setup of the emission monitor device.

IoT requires a cloud for storing and sharing the data obtained from the kit. ThingSpeak is an open-source server that helps to transmit live emission data stored in the cloud and to visualize and analyze diesel emission results for analysts.

2.5. Uncertainty Analysis. There was no error-free experimental setup. Errors may occur owing to the inaccuracy of devices or instruments, inaccurate calibration, and lack of humanity; therefore, before starting any experimental work, uncertainty analysis is mandatory. To obtain the uncertainties of the independent and performance characteristics, a sequential perturbation technique was employed. These include the air flow rate (1.1%), engine load (0.1%), fuel flow rate (0.1%), and engine speed (1.3%). As a result, the

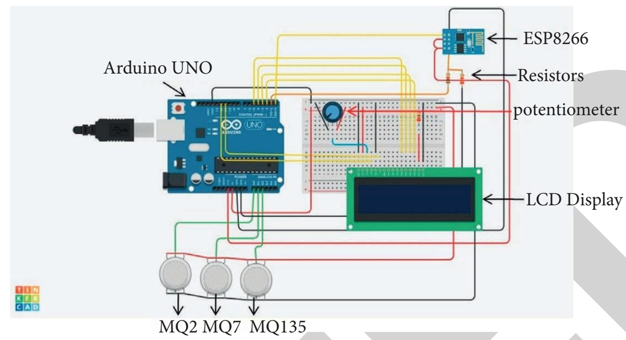


Figure 4: The circuit diagram for multiple gas sensors connected emission monitor device.

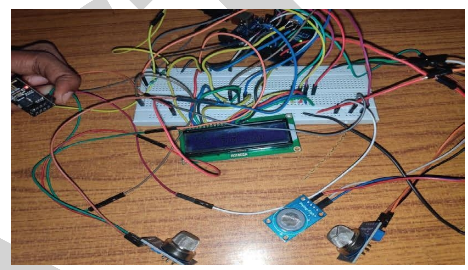


Figure 5: Emission monitors device IoT setup.

calculated accuracy of the performance and combustion study for both nano-based water emulsion and diesel-run engines were found to be within ±3.6. However, the emission accuracy was within ±2.1%. Generally, the uncertainty calculation value is obtained using the following equation:

$$R = \sum X_i^2, \quad (3)$$

where R = root mean square value of the uncertainty and X_i = parameter's uncertainty values.

The standard deviation formula is given as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - x^{-})^2}{N}}, \quad (4)$$

where σ = standard deviation, x_i = terms given in the data, $\overline{x}$ = mean, and N = total number of terms.

The standard error formula is given as follows:

$$\text{SE} = \frac{\sigma}{\sqrt{N}}, \quad (5)$$

where SE = standard error, σ = standard deviation, and N = total number of terms.

Table 4shows the error chart for brake thermal efficiency, brake-specific fuel consumption and emissions at regular intervals of time operation.

3. Results and Discussion

3.1. Performance Analysis. The brake-specific fuel consumption (BSFC) of the engine using diesel and the three types of nano-W/D under different load conditions with constant speed are illustrated in Figure 6. As shown in the

Table 4: Error chart.

	Brake power (kW)	Brake thermal efficiency (%)	Brake-specific fuel consumption (kg\kWh)	Carbon monoxide (%)	Hydro carbons (Ppm)	Oxide of nitrogen (Ppm)	Smoke (%)	Time of operation (min)
	2.61	27.73	0.31	0.025	27	991	14.7	30
	2.61	27.73	0.32	0.026	25	990	14.6	60
	2.61	27.74	0.29	0.025	27	991	14.7	90
	2.61	27.73	0.31	0.025	27	992	14.7	120
	2.61	27.74	0.31	0.024	26	991	14.8	180
Mean	2.61	27.73	0.31	0.025	26.4	991	14.7	
Standard deviation	0	0.005	0.011	0.0007	0.89	0.71	0.07	
Standard error	0	0.002	0.005	0.0003	0.4	0.32	0.03	
Upper control limit	2.61	27.745	0.343	0.0271	29.67	992.13	14.91	
Lower control limit	2.61	27.724	0.295	0.024	25	990	14.6	

