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Investigation of Fuel Flow Velocity on CNG Engine using New Injector

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ABSTRACT— ***In this paper, the new injector has been developed based on computational model. The methods of fuel flow velocity investigation from the CNG engine using new injector simulations focused on the combustion chamber area. The fuel flow velocity in the combustion chamber affected the combustion and performance of the engine. From the simulation of every new injector nozzle holes type, the velocity in the combustion chamber was different and most of the velocities were higher and better compared to the original injection nozzle.***

Keywords— CNG engine, computational simulation, fuel flow velocity, new injector

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1. INTRODUCTION

Compressed Natural Gas (CNG) has been used in the internal combustion engine to substitute the liquid fuel such as gasoline and diesel fuel. This paper has been investigated the effect of new injector on the fuel flow velocity of CNG marine engine. The CNG has been as an alternative fuel to substitute of liquid fuel such as diesel and gasoline [1-25]. Unfortunately, the conversion of liquid fuel to CNG fuel has been reduced the engine performance [1-25]. Based on the above research result statement this research has been done by improvement the injector nozzle of CNG engine. The objective of this research is to investigate the effect of new injector on the fuel flow velocity of CNG marine engine.

2. RESEARCH METHODS

The data of engine for this research is shown in Table 1. The design and types of nozzles are shown in Table 2 and Figure 1. The first design of the new injector was based on the diameter of the nozzle holes (DH), the second design was based on the shape, angle or number of the inner nozzle holes (DN), the third design was based on the shape, angle or diffuser degree of the inner nozzle holes (DD) and the fourth design was based on a multi-hole nozzle (H).

Table 1: Specifications of the Engine

Engine Parameters	Value
Bore (mm)	86.0
Stroke (mm)	70.0
Displacement (cc)	407.0
Number of cylinders	1
Connecting rod length (mm)	118.1
Piston pin offset (mm)	1.00
Max. intake and exhaust valve open (mm)	7.095

The development of the new injector nozzle with multi-hole geometry for port injection-dedicated compressed NG (CNG) engine spark ignition is needed to improve engine model performance. Based on model performance, a number of physically diverse injector nozzles with multi-hole geometry were designed, developed and manufactured.

Table 2: New injector multi-diameter nozzle holes size

Type	Multi Diameter Holes Nozzle
1.0DH	Nozzle with diameter 1.0 mm
1.5DH	Nozzle with diameter 1.5 mm
2.0DH	Nozzle with diameter 2.0 mm
2.5DH	Nozzle with diameter 2.5 mm
3.0DH	Nozzle with diameter 3.0 mm

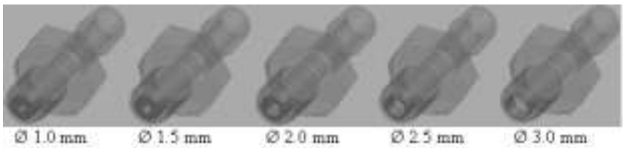

Figure 1: New injector multi-diameter nozzle holes

3. RESULT AND DISCUSSION

In this study, the results of fuel flow velocity from the simulations focused on the combustion chamber area. The fuel flow velocity in the combustion chamber affected the combustion and performance of the engine. From the simulation of every new injector nozzle hole type, the velocity in the combustion chamber was different and most of the velocities were higher and better compared to the original injection nozzle.

Figure 2 shows the fuel flow velocity of injected CNG fuel and intake air from the start of flow, fuel flow velocity in the valve stem area, on the cylinder wall and on the piston surface of the combustion chamber. Based on Figure 2, decreasing intake valve lift or decreasing injection timing degree from BBDC increased the flow velocity of the injected gas fuel and intake air. When the CNG fuel was injected with injection timing at a higher degree BBDC or when the intake valve lift was higher, the open area for intake air and CNG fuel in the combustion chamber is greater. The effect of the greater area was a decrease in the velocity of intake air and injected CNG fuel. The injected CNG fuel flow velocity was higher than the intake air because the pressure at the start of flow of the injected fuel was higher than that of the intake air.

