EFFECT OF INJECTION TIMING ON SINGLE CYLINDER DIESEL ENGINE WITH BIOFUEL

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ABSTRACT

The use of a diesel fuel blend in this study aims to investigate the effect of temperature on a single cylinder diesel engine. The use of GT-POWER software serves to simulate and analyze one-dimensional numerical on a single cylinder engine. Simulations on diesel engines operated using a fuel mixture or better known as fuel alternatives are conducted to investigate performance characteristics and emissions on a single cylinder diesel engine. The operation and simulation of this engine are done with a variety of temperature and different load conditions. The simulation results have been performed indicate that when the engine is operated by using a fuel mixture at different load and temperature brake power and also brake torque can be reduced. The difference shown is not so significant because the value of the energy composition has a very small gap. The increases in fuel consumption on specific brakes due to reduced energy content while reductions and also occur in thermal brake efficiency and engine performance when full load conditions. This study specifically discusses the simulation with the latest data on biodiesel found on GT-POWER by using a mixture of alcohol fuel into biodiesel commonly used on engines.

Keywords: Single cylinder, Fuel blends, Temperature fuel, Simulation, Injection timing.

INTRODUCTION

Nowadays, the environmental problems which caused by global warming and also the greenhouse effect are very high. The policies to use alternative fuels such as biodiesel or alcohol-based ones that are considered as renewable sources are very important to replace fossil diesel so that the emission of chlorine dioxide to the environment can be reduced. Many sources of oil can be produced into biodiesel, but of the many sources of palm oil becomes a more attractive option, because palm oil is easy to obtain and also has a lower price than others. The properties contained in the material can be identified so that we are easier to use. With more and more identification that we can do to the nature of the fuel, then we are easier to understand the combustion system of the fuel. To use fuel alternatives should be accurately predicted since the prediction of the physical properties of these alternative fuels is essential so that the combustion representation of the fuel produced can be known.

The type of ethyl ester or fatty acid methyl esters for this type is usually called biodiesel produced from a variety of different feedstocks and can automatically be used for engine fuel. This vegetable oil or animal fat is obtained from transesterification results added with methanol or other alcohol-based ones (Johari et al. 2015; Kareem et al. 2016; Mat Yasin et al. 2017b). A very feasible method of producing biodiesel fuel is through transesterification of alcoholysis. The alkaline liquid catalysts present in alcohols and also triglycerides are processed to give birth to a chemical reaction called potassium methoxide, or it can also be sodium. Methyl esters or as (biodiesel) formed through fatty acids and also glycerol are the reaction products of alcohols (Barik et al. 2017; Hoseini et al. 2017; Mat Yasin et al. 2017a; Ruhul et al. 2017). Physically as well as the chemical properties of all products of vegetable oils can be used (Abdul-Manan et al. 2014; Ozturk et al. 2017). The characteristics and composition contained from the liquid inside have similarities such as viscosity, number of deposits, energy levels, and phase changes, but have differences with the original diesel derived from petroleum. Although without having to make fuel modifications can be used on CI diesel engines and can also be mixed with petroleum such as diesel. Worldwide, these biodiesel fuels have been very well known from diesel because they have some very different benefits such as burning values and higher levels of impurities, while the lowest is in greenhouse gas emissions (Johari et al. 2015; Mat Yasin et al. 2017b).

The largest income of palm oil worldwide is in Malaysia as well as in Indonesia, and even these two countries have contributed the largest amount of palm oil to 85% (Mukherjee and Sovacool 2014; Renner et al. 2018.; Thapa et al. 2018). The progressive growth of palm oil production will be a very rapid fuel growth in various industries in the future. By 2020 it is estimated that the production of biodiesel fuel will increase by about 20% more and will annually reach 13 billion liters by 2020. The drastically increased production of biodiesel fuel occurs in Southeast Asia because the catch is very high potential (Mukherjee and Sovacool 2014; Thapa et al. 2018). The cheaper human resources and in tropical climates are the most suitable places to grow crops such as palm oil (Subramaniam and Hashim 2018; Umar et al. 2017). The European Union (EU) is the largest market for industrial exports that is the main target for marketing the products (Bourgeois and Sette 2017; Tomich et al. 2018).