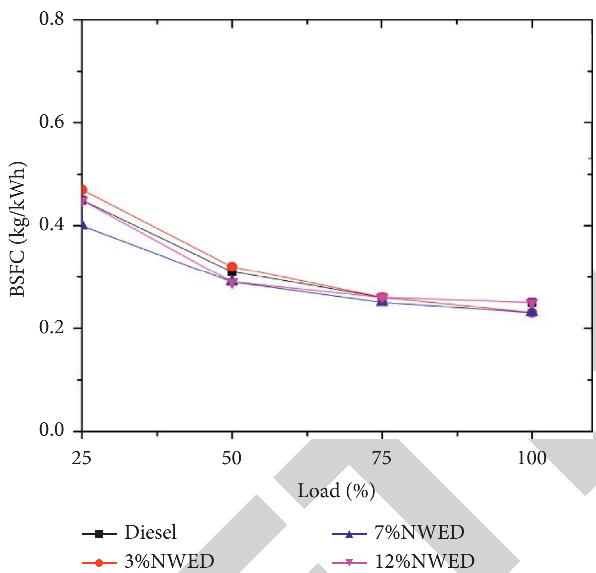


Figure 6: Load vs. BSFC.

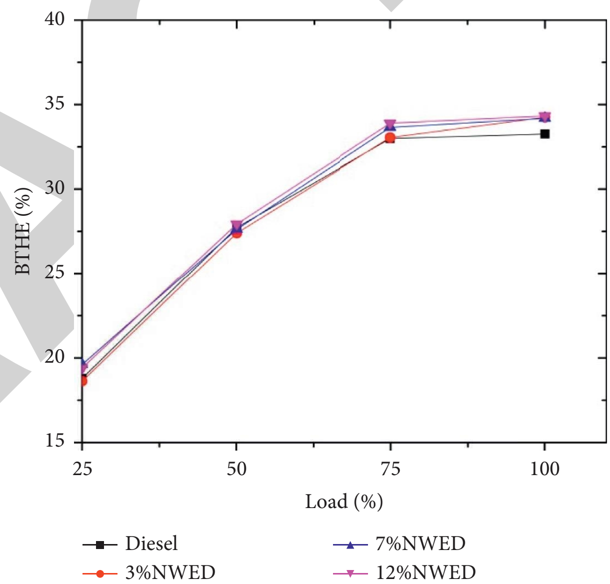


Figure 7: Load vs. BTHE.

graph, all three nano-W/D ratios show that BSFC at initial loads is high owing to the lower heating value in the presence of nano-based water emulsion and gradually reduces when the load is increasing, which indicates that the fuel burns in the engine effectively at higher engine loads. While running the engine with nano-W/D no identities are found in misfiring or unusual behavior. The potential benefit of water in diesel nanoemulsion fuels are as follows: (i) The overall impact of the secondary atomization and microexplosion phenomenon, resulting in strong evaporation and better mixing of air and changes in improving the combustion reactions inside the engine cylinders, (ii) Improved air-penetration in the spray due to increased spray momentum, (iii) Better-premixed combustion due to ignition delay, (iv) Increase in excess air ratio due to the presence of water in the emulsion, (v) Reduction of cooling loss due to a decrease in combustion temperature, (vi) Quash of thermal dissociation as a result of dropping in combustion temperature, and (vii) The presence of Al_2O_3 nanofluid in diesel emulsion that triggers less combustion gas release. Both 7% and 12% NWED blends show better fuel consumption, and it was observed that 7% NWED showed better load conditions. If the percentage of emulsion increases, the cylinder temperature decreases owing to the water percentage and its effect on combustion and emissions.

Figure 7 shows the variations in brake thermal efficiency of γ-Al2O3 with water and diesel test fuels under different engine loads. Compared with diesel and nano-based water emulsion blends, the blends showed an improvement in performance at higher loads. This is due to the addition of γ-Al2O3 in water and diesel at high temperatures; these mixtures turn into hydro-liquid fuel and emit high energy in the combustion process. Figure 8 clearly shows that the brake thermal efficiency increased at different concentrations of aqueous nanofluid emulsion on diesel engines with different loads. The percentage of aqueous nanofluid increased the brake thermal efficiency at higher loads.

