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Research paper

Energy Analysis of Diesel Engine Using Diethyl Ether Under Different Loading Condition

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Abstract

In the recent scenario needless to say consumption of the fossil fuels to make energy available for utilisation in different purposes, leading to the progress of the country, results in the depletion of the underground resources of fuels at a very high rate. The present paper analyses the energy, exergy and performance of a compression ignition (CI) engine using diesel and diethyl ether blends. The results are calculated at different engine loads at a constant compression ratio of 18:1. It is found that the exergy efficiency, maximum combustion gas temperature, brake thermal efficiency increases with increase in engine load. The all blends of fuel the exhaust gas temperature and destruction of exergy increases with increase in load.

Keywords: *diesel engine; exergy; diethyl ether; emission; energy*

1. Introduction

From the economic point of view the effective and efficient combustion of a liquid fuel to make available sufficient energy to be utilised in the transport vehicles, with the minimum generation of harmful toxic gasses in the products of combustion thereby reducing environmental pollution [1, 2]. From the literature it is found that using biodiesel their performance and emissions parameters improved [3, 4, 5]. Exergy is destroyed mostly as low temperature heat transfer [6]. The exergy content of a natural material input can be interpreted as a measure of its quality or potential usefulness [7]. Patil et al. [8] used DI diesel engine for obtaining the details pertaining the process of combustion, engine performance and emission parameters in the exhaust. DEE was used as a fuel with the additives like kerosene and diesel. DEE was blended with diesel in dissimilar proportions. The trade-off of the engine between particulate matter (PM) and NO got reduced by the use of the DEE-diesel blend as compared to diesel alone. The engine performance was optimum with the use of DE15D blend. The effect of diethyl ether (DEE) on the functioning of DI diesel engine using water-diesel emulsion was experimentally studied by Subramanian et al. [9]. A ratio of 0.4:1 (by weight) of water-diesel was maintained in the emulsion. The NO_x and smoke levels got reduced with no adverse effect on the BTE with the addition of DEE along with water-diesel emulsion. Karabetas et al. [10] included diesel fuel, dual fuel containing DEE as an additive. 5% and 10% of DEE was blended with diesel respectively to constitute the pilot fuel. At low and medium loads CO and HC emissions increased with the use of dual fuel and the same decreased at high engine loads. Ethanol addition to diesel–DEE blends increased the efficiency of the engine [11]. Attempts were made [12] to obtain a reduction of NO_x and smoke emissions in a diesel engine. The fuels used for operation consisted of pure diesel and DEE-diesel blends. Rath et al. [13] found that the destruction of exergy was measured to have a higher value for B60 at full load as compared to diesel, B20 and B40. The main focus of this paper is to analyze the energy, exergy and performance of a CI engine using pure diesel & diethyl ether in different blends (5%, 10% and 15%) with diesel at variable loads.

2. Experiment

2.1. Experimental Setup and Procedure

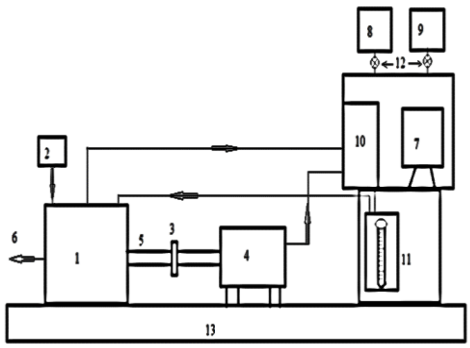

Figure 1: Actual experimental setup

1. Engine 5. Shaft 8. Diesel
Tank 12. Valve
2. Air Filter 6. Exhaust 9. Other Tank
13. Bed
3. Coupling 7. Computer 10. Data
Acquisition System

A Kirloskar made, 661cc capacity, naturally aspired, four stoke, and single cylinder diesel engine developing a maximum power of 3.5kW at 1500rpm is used to conduct the experiment. The engine

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is connected to an eddy current dynamometer. The engine could be gradually loaded by actuating a knob on the dynamometer. A load indicator indicates the engine load. Layout of the engine is given in figure 1.

