Performance of compressed natural gas (CNG) engine with pre chamber

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Keywords: Pre chamber; CNG; performance

ABSTRACT – Pre chamber is use to extend lean limit of mixture and improve combustion efficiency. Pre chamber used in this study was pre chamber without auxiliary fuel. Then, this pre chamber was applied to single cylinder compressed natural gas engine. The effects of pre chamber on CNG performance are increase in power and torque starting at engine speed 3000 rpm. However, disadvantage by the pre chamber had been discovered on the brake specific fuel consumption (BSFC). It caused the BSFC by CNG was higher than a CNG without pre chamber.

1. INTRODUCTION

Original design of pre chamber was found on 2-stroke Ricardo Dolphin engine [1]. Based on this original design, many studies were carried out with different design of pre chamber. The pre chambers are divided by two types which are pre chamber with auxiliary fuel and pre chamber without auxiliary fuel. Pre chamber with auxiliary fuel is the pre chamber equip with injector inside pre chamber volume [2,3]. Pre chamber without auxiliary fuel is the pre chamber does not have any injector inside pre chamber volume[4,5]. In this study, pre chamber without auxiliary fuel was selected because it easy to fabricate and install to the engine. Then, the single cylinder spark ignition engine fuel with CNG is tested with the pre chamber. The effects of pre chamber to the CNG engine are focus on power, torque, and BSFC.

2. METHODOLOGY

The engine was tested using hydraulic dynamometer and data acquisition. The engine used in this study is single cylinder spark ignition engine. Fuel types used is CNG fuel. The complete setup for all these equipments are shown in Figure 1.

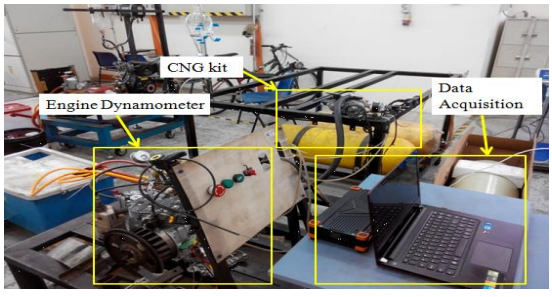

Figure 1 Complete experiment setup.

The experiment was conducted based on SAE International standard (J1349). The pre chamber was installed in front of spark plug. This pre chamber located at top of engine head. Figure 2 shows the location of pre chamber and spark plug on the engine.

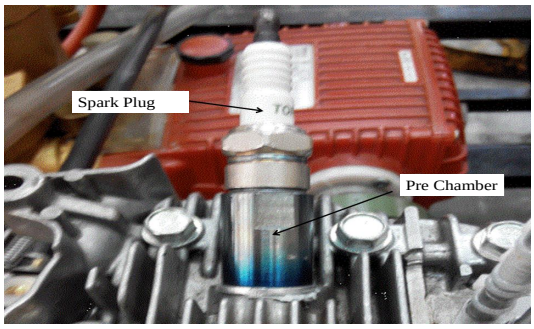

Figure 2 Location for pre chamber installed.

This methodology was illustrated by using flow chart in Figure 3.

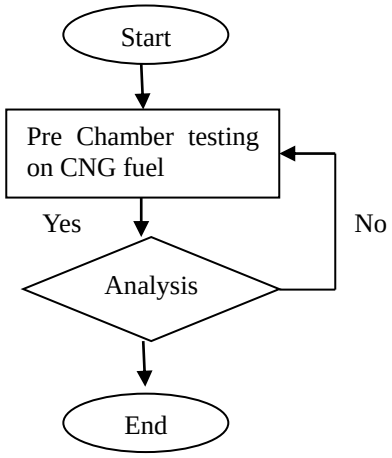

Figure 3 Flow chart for methodology.

2.1 Mathematical equation

The performance effects by the pre chamber were observer on power, torque, and BSFC. Mathematical equation for the power and torque is described based on the Equation (1):

$$\text{Torque} = \frac{\text{Power} \times 60}{2 \times \pi \times N} \quad (1)$$

Equation (1) represents the relation between the power and torque. When the powers increase, theoretically the torque should be increase. The equation for BSFC is shown in Equation (2):

$$\text{BSFC} = \frac{\dot{m}}{\text{Power}} \quad (2)$$

Based on Equation (2), main parameter for the BSFC in mass flow rate ($\dot{m}$). The power in the Equation (2) is relate with Equation (1).