High viscosity in vegetable oil can be reduced by using four methods so that its use allows for diesel engines without having to modify as engine deposits as studied among them by methods (mixing into petrodiesel, transesterification, pyrolysis, and micro emulsification) (Ge et al. 2017; Journal et al. 2016; University of Chicago Institute of Environmental Sustainability Biodiesel Program 2017). The projected biodiesel in the early stages observed by a simple technological process with basic purification required in modern diesel engines does not achieve very high quality (Ali et al. 2017; Chuah et al. 2017; Đurišić-Mladenović et al. 2018; Hasan and Rahman 2017). This study will analyze engine performance with new biodiesel data contained in GT-POWER as it does not exist in diesel as it is commonly used. This study aims to investigate the effects of performance and specifications on diesel engines fueled by alternative biodiesel fuels. The properties contained in biodiesel fuels vary significantly with those on diesel fuel. The analysis of the combustion process includes in-cylinder temperature, pressure, brake torque, heat transfer rate, BMEP, and BSFC.

SIMULATION AND SETUP

One-dimensional (1D) engine simulation model in general such as intake system, variable geometry turbocharger system (VGT) and also a compressor, injection system for fuel, exhaust system, engine cylinder, drain valve, and exhaust gas recirculation system. The one-dimensional simulation modeled with the development of four-stroke direct-injection (DI) diesel engine for single cylinders will be presented in this study. The engine modeling used in this study parameters and specifications in detail Table as shown in Table 2. While Table 1 describes the properties of the fuel used. Modeling for diesel engines in GT-POWER software is used as shown in Figure 1. The intake system for the machine used there is some data, size, and components are not the same. Initially, the system will start in the environment and end in the intake valve. The model for the GT-POWER has several components on the intake system such as air filter, import, environment, involve, and in turner. Some of the required data system components are equipped to be able to run the modeling simulations created. To support the performance of cylinder engines, exhaust gases, and fresh air intake systems into exhaust systems fueled by alternative fuels such as biodiesel, it should focus fuel injection systems for cylinder engines. All components such as data specifications and sizes must be adjusted and incorporated into the GT-POWER software. While the last system contained in a diesel engine is an exhaust system. The exhaust valve is the initial process of the system and then terminated in the environment. The exhaust system exhrunner, exhrunnerexit, export, exhwatve, exhaust, and also environment are all components contained in GT-POWER.

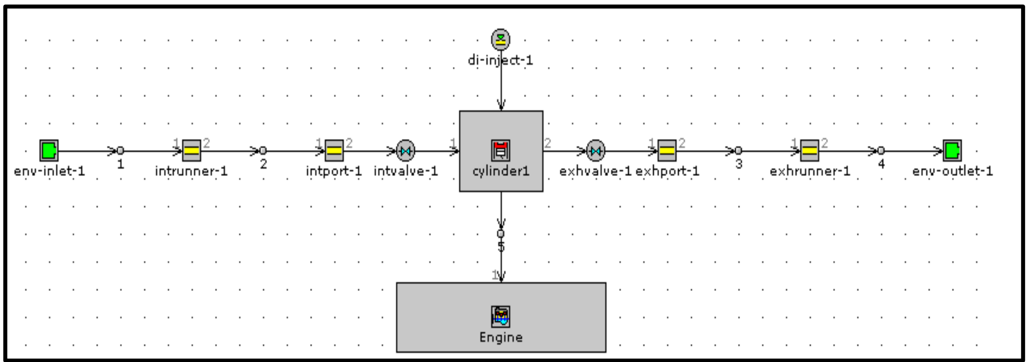

Figure 1: One-dimension modelling of single-cylinder cycle diesel engine (Mamat and Abdullah 2010)