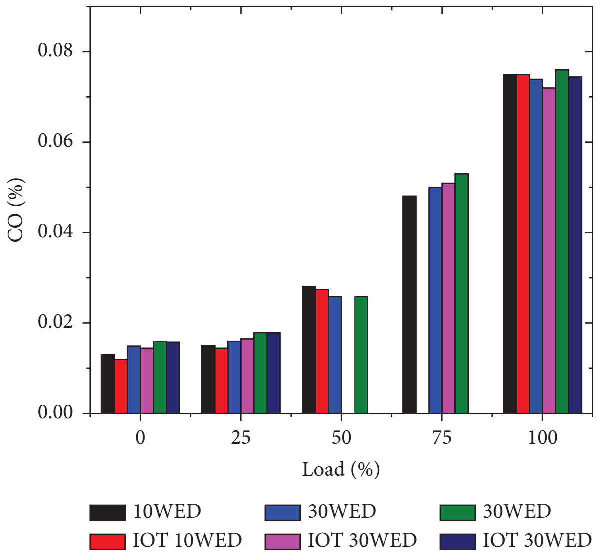


Figure 8: Load vs. CO.

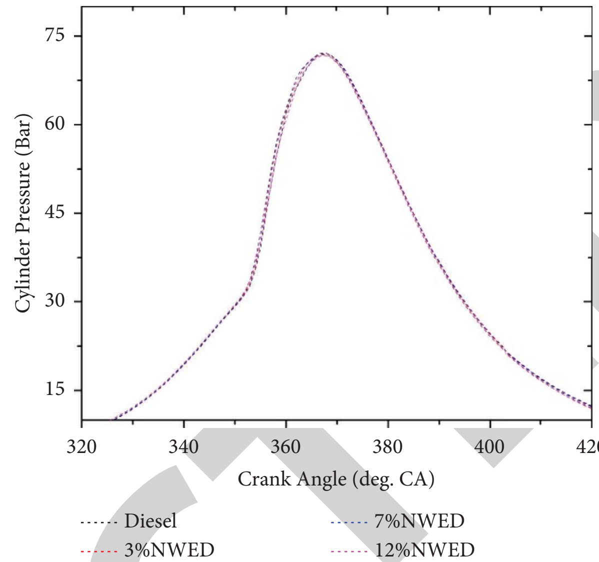


Figure 9: Crank angle vs. cylinder pressure.

3.2. Combustion Analysis. Figure 9 shows the crank vs. cylinder pressure at full load with diesel, 3%, 7%, and 12% aqueous γ-Al2O3 emulsion blends. The peak pressures at full load on diesel are 71.99 bar, 71.82 bar, 72.17 bar, and 71.75 bar at 23°. BTDC injection timing. In addition, the cylinder pressure is improved owing to the better atomization of air and nano-W/D fuel particles during ignition, which helps to improve the heat release rate inside the engine cylinder.

Figure 10 shows the rate of heat released inside the combustion chamber with different fuel blends under full load conditions in diesel engines. The addition of γ-Al_2O_3 with water and diesel at the time of surface flame formation causes, water and nanoparticles to penetrate and convert water into hydrogen gas, and γ-Al_2O_3 procures a sufficient amount of oxygen for better atomization to improve the combustion rate. When compared with aqueous blends, the 7% NWED blend showed the best results.

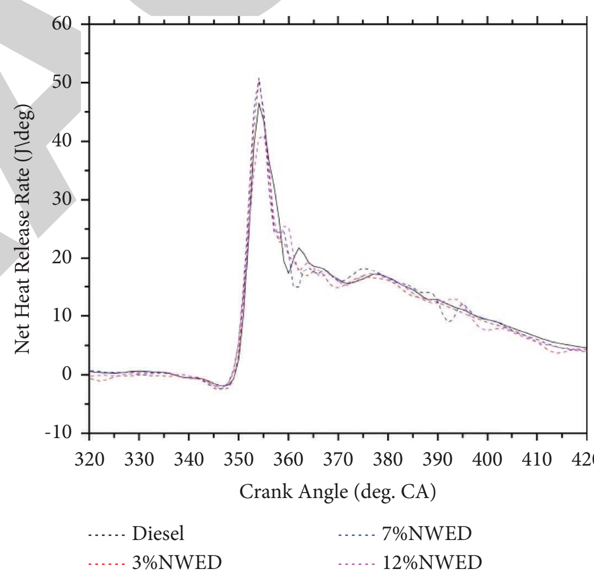


Figure 10: Crank angle vs. net heat release rate.

