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Liquid Fuel Injected of Diesel Engine Fuel Nozzle Injector Variation Holes Number

Semin, Rosli Abu Bakar and Abdul Rahim Ismail

Automotive Excellent Center, Faculty of Mechanical Engineering, University Malaysia Pahang, P.O Box 12, 25000 Kuantan, Pahang, Malaysia.

Abstract: The objective of this paper is to present the performance effect on fuel nozzle injector multi holes number analysis using computational simulation. The single-cylinder direct injection diesel engine model is developed in this research to simulate the fuel nozzle holes number performance in liquid fuel in engine cylinder. The computational development model simulation is use GT-POWER 6.2 software. The research concentrated on the one dimensional model and focuses on fuel nozzle hole numbers variation. The engine modeling is developed from the original selected diesel engine after this engine were opened, breakdown and measurement of all its components size in manually. All of the measurements data input to the window engines component menu of the model. The simulation of the fuel nozzle injector variation holes number is focuses in 1 hole until 10 holes and in variation engine speeds. The results are shown in figures in this paper.

Keywords: Computational simulation, in-cylinder pressure and temperature, simulation

INTRODUCTION

The diesel engines is a type of internal combustion engine, more specifically it is a compression ignition engine, where the fuel is ignited solely by the high temperature created by compression of the air-fuel mixture (Bakar and Semin, 2006; Heywood, 1998; Kowalewicz, 1984; , Stone, 1997; Ganesan, 1999). A four-stroke direct-injection diesel engine typical was measured and modeling by Bakar *et al*. (2007a) using GT-POWER computational model and explored of single-cylinder diesel engine performance effect based on engine rpm. GT-POWER is the leading engine simulation tool used by engine and vehicle makers and suppliers and is suitable for analysis of a wide range of engine issues (Gamma Technologies, 2004; Riegler *et al*., 2002). The details of the diesel engine design vary significantly over the engine performance and size range. In particular, different combustion chamber geometries and fuel injection characteristics are required to deal effectively with major diesel engine design problem achieving sufficiently rapid fuel-air mixing rates to complete the fuel-burning process in the time available. According to Heywood (1998) and Ganesan (1999) a wide variety of inlet port geometries, cylinder head and piston shapes, and fuel-injection patterns are used to accomplish this over the diesel size range. The engine ratings usually indicate the highest power at which manufacturer expect their products to give satisfactory of power, economy, reliability and durability under service conditions. Maximum torque and the speed at which it is achieved, is usually given also by Heywood. The importance of the diesel engine performance parameters are geometrical properties, the term of efficiency and other related engine performance parameters. The engine efficiencies are indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, volumetric efficiency and relative efficiency (Ganesan, 1999). The other related engine performance parameters are mean effective pressure, mean piston speed, specific power output, specific fuel consumption, intake valve mach index, fuel-air or air-fuel ratio and calorific value of the fuel (Heywood, 1998; Ganesan, 1999; Bakar *et al*., 2007b). According to Heywood (1998) in the diesel engine geometries design written that diesel engine compression ratio is maximum cylinder volume or the displaced volume or swept and clearance volume divided by minimum cylinder volume. And the power delivered by the diesel engine and absorbed by the dynamometer is the product of torque and angular speed. The engine efficiencies, every its efficiencies defined by Ganesan (1999). In this research is want to investigated the performance effect of fuel nozzle holes material geometries on the engine indicated power, indicated torque, fuel consumption and fuel in-engine cylinder.

Corresponding Author: Semin, Automotive Excellent Center, Faculty of Mechanical Engineering, University Malaysia Pahang, P.O Box 12, 25000 Kuantan, Pahang, Malaysia.

