Performance and Emission Features of a Light Duty Diesel Engine Generator Powered with Water-Diesel Emulsions

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ABSTRACT

Today's world is being confronted with couple of issues, namely environmental degradation and oil crisis. The technical community has dedicated many methods to eradicate the harmful pollutants generated from diesel engine sectors to protect the ecological environment without ensuing any inferior effect with regards to brake thermal efficiency. In this research work, normal water is incorporated with diesel fuel in presence of surfactants (such as Span80 and Tween80) in specific proportions. The purpose of adding water with diesel fuel is to diminish the harmful pollutants, and to enhance the performance features of the diesel engine. In this research investigation, totally four phases of investigation have been carried out. In the first phase, the diesel engine generator was fueled with pure diesel fuel to obtain the baseline readings (from zero load to full load). In the second phase, two fuels of water-diesel emulsions (2% and 4% by volume) were prepared in the presence of surfactants with the aid of a digital overhead stirrer systematically. In the third phase, stability and thermal properties of waterdiesel emulsion fuels were determined. In the fourth phase, the stable water-diesel emulsion fuels were tested in a diesel engine generator and compared to those readings (performance and emission features) of pure diesel fuel. It was observed that on adding water to the diesel fuel, the performance features (such as brake thermal efficiency and brake specific fuel consumption) were improved, and

1. Introduction

According to the current global environmental pollution issues that are generated from the industrial and transportation sectors, there are numerous researches have been carried out to minimize the hazardous pollutants (such as, NOx (Nitrogen Oxides), CO (Carbon Monoxides), CO2 (Carbon Dioxides), and HC (unburnt hydrocarbons)) that are produced from the diesel engine.
Due to these harmful pollutants, the environment has been affected ecologically, resulting in considerable environmental issues (for instance, ozone layer depletion, global warming, and acid

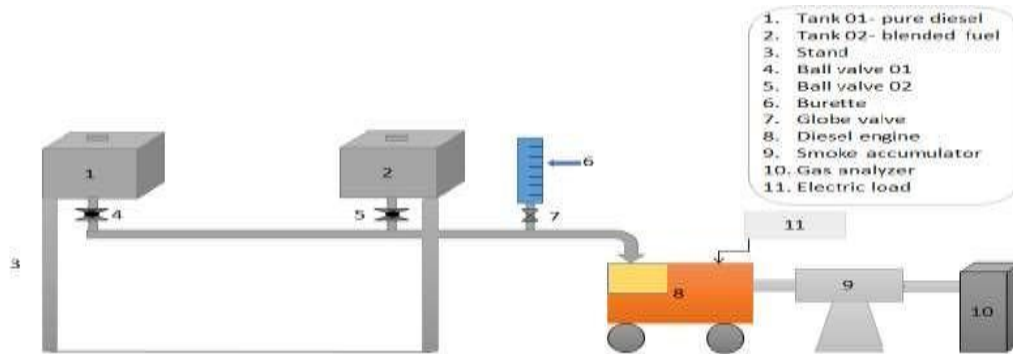www.istconf.org
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rain [1-5]. To protect our environment, many scientists and environmental researchers have concocted their efforts to eradicate the global environment hitches with regards to the diesel engine power applications. The global environmental issues can be eliminated by various methodologies, such as engine design alteration techniques, exhaust gas post-treatment techniques, and fuel modification techniques. Most of the researchers [1-19] preferred fuel modification methods than the other available techniques. This is due to the fact that the fuel modification is simply workable, and does not require any engine adjustments. In modern research fuel modification techniques, many engineers and scientists devoted many efforts to improve the base fuel properties (such as diesel fuel, biodiesel fuel, petrol fuel) on adding oxygenated additives, nanoparticle additives, and normal water. Currently, the research trend has been practiced on blending normal water with diesel fuels by a process called emulsification. Emulsification is a process of mixing normal water with diesel fuel or any fuel in the presence of emulsifiers. Recent researches have revealed that on adding water with the diesel fuel, the trend of improved performance and reduced emissions can be attained. Henceforth, in this research exploration, a normal water-diesel emulsion fuel modification technique is materialized on mixing diesel fuel and normal water in the presence of emulsifiers to evaluate the performance and emission attributes of a light-duty diesel engine generator.