3.3. Emission Analysis. According to Zeldovich's approach, the formation of nitrogen oxides depends on oxygen density, the time required for formation, and temperature. In water with high oxygen content, the water content within the inner phase absorbs the calorific heat charge of the emulsion. Consequently, this reduces the burning gasoline temperature during the combustion and consequently restricts the generation of NOx. At the time of combustion, the aqueous solution vaporized and tended to reduce the flame temperature. Figure 11 shows the variation between NOx and the load. Compared with diesel, the emulsion blends showed little difference in the graph. This is because γ-Al2O3 reduces the cylinder wall temperature inside the engine chamber, thus restricting the NOx formation. An increase in the percentage of aqueous emulsions reduced the NOx level. The average reduction of 3%, 7%, and 12% NWED for every load were 31.46%, 38.76%, and 45.48%, respectively.

Figure 12 shows the CO formation at various loads. The formation of CO depends on the air-fuel ratio. The lean mixture led to the low CO formation in the CI engines. By the addition of γ-Al2O3 in water emulsion diesel formation of OH levels, leads to a clean and high combustion rate and clearly shows that incomplete combustion is reduced. When the percentage of aqueous γ-Al2O3 increased, it enhanced the rate of combustion, and the nanoparticles provided a sufficient amount of oxygen to help reduce CO and HC emissions. Figure 13 shows HC versus load. In the 7% NWED blend, the diesel engine showed a reduction in HC and CO emissions compared with diesel. Nanoparticles provide a surplus of oxygen molecules at a higher load to complete the combustion process.

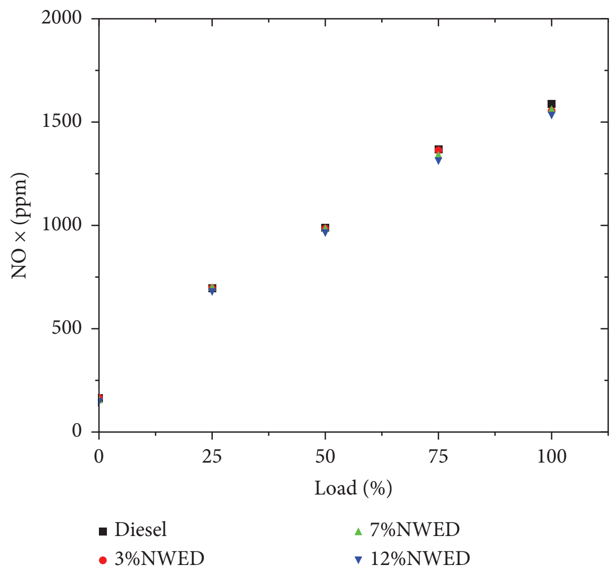


Figure 11: Load vs. NO_x.

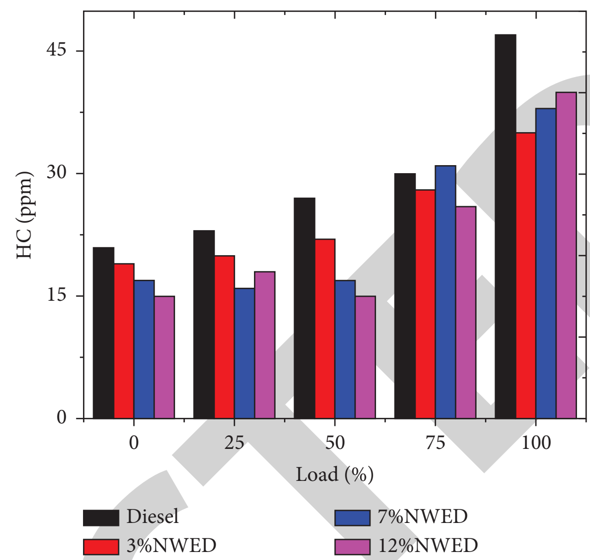


Figure 13: Load vs. HC.

