



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 4, April 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com



ONE-DIMENSIONAL SIMULATION FOR SINGLE CYLINDER DIESEL ENGINE OPERATING WITH ETHANOL

¹S. Blesson Raja, ²A. Ebeneasar, ³S. Mariappan ⁴B. Jeyamutuganesh

^{1,2,3,4} Final Year, Department of Mechanical Engineering, St. Mother Theresa Engineering College,
Vagaikkulam, Thoothukudi, India

ABSTRACT

This study intended to perform the one-dimensional simulation for single cylinder diesel engine. The one-dimensional numerical analysis of GT-Power software is used to simulate the commercial single cylinder diesel engine. The diesel engine is simulated to study the characteristic of engine performance when the engine is operating with alcohol as alternative fuel. The simulation results were compared with the data from the diesel engine operating with conventional diesel. It is found that the performance of diesel engine operating with alcohol (ethanol) demonstrate lower engine performance and engine efficiency. The simulations are conducted at full load condition for the engine operating with ethanol and conventional diesel. The simulation results show that the brake power and brake torque reduced maximum of 38.84% and 37.67% respectively for the engine operating with ethanol as compared to conventional diesel. Nowadays, the ethanol is able to compete with standard diesel and the economics have become much more favourable in its production. The decrease of low heating value resulted to increase brake specific fuel consumption and reduces the brake thermal efficiency of engine performance at full load.

Keywords: One-dimensional, Ethanol, Diesel engine, Biodiesel

INTRODUCTION

The increasing of air pollution from vehicles is at critical level since the commencement of the internal combustion engine and this phenomenon rise especially after major commercialization. The exhaust emissions generally come from the combustion of fossil fuel in vehicle engines. Diesel is toxic and may cause long term adverse effects to the aquatic environment. Biofuel are available alternative fuels which have a promising future as a substitute for conventional diesel. Suitable feedstock includes soybean, sunflower, cottonseed, corn, groundnut, safflower, rapeseed, coconut oil, palm oil, jatropha seed, tallow (animal fat) or even waste cooking oil. In the US, most biodiesel is derived from soy bean while in Europe; rapeseed is the largest source for biodiesel production. In most tropical countries in Asia such as Malaysia palm oil is the preminent choice since it is the major vegetable oil produced in the region.

In 2003, the world total biodiesel production was around 1.8 billion liters (Bozbas, 2008). The EU countries contributed 1.5 million tons for the same year; Germany leads the production followed by France and Italy. The European Parliament and the Council of the European Union encourage the public to use biodiesel as the alternative especially for the transport sector. This is due to the fact that the

transportation sector accounted for 21% of all CO₂ emissions worldwide in 2002. Currently, 95% of all energy for the transportation sector comes from fossil fuel (Kreith and Goswami, 2007). 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.

The main benefit of biofuel is that it is 'carbon neutral'. Although the engines running on biofuel produce more CO₂ compare to conventional diesel fuels, if the analysis includes the carbon cycle, the use of biofuel actually emit less CO₂ to atmosphere (Mamat et al., 2008). The biodiesel could be used as it own or blended with conventional fossil fuel without having to make any modification to the standard diesel engines because biodiesel has comparable properties to diesel (Agarwal, 2007). A large amount of research has been conducted on biofuel to perceive the performance and the impact on emission levels to the environment. (Demirbas, 2007) suggested that the combustion of biodiesel alone provides over a 90% reduction in total unburned hydrocarbons (HC) and a 75-90% reduction in polycyclic aromatic hydrocarbons (PAHs). The results from previous experiments on biodiesel and their blends with mineral diesel in a single cylinder engine show that an increased proportion of biodiesel blend resulted in higher NO_x, reduced smoke and increased brake specific fuel consumption (Chuepeng et al., 2007). The advantage of biodiesel was also reported by many researchers as renewable energy, non-toxic, biodegradable and sulphur free (Labeckas and Slavinskas, 2006; Bozbas, 2008, Mamat et al., 2009). In addition, mixing of biodiesel with standard diesel fuel improves the lubricating properties of the fuel and reduced cylinder friction (Nwafor, 2004).