2. Experimental Methodology

The experimentation of the current research work has been carried out systematically in accordance with international standards of testing and evaluation. A light-duty diesel engine generator connected with an electrical loading was utilized for the research investigation to evaluate the performance features (brake thermal efficiency and brake specific fuel consumption) and emission features (level of NOx, CO, CO2, HC) from zero load to full load. The emissions from the diesel engine generator were measured by a calibrated KANE gas analyzer. During the experimentation work, starting and stopping operation of the diesel engine generator was carried out on using the pure diesel fuel. The fuel consumption of each tested fuel was measured using a burette and stopwatch combination. Using the time taken values during the fuel consumption, the performance features of the diesel engine (i.e., brake thermal efficiency and brake specific fuel consumption) were determined.

Figure 1: Experimental Setup

1. Tank 01- pure diesel
2. Tank 02- blended fuel
3. Stand
4. Ball valve 01
5. Ball valve 02
6. Burette
7. Globe valve
8. Diesel engine
9. Smoke accumulator
10. Gas analyzer
11. Electric load

In this research investigation, totally four phases of investigation have been carried out. In the first phase, the diesel engine generator was fueled with pure diesel fuel to obtain the baseline readings. In the second phase, two fuels of water-diesel emulsions (2% and 4% of water by vol.) were prepared in the presence of surfactants with the aid of a digital overhead stirrer systematically. In the third phase, stability and thermal properties of water-diesel emulsion fuels were determined. In the fourth phase, the stable water-diesel emulsion fuels were tested in a diesel engine generator and compared to those readings (performance and emission features) of pure diesel fuel. With regards to performance and emission attributes of the diesel engine generator, the following characteristic curves will be studied for both diesel and additive blended diesel fuels: 1. Fuel consumption vs Engine Load
2. Emissions (NOx, CO, CO2, HC) vs Engine Load

3. Results and Discussions

The features of diesel engine generator in terms of performance and emissions on using diesel and water-diesel emulsion fuels have been discussed in this section.
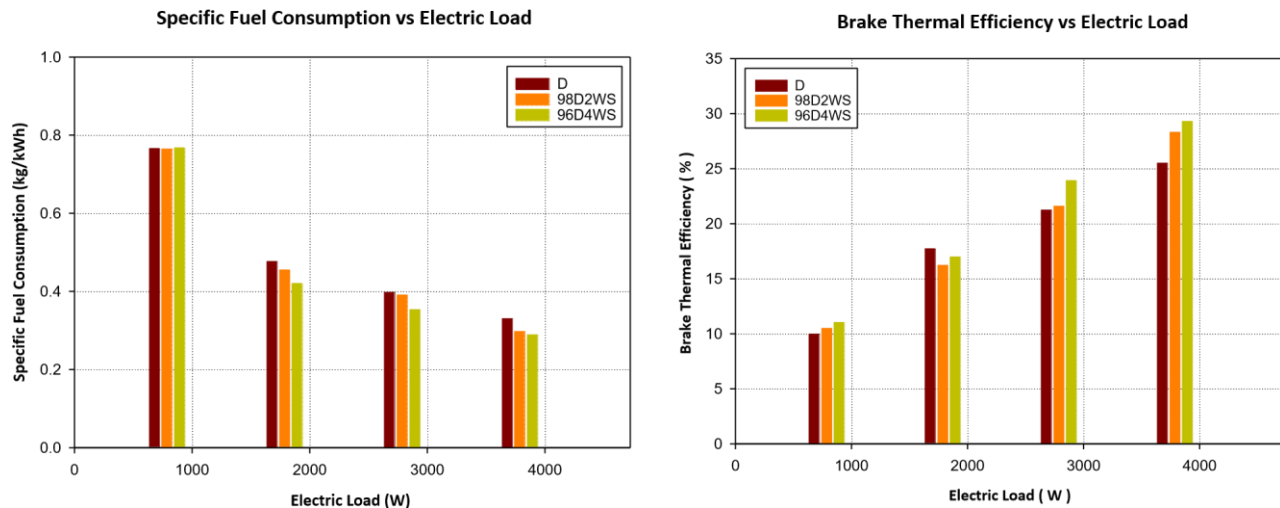
3.1 Performance Attributes of the diesel engine generator