MATERIALS AND METHODS

The development of the single cylinder modeling and simulation for four-stroke direct-injection (DI) diesel engine is presented in this paper. The specification of the selected diesel engine model is presented in Table 1. To develop the GT-POWER of single-cylinder four-stroke direct-injection diesel engine modeling is step by step, the first step is open all of the selected diesel engine components to measure the engine components part size. Then, the engine components size data will be input to the GT-POWER library of the all engine components data. To create the GT-POWER model, select Window and then Tile with Template Library from the menu. This will place the GT-POWER template library on the left hand side of the screen. The template library contains all of the available templates that can be used in GT-POWER. Some of these templates those that will be needed in the project need to be copied into the project before they can be used to create objects and parts. For the purpose of this model, click on the icons listed and drag them from the template library into the project library. Some of these are templates and some are objects that have already been defined and included in the template library (Gamma Technologies, 2004).

Table 1: Specification of the selected diesel engine

Engine Parameters	Value	Engine Parameters	Value
Model	CF186F	Intake valve close (^{0}CA)	530
Bore (mm)	86.0	Exhaust valve open (^{0}CA)	147
Stroke (mm)	70.0	Exhaust valve close (^{0}CA)	282
Displacement (cc)	407.0	Maximum intake valve open (mm)	7.095
Number of cylinder	1	Maximum exhaust valve open (mm)	7.095
Connecting rod length (mm)	118.1	Valve lift periodicity (deg)	360
Piston pin offset (mm)	1.00	Fuel nozzle diameter (mm)	0.1
Intake valve open (^{0}CA)	395	Fuel nozzle hole number	4

In this model the engine according to Bakar *et al*. (2007b) was breakdown to the tree system, there are intake system, engine cylinder and fuel injection system, and exhaust system. In the selected diesel engine, the intake system its have any component, size and different data. The system was started from environment till the intake valve. The 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. There are any components in the engine cylinder and fuel injection system in the diesel engine. The components, size and data must be record and inserted to the GT-POWER form. The components are injector, cylinder and engine. The last system in the diesel engine is the exhaust system. In this system was started from exhaust valve and finished in the environment. All of this diesel engine components connected by orifficeconn. Then, the modeling the diesel engine model using GT-POWER software in this research can be developed. The modeling focuses on fuel injection shown in Figure 1. Data component and fuel nozzle hole needed for building an engine model. A list of information that is needed to build a model in GT-POWER is included in library. Not every item will be needed for all models. 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.

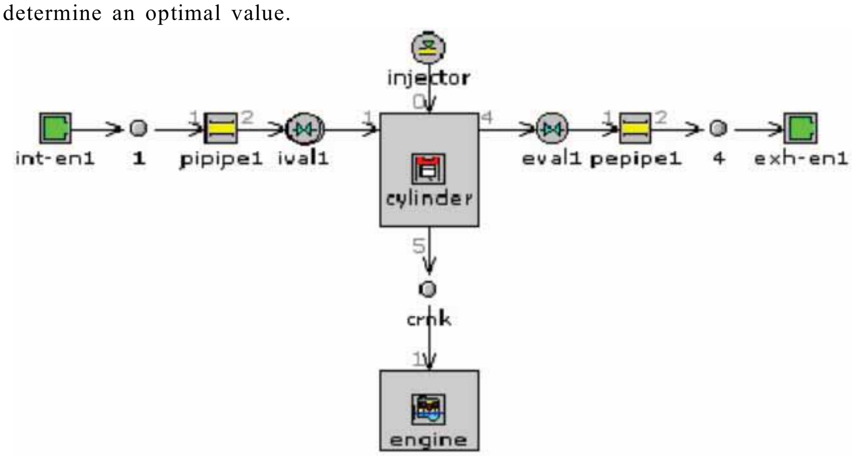

Fig. 1: Single-cylinder diesel engine model using GT-POWER

Data in engine characteristics are compression ratio, firing order, inline or V configuration, V-angle (optional), 2 or 4 stroke. Data in cylinder geometry are bore, stroke, connecting rod length, pin offset, piston TDC clearance height, head bowl geometry, piston area and head area. Data 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.