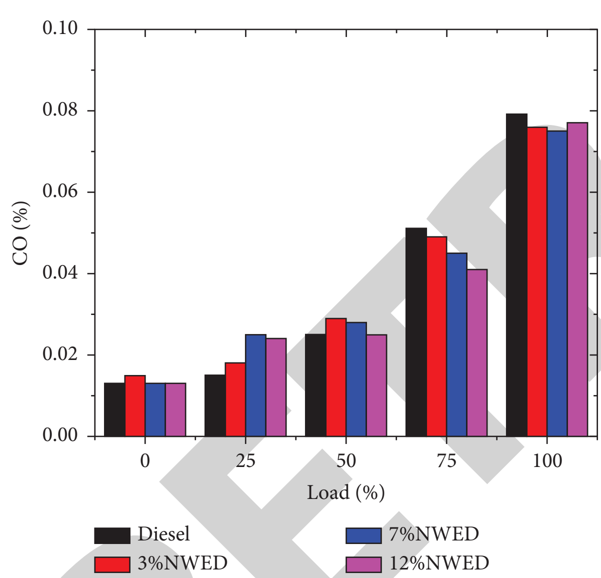


Figure 12: Load vs. CO.

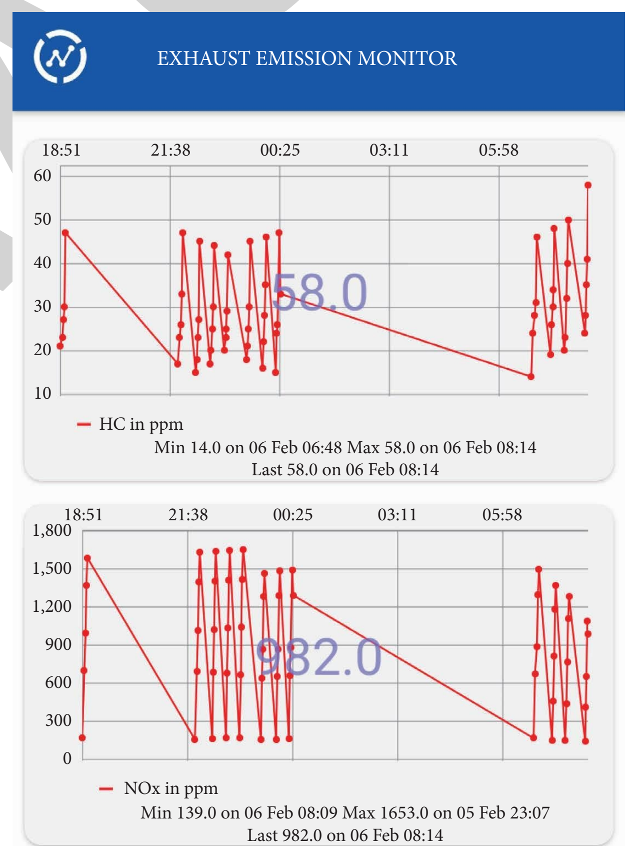


Figure 14: The channel opens the access to read the data stored (portrait mode).

3.4. Emission Analysis with IoT. Emissions are monitored with the help of AVL DI GAS 444 N. AVL compulsorily needs a human presence for collecting the emission data and it is an expensive process. In the 20^{th} century Internet of things (IoT), there are tremendous changes in the usage of mechanical equipment and the monitoring system. With the help of IoT and the arrangement of its auxiliary components without the presence of human need emissions would be recorded and sent to the server. By comparing the IoT kit and AVL gas analyzer the emission values are aqua-rated. Figure 14 shows the emission monitoring data visualized in the system. The comparison of HC, CO, and NOx with both analyzers shows that the variations vary around ±0.2 as shown in Figures 8, 15, 16.