Panel box housing, a manometer, air tank, fuel measuring unit, devices for measurement of fuel flow and air flow including the engine load indicator is used for recording the experimental results. Fuel is supplied from a 15 lt capacity fuel tank mounted on the top of the panel box with appropriate connections for fuel flow. The cylinder pressure is used by the help of a piezo sensor. A rota- meter provided the measured data pertaining to the amount of cooling water flow. Engine rpm is measured by a Kubler make digital rotary encoder with a range of 1 to 10000 rpm. The compression ratio of the engine is 18. The test rig (engine) contains the following components; a loading unit, an air flow unit, calorimeter, pressure sensors etc. Software package "Engine SoftLV" version 8.51 has been used to record the details of the measured experimental parameters related with the experiment. The experiment is started with zero load condition to full load condition at a constant compression ratio of 18. Fuel consumption is measured using a burette in the data acquisition system. The tests were conducted using neat diesel and blends of diethyl ether (DEE5, DEE10 and DEE15). The data were stored in a computer for further use.

2.2. Preparation of Diethyl Ether

Diethyl ether is used as a premixed fuel because of its high latent heat of vaporization allowing a denser fuel–air charge, and excellent lean-burn properties. DEE was blended with diesel at a proportion of 5% (DEE5), 10% (DEE10), and 15% (DEE15) that is 50ml, 100ml and 150 ml of DEE mixed with 950ml, 900ml and 850 ml of diesel.

3. Results and Discussion

3.1. Brake Specific Fuel Consumption (BSFC)

The variation of BSFC at different loads is shown in Figure 2. It seen that the BSFC decreases with increase in load. It is due to decrease in pumping losses with increasing load. As compared to diesel mode a DEE15 combination results in a 15.78% decrease in the BSFC. This decreased BSFC is recorded as 0.32 kg kWh^{-1} at 80% engine load. It is evidence to Patil and Thipse [14]. The decrease in the BSFC with DEE addition is related with the improved combustion processes due to a upper cetane number of DEE in additions to its low boiling point and additional oxygen content that suppresses the unfavorable combustion characteristics [15, 16].

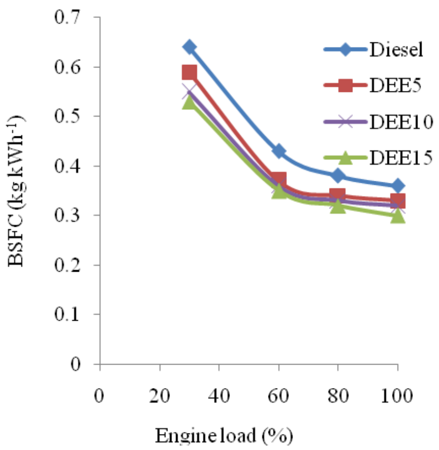

Figure 2: Variation of BSFC with engine load.

3.2. Brake Thermal Efficiency (BTE)

Figure 3 shows the BTE of the engine at different engine loads. BTE increases with an increase in engine load due to a reduction in ignition delay, loss of heat and increase in output power. DEE15 gives, BTE increases to 27.12% at 80% engine load, the increased being higher compared to the case when the engine is run in the diesel mode. DEE additions increase in the BTE is due to fast evaporation of DEE that without difficult mix with air forming a complimentary mixture for combustion. Also the accompanied additional oxygen availability with DEE additions also improves the BTE. The maximum brake thermal efficiency is obtained by 29.44% for DEE15 at full load.

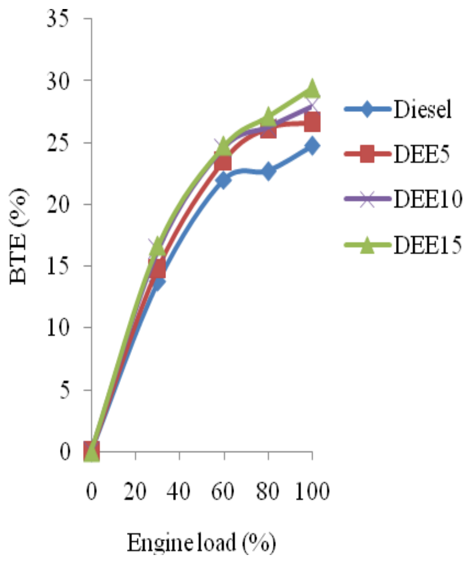

Figure 3: Variation BTE with Engine load.

