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Power Performance Characteristics Investigation of Gas Engine using New Injector

Semin, Nilam S. Octaviani, Ayudhia P. Gusti and M. Badrus Zaman
Department of Marine Engineering, Faculty of Marine Technology,
Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia.

Abstract
The conversion of marine diesel engine to Gas engine has been reduced the engine power. The Gas engine is need improvement to increase the engine power. In this paper, the new injector has been improved to increase the Gas engine power. The investigation results of the effect of new injector on power performance of a Gas engine are based on experimental. The effect of the new injector nozzles with multi-diameter holes on the indicated and brake power performance of the Gas engine is shown that new injector nozzle with 3.0 mm diameter holes produced the highest power compared to the other injectors. In this investigation, the 3.0 mm diameter hole injector nozzle increased the higher power by 8.5%, since the greater diameter nozzle holes injected gas fuel more evenly and enhanced mixing with intake air in the combustion chamber.

Keywords: Gas engine; diameter holes injector; engine conversion; new injector; power performance

INTRODUCTION

Natural Gas (NG) has been found in various locations in oil and gas-bearing sand strata located at various depths below the earth's surface [1]. CNG is NG in compressed form. It has been recognised as one of the most promising alternative fuels due to its substantial benefits compared to gasoline fuel and diesel fuel. These include lower fuel costs, cleaner exhaust gas emissions and higher octane number.

Diesel engine can be converted to CNG engine. Unfortunately, the conversion of engine has been reduced the engine power performance characteristics. So, the CNG engine is need the improvement to increase the power performance.

The objective of this paper is to improve the CNG engine injector to increase the engine power performance. The improved CNG engine injector has called the new injector.

LITERATURE REVIEW

To improve the mixing process of CNG fuel and air in the combustion chamber, the geometry of nozzle holes, nozzle spray pressure, piston head modifications, the arrangement of piston top clearance, turbulent flow of air intake and variations in the CNG fuel angle of spray can be investigated [2].

Indicated power represents the thermodynamic power transferred from the gas to the engine. The calculation is made using Equation (1).

$$ipwr = itq \bullet avrgrpm \bullet \left[\frac{2\pi}{60000}\right] \qquad (1)$$

The indicated power is called *ipwr* in kilowatts (kW). *itq* is the indicated torque of the engine in Newton-metres (N-m), *avgrpm* is the engine speed in rpm; π is instantaneous and the nominal value is 3.14.

The instantaneous brake power, *bkw*, represents the power available at the flywheel, after accounting for all friction and attachment losses as well as the acceleration of the cranktrain inertia for brake torque. Brake power, *bkw* is calculated using Equation (2).

$$bkw = btq \bullet avgrpm \bullet \left[\frac{2\pi}{60000}\right] \qquad (2)$$

Brake power is in kilowatts (kW), *btq* is brake torque in Newton-metres (N-m) and *avgrpm* is engine speed (rpm).

METHODS

A CNG engine was developed in this study. Engine specifications for the base engine are presented in Table 1. The specific values of the input parameters, including the air fuel ratio, engine speed, injection timing, injection pressure, ignition timing and the compression ratio were defined in the model.

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 & exhaust valve open (mm)	7.095

The experimental method in this research was performed according to International Standard ISO 3046 for Reciprocating Internal Combustion Engine Performance. ISO (the International Organisation for Standardisation) is a worldwide federation of national standards bodies (ISO member bodies). Heywood [3] and Ganesan [4] have presented a guide to internal combustion engine experiments. ISO 3046 covers reciprocating internal combustion engines for land, rail-traction and marine use, excluding engines used to propel agricultural tractors, road vehicles and aircraft. This part of ISO 3046 applies to engines used to propel road construction and earth-moving machines, industrial trucks and for other applications where no suitable international standard exists for these engines. This part of ISO 3046 was applied to the test on a test bed.

The experimental testing of the SPI CNG engine using the original injector and the new injector nozzle with multi-hole geometry was run based on engine speed variations [5].

The engine was run from 1000 rpm-4000 rpm with a range of 500 rpm. The throttle positions were opened at 25%, 50%, 75% and 100%. The CNG was injected into the intake manifold at variable pressures from 1 Bar to 4 Bar. A detailed schematic of the SPI CNG engine experimental set-up is shown in Figure 1.