3.4.1. Carbon Monoxide (CO). A comparison of CO emissions with the five gas emission analyzer and IoT emission kit is shown in Figure 8. Carbon monoxide is produced during incomplete combustion. Anything that leads to incomplete combustion increases CO production. In other words, as the

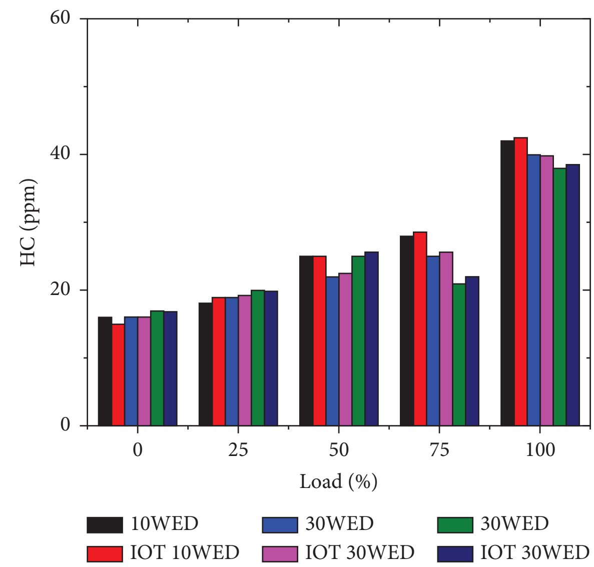


Figure 15: Load vs. HC.

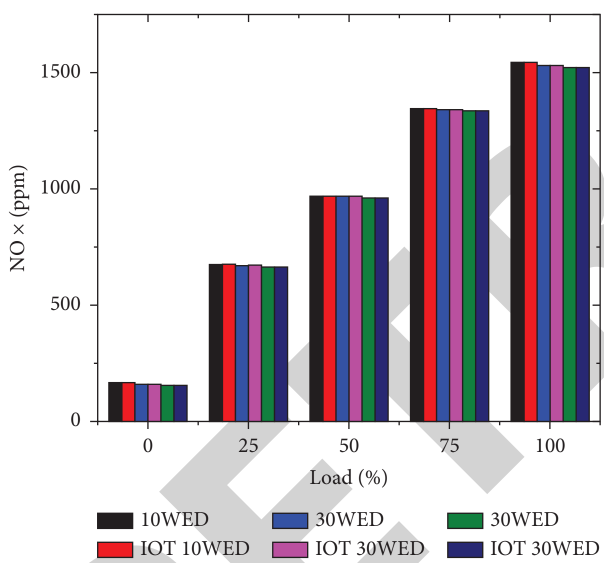


Figure 16: Load vs. NOx.

load increases, CO emissions increase, as a lower combustion temperature results in higher CO emissions.

3.4.2. Hydrocarbons (HC). In an engine, there is a small amount of fuel oil, rich in hydrocarbons, which pass through unburnt, while other hydrocarbons are produced during combustion. As a result, hydrocarbons are mainly particles of unburned or partially burned fuels. Additionally, lubrication oil emits hydrocarbons. The variation in hydrocarbon emissions with load is shown in Figure 15.

3.4.3. Oxide of Nitrogen (NO_x). At high temperatures, combining oxygen with nitrogen results in nitrogen oxides (NOx) released into the atmosphere. The two types of emission analyzers are shown in Figure 16 to illustrate the variation in NOx emissions.

4. Conclusion

In this study, emphasis was placed on the impact of an aqueous nanofluid diesel emulsion on diesel engine performance, combustion, and emission characteristic in comparison with diesel. Based on the results and investigation, the following conclusions were drawn:

(1) It has been observed that the brake-specific fuel consumption is reduced to 4.2% when compared with diesel on the addition of γ-Al_2O_3 in water emulsion. However, the engine brake thermal efficiency slightly improved when compared with aqueous nanofluids diesel emulsion, and diesel fuel.

(2) With the addition of aqueous γ-Al_2O_3 to diesel, the combustion rate, and cylinder pressure exhibited almost the same peaks. Further, increases the blend percentage of aqueous γ-Al_2O_3 it affects in-cylinder temperature.