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. Pure biodiesel or blends with mineral diesel may reduce the calorific value of the fuel thus may lead to reduced engine power and increased fuel consumption (Rakopoulos et al., 2006). The cetane numbers of biodiesel and mineral diesel are about the same but the volatility of biodiesel is slightly higher which may affect the ignition delay and increase the amount of fuel for rapid combustion and boost the combustion temperature, thus producing higher NO_x levels (Labeckas and Slavinskas, 2006). Some purpose such as water pumping for a single cylinder engines are expansively used in agricultural area. The use of the diesel fuel and having only one cylinder make them an economic alternative due to their low investment cost and limited fuel consumption. As a result, these engines are important auxiliary agricultural tool for rural areas. In some cases these engines are also used for driving some vehicles (Bayrakceken et al., 2007). Alcohol maintains to get the global attention as alternative fuels despite of excess in crude oil. For a long period, as the world's crude oil supplies stop to meet worldwide consumption, it is likely that engines running on pure alcohol will become more feasible. In the short term, particularly in those countries susceptible to a shortage in crude oil supplies, contingency plans in the form of alternative liquid fuels to meet the needs of their transport and agricultural sectors are necessary. According to the extension of diesel fuel supplies, it is recently as a particular concern. The use of ethanol in compression – ignition engines has, therefore, received considerable attention with particular emphasis on adapting the fuel to meet the requirements of the engine (Ajav et al., 2000).

Hansen et al. (1989) investigated the combustion of ethanol and blends of ethanol with diesel fuel with the support of a heat release model. 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. Czerwinski (1994) used a rapeseed oil, ethanol and diesel fuel blend and compared the heat release curves with diesel fuel. He observed that the addition of ethanol caused longer ignition lag at all operating conditions. At higher and full loads, the combustion speeds were high with strong premixed phases. Ali et al. (1996) operated a Cummins N 14-410 engines on 12 fuels produced by blending methyl tallow ate, methyl soy ate and fuel ethanol with diesel fuel. The addition of ethanol to the fuel blends did not have an effect on ignition delay. The charge temperature was reported to decrease with a decrease in the diesel content of the fuel blends. Table 1 shows the typical fuel properties for diesel, ester and ethanol (Chen et al., 2008). 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(Rakopoulos et al., 2007)

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
Latent heat of evaporation	kJ/kg	250	840
Bulk modulus of elasticity	Bar	16 000	13 200
Stoichiometric air-fuel ratio	-	15.0	9.0
Molecular weight	kg	170	46

MODEL SETUP

In general, a one dimensional (1D) simulation of an engine model consists of intake system, exhaust system, compressor and variable geometry turbocharger system (VGT), common rail fuel injection systems, exhaust gas recirculation systems, engine cylinders and valve train. The development of the single cylinder modeling in one-dimensional simulation for four-stroke direct-injection (DI) diesel engine was presented in this paper. The details of the engine parameters used in this model are described in Table 2. Figure 1 shows the diesel engine modeling using GT-POWER software. In the selected diesel engine, the intake system its have a few component, size and different data. The system was started from environment till the intake valve. All of the intake system components in the GT-POWER model are environment, intrunnerairfilter, air filter, intrunner, inport, intvalve. The components in this system need a few data to complete the data form and running the model. Engine cylinder and fuel injection system is focused in engine cylinder performance were support diesel fuel from fuel injection system, fresh air intake system and exhaust gas to exhaust system. The components, size and data must be record and inserted to the GT-POWER form. All of the engine cylinder and fuel injection system component are injector, cylinder and engine. Exhaust system is the last system in the diesel engine. The system was started from exhaust valve and finished in the environment. The GT-POWER components in the exhaust system are exhvalve, exhport, exhrunner, muffler, exhrunnerexit, and environment.

Table 2: Detail parameter of a single cylinder diesel engine

No	Description	Value
1	Fuel	Diesel
2	Engine Type	Single cylinder
3	Displacement	406.6 cc
4	Piston pin offset	1 mm
5	Number of Cylinder	1
6	Bore	86.0 mm
7	Stroke	70 mm

8	Connecting Rod Length	118.1 mm
9	Compression Ratio	17.3
12	Maximum Intake Valve Open	7.095 mm
13	Maximum Exhaust Valve Open	7.095 mm
14	Intake Duration	252 CAD
15	Exhaust Duration	291 CAD