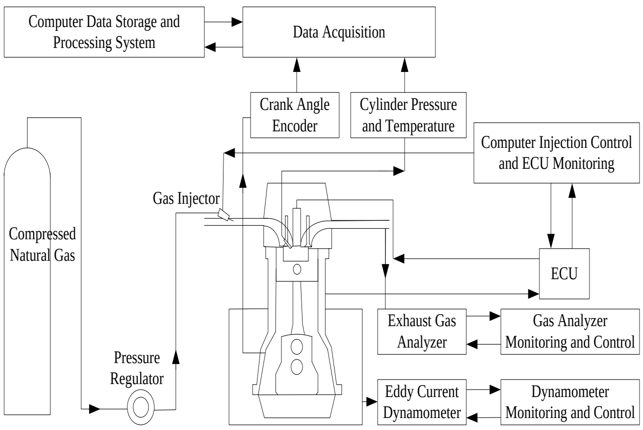


Figure 1: Schematic of CNG engine experimental testing

RESULTS AND DISCUSSION

The investigation results of the effect of new injector nozzles with multi-hole geometry on indicated power performance of a sequential port injection CNG engine are shown in Figure 2.

The effect of the new injector nozzles with multi-diameter holes on the indicated power performance of the sequential port injection CNG engine is shown in Figure 2 (a). The new injector nozzle with 3.0 mm diameter holes produced the highest indicated power compared to the other injectors. In this investigation, the 3.0 mm diameter hole injector nozzle increased the higher indicated power by 8.5%, since the greater diameter nozzle holes injected gas fuel more evenly and enhanced mixing with intake air in the combustion chamber. But, too-large diameter nozzle holes, such as in the original injector, can reduce the flow velocity of the injected gas fuel. Given this phenomenon in fuel flow, the combustion in the engine was certainly excellent with the 3.0 mm diameter hole nozzle compared to the other injectors. Better air-fuel mixing produces better indicated power [6 - 25].

Figure 2 (b) shows the effect of the new injectors with multi-degree nozzle holes on indicated the power performance of the sequential port injection CNG engine. In the new injector nozzles with multi-degree nozzle holes, the new injector nozzle with 25 degree nozzle holes produced the highest indicated power compared to the others. Baumgarter [6] (2006) has postulated that injector with higher degree nozzle holes would produce higher indicated power because, with higher degree nozzle holes, the injected CNG fuel is sprayed more evenly and mixes more with the intake air in the combustion chamber. Unfortunately, too-high degree nozzle holes, such as the 30 degree nozzle hole, reduced the flow velocity of injected CNG fuel in the combustion chamber of the engine.

This was caused by better fuel flow and fuel-air mixing, resulting in excellent combustion with the 25 degree nozzle holes compared the other new injectors with multi-degree nozzle holes. This excellent combustion increased the indicated power of engine by 13.4%. This was caused by the dominant in-flow velocity effect, where the velocity with the 25 degree nozzle hole was higher than with the other injectors. Unfortunately, the new injector nozzle with 10 degree nozzle holes produced lower indicated power for the sequential port injection CNG engine compared to the other new injectors. Generally, the new injectors increased the indicated torque.

Figure 2 (c) shows the indicated power performance of the sequential port injection CNG engine using injectors with multi-degree diffuser holes. The new injector nozzle with 25 degree diffuser holes produced the highest indicated power compared to the others. In this investigation, the injector with 25 degree diffuser holes increased the indicated power by 10.95% compared to the original injector. The new injector with 25 degree diffuser holes produced higher indicated power because with higher degree diffuser holes, the injected gas fuel can be sprayed at a higher velocity and spread evenly in the combustion chamber. But, too high an angle, such as with the 30 degree diffuser holes, reduced the flow spray and mixing of the injected gas fuel. So, the combustion of the engine was excellent with 25 degree diffuser holes compared to the other injectors. The increased indicated power was caused by the fuel flow spray, fuel-air mixing and the flow velocity of CNG fuel in the combustion chamber of the engine. The effect of increasing fuel spray, fuel-air mixing and fuel velocity is increased indicated power performance of the engine.

Figure 2 (d) shows the indicated power performance of the sequential port injection CNG engine using the new multi-hole injector nozzles at varying engine speeds. All of the new multi-hole injectors increased the indicated power compared to the original injector. The new injector nozzle with four holes produced the highest indicated power compared to the other injectors. The new injector with four holes increased the indicated power by 9.5% compared to the original injectors. The increase in indicated power occurred because the new injector with four holes sprayed the fuel more evenly in the combustion chamber, the injected CNG fuel mixed more with the intake air and the fuel flow velocity was higher in the combustion chamber of the engine. The effect of the new injector in the combustion of engine was excellent with four holes compared to injectors with fewer holes.

The results of the effect of new injector nozzles with multi-hole geometry on brake power performance of the sequential port injection CNG engine are shown in Figure 3.

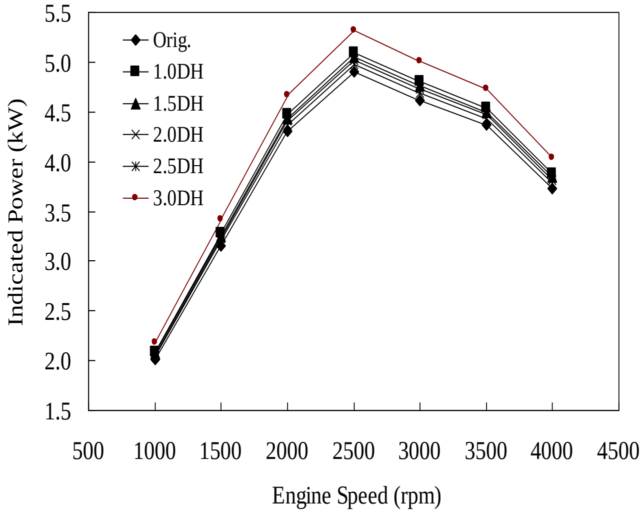
Figure 3 (a) shows the effect of the new injector nozzles with multi-diameter holes on the brake power performance of the sequential port injection CNG engine. With the new injector nozzles with 1.0 mm, 1.5 mm, 2.0 mm, 2.5 mm and 3.0 mm diameter holes, the highest brake power was determined at an engine speed of 2500 rpm.

Figure 3 (b) shows the effect of the new injector nozzles with multi-degree holes on the brake power performance of the sequential port injection CNG engine. In the new injector nozzles with 10, 15, 20, 25 and 30 degree nozzle holes, the highest brake power was determined at an engine speed of 2500 rpm. The new injector nozzle with multi-degree holes increased brake power performance compared to the original injector.

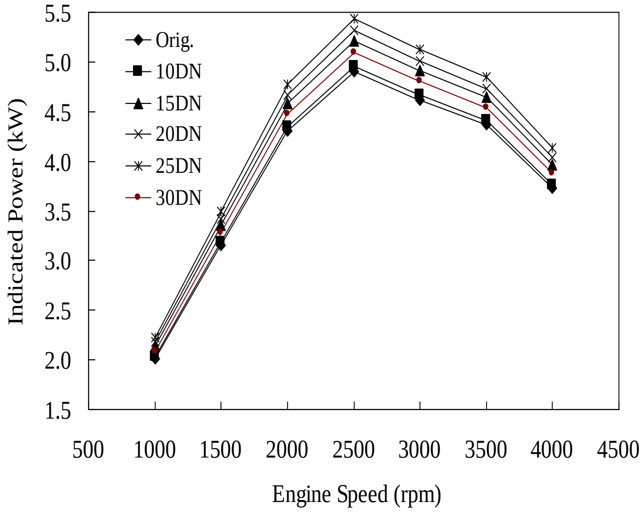
Figure 3 (b) shows the effect of the new injector nozzles with multi-degree holes on the brake power performance of the sequential port injection CNG engine. In the new injector nozzles with 10, 15, 20, 25 and 30 degree nozzle holes, the highest brake power was determined at an engine speed of 2500 rpm. The new injector nozzle with multi-degree holes increased brake power performance compared to the original injector. The new injector nozzle with 25 degree nozzle holes produced the highest brake power compared to the other injectors. The highest increase in brake power of 13.5% compared to the original injector was seen with the new injector nozzle with 25 degree holes. This was caused by the dominant in-flow velocity effect, where the velocity from the 25 degree nozzle hole was higher than with the other injectors. In the new injector nozzle with 25 degree holes, the fuel flow was sprayed evenly in the combustion chamber; furthermore, the fuel and air were mixed completely in the combustion chamber.

Figure 3 (c) shows the effect of the new injector nozzles with multi-degree diffuser holes on the brake power performance of the sequential port injection CNG engine. In the new injector nozzles with 10, 15, 20, 25 and 30 degree diffuser holes, the highest brake power was determined at an engine speed of 2500 rpm. All of the new injector nozzles increased the brake power compared to the original injector. The new injector nozzle with 25 degree nozzle holes produced the highest brake power compared to the other injectors. In this investigation, the injector with 25 degree diffuser holes increased the brake power by 10.9% compared to the original injector, because the injected gas fuel flow was sprayed at a higher velocity and spread evenly throughout the combustion chamber with the new nozzle. However, too-high degree diffuser holes such as the 30 degree diffuser hole reduced the fuel flow spray, fuel-air mixing and the velocity of the injected gas fuel. Combustion in the engine was excellent with the 25 degree diffuser hole injector nozzle compared to the other injectors.

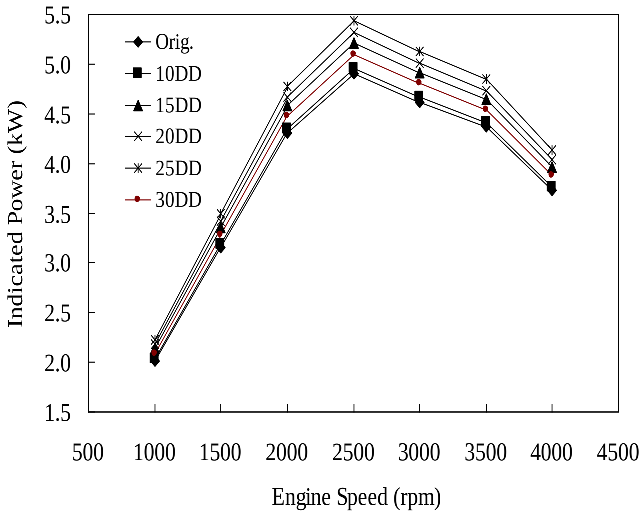
Figure 3 (d) shows the effect of the new multi-hole injector nozzles on the brake power performance of the sequential port injection CNG engine. With the new injector nozzles with two holes, three holes, four holes and five holes, the highest brake power was determined at an engine speed of 2500 rpm. The new injector nozzle with four holes produced the highest brake power compared to the original injector, and the injectors with two, three or five holes. The injector with four holes increased the brake power by 9.5% compared to the original injector, since with four holes, the injected gas fuel was sprayed more evenly, mixed more with air and was injected with higher velocity into the combustion chamber.



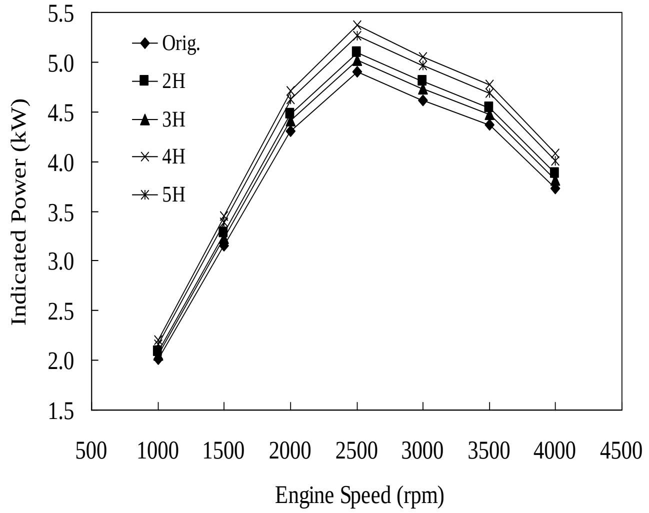
(a). Indicated power of new multi-diameter hole injector nozzles



(b). Indicated power of new multi-degree hole injector nozzles

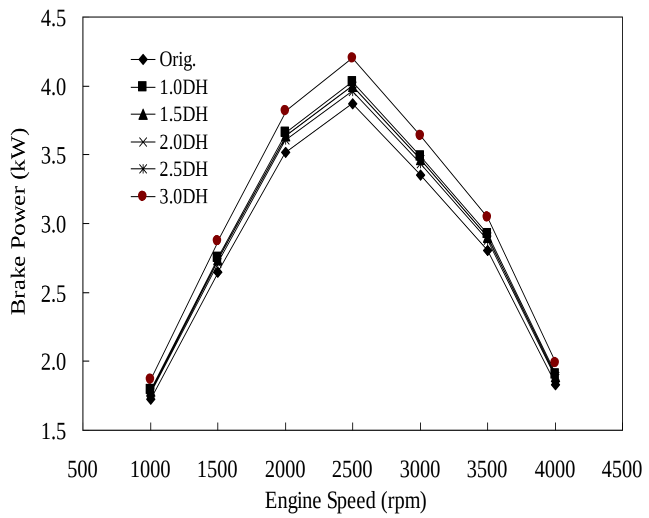


(c). Indicated power of new multi-degree diffuser hole injector nozzles

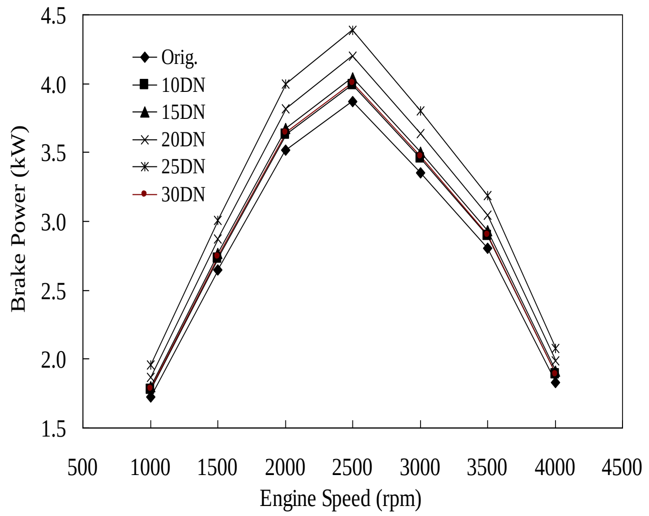


(d). Indicated power of new multi-hole injector nozzles

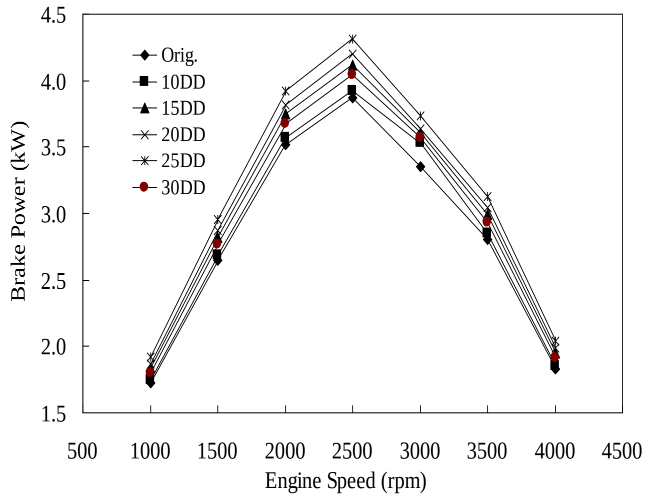
Figure 2: Indicated power against engine speed



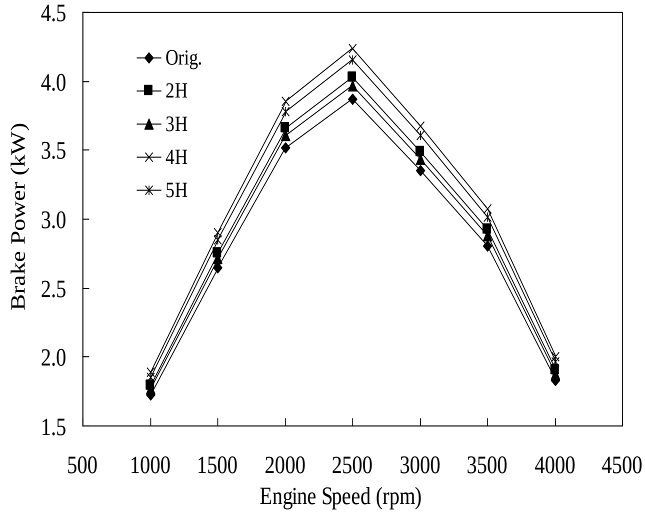
(a). Brake power of new multi-diameter hole injector nozzles



(b). Brake power of new multi-degree hole injector nozzles



(c). Brake power of new multi-degree diffuser hole injector nozzles



(d). Brake power of new multi-hole injector nozzles

Figure 3: Variation of brake torque against engine speed

CONCLUSIONS

In the indicated power performance, this was caused by better fuel flow and fuel-air mixing, resulting in excellent combustion with the 25 degree nozzle holes compared the other new injectors with multi-degree nozzle holes. This excellent combustion increased the indicated power of engine by 13.4%. This was caused by the dominant in-flow velocity effect, where the velocity with the 25 degree nozzle hole was higher than with the other injectors. Unfortunately, the new injector nozzle with 10 degree nozzle holes produced lower indicated power for the sequential port injection CNG engine compared to the other new injectors. Generally, the new injectors increased the indicated torque.

The new injector nozzle with 3.0 mm diameter holes produced the highest brake power compared to the other new injectors and the original injector. Combustion in the engine was excellent with the 3.0 mm diameter hole nozzle compared to the others. By using the new injector nozzles with 3.0 mm diameter holes, the brake power increased by 8.51%.

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