3.3. Exhaust Gas Temperature (EGT)

Variation of EGT with engine load is shown in Figure.4. It is found that the EGT increases with increase in engine load. At higher loads fuel prosperity increases and combustion is less. An EGT value of DEE15 is 304.95°C at 80% engine load when the engine is run in the DEE15 mode. This is about 5% lower than the EGT recorded when the engine is run in the diesel mode. This lowering of the EGT is due to a decrease in boiling point of DEE with an elevated cetane number. EGT is decreased when the engine is run by the DEE15 fuel-mix, the blend decreasing the ignition duration. The elevated warm of vaporization of DEE also decreases the in-cylinder temperature there by lowering the EGT. Cylinder temperature there by lowering the EGT.

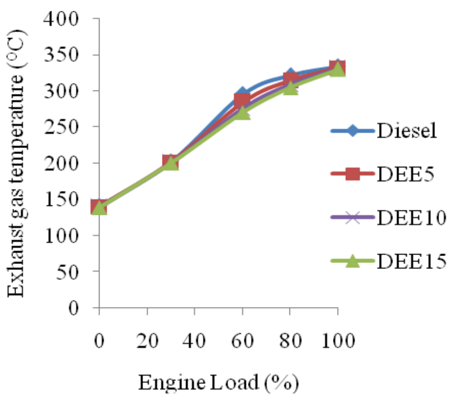

Figure 4: Variation of EGT with engine load.

3.4. Maximum Combustion Gas Temperature (MGT)

The variation of maximum combustion gas temperature with load is shown in Figure 5. Maximum combustion gas temperature enhance with enhance in load for diesel and diethyl ether blends. This is due to the fact that with increase in load the heat release rate increases. DEE15 blend decrease the maximum combustion gas temperature to 1230°C at 100% engine load. As compared to the diesel, the value of the maximum combustion gas temperatures is 6.81% lower. This decrease in the maximum gas temperature may be recognized to the reduction in the in-cylinder temperature on the account of the heat of evaporation of DEE which is absorbed from the total heat available in the cylinder. The DEE ignition becomes faster unaccounted of its low flash point and the heat so generated helps a better combustion of the associated diesel.

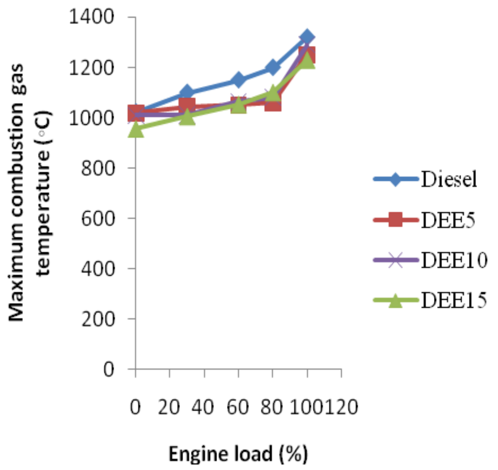

Figure 5: Variation of MGT with Engine load.

3.5. Destruction of Exergy

The variation of destruction of exergy for various loads is shown in figure 6. It is found that destruction of exergy enhance with enhance in load for all fuels tested due to increase in fuel richness cause additional energy and heat transfer loss. Destruction in exergy is found to be more for DEE15 as compared to diesel, DEE5 and DEE10 because of its higher viscosity which leads to incomplete combustion. The exergy destruction is caused by irreversibilities due to combustion of fuel, frictional losses and heat transfer losses. Destruction in exergy is found to be 15.95 kW, 15.57 kW, 14.47 kW, and 13.13 kW for DEE15, diesel, DEE10 and DEE5 respectively.

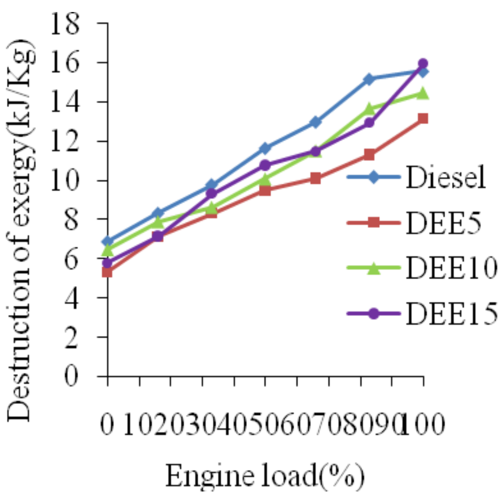

Figure 6: Variation of Destruction of exergy with Engine load.

