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The effect of injection timing on energy and exergy analysis of a diesel engine with biodiesel fuel

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Introduction

Nowadays, due to higher environmental pollution and decreasing fossil fuels many countries make decisions to use renewable fuels and restrict using of fossil fuels. Renewable fuels generally produce from biological sources. Biodiesel is an alternative diesel fuel derived from the transesterification of vegetable oils, animal fats, or waste frying oils. Considering the differences between diesel and biodiesel fuels, engine condition should be modified based on the fuel or fuel blends to achieve optimum performance. One of the simplest and yet the most widely used models is the thermodynamic model. After verification of the data obtained by model with experimental data it is possible to generalize the extracted data to an unlimited number of functional conditions or unlimited number of fuel types which saves time and reduces costs for experimental engine tests. Using the second law of thermodynamics, it is possible to calculate and analyze the exergy of the engine.4

Materials and Methods

In this work, the zero-dimensional model was used to account for internal energy variations, pressure work, heat transfer losses to the solid walls and heat release. The applied assumptions include:

The cylinder mixture temperature, pressure and composition were assumed uniform throughout the cylinder. Furthermore, the one-zone thermodynamic model assumes instantaneous mixing between the burned and unburned gases. The cylinder gases were assumed to behave as an ideal gas mixture, Gas properties, include enthalpy, internal energy modeled using polynomial equations associated with temperature.

In this research, the equations 1 to 20 were used in Fortran programming language. The results of incylinder pressure obtained by the model were validated by the results of experimental test of OM314 engine. Then the effects of injection timing on Energy and Exergy of the engine were analyzed for B20 fuel.

Results and Discussion

Comparing the results of the model with the experimental data shows that there was a good agreement between the model and experimental results. The results showed that advancing fuel injection timing increases the peak cylinder pressure. When fuel injecting occurs before the standard injection timing, the pressure and temperature of the charged air in the cylinder is less than that of the fuel when it is injected at standard injection timing. Thus, ignition delay of the injected fuel extends further. As a consequence, the reaction between fuel and air improves, which prepares a good mixture for burning. When the combustion starts, the rate of heat release increases in the premixed or rapid combustion phase of the combustion process due to the suitability of the mixture of air and fuel and hence the peak pressure of cylinder increases. When the injection timing is retarded, the fuel is injected into charged air that has a high temperature and pressure. Thus, in the injection timing of 10 degrees before top dead center, the maximum of incylinder pressure and temperature are reduced compared to the standard injection timing. By retarding the fuel injection into the cylinder, the indicator availability, the heat loss availability by heat transfer from cylinder walls and irreversibility are increased and by advancing the fuel injection into the cylinder, the indicator availability, the heat loss availability by heat transfer from the cylinder walls and irreversibility are reduced. High temperature will increase the produced entropy, so by advancing the injection timing the produced entropy will increase while the retarding injection timing reduces the produced entropy. Exergy and energy efficiencies increased by advancing the injection timing. At 2000 rpm the total

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availability and heat loss availability by heat transfer was increased compared to 1200 and 1600 rpm.

Conclusions

The proposed model was able to predict the pressure and temperature of the cylinder at different injection timings. By advancing the fuel injection timing energy and exergy efficiency and heat loss availability by heat transfer was increased. At 2000 rpm the total availability and heat loss availability by heat transfer was increased.

Keywords: Biodiesel, Energy, Exergy, Injection timing