Figure 2 and Figure 3 reveals about the brake thermal efficiency and specific fuel consumption (performance characteristics) of the diesel engine generator for all the tested fuels. It is observed from the figures that water-blended diesel fuels reflected lesser fuel consumption compared to that of neat diesel fuel. This could be due to the fact that water mixed diesel fuels consumed lesser fuel to maintain the diesel engine speed constant. Further, it could be also due to the micro-explosion and secondary atomization effects [Sadhik and Anand, 2011]. Due to secondary atomization effects, the water mixed diesel fuels could have ameliorated the degree of fuel-air mixing in the engine cylinder, and thereby enhanced the brake thermal efficiency [20]. Increased brake thermal efficiency of water mixed diesel fuels have reflected decreased brake specific fuel consumption. This is due to the fact that the brake thermal efficiency and brake specific fuel

consumption are inversely proportional to each other. Figures 2 and 3 also reveals that on increasing the water content with the diesel fuel, the brake thermal efficiency feature was increased compared to that of neat diesel. At the full load (4000 W), the fuel consumption for the neat diesel was 0.331 kg/kWh; whereas it was 0.298 kg/kWh and 0.289 kg/kWh for the 98D2WS and 96D4WS respectively. A similar trend of enhanced brake thermal efficiency was noted for the water mixed diesel fuels compared to that of neat diesel fuel. At the full load (4000 W), the brake thermal efficiency for the neat diesel was 25.52%; whereas it was 28.33% and 29.32% for the 98D2WS and 96D4WS respectively.

*Figure 2 and Figure 3: Performance Features variation of Diesel and Water blended diesel fuels*

3.2 Emission Attributes of the diesel engine generator

The following Figures 4, 5, 6 & 7 indicates the emission levels of diesel fuel and water mixed diesel fuels. Improved quality of water blended diesel fuels has led to better combustion attributes in the engine cylinder. Owing to these effects, the magnitude of the emission levels (CO, CO2, HC, and NOx) were significantly reduced for the water mixed diesel fuels while comparing to that of neat diesel fuel. The presence of water in diesel fuel has significantly influenced to reduce the harmful emissions for the water mixed diesel fuels. In accordance with the secondary atomization and micro-explosion effects associated with the water mixed diesel fuels, there could have been effects of decrement in combustion temperature and improved mixing of diesel, water droplets and air [11-19]. Owing to this fact, the combustion efficiency of the water mixed diesel fuels could have ameliorated better than that of neat diesel fuel. At the full load (4000 W), the CO emissions for the neat diesel was 0.22% (by vol.); whereas it was 0.05% and 0.04% (by vol.) for the 98D2WS and 96D4WS respectively. A similar trend of reduced NOx emissions was noted for the water mixed diesel fuels compared to that of neat diesel fuel. At the

full load (4000 W), the level of NOx emissions for the neat diesel was 412 ppm; whereas it was 391 ppm and 384 ppm for the 98D2WS and 96D4WS respectively. A similar trend of marginal reduction of HC emissions were noted for the water mixed diesel fuels compared to that of neat diesel fuel. At the full load (4000 W), the level of HC emissions for the neat diesel was 75 ppm; whereas it was 72 ppm and 70 ppm for the 98D2WS and 96D4WS respectively.