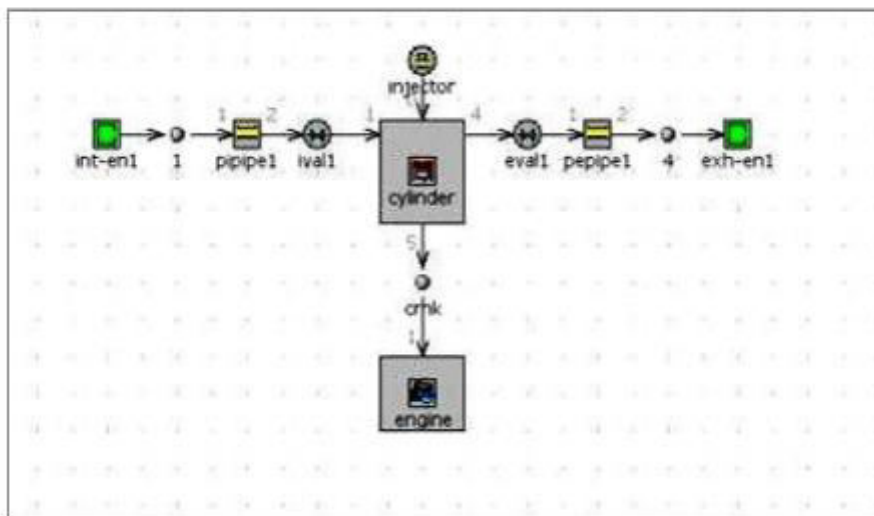


Figure 1: GT POWER single-cylinder diesel engine

The diesel engine modeling using GTPOWER computational model consist of the intake system model, engine cylinder and fuel injection system model, and exhaust system model. The intake system, the engine cylinder and fuel injection system were connected in which the intvalve in the intake system and cylinder in the engine cylinder and fuel injection system. All of this diesel engine components connected by orificeconn. If the work was finish its can developed the diesel engine modeling using GTPOWER software as shown in Figure 1. The data is very important for building an engine model. A list of information that is required to build a model in GTPOWER is included in library. Not every item will be required for all models, and sometimes additional information will be needed, but the list is generally a good starting point. If the model is being built at an early design stage, determining optimal values for some of the items listed may be the purpose of the simulation. If this is the case, those particular attributes should be defined as parameters and run for a series of cases to determine an optimal value. Data required in engine characteristics are compression ratio, firing order, inline or V configuration, V-angle (optional), 2 or 4 stroke. Data required in cylinder geometry are bore, stroke, connecting rod length, pin offset, piston TDC clearance height, head bowl geometry, piston area and head area. Data needed in intake and exhaust system is geometry of all components. Data in throttles are throttle location and discharge coefficients versus throttle angle in both flow directions. Data in fuel injectors are location and number of injectors, number of nozzle holes and nozzle diameter, injection rate, fuel type and LHV. Data in intake and exhaust valves are valve diameter lift profile, discharge coefficient, valve lash. Data in ambient state are pressure, temperature and humidity. Performance data can be very useful when tuning a model after it has been built. The preparation was important before the model simulation was running. The preparations are to review the completed model, run setup, case setup, plot requests and plot setup. All of the parameters in the model will be listed automatically in the setup and each one must be defined for first case of the simulation. Commonly, computation time can be reduced in steady state simulations by planning the



order of the simulations and utilizing the initialization state in run setup. Cycle and/or time plots may be requested by selecting the appropriate plot from the plot options folder within each part. All plots requested in individual parts will be stored regardless of whether the user chooses to use plot setup. If the model has been prepared for simulation, the GT-POWER simulation may be started and this will start the simulation running. A window will be progress of simulation in the form of scrolling text. Once the input has been read successfully, the simulations will begin, and occasional reports of the progress will be given.

Engine Performance Parameters

In this section, some basic parameters that commonly used to characterize engine operation are developed. These include the mechanical output parameters of work, torque, and power; the input requirement of air, fuel and combustion; efficiencies; and emission measurement of engine exhaust (Heywood, 1988, Pulkrabek, 2004).

Volumetric Efficiency: Volumetric efficiency is used as an overall measure of the effectiveness of a four stroke cycle engine and its intake and exhaust system as an air pumping device. The equation use for volumetric efficiency is expressed as Eq. (1) (Pulkrabek, 2004):

where ρ_a

= the inlet air density.

$$\eta_v = \frac{\rho_a V}{m \&_a \text{ disp}}$$

$N / 2$

(1)

$$\frac{m \&_a}{V \text{ disp}}$$

= the steady-state flow of air into the engine

= displacement volume

Brake Engine Torque: Torque is a good indicator of an engine's ability to do work. It is defined as force acting at a moment distance and has units of N-m or lbf-ft. Torque (τ) is related to work by Pulkrabek (2004):

$$2\pi\tau = W_b = (bmep)V_d / n$$

(2)

where W_b = brake work of one revolution

V_d = displacement volume



n = number of revolutions per cycle

For a four-stroke cycle engine that takes two revolutions per cycle,

$$\tau = (bmep)V_d / 4\pi$$

(3)