Table 1: Properties of diesel and methanol

Vapor Fuel Properties	Diesel	Methanol
Kinematic Viscosity at 40°C mm^2/s	2.6	0.44
Specific heat capacity J/kg°C	1850	2545
Surface tension at 20°C N/m	0.023	0.023
Oxygen %weight	0	49.9
Density (kg/m^3)	82.8	792
Lower Heating Value (J/kg)	42.7	21.1
Boiling point °C	180-360	65

Table 2. Engine specifications of a four-cylinder diesel engine

Model	Yanmar Model TF120M
Type	Horizontal single-cylinder 4-stroke diesel engine
Bore (mm)	92
Stroke (mm)	96
Displace volume (cm^3)	638
Compression ratio	17.7:1
Continuous rating output	10.5 HP @ 2400 rpm
Maximum rating output	12.0 HP @ 2400 rpm
Fuel injection type	Direct Injection
Max power	7.7 kW @ 2400 rpm
Max torque	161 Nm @ 4500 rpm
Cooling system	Water-radiation
Fuel tank capacity	11L

This diesel engine model uses GT-POWER computation model with intake system model consisting of fuel injection, exhaust system model, and cylinder engine model. The intake system of a fuel injection system with a cylinder on connected engine into a cylinder and an intake system on a cylinder engine as well as an injection system for fuel. Orifficeconn works to connect all the components on a diesel engine. Modeling diesel engines with GT-POWER as software for its development if experimental has been completed used as shown in Figure 1. Modeling the system to be built requires data from the experimental results. Models built with GT-POWER need the information included from the library. This model does not require all item, unless necessary if there is additional information. However, a better starting point is a list of information in general. For the initial stage of the model being built, on some items, the optimum value should be determined as listed to allow this simulation to be run. To determine the optimal value, the parameters must be defined for certain attributes so that for some cases it can run. The characteristics of engines require data such as inline or V convection, compression ratio, V-angle, 2 or 4 strokes, and shooting sequence. The geometry for engine cylinders requires data such as connecting rod length, high piston TDC clearance, head area, offset pin, piston area, head bowl geometry, stroke, and also bore. All geometry component data is required for the exhaust system and also the intake. While the throttle location with the discharge coefficient versus the throttle angle for the throttle data both directions of different flow. Jumlag and injector location, injection speed, nozzle diameter and the number of nozzle holes, and also LHV and fuel type are data from fuel injectors. To lift the valve diameter, eyelash valve, the discharge coefficient is data derived from the exhaust and intake valve lash. While the temperature and also the humidity comes from the pressure area. Performance produces better data when model development is ready to build. Before the simulation of a newly built model is executed preparation is very important to do first. Preparation models that need to be reviewed include plot request, set up a case, setup run, and plot setup. The automatically all parameters are listed in the model so that each setting for the first simulation should be defined. Computing time on the simulation can be reduced by creating a simulator sequence in the run settings that can be used for initialization. Each section is required to select a plot or plot time corresponding to the data and engine specifications on GT-POWER. From each section, the requested plot will be stored depending on the user whether the prepared plot will be used for the simulation. When all the model preparations are ready for simulation, the GT-POWER will run the simulation, as long as the simulation run no longer exists for parameter change, if there is any parameter setting on GT-SUITE then it must be re-simulated, because the simulated data will be different when parameter changes in modeling.

RESULTS AND DISCUSSION

The simulation results will focus on the engine performance output. When GT-POWER is ready to run, the simulation results will produce different output files with different formats. The post-processing output data from GT-POST is mostly accessible, display and also data is possible to be manipulated using a graphical interface with data generated from the simulation. To see the results of analysis and animation can use GT-POST because this tool is very powerful for analysis with the simulation system. This simulation result provides very important information for the tabular simulation. With this result, engine performance can be configured on a diesel engine using standard parameters. In this result can also create a table by generating detailed data.

