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Proceeding Paper

Effects of Water-Based Nano-Fluid Emulsions on Pollutant Emissions Using an Internet-of-Things-Based Emission Monitoring System †

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Abstract: The objective of this study is to investigate the impact of employing water nano-emulsion technology in mitigating pollutants in diesel engines and controlling emissions. The diesel used in this experiment was prepared by blending it with a water-based nano-emulsion, comprising 8% of the total mixture. The integration of the Internet of Things (IoT) facilitated the implementation of a multi-user remote management system for diesel engines, enabling real-time monitoring of emissions. An 8% combination of water-based nano-emulsion (WBNE) reduces oxides of nitrogen and hydrocarbons better than diesel, according to trials using an IoT kit and gas analysers.

Keywords: water-based nano-emulsion; IoT; emission monitoring system; CI engine

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1. Introduction

Due to the increasing daily rates of fossil fuel depletion, increasing energy demands must be satisfied by non-fossil fuel sources. In order to meet the need for energy, since the 1970s, there has been a considerable growth in the use of energy resources, such as oil, gas, coal, nuclear, and hydro energy resources [1]. Petroleum fuels are predominantly employed in the non-biodegradable domains of construction, transportation, and manufacturing. The emission of combustion-related substances into the atmosphere, including carbon monoxide, carbon dioxide, hydrocarbons, nitrogen oxides, and particulate matter, occurs through exhaust pipes. The release of these pollutants leads to chemical processes inside the atmosphere, thereby giving rise to a greenhouse effect [2]. The main focus of numerous research studies has been to reduce emissions and enhance the performance of diesel engines. As a result, alternative fuels that do not have any negative impact on the engine have been identified [3]. Extensive research has been conducted on biodiesel due to its prominent role as a primary diesel fuel. In order to enhance performance and reduce pollution, researchers have employed a range of strategies, such as the selection of diverse biodiesel feedstocks and the modification of engine settings. These modifications include adjustments to injecting opening pressures (IOPs), fuel injection timings, compression ratios (CRs), and the incorporation of additives like diethyl ether and antioxidants [4]. As a result, biodiesel blends exhibited reduced emissions of carbon monoxide (CO), hydrocarbons (HC), and smoke, although they had greater levels of combustion exhaust gas temperature, carbon dioxide (CO_2), and nitrogen oxide (NOx) emissions compared to diesel fuel [5,6]. The objective of this study is to enhance the combustion process in diesel engines with the use of nano-fluids, with the ultimate aim of reducing the emissions of nitrogen oxides, hydrocarbons, and carbon monoxide. An additional objective of this effort is to advance Internet-of-Things technologies capable of monitoring diesel engine emissions at scheduled intervals.

2. Experimental Setup and Procedure

2.1. Fuel Preparation

In the context of the natural environment, molecules can be categorised into two groups: polar and nonpolar. It is important to note that both polar and nonpolar molecules share a common characteristic, namely their inability to establish chemical bonds. The emulsification technique was employed to attain a consistent and homogeneous amalgamation. The introduction of scattered Al_2O_3 nanoparticles into aqueous emulsions results in an improvement in thermophysical combustion properties. The integration of nanoparticles into a host fluid holds significant significance. Consequently, a particular emphasis was necessitated. The production of nano-fluids involves the development of a stable solution that is devoid of agglomerates and exhibits prolonged resistance to sedimentation. The aqueous nano-fluids were titrated using diesel fuel subsequent to their preparation in accordance with the specified blending ratio. An emulsion blend consisting of 8% water-based nano-emulsion (WBNE) was created for experimental purposes.

2.2. Engine Setup

The study was conducted using a water-cooled diesel engine with a single cylinder. The engine was naturally aspirated and vertically mounted, with a compression ratio of 17.5:1. It had a rated power output of 5.12 kW at an engine speed of 1500 revolutions per minute. This section provides a detailed description of the engine that was utilised for the purpose of testing.