Brake Power: Power is defined as the rate of work of the engine. If n = number of revolutions per cycle and N = engine speed, then brake power is expressed as Eq. (4) Pulkrabek (2004):

$$\begin{aligned} W^{\&} &= \\ &WN / n \\ W^{\&} &= \\ &2\pi N\tau \\ W^{\&} &= (1/ 2n)(mep) A_p U_p \end{aligned}$$

where W = work per cycle

$$W^{\&} = (mep) A_p U_p / 4$$

(4)

A_p = piston face area of all pistons

U_p = average piston speed

Brake Thermal Efficiency: Brake thermal efficiency (η_{bth}) is the ratio of energy in the brake power, (bp), to the input fuel energy in appropriate units (Ganesan, 2003). Solving for thermal efficiency as per below:

$$\eta_{bth} = \frac{bp}{\text{Mass of fuels} \times \text{calorificvalue of fuel}}$$

(5)

Brake Mean Effective Pressure: Mean effective pressure is a good parameter for comparing engines with regard to design or output because it is independent of both engine size and speed. If brake work is used, brake mean effective pressure is obtained:

$$\begin{aligned} bmep &= w_b / \\ \Delta v \quad bmep &= \\ &2\pi n\tau / V_d \end{aligned}$$

where

$$\Delta v = v_{bdc} - v_{tdc}$$



Brake Specific Fuel Consumption: Brake power gives the brake specific fuel consumption:

where

$$m\&_f$$

= rate of fuel flow into engine

$$bsfc = m\&_f$$

$$/W_b$$

(6)

RESULTS AND DISCUSSION

In this study, the effects of ethanol and diesel fuel on the engine performance were being discussed. The tests were performed by varying the engine speed starting from 500 rpm until 4000 rpm with the increment of 500 rpm. The variation of the engine performance that had been discussed were engine air flow, volumetric efficiency, brake power, brake thermal efficiency, brake engine torque, brake mean effective pressure, brake specific fuel consumption and in-cylinder pressure. The results from the simulation model were compared the trends between the diesel and ethanol fuel. Figure 2 shows the effect of engine air flow with respect to engine speed. It can be seen that the trend for this fuel were similar for diesel fuel and ethanol. The engine air flow increase as increasing of the engine speed. The stoichiometric air-fuel ratio (AFR) for ethanol is 40% lower than diesel fuel. Therefore, the engine air flow operating with ethanol is slightly lower due to inducted less air as compared to diesel fuel.

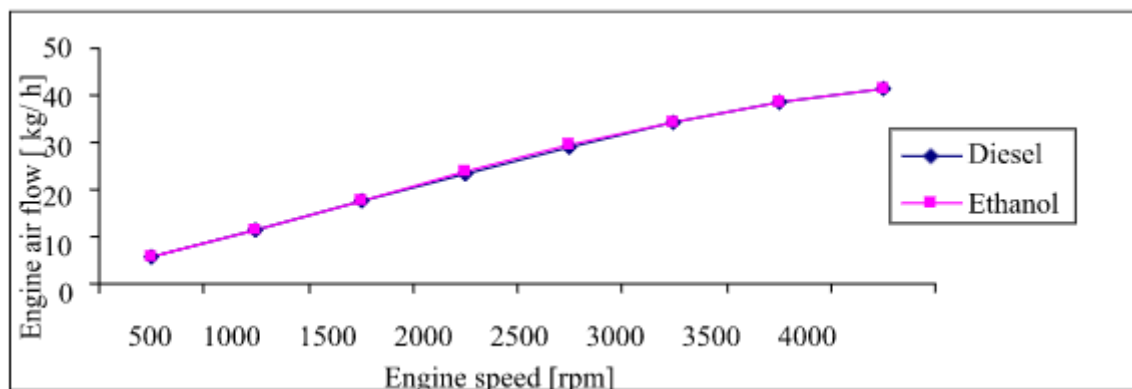


Figure 2: Effect of engine speed variation on engine air flow



SJIF Scientific Journal Impact Factor

Impact Factor: 8.423



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details