Notable analyzes of GT-POWER software with parameters and also engine responses are used to provide an understanding of better engine reactions when using diesel fuel with methanol to effect temperature on the fuel to be used. The fuel temperature analyzed by simulation starts from a minimum point up to a point between 300K and 500K. To be able to vary this testing machine starts at 1000-4000 rpm at every 500rpm increase with diesel-methanol fuel. This investigation is performed with varying engine performance such as brake engine torque, brake fuel consumption, brake power, effective brake pressure, and thermal brake efficiency. Any fuel temperature output will give the right reasons for their condition.

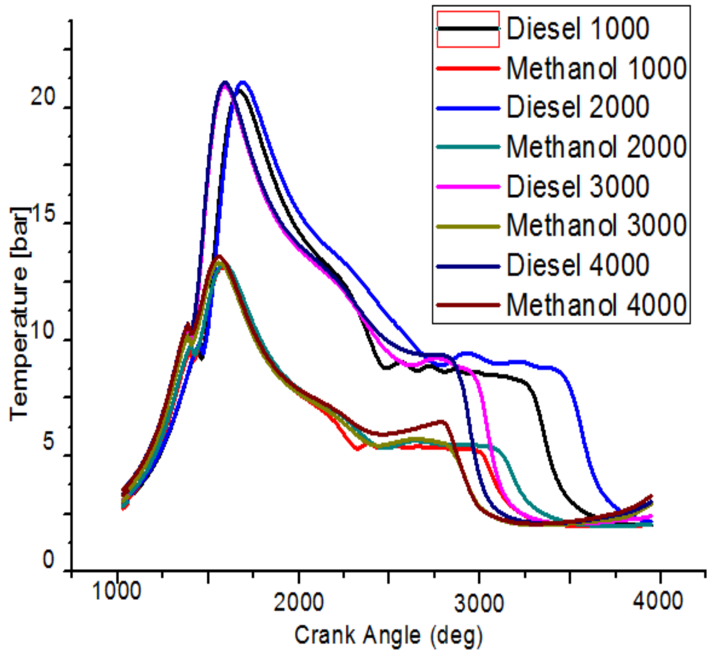

Figure 2. Effect of crank angle on In-cylinder temperature different load and fuel

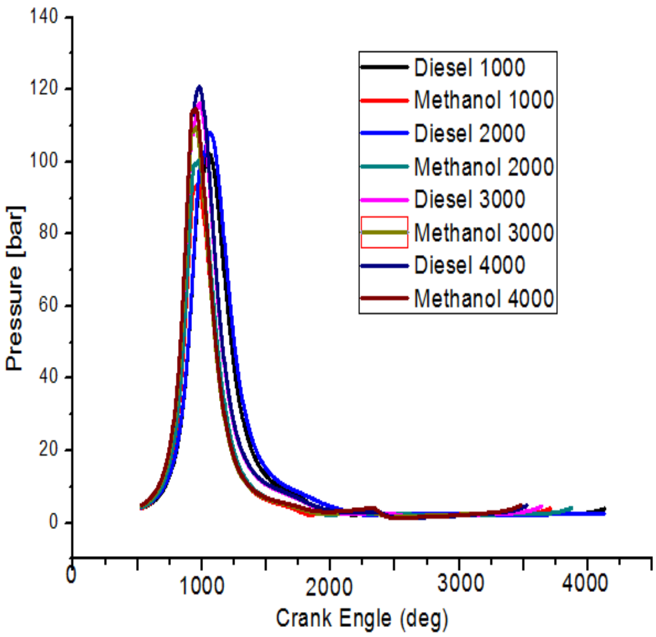

Figure 3. Effect of crank angle on In-cylinder pressure different load and fuel

The effect of diesel fuel temperature with methanol at different speeds on brake engine torque as shown in Figure 2. The simulation results for diesel engine temperature triggered with different fuels at speeds of 1000 to 4000 rpm indicate that the decline occurs in methanol fuel at all different speeds than diesel. Because diesel fuel has a higher cetane than methanol.