2.3. IoT Emission Setup

The utilisation of computer-aided design (CAD) facilitates the assessment of the compatibility between the algorithm and the software during the construction of the Internet of Things (IoT) kit. The present study focuses on the circuit design of diverse gas sensors that are interconnected with emission monitoring equipment. Ultimately, the connection between all emission sensors and the Arduino board is established, allowing for the instant execution of the programme subsequent to the successful uploading of the code. The Internet of Things (IoT) configuration of the pollution monitoring equipment.

3. Results and Discussion

3.1. Emission Analysis

The quantity of air present in the fuel has a direct influence on the quantity of carbon monoxide (CO) generated. The combustion rate was enhanced through the augmentation of the aqueous cerium oxide nanoparticle concentration, thereby facilitating the provision of a sufficient quantity of oxygen by the nanoparticles to effectively mitigate carbon monoxide and nitrogen oxide emissions.

3.2. Emission Analysis with IoT

The AVL DI GAS 444 N instrument is used to measure emissions. The acquisition of emission data in AVL systems requires the involvement of human operators, leading to substantial expenses. Through the 20th century, there were significant improvements in the usage of mechanical equipment and monitoring systems, which are largely credited to the creation of the Internet of Things (IoT). The utilisation of the Internet of Things (IoT) and its corresponding components enables the acquisition of emissions data and its subsequent transmission to a server, obviating the necessity for human intervention [7]. An examination of the IoT kit and the AVL gas analyser's results is used to compare the emission data. The analysis of HC and NOx, as seen in Figures 1 and 2, reveals differences of around ±0.2.

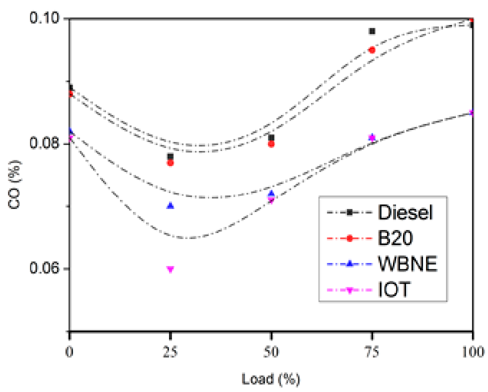

Figure 1. Variation in carbon monoxide with load.

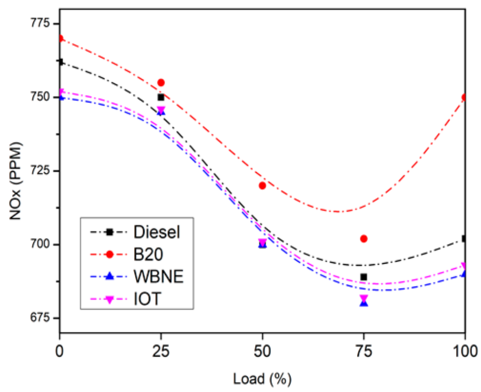

Figure 2. Variation in nitrogen oxides with load.

3.3. Carbon Monoxide

Figure 1 illustrates the relationship between load and carbon monoxide (CO) levels. It is observed that as the load increases, the CO levels also increase. This may be attributed to incomplete combustion occurring within the combustion chamber. The measured CO values are then compared to the ideal IOT values, which exhibit close proximity to each other.

3.4. Nitrogen Oxides

Figure 2 illustrates the relationship between NOx emissions and load. The chemical interactions occurring between nitrogen and oxygen constituents within the atmosphere of Earth lead to the creation of NOx, which encompasses a collection of molecules that display a notable reliance on temperature. due to the high temperatures that are generated during combustion. This study examines the influence of gas temperature and residence duration on a specific process. The reduction in NOx emissions occurred when the load was set to 75%, which can be attributed to a decrease in temperature within the cylinder.

4. Conclusions

The main aim of this study was to evaluate the effects of an aqueous nano-fluid diesel emulsion on the operating emission characteristics of a diesel engine in comparison to conventional diesel fuel. Based on the obtained results and subsequent analysis, the following deductions were made: This phenomenon has a significant role in reducing nitrogen oxide (NOx) emissions by 3% compared with diesel and carbon monoxide (CO) emissions by 14%. The emission monitoring kit for the Internet of Things (IoT) enables the continuous monitoring of emission data.

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