

Emissions of a Single Cylinder Diesel Engine Operating with Ethanol

The conventional software of GT-Power is used to simulate a single cylinder diesel engine. The diesel engine is simulated to study the engine emission when the engine is operating with ethanol as alternative fuel. The simulation results were compared with the data from the diesel engine operating with mineral diesel. The diesel engine modeling using GT-Power computational model consist of the intake system model, engine cylinder and fuel injection system model, and exhaust system model. The actual engine dimension such as bore stroke, intake pipe diameter and exhaust diameter are measured. Some of the data such as compression ratio, connecting rod length and fuel injector properties is base on the engine data sheet. These engine dimension and parameter are inserted into the software pop up table. The simulations are conducted at full load condition for the engine operating with ethanol and mineral diesel. The emissions of exhaust gas from the combustion of mineral diesel and ethanol have been discussed detail from the analysis of one-dimensional simulation software. The result show that the ethanol produce more emission as compared to mineral diesel due to the difference of fuel properties especially cetane number and low calorific value. The simulation result show big difference between emissions of nitrogen oxide (NOx) from the combustion of ethanol and mineral diesel. However, ethanol fuel is considered as renewable energy which is good alternative for mineral diesel. The diesel engine may need small modification to minimize the emission when it is operated with ethanol. Recent technology on engine component to reduce emission such as exhaust gas recirculation system (EGR) is highly recommended. The EGR is successfully used on diesel engine to reduce emission especially NOx.

Emissions of a Single Cylinder Diesel Engine Operating with Ethanol

Rizalman Mamat¹, Nik Rosli Abdullah², Noreffendy Tamaldin³

1. Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600Pekan, E-mail: rizalman@ump.edu.my

2. Faculty of Mechanical Engineering, Universiti Teknologi MARA, 19999 Shah Alam, E-mail: nrosli75@yahoo.com

3. Faculty of Mechanical Eng, Universiti Teknikal Malaysia Melaka, 76109 Melaka, E-mail: noreffendy@utem.edu.my

Abstract – *The conventional software of GT-Power is used to simulate a single cylinder diesel engine. The diesel engine is simulated to study the engine emission when the engine is operating with ethanol as alternative fuel. The simulation results were compared with the data from the diesel engine operating with mineral diesel. The simulations are conducted at full load condition for the engine operating with ethanol and mineral diesel. It is found that the emission of diesel engine operating with ethanol is higher as compared to mineral diesel.*

Keywords – ethanol, diesel engine, emission

I. Introduction

The European Parliament and the Council of the European Union encourage the public to use biodiesel as the alternative fuel especially for the transport sector. This is due to the fact that in 2002 only, the transportation sector accounted for 21% of all CO₂ emissions worldwide. Currently, statistical study has shown that 95% of all energy for the transportation sector comes from fossil fuel [1]. The use of biofuel in the transport sector may not be just to reduce the emissions but also to shrink the dependence upon imported energy and influence the fuel market for transport and hence to secure the energy supply.

Biofuel is normally characterized by its properties of density, viscosity, low heating value, cetane number, cloud and pour points, characteristics of distillation, and flash and combustion points. Many researches have been conducted on the diesel engine operating with ethanol. This fuel is already in a market in some countries like Brazil. Hansen et al has investigated the combustion of ethanol and blends of ethanol with diesel fuel with the support of a heat release model [2]. They observed that the effects of adding ethanol to diesel fuel were increased ignition delay, increased rates of premixed combustion, increased thermal efficiency and reduced exhaust smoke. Table 1 shows the typical fuel properties for diesel and ethanol [3]. The properties for these fuels includes boiling point, cloud point, oxygen content, carbon, hydrogen, viscosity, density, cetane number, flash point, heat value.

Table 1: Properties of diesel fuel and ethanol[4]

Fuel Properties	Unit	Diesel fuel	Ethanol
Density at 20°C	kg/m ³	837	788
Cetane number	-	50	5-8
Kinematic Viscosity at 40°C	mm ² /s	2.6	1.2
Surface tension at 20°C	N/m	0.023	0.015
Lower Calorific Value	MJ/kg	43	26.8
Specific heat capacity	J/kg. °C	1850	2100
Boiling point	°C	180-360	78
Oxygen	%weight	0	34.8

II. Model Setup & Discussion

The development of the single cylinder engine modeling in one-dimensional simulation was presented in this paper. The model of four-stroke direct-injection (DI) diesel engine is shown in Figure 1.