Figure 3 engine speed variations show a slightly more increased effect for fuel use between diesel and methanol. Based on the simulation results that at peak pressure with load 1000 and 4000 rpm, methanol slightly decreased compared to diesel. While diesel has less delay on ignition because the couture on the diesel is higher, so the pressure on the cylinder increases further. The decrease and increase of pressure shown on the graph line of ignition delay indicated that smaller occurs so that at the beginning of the initial burning the engine is operated more easily. However, when the displacement of the piston at work into the gas inside the cylinder will be very large at the end of the compression if the combustion is carried too early in the cycle. The peak pressure on the cylinder will decrease, in case of delay during combustion, so it will also reduce the expansion work when the gas to the piston displacement (Noor and Kadirgama 2010).

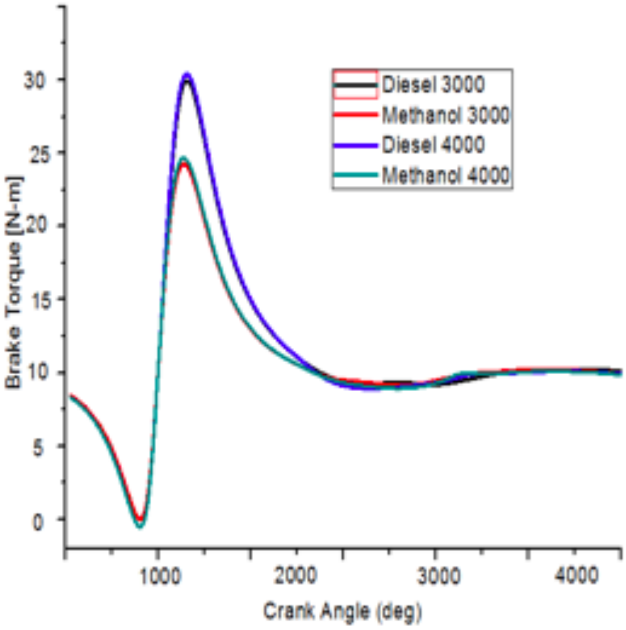

Figure 4. Variation of brake torque of different fuel and load

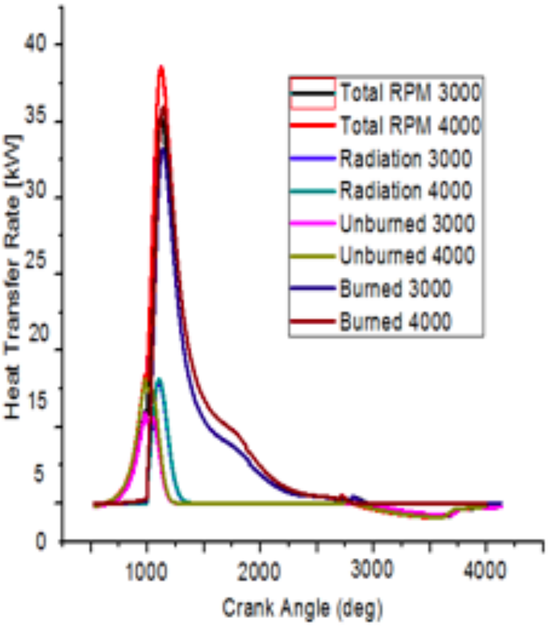

Figure 5. Heat transfer rate of different

Figure 4 shows the variation of torque on the engine with different fuels that serves for engine rotation. The observed increase in engine torque is found in diesel with varying speeds compared to methanol, increased engine torque because diesel has high cetane amounts. Volumetric efficiency in the engine cylinder increases with the amount of air intake as engine speed will continue to increase so that engine torque will increase. Therefore, volumetric efficiency is associated with increased engine torque for all engine cycles (Yusoff et al. 2017). However, engine torque decreases when using methanol fuel than when using diesel for each different load.

Figure 5 shows the variation between total, radiation, non-burning, and burning at Heat Transfer Rate with engine speed at 3000 and 4000 rpm. At times (HTR) the speed of 3000 to 4000 rpm engine devaluation decreases, while the decline also occurs in radiation, but the radiation decreases only at 4000 rpm, while for 3000 rpm increases as the pressure on the cylinder has increased. The highest cylinder pressure increases at 4000 rpm due to the spikes triggered by both of these fuels.

