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THE EFFECTS OF INLET PORT DIAMETER-BORE (IPD/B) RATIO ON EFFECTIVE RELEASE ENERGY, RESIDUAL GAS AND EMISSION CHARACTERISTICS OF A SMALL SI-ENGINE

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ABSTRACT

This article has presented the inlet port diameter-bore ratios (IPD/B) on engine performance and emission characteristics. For the first time, the effect of inlet port diameter-bore ratio on the residual gas, peak firing pressure rise and effective release energy were discussed. Through combined experimental and simulative methods the drawbacks of hardware optimization method were eliminated. The results of the research show that the IPD/B ratio has a significant effect on the residual gas, peak firing pressure rise and effective release energy. Following increased IPD/B ratio from 0.3 - 0.5. The residual gas ratio shows an uptrend from 0.11% to 0.14%. The effective release energy increases from 0.33 KJ to maximum value of 0.45 KJ after that decrease. At IPD/B ratio is 0.4 effective release energy achieved the maximum values. The HC and CO emission was decreased, but the NOx was increased until a maximum value was achieved after that, a subsequent decrease. At IPD/B ratio is 0.4 the NOx was maximum value of 0.66 g/kWh, the BSFC was minimum value of 849.5 g/kWh.

Keywords: IPD/B ratio, residual gas, effective release energy, engine emission characteristics.

1. INTRODUCTION

In the internal combustion engine, the exhaust residual gas and the effective release energy are known as essential factors, which influence the engine performance and engine exhaust emission characteristics. In the exhaust stroke, there are some mount of exhaust gases are trapped inside the combustion chamber after exhaust stroke. This mount of exhaust residual gases will take part and premix with fresh air-fuel mixture in the next combustion process. The mount of exhaust residual gases decisions the influence level on the next combustion process, engine performance, and toxic products emission. The intake port configuration is known as a crucial parameter has strong effect on exhaust residual gas and engine performance. Some recently published papers presented the effect of intake port parameters on the air flow characteristics in the cylinder.

M. Raghu, at el. [1] presented the effect of intake port parameters on the air motion characteristics of a diesel engine. The intake port parameters were analyzed such as: intake valve diameter, valve seat angle and width, intake port eccentricity and orientation angle. In their research, the results showed that the geometries of the combustion chamber and intake port had significant effect on the flow into the cylinder. They also found that, when the intake valve diameter increased from 43 to 55 mm, the swirl ratio decreased 27.61% with directed port and decreased 17.65% with helical port. A. Yasar, et al. [2] also experimented with an internal combustion engine to study the effect of various intake port shapes on the intake air flow motion in the cylinder. In order to analyses the air flow behavior and to measure air flow velocity distribution, a particle image velocimetry technique (PIV) was employed in their research. Their results showed that the intake port geometry had sensitive effect on the air flow structure into the cylinder. With valve lift was 7mm and intake valve seat angle was 30 degrees, the inlet flow into the cylinder was a jet flow. Most of the air flow direction followed the axial direction; a reversed flow appeared due to the presence of the side wall of the cylinder. Y.L.QI, at el. [3] used CFD simulation model to study the effects of intake port geometry on the intake air flow characteristics in the cylinder of a SI-engine. They found that a small change of intake port has significant effect on in-cylinder flow. A suitable inlet port design helps to increase tumble and reduce recirculation of the intake air flow. A strong tumble leads to increase the homogenous of air-fuel and improve the stability of combustion. Their final design improved of 20% of the fuel vaporization.

All previous studies lacked detail on the investigation the effect of inlet port diameter-bore ratio on effective release energy, residual gas and engine emission characteristic. These studies focus to present the inlet port configuration effect on intake air flow characteristics such as: swirl ratio, air flow motion, flow velocity distribution or air flow tumble.

In our article, in the first time, the effect of inlet port diameter-bore ratio on effective release energy, residual gas and emission characteristics will be discussed.