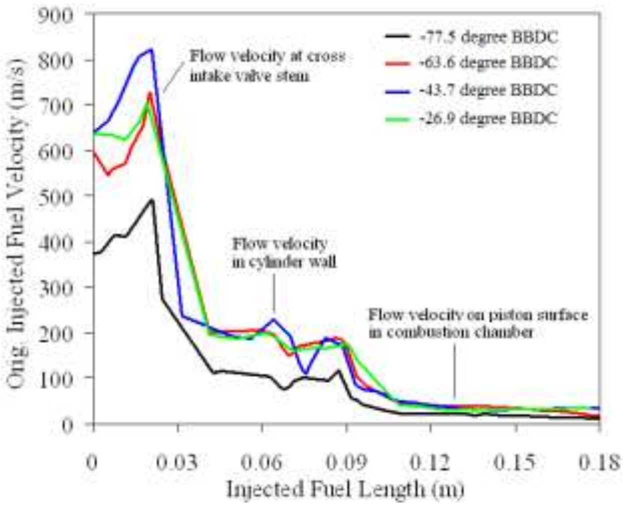

Figure 2: Fuel flow velocity of the original injector

Figure 3-7 shows the injected CNG fuel flow velocity of the new multi-diameter hole injectors. The simulations are focused on the new injectors with 1.0 mm, 1.5 mm, 2.0 mm, 2.5 mm and 3.0 mm diameter holes with variable injection timing from 26.9 to 77.5 degrees BBDC.

The computational simulation results of the effect of new multi-diameter hole injectors on fuel velocity are shown in Figure 3-7. At a distance between 0 to 0.02 metres of flow length, the gas fuel flowed from the injection start to the valve stem. At a distance between 0.02 to 0.034 metres of flow length, the gas fuel flow crossed the valve stem. At a distance between 0.034 to 0.12 metres in flow length, the gas fuel flowed over the walls and cylinder of the engine combustion chamber. At a distance between 0.12 to 0.18 metres of flow length, the gas fuel flowed over the piston surface in the combustion chamber of engine.

The Figure 3-7 shows that the velocity changed at every length of the injected CNG fuel flow. Based on computational simulation results with the new injectors with 1.0 mm, 1.5 mm, 2.0 mm and 2.5 mm diameter nozzle holes, the flow fuel velocity shown at injection start was similar with injection timing of 77.5 degrees BBDC, 63.6 degrees BBDC and 43.7 degrees BBDC, but with 26.9 degrees BBDC, the fuel velocity was lower than the others. In the new 3.0 mm diameter nozzle hole injector, the injection start was similar with injection timing of 77.5, 63.6, 43.7 and 26.9 degrees BBDC.

In Figure 3–7 for the new 1.0 mm to 2.5 mm diameter nozzle hole injectors, the fuel flow on the piston surface or the bottom of the combustion chamber was slowed down with injection timing of 77.5, 63.6 and 43.7 degrees BBDC, but the fuel flow velocity was strongly increased with injection timing of 26.9 degrees BBDC. With the 3.0 mm diameter nozzle injector, the fuel flow on the piston surface or the bottom of the combustion chamber was slowed down with injection timing of 77.5, 63.6, 43.7 and 26.9 degrees BBDC.