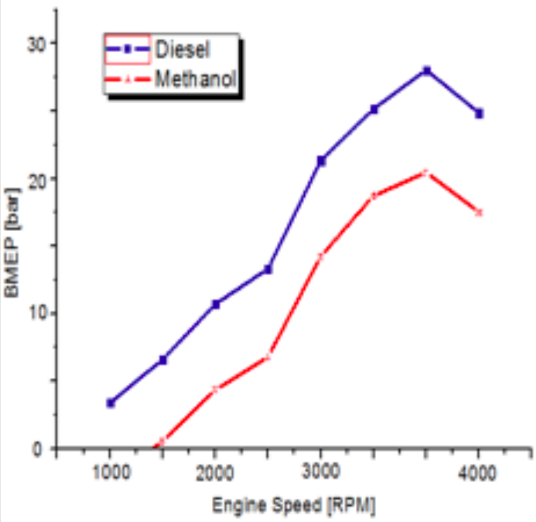

Figure 6. BMEP [bar] of different case

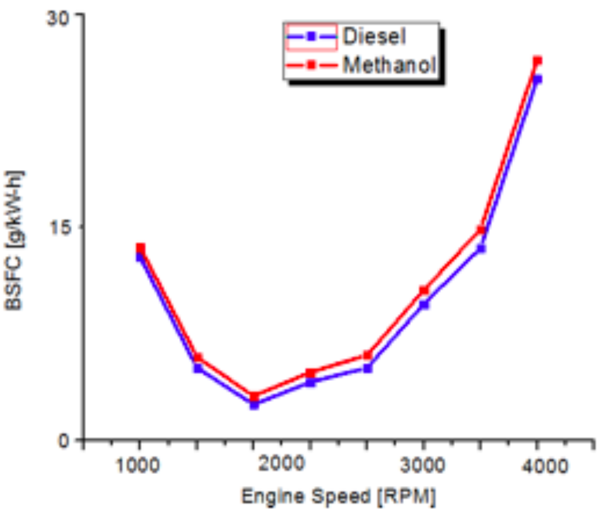

Figure 7. BSFC [g/kW-h] of different case

The effective brake pressure will be defined as the mean pressure. Then evenly the piston will be cut from top to bottom for each blow power so that it will produce brake power output. The brake variation shown in Figure 6 is the effective pressure (BMEP) on the engine rotation. The average pressure effectively used to calculate the performance of internal combustion engines fueled by fuel. In general, the trend shown for each temperature is the same. The maximum effective brake pressure measured is the same as that on the brake engine torque. BMEP trends and brake torque are shown the same, but they are only used as differences. Of the two fuels used with different loads indicates that methanol is more efficient than diesel. However, diesel fuel has a higher cetane amount, so engine combustion is faster than methanol.

Figure 7 shows that with different fuel temperatures will affect engine variation to specific brake fuel consumption (BSFC). Of the two fuels generally, show the same trend. At the highest temperature, 500K will produce a minimum amount of BSFC around (255,907 g / kWhr), whereas with the lowest temperature 300K generates a maximum amount of approximately (301.668 g / kWhr). The fuel with low energy content will result in high BSFC (Mat Yasin et al. 2017a). Increased energy content, as the temperature increases so that BSFC will decrease at 500K when compared to when the temperature is at 300K. Ruhul et al. (Ruhul et al. 2017) reported results that specific fuel consumption is highly desirable with low value.

CONCLUSION

This study was made using simulation with GT-Power Software; the simulation aims to investigate the effect of fuel induced engine performance with different loads for single cylinder diesel engines. The simulation results with GT-Power Software can be made some conclude as follows:

1. Diesel methanol blended fuels can be reduced efficiency as the heating rate in methanol is lower.
2. Diesel methanol blends show lower temperature, pressure, brake torque and heat transfer rate than using pure diesel.
3. Especially for the consumption of methanol fuel is higher than diesel fuel. However, methanol can increases ignition delay, because of the methanol amount of the made is lower than diesel.

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