3.6. Exergy Efficiency

The figure 7 shows the variation of exergy efficiency. It is found that the exergy efficiency enhance with enhance in load due to increase in the power output and decrease in the BSFC at higher loads. Exergy efficiency is measured higher for DEE10 as compared to other fuels. The reason may be due to the presence of inherent oxygen which leads to better combustion of the DEE10 blend. Exergy efficiency for DEE10, DEE5, diesel and DEE15 are found to be 34.82%, 31.46%, 30.33%, and 30.05% respectively.

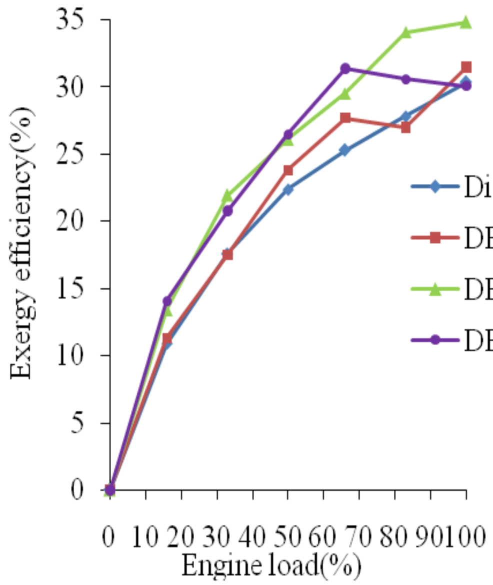

Figure 7: Variation of Exergy efficiency with Engine load.

3.7. Energy Balance Analysis

Figure 8.shows the percentage of energy with respect to different fuel at compression ratio 18 and 100% load. Total energy includes useful energy (UE), exhaust gas losses (EGL), cooling water losses (CWL) and unaccounted losses (UAL). The unaccounted loss is calculated by subtracting brake power, exhaust energy losses and cooling water losses from input energy. Exhaust gas loss increases as the blend % increases due to incomplete combustion, poor atomization. Cooling water loss also increases for higher blends due to more energy losses in combustion chamber. Result shows cooling water loss and exhaust gas loss for DEE15 is 31.13% and 18.5% respectively which is 26.7% and 5.1% higher compared to diesel.

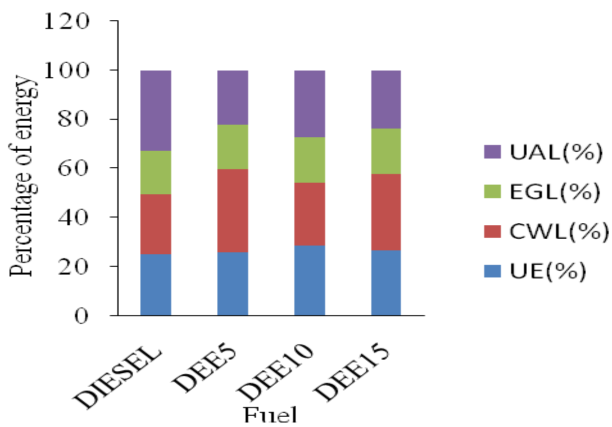

Figure 8: Percentage of energy Vs fuel at Compression ratio (18:1)

4. Conclusion

From this study it was found that the BSFC decreases with increase in load for all blends of fuel. DEE15 blend decrease the maximum combustion gas temperature to 1230°C at 100% engine load. The destruction of exergy increases with increase in load for all blends of fuel. The destruction of exergy was measured to have a higher value for DEE15 at 100% load as compared to diesel, DEE5 and DEE10. The exergy efficiency was observed to increase with higher compression ratio and load for all blends of fuels. Exhaust temperature higher with increase in load for all other blends of fuel. Exergy efficiency was obtained highest for DEE10 compared to DEE5 at 100% load. Brake thermal efficiency increases with increase in load.

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