In this research is focuses in variation of diameter and number of fuel nozzle hole geometries effect on diesel engine in-cylinder liquid fuel performance. The variations of fuel nozzles injection holes number are 1 till 10. And the diameters of fuel nozzle injection holes geometries are start from the wide and single hole then finished on multi holes number and very small diameter. Total area of the fuel nozzle on one hole till to ten holes is the same with the original fuel nozzle holes area. Before running the model the preparing to run the model simulation needed. Preparing to run the model simulation are review the completed model, run setup, case setup, plot requests and plot setup. All of the intake and exhaust parameters on the model is shown in Table 2, will be listed automatically in the case setup and each one must be defined for first case of the simulation.

Table 2: Intake and exhaust engine parameter for GT-POWER model

Intake system					Exhaust system				
Parameter	Intrunner _airfilter	Airfilter -01	Intrunner -01	Intport -01	Parameter	exhport -01	exhrunner -01	Muffler -01	exhrunner -exit-01
Diameter at inlet end (mm)	44.88	159.63	40.44	40.69	Diameter at inlet end (mm)	26.38	27.86	138.88	34.6
Diameter at outlet end (mm)	62.13	159.63	40.1	32.78	Diameter at outlet end (mm)	29.82	27.86	138.88	34.6
Length (mm)	80	69.64	59.7	55.2	Length (mm)	40.4	98	283.4	25.6
Discreatization length (mm)	34.4	34.4	34.4	34.4	Discreatization length (mm)	47.3	47.3	47.3	47.3
Wall temp. (ºC)	28.85	28.85	76.85	176.85	Wall temp. (ºC)	480	480	480	480

RESULTS AND DISCUSSIONS

Results:

The results of this simulation is start from whenever a simulation is run, GT-SUITE produces several output files that contain simulation results in various formats. Most of the output is available in the post-processing application GT-POST. GT-POST is powerful tool that can be used to view animation and order analysis output (Gamma Technologies, 2004). After the simulation was finished, report tables that summarize the simulations can be produced. These reports contain important information about the simulation and simulation result in a tabular form. The computational simulation of the engine model result is informed the engine performance. The running simulation result in this research is focuses on the engine performance data based on variation of fuel nozzle material hole diameter size, diameter number and the different engine speed (rpm). The diesel engine model was running on any different engine speed in rpm, there are 500, 1000, 1500, 2000, 2500, 3000, 3500 and 4000. The variations of fuel nozzle material holes number are multi holes and several number holes, the simulation model there are start from fuel nozzle 1 hole until 10 holes on the same of total fuel nozzle holes area. The performance effect of fuel nozzle holes number and geometries of in-cylinder engine liquid fuel is shown in Fig. 3 – Fig. 12.

Discussions:

The simulation results discussions is in every cases, case 1 is on 500 rpm until case 8 on 4000 rpm. Figure 3 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 1 hole and examined at variation engine speeds. Figure 4 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 2 holes and examined at variation engine speeds. Figure 5 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 3 holes and examined at variation engine speeds. Figure 6 is shows the performance effect of liquid