(3) In the combustion process, the addition of aqueous γ-Al_2O_3 to diesel produces a surplus amount of oxygen atoms to complete the effective combustion inside a diesel engine, which helps to reduce HC, NO_x, and CO.

(4) The IoT emission monitoring kit helps for continuous monitoring of emission data.

Nomenclature/Abbreviations

Al_2O_3:	Aluminum oxide
BSFC:	Brake-specific fuel consumption
BTDC:	Before top dead center
BTHE:	Brake thermal efficiency
B0:	Pure diesel
CAD:	Computer-aided design
CO:	Carbon monoxide
CO2:	Carbon dioxide
HC:	Hydrocarbons
Gm/cc:	Gram per cubic centimeter
IOPs:	Injecting opening pressures
IoT:	Internet of Things
Kg\kWh:	Kilogram/kilowatt-hour
KW:	Kilo Watt
Mj/kg:	Mega joules per kilogram
Mm:	Millimeter
Min:	Minute
NWED:	Nano-based water emulsion Diesel
NOx:	Nitrogen oxides
OH:	Hydroxyl radical
O/W:	Oil-in-water
O/W/O:	Oil-in-water-in-oil
Ppm:	Parts per million
RFID:	Radio-frequency identification
Rpm:	Revolutions per minute
SEM:	Scanning electron microscope
TEM:	Transmission electron microscope

W/D: Water/diesel
W/O: Water-in-oil
W/O/W: Water-in-oil-in-water.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