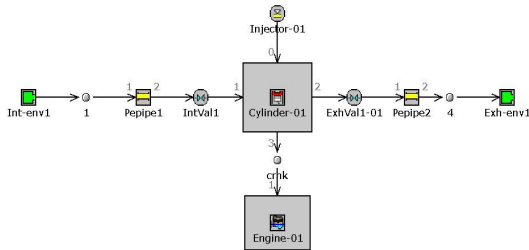


Figure 1. One dimensional model of diesel engine

Figure 2 shows the specific emission of carbon monoxide is increased as engine speed increase for both mineral diesel and ethanol fuel. The magnitude of the emission is almost similar for mineral diesel and ethanol at low engine speed. However, at engine speed more than 3000 rpm, the emission of CO for ethanol is slightly higher as compared to mineral diesel.

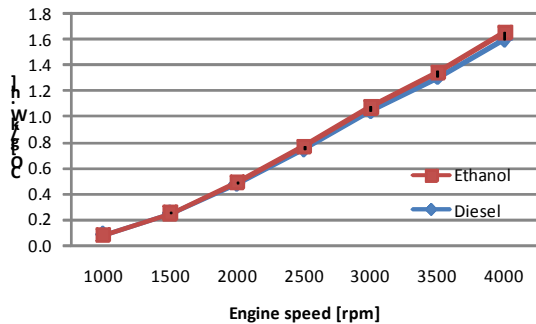


Figure 2 Emission of carbon monoxide

Figure 3 shows the specific emission of total hydrocarbon is decreased as engine speed reduce from 1000 to 2000 rpm for both mineral diesel and ethanol fuel. Then, the emission is increase as engine speed increase for both fuel. The magnitude of the emission is twice higher for the engine operating with ethanol. This trend is almost for all engine speed. The lowest emission

of THC is 0.3 and 0.11 g/kWh for ethanol and mineral diesel respectively.

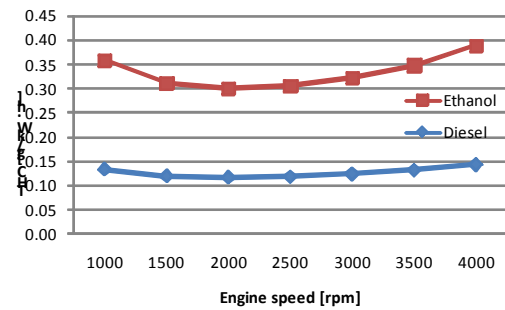


Figure 3 Emission of total hydrocarbon

Figure 4 shows the specific emission of total hydrocarbon is decreased as engine speed reduce from 1000 to 2500 rpm for both mineral diesel and ethanol fuel. The, the emission is increase as engine speed increase for both fuel. The magnitude of the emission is twice higher for the engine operating with ethanol.

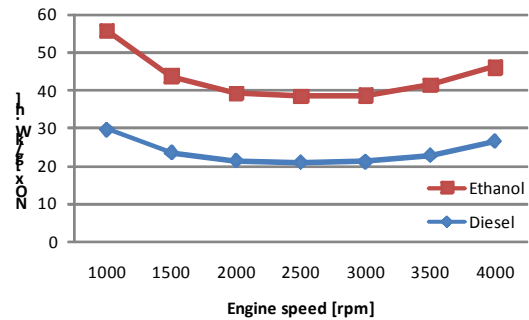


Figure 4. Emission of nitrogen oxide

III. Conclusion

The emission of exhaust gas from the combustion of mineral diesel and ethanol have been discussed detail from the analysis of one-dimensional simulation software. The result show that the ethanol produce more emission as compared to mineral diesel due to the difference of fuel properties especially cetane number and low calorific value. However, ethanol fuel is consider as renewable energy which is good alternative for mineral diesel. The diesel engine may need small modification to minimize the emission when it is operated with ethanol.

References

1. Kreith, F. and D.Y. Goswami, *Handbook of Energy Efficiency and Renewable Energy*. London: CRC Press., 2007.
2. Hansen, A.C., et al., *Heat Release in the Compression-Ignition Combustion of Ethanol*. Transaction of the ASAE, 1989. 32(5): p. 1507-11.
3. Rakopoulos, C.D., K.A. Antonopoulos, and D.C. Rakopoulos, *Experimental Heat Release Analysis and Emissions of a HSDI Diesel Engine Fueled with Ethanol-Diesel Fuel Blends*. Energy, 2007. 32(10): p. 1791.
4. Rakopoulos, C.D., K.A. Antonopoulos, and D.C. Rakopoulos, *Experimental heat release analysis and emissions of a HSDI diesel engine fueled with ethanol-diesel fuel blends*. Energy, 2007. 32: p. 1791-1808.