3. RESULT AND DISSCUSSION

The results for this study are power, torque, and BSFC. The effect of pre chamber on the power by CNG fuel is shown in Figure 3.

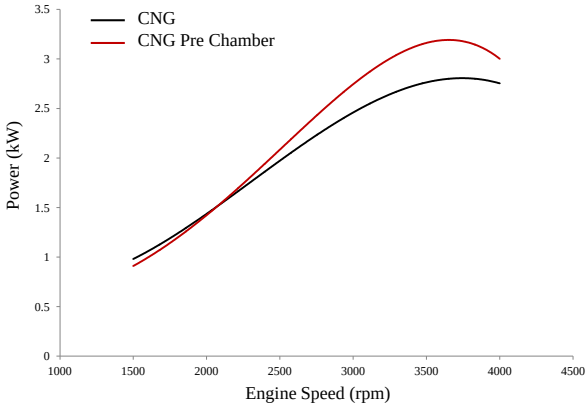

Figure 3 Effect of pre chamber on the power by CNG at various engine speeds.

Based on Figure 3, below engine speed 2000 rpm, the pre chamber caused power decrease. However, start at engine speed 2500 rpm until 4000 rpm, the pre chamber increased power by CNG fuel. The improvement by pre chamber on the power by CNG fuel is about 16%-20% improvement. This improvement also founded in torque as shown in Figure 4.

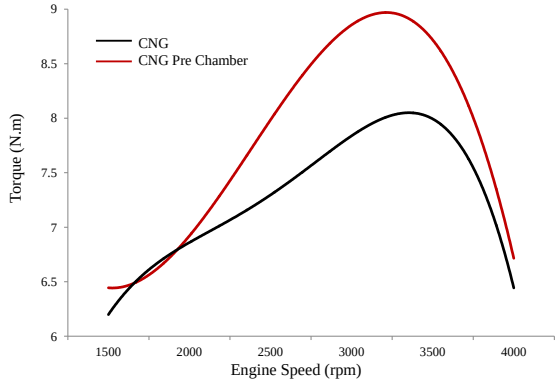

Figure 4 Effect of pre chamber on torque by CNG fuel at various engine speeds.

The pre chamber also improve the torque by CNG fuel same as power. This improvement occurred start at engine speed 2500 rpm. This improvement occurs at same engine speed for both results are support by Equation (1). Final result is BSFC as shown in Figure 5.

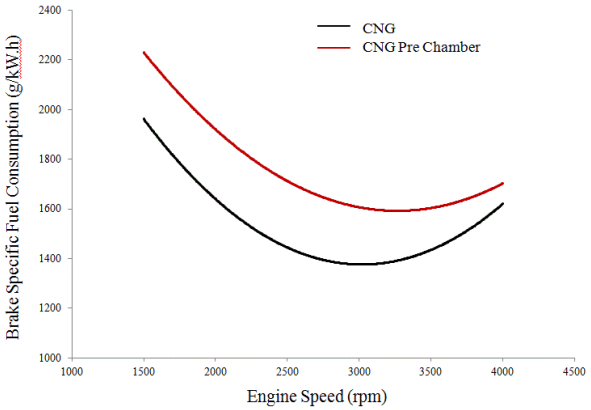

Figure 5: Effect of pre chamber on the BSFC by CNG at various engine speeds.

The pre chamber somehow increases the BSFC by CNG fuel. This is because of increase in mass flow rate and power by CNG fuel with pre chamber.

4. CONCLUSION

Application of pre chamber on CNG engine caused CNG performance increase in power and torque. However, it only starts to increase at engine speed 2500 rpm for both. Besides that, this pre chamber also gives disadvantage on the BSFC by CNG fuel. It caused BSFC increase at all engine speeds.

ACKNOWLEDGEMENT

This article had been successfully complete with research activities under UTeM's short terms grant (PJP/2014/FKM (6A)/S01323).

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