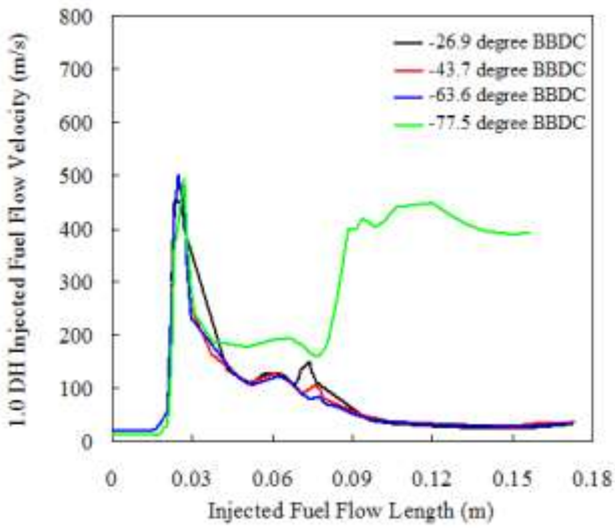

Figure 3: Fuel velocity of 1.0 mm DH

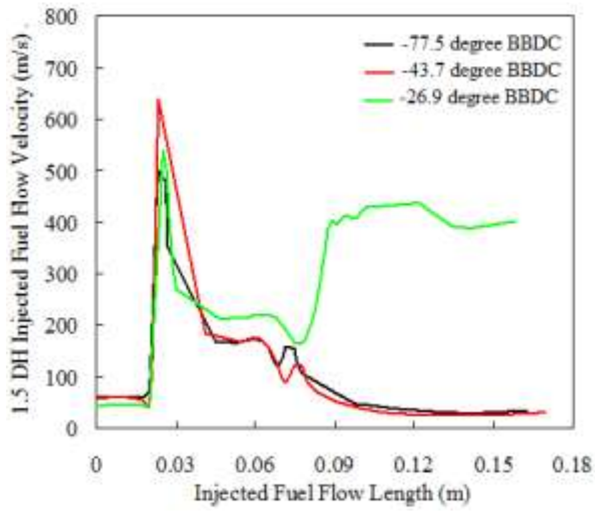

Figure 4: Fuel velocity of 1.5 mm DH

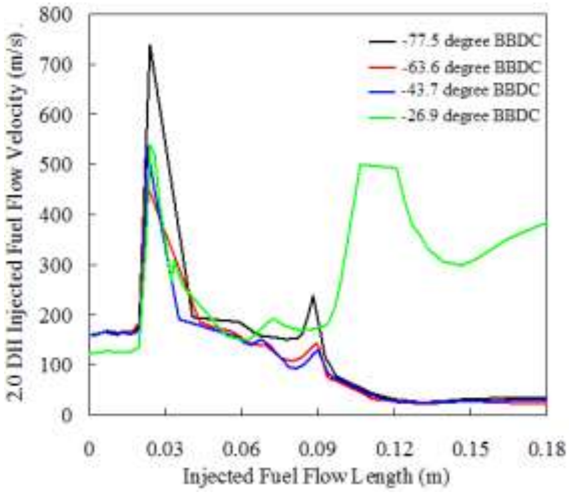

Figure 5: Fuel velocity of 2.0 mm DH

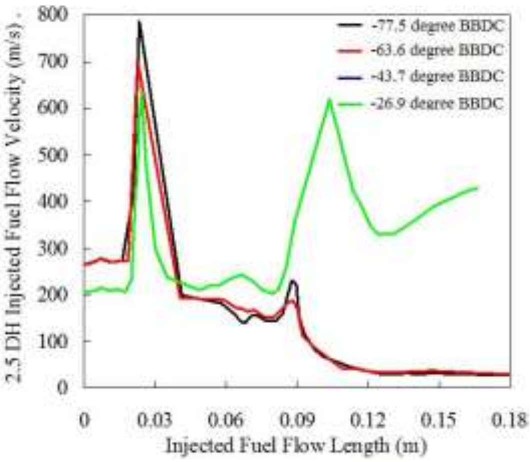

Figure 6: Fuel velocity of 2.5 mm DH

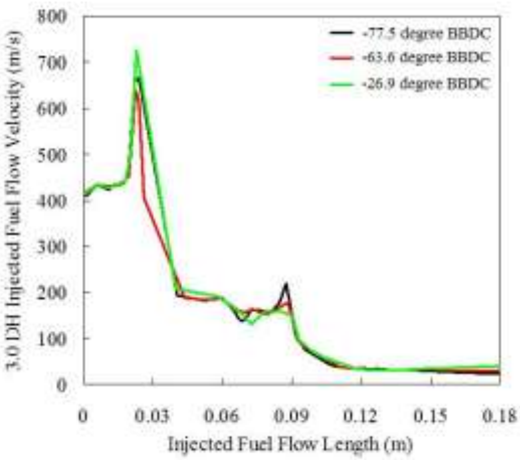

Figure 7: Fuel velocity of 3.0 mm DH

The fuel flow velocity on the piston surface with the new multi-diameter hole injector nozzles was higher compared to the original injector. The increase in fuel velocity was caused by the different nozzle hole diameters. With the same pressure of fuel injection, the small diameter injector nozzles produced higher velocity fuel than the greater diameter nozzle holes. The fuel flow velocity in this step was used to pressurise the air-fuel mix from BDC to TDC in the combustion stroke. Theoretically, a higher fuel flow velocity in the combustion chamber can improve combustion results [3, 19, 25].

4. CONCLUSIONS

The highest fuel flow velocity of new injector has been shown at 26.9 degrees BBDC. The increased fuel flow velocity with 26.9 degrees BBDC injection timing was caused by the effect of intake valve opening, since during injection timing, the intake valve is slightly opened. Fortunately, the lower valve lift or smaller area opened increased the fuel velocity.

5. ACKNOWLEDGEMENT

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