References

[1] B. Dudley and S. Dale, *BP Statistical Review of World Energy*, London, UK, June 2018.
[2] P. J. Landrigan, R. Fuller, S. Fisher et al., "Pollution and children's health," *Science of the Total Environment*, vol. 650, pp. 2389–2394, 2019.
[3] A. Mahalingam, D. B. Munuswamy, Y. Devarajan, and S. Radhakrishnan, "Emission and performance analysis on the effect of exhaust gas recirculation in alcohol-biodiesel aspirated research diesel engine," *Environmental Science and Pollution Research*, vol. 25, no. 13, Article ID 12641, 2018.
[4] L. Subramani and H. Venu, "Evaluation of methyl ester derived from Novel Chlorella emersonii as an alternative feedstock for DI diesel engine & its Combustion, Performance and Tailpipe Emissions," *Heat and Mass Transfer*, vol. 55, no. 5, pp. 1513–1534, 2019.
[5] R. Shan, J. Shi, B. Yan, G. Chen, J. Yao, and C. Liu, "Transesterification of palm oil to fatty acids methyl ester using K2CO3/palygorskite catalyst," *Energy Conversion and Management*, vol. 116, pp. 142–149, 2016.
[6] C. Y. Lin and H. A. Lin, "Engine performance and emission characteristics of a three-phase emulsion of biodiesel produced by peroxidation," *Fuel Processing Technology*, vol. 88, no. 1, pp. 35–41, 2007.
[7] C. Srinidhi, A. Madhusudhan, and S. V. Channapattana, "Parametric studies of CI engine at various injection strategies using biodiesel blended nanoparticles as fuel," *International Journal of Ambient Energy*, vol. 43, no. 1, pp. 117–127, 2022.
[8] M. Elkelawy, H. A. E. Bastawissi, K. K. Esmaeil et al., "Maximization of biodiesel production from sunflower and soybean oils and prediction of diesel engine performance and emission characteristics through response surface methodology," *Fuel*, vol. 266, Article ID 117072, 2020.
[9] M. R. Mitchell, R. E. Link, M. J. Kao, C. C. Ting, B. F. Lin, and T. T. Tsung, "Aqueous aluminum nano-fluid combustion in diesel fuel," *Journal of Testing and Evaluation*, vol. 36, no. 2, Article ID 100579, 2008.
[10] C. Srinidhi, A. Madhusudhan, and S. V. Channapattana, "Comparative analysis of exhaust gas recirculation and nanoparticles on the performance and emission of diesel engine fuelled with Neem biodiesel blend," *International Journal of Ambient Energy*, vol. 43, no. 1, pp. 290–299, 2022.
[11] C. Srinidhi, A. Madhusudhan, and S. V. Channapattana, "Effect of NiO nanoparticles on performance and emission characteristics at various injection timings using biodiesel-diesel blends," *Fuel*, vol. 235, pp. 185–193, 2019.
[12] C. Srinidhi, A. Madhusudhan, S. V. Channapattana, S. V. Gawali, and K. Aithal, "RSM based parameter optimization of CI engine fuelled with nickel oxide dosed Azadirachta indica methyl ester," *Energy*, vol. 234, Article ID 121282, 2021.
[13] C. Y. Lin and K. H. Wang, "Diesel engine performance and emission characteristics using three-phase emulsions as fuel," *Fuel*, vol. 83, no. 4-5, pp. 537–545, 2004.
[14] B. Tal-Figiel, "The formation of stable w/o, o/w, w/o/w cosmetic emulsions in an ultrasonic field," *Chemical Engineering Research and Design*, vol. 85, no. 5, pp. 730–734, 2007.
[15] A. L. Márquez, G. G. Palazolo, and J. R. Wagner, "Water in oil (w/o) and double (w/o/w) emulsions prepared with spans: microstructure, stability, and rheology," *Colloid and Polymer Science*, vol. 285, no. 10, pp. 1119–1128, 2007.
[16] W. Yuan, F. Wu, M. Guo, and T. Jin, "Development of protein delivery microsphere system by a novel S/O/O/W multi-emulsion," *European Journal of Pharmaceutical Sciences*, vol. 36, no. 2-3, pp. 212–218, 2009.
[17] J. S. Basha and R. B. Anand, "An experimental study in a CI engine using nanoadditive blended water–diesel emulsion fuel," *International Journal of Green Energy*, vol. 8, no. 3, pp. 332–348, 2011.
[18] K. A. Subramanian, "A comparison of water–diesel emulsion and timed injection of water into the intake manifold of a diesel engine for simultaneous control of NO and smoke emissions," *Energy Conversion and Management*, vol. 52, no. 2, pp. 849–857, 2011.
[19] S. Radhakrishnan, D. B. Munuswamy, Y. Devarajan, and A. Mahalingam, "Performance, emission and combustion study on neat biodiesel and water blends fuelled research diesel engine," *Heat and Mass Transfer*, vol. 55, no. 4, pp. 1229–1237, 2019.
[20] J. S. Basha and R. B. Anand, "Effects of nanoparticle additive in the water–diesel emulsion fuel on the performance, emission and combustion characteristics of a diesel engine," *International Journal of Vehicle Design*, vol. 59, no. 2/3, p. 164, 2012.
[21] S. Karthikeyan and A. Prathima, "Emission analysis of the effect of doped nano-additives on biofuel in a diesel engine," *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, vol. 38, no. 24, pp. 3702–3708, 2016.
[22] A. Prabu and R. B. Anand, "Emission control strategy by adding alumina and cerium oxide nano particle in biodiesel," *Journal of the Energy Institute*, vol. 89, no. 3, pp. 366–372, 2016.
[23] Y. Devarajan, D. B. Munuswamy, B. Nagappan, and A. K. Pandian, "Performance, combustion and emission analysis of mustard oil biodiesel and octanol blends in diesel engine," *Heat and Mass Transfer*, vol. 54, no. 6, pp. 1803–1811, 2018.
[24] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): a vision, architectural elements, and future directions," *Future Generation Computer Systems*, vol. 29, no. 7, pp. 1645–1660, 2013.
[25] F. Mattern and C. Floerkemeier, "From the internet of computers to the internet of things," in *From Active Data Management to Event-Based Systems and More*, pp. 242–259, Springer, Berlin, Heidelberg, 2010.
[26] C. Srivastava, S. Singh, and A. P. Singh, "IoT-enabled air monitoring system," in *Intelligent Systems, Technologies and Applications*, pp. 173–180, Springer, Singapore, 2020.
[27] C. Nandi, R. Debnath, and P. Debroy, "Intelligent control systems for carbon monoxide detection in IoT environments," in *Guide to Ambient Intelligence in the IoT Environment*, pp. 153–176, Springer, Cham, New York, NY, USA, 2019.