Figure 4,5, 6 and Figure 7: Emission Features variation of Diesel and Water blended diesel fuels
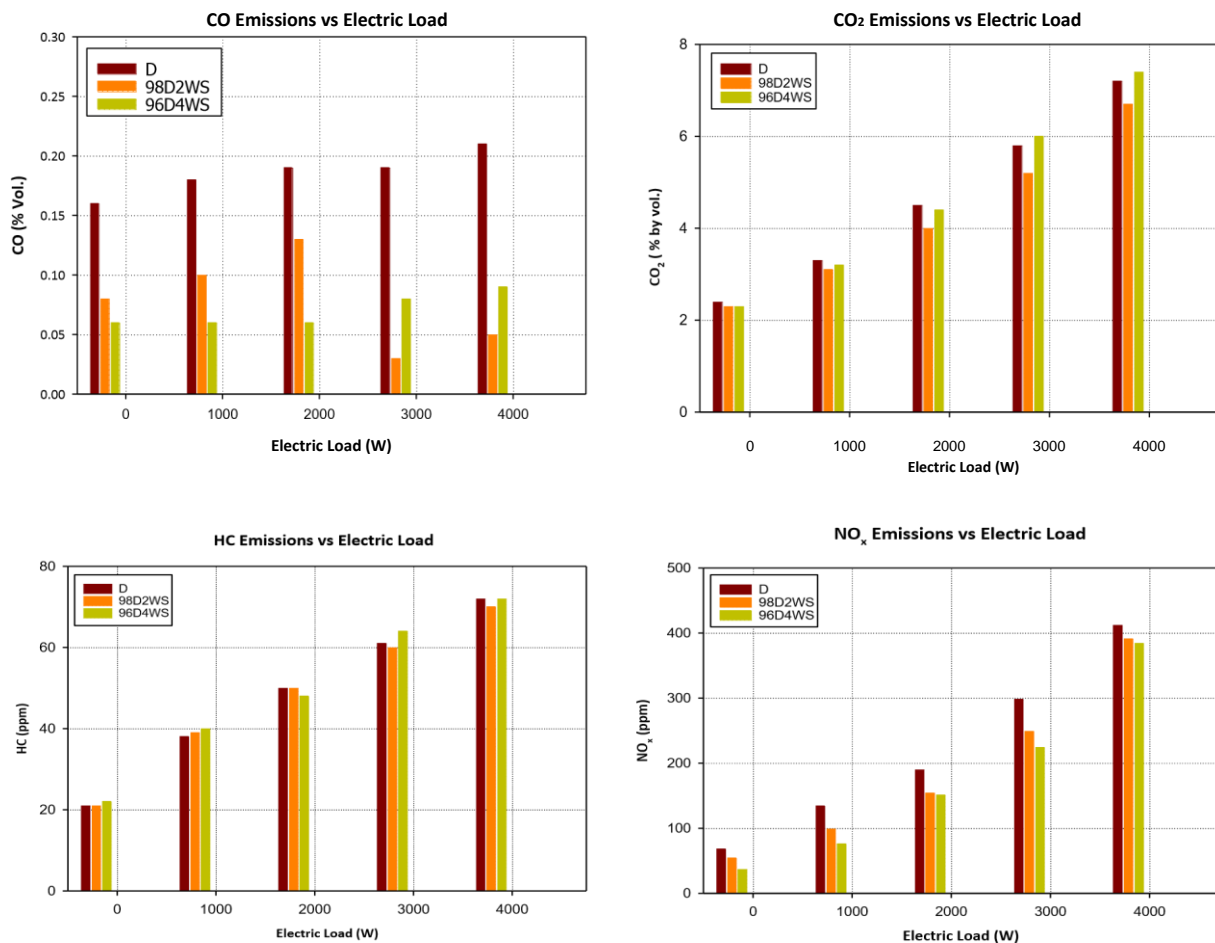
4. Conclusions

With a determination to enhance the performance feature and reduce emissions from a diesel engine generator, the current analysis was carried out on blending water with diesel fuel. On carrying out the experiments, the following conclusions were drawn:

- The stability of the water mixed diesel fuels (98D2WS, 96D4WS) was more than two weeks under static conditions.
- There was no abnormal noise or starting difficulty during the entire experimentation using water mixed diesel fuels.
- Water mixed diesel fuels have considerably improved the working aspects of the diesel engine generator.
- At all the loads, the monoxides of carbon and oxides of nitrogen of the water mixed diesel fuels were convincingly reduced. At the full load, the CO pollutants for the neat diesel was 0.22% (by vol.); whereas it was 0.05% and 0.04% (by vol.) for the 98D2WS and 96D4WS respectively.

Overall, it is established that 4% of water with diesel fuel has the potentiality to ameliorate the working attributes of diesel engine generator.

Acknowledgment

Nomenclature

CI	-	Compression Ignition
CO2	-	Carbon Dioxides
CO	-	Carbon Monoxides
D	-	Diesel
HC	-	Hydrocarbons
NOx	-	Nitrogen Oxides
PM	-	Particulate Matter
98D2WS	-	98% of Diesel + 2% of Water+Surfactant
96D4WS	-	96% of Diesel + 4% of Water+Surfactant

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