2. EXPERIMENTAL SETUP AND METERIAL

2.1 Experiment setup

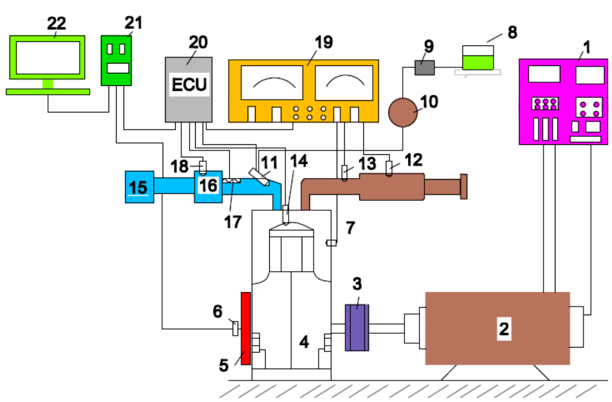

Fig 1 The the schematic of the small-SI engine testing system

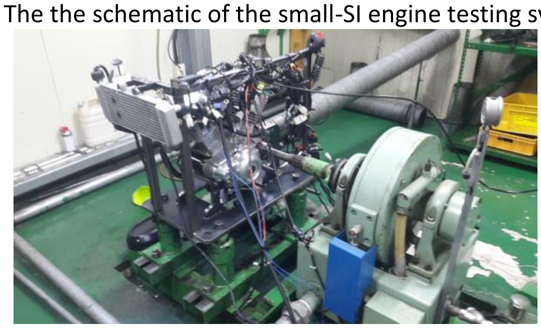

Fig 2. Engine experimental system

Figures 1 and 2 show the schematic of the small-SI engine testing system and experimental setup. The conditions of the experimental included a compression ratio of 11.8:1.0, and an air-fuel ratio of 13.6. The temperature of environment ranged from 29.5 to 30 deg C. Air was used for coolant, the engine oil temperature was maintained at 80 deg C; when the engine was running and the opening throttle angle was 90 degrees.

2.2 Applied engine

The applied engine specifications are shown in Table 1.

Table 1. Engine specifications.

Parameter	Unit	Value
Engine model	-	Four stroke, Spark ignition
Number of cylinder	-	2(V-Twin)
Compression ratio	-	11.8:1
Bore	mm	57
Stroke	mm	53.8
Connecting rod	mm	107.9
Intake valve	-	2
Exhaust valve	-	2
Cooling system	-	Air cooled

2.3 Simulation model setup

The AVL-Boost is well known as effective and useful simulation software of internal combustion engine field. AVL-Boost software allows researchers simulate all type of combustion engine as well as: SI – engine [4], CI-engine [5], engine 4 strokes or engine 2 strokes.

The simulation model of researching small-SI engine is showed in Fig. 3.

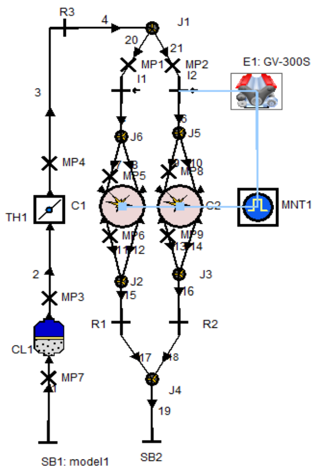

Fig 3 Simulation model

The elements in the simulation model describe for engine parts of researching engine. Those simulation elements are used to define researching engine's parts characteristics. The simulation condition of steady state or transient state is permitted to select in the engine element E1. The monitor element MNT1 is an extra element because this part is not in researching engine. This monitor element helps researcher is able to select observing output data as well as engine torque, residual gas ratio, effective release energy, etc. And the selected observing output data is able to shows in transient results. The element SB1and SB2 is system boundary of intake and exhaust pipe. Element CL1 is the air cleaner of the system. The opening of the throttle angle is set in element TH1, in this research the throttle is kept for opening 100%. The pressure loss in the intake and exhaust pipe (1, 2, 3…21) is described by element restriction R1, R2, R3. The element junction J1, J2, J3, J5, and J6 help to collect or to distribute the flow in the pipe. By using measuring element MP1, MP2 on the intake and exhaust pipe to determine the flow characteristic as well as: air mass flow, flowing velocity, air flow temperature. Injector I1 and I2 provides fuel in to cylinder C1 and C2 of the engine.

2.4 Model validation

The experimental data were used for validation before using the simulation model. The black curves describe the experimental results while the red curves describe simulated results. Upon comparisons between these cases, a steady base model was produced to support the simulated model, which had a more accurate method for predicting engine performance and emission characteristics. The effects of various IPD/Bratios on the emission and performance of the engine could be investigated via simulated model.