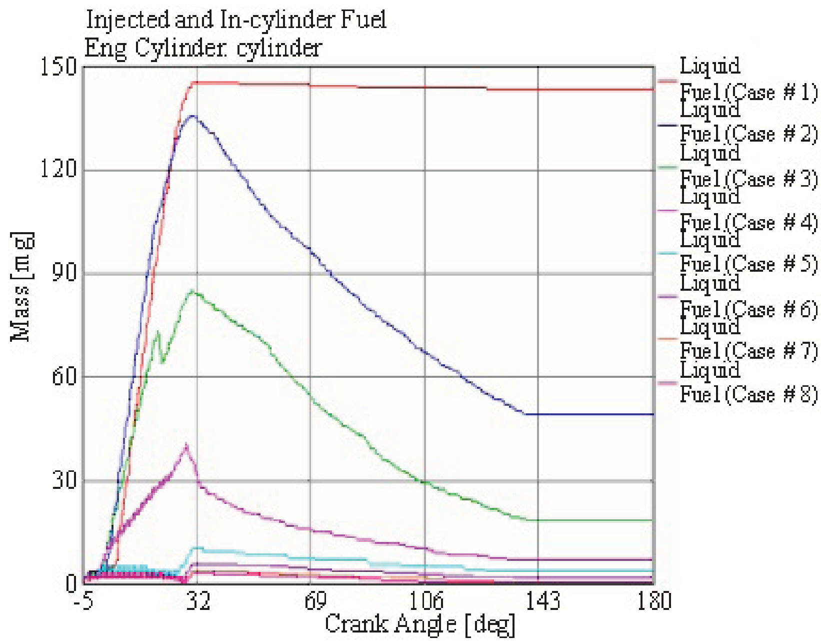

Fig. 3: In-cylinder liquid fuel of nozzle 2 holes

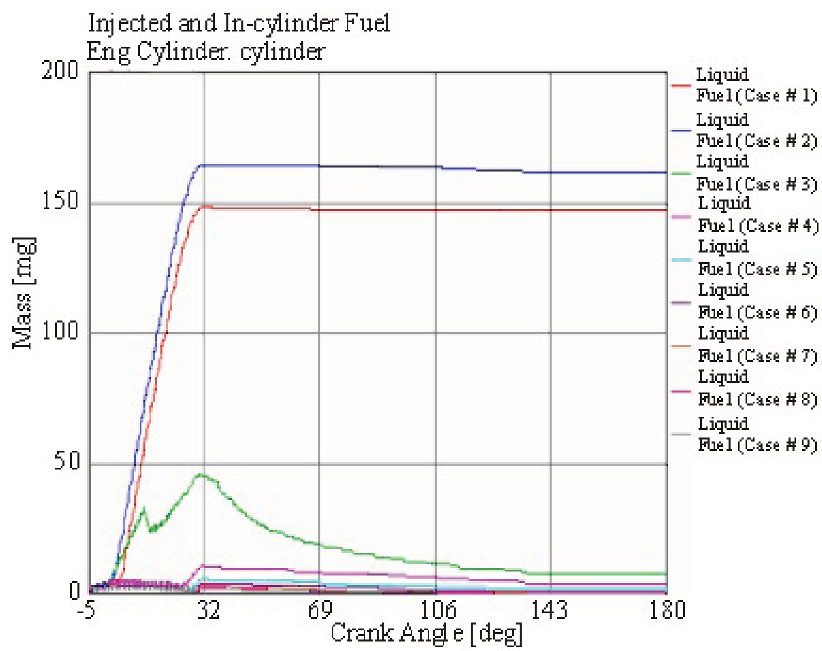

Fig. 4: In-cylinder liquid fuel of nozzle 2 holes

fuel of in injected and in-cylinder fuel in fuel nozzle number is 4 holes and examined at variation engine speeds. Figure 7 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 5 holes and examined at variation engine speeds. Figure 8 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 6 holes and examined at variation engine speeds. Figure 9 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 7 holes and examined at variation engine speeds. Figure 10 is shows the performance effect of

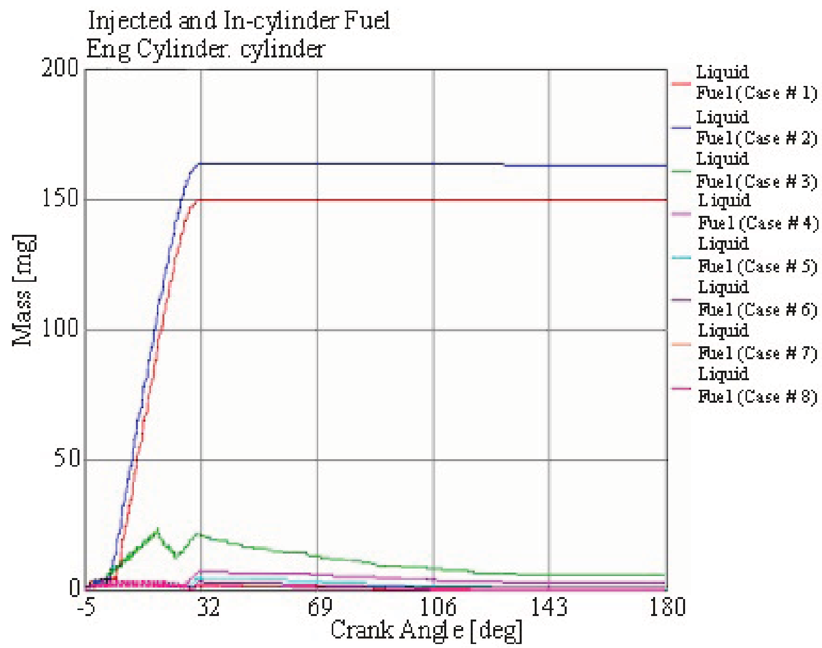

Fig. 5: In-cylinder liquid fuel of nozzle 3 holes

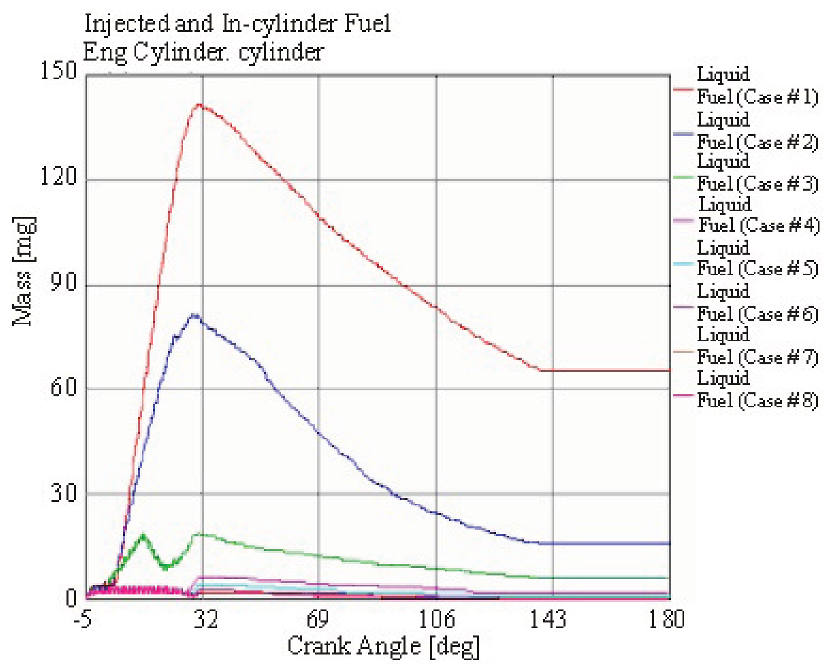

Fig. 6: In-cylinder liquid fuel of nozzle 4 holes

liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 8 holes and examined at variation engine speeds. Figure 11 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 9 holes and examined at variation engine speeds. Figure 12 is shows the performance effect of liquid fuel of in injected and in-cylinder fuel in fuel nozzle number is 10 holes and examined at variation engine speeds.

Numerous studies have suggested that decreasing the injector nozzle orifice diameter is an effective method of increasing fuel air mixing during injection (Baik, 2001). Smaller nozzle holes were found to be the most

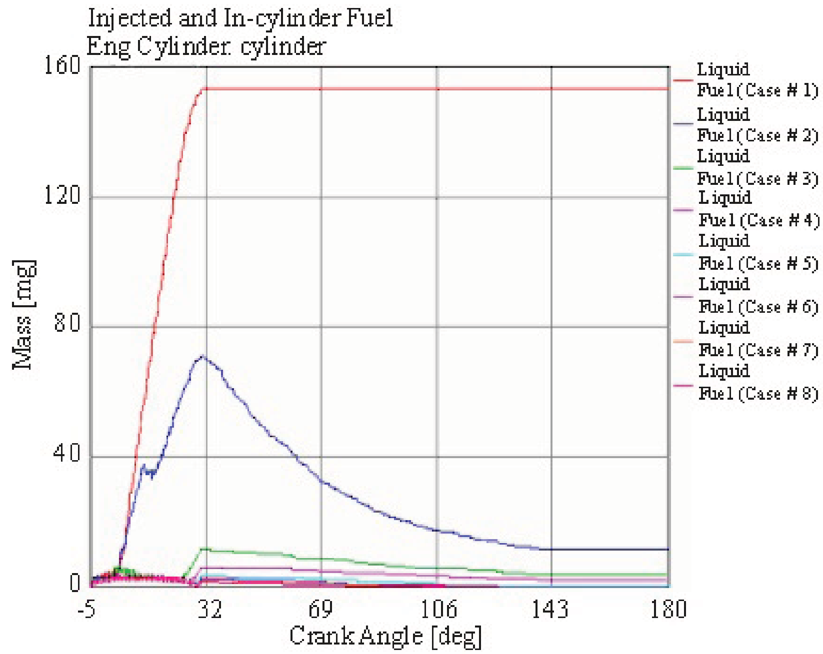

Fig. 7: In-cylinder liquid fuel of nozzle 5 holes

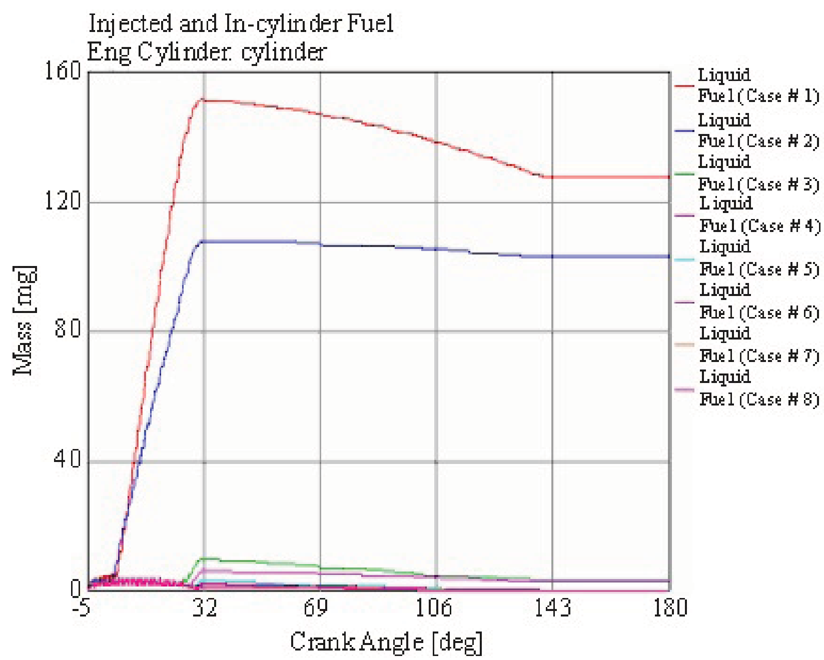

Fig. 8: In-cylinder liquid fuel of nozzle 6 holes

efficient at fuel/air mixing primarily because the fuel rich core of the jet is smaller. In addition, decreasing the nozzle hole orifice diameter, would reduce the length of the potential core region. Unfortunately, decreasing nozzle holes size causes a reduction in the turbulent energy generated by the jet. Since fuel air mixing is

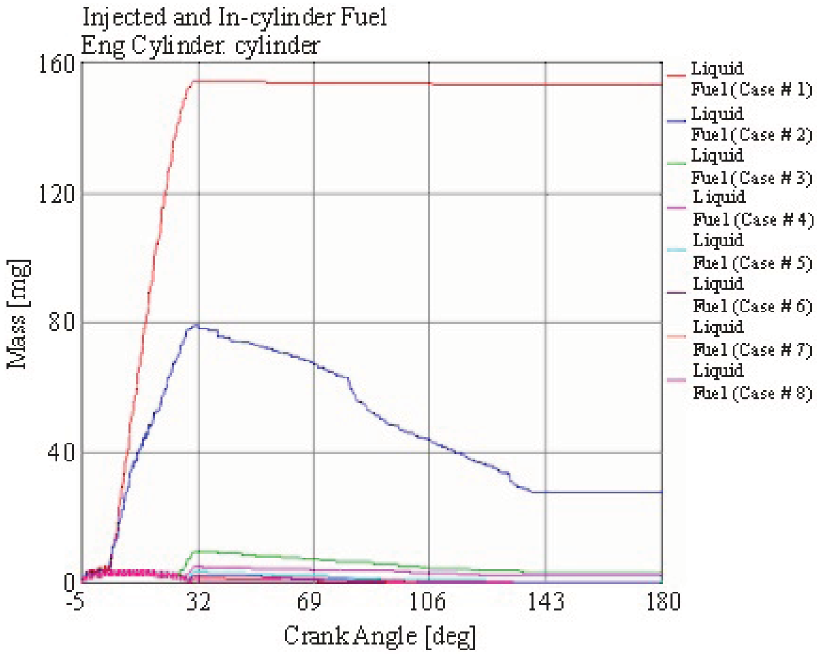

Fig. 9: In-cylinder liquid fuel of nozzle 7 holes

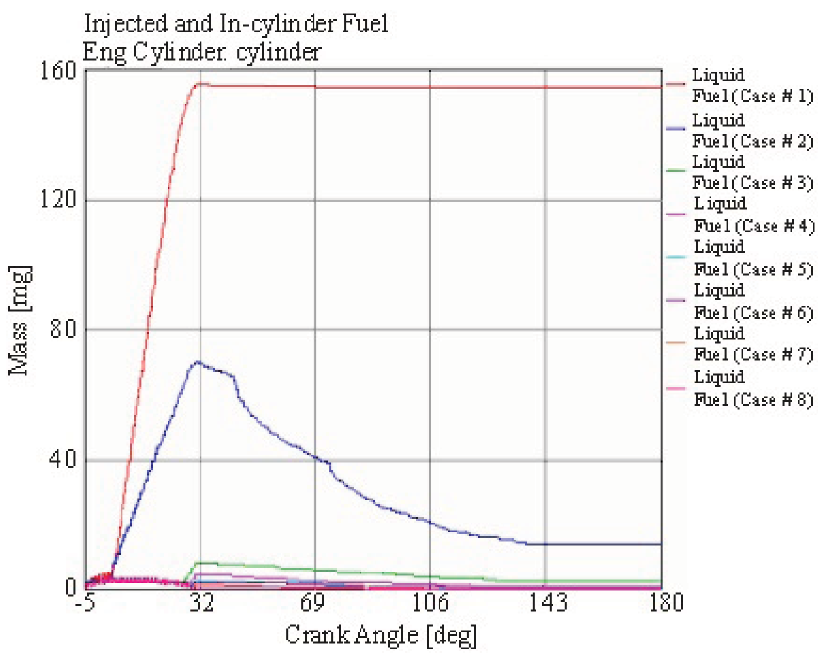

Fig. 10: In-cylinder liquid fuel of nozzle 8 holes

controlled by turbulence generated at the jet boundary layer, this will offset the benefits of the reduced jet core size. Furthermore, jets emerging from smaller nozzle orifices were shown not to penetrate as far as those emerging from larger orifices. This decrease in penetration means that the fuel will not be exposed to all of the available air in the chamber. For excessively small nozzle size, the improvements in mixing related to decreased plume size may be negated by a reduction in radial penetration (Baumgarter, 2006). This behavior

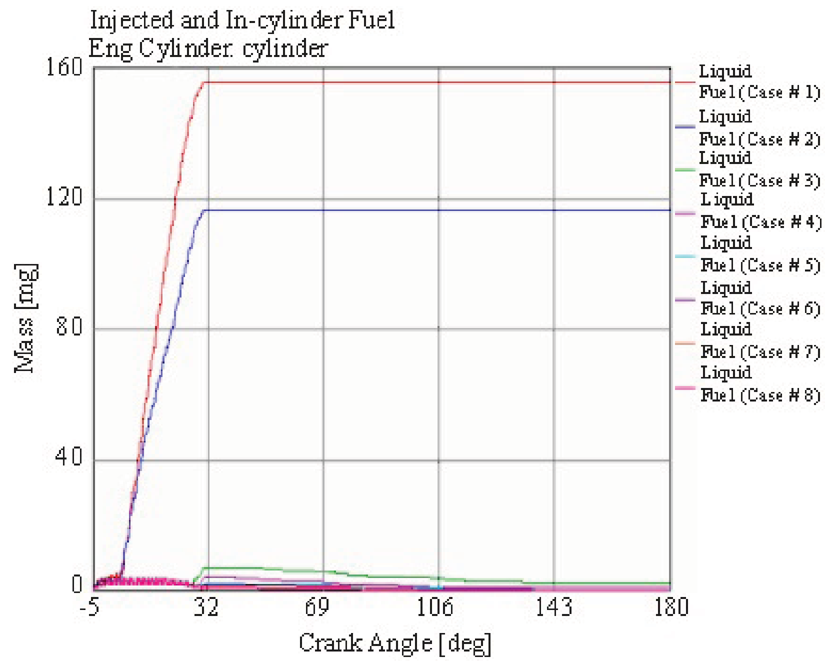

Fig. 11: In-cylinder liquid fuel of nozzle 9 holes

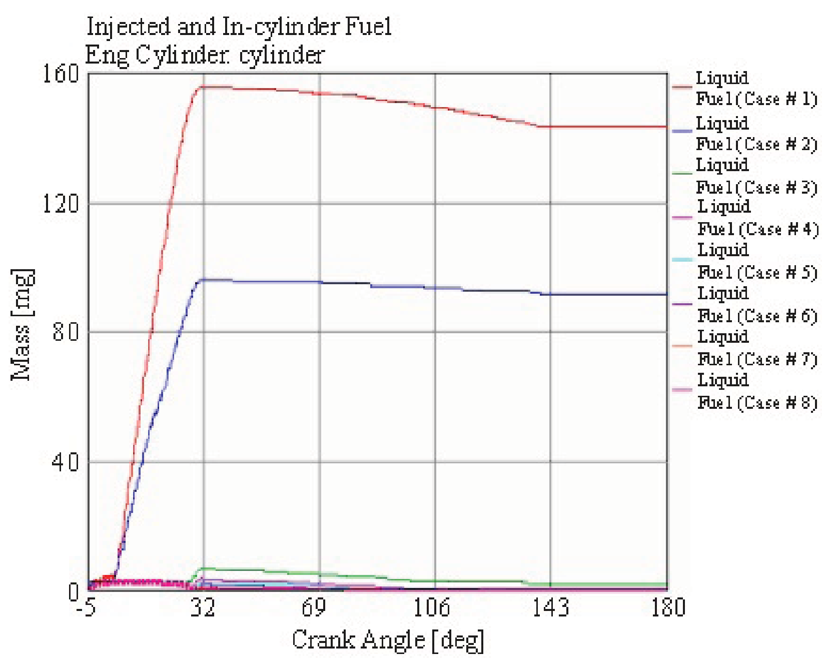

Fig. 12: In-cylinder liquid fuel of nozzle 10 holes

is undesirable because it restricts penetration to the chamber extremities where a large portion of the air mass resides. Furthermore, it hampers air entrainment from the head side of the plume because the exposed surface area of the plume is reduced. It has been suggested that a nozzle containing many small holes would provide better mixing than a nozzle consisting of a single large hole. This hypothesis has been tested by studying injectors with varying numbers of nozzle holes.

The optimal nozzle design would be one that provided the maximum number of liquid fuel burn in combustion process and minimum number of liquid fuel unburned. Theoretically, a 10 holes nozzle satisfies this requirement. Unfortunately, jets emerging from a 10 holes nozzle tended to be very susceptible. All of the nozzles examined and the result shown that the 7 holes nozzle provided the best results for any different engine speed in simulation and the best performance shown on low speed engine.

Conclusion:

The fuel nozzles holes number from 1 hole until 10 holes in difference orifice diameter have been examined using GT-POWER simulation. The simulation result shown that the fuel nozzle with 7 holes number provided the best performance liquid fuel in-cylinder in any different engine speeds in simulation. The results is will be used in future work to investigate the effect of fuel nozzle holes number and liquid fuel in injected and in-cylinder on indicted power, indicated torque and indicated specific fuel consumption in any different engine speed in simulation.

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