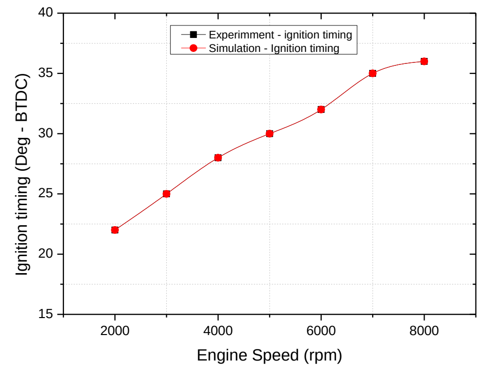

Fig 4 Ignition timing versus engine speed

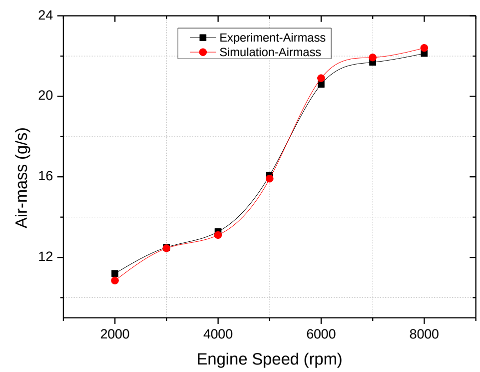

Fig 5 Air mass flow versus engine speed

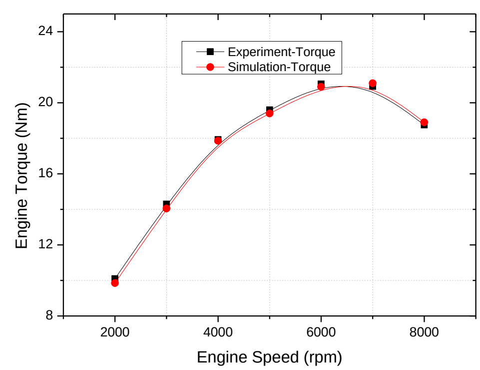

Fig 6 Brake torque versus engine speed

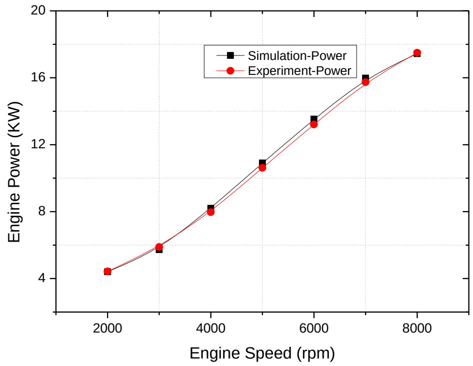

Fig 7 Engine power versus engine speed

2.5 Results

The results show: the effect of IPD/B ratio on residual gas, effective release energy, BSFC and emission characteristic as well as HC, CO, NOx.

Fig 8 shows the effect of IPD/B ratio on residual gas. When the IPD/B ratio increased from 0.3 to 0.5, the residual gas ratio increased from 0.11 to 0.14%. The minimum residual gas ratio was 0.107% at a 0.3 IPD/B ratio and the maximum residual gas ratio was 0.144% at a 0.5 IPD/B ratio. This can be explained by an increase of IPD/B ratio led to decrease the swirl ratio [1]. This was cause to reduce amounts of air fill into the cylinder as the subsequent effect of the intake stroke by decreasing fresh air fuel to sweep the exhausted gas out of the cylinder. This accounts for the reason why the residual gas ratio increases as the IPD/B ratio increases.

In Fig. 9, as the IPD/B ratio increases, the effective release energy increases until a maximum value was achieved after that, a subsequent decrease was observed, because the increase of residual gas in the combustion chamber led to reduce of homogeneous of air-fuel mixing, so the chemical energy of fuel could not be completely converted to thermal energy because of increase in unburned fuel. In this research, the maximum effective release energy was 0.45 KJ at 0.4 IPD/B ratios.

Figure 10 shows that the BSFC was influenced by IPD/B ratio. The BSFC was decreasing until achieved a minimum value after that increase even IPD/B ratio was still increasing. At 0.4 of IPD/B ratio, the minimum BSCF was 849.5 g/kWh. The maximum BSFC was 1542.17 g/KWh at 0.3 of IPD/B ratio. It can be seen that, at the IPD/B ratio value is smaller than 0.35 the missing firing was happened because at this band of IPD/B ratio, the BSFC value, HC emission (Fig. 11) were very high and NOx emission was nearly zero (Fig. 13). So at IPD/B ratio values are smaller than 0.35 it is not good condition to engine operate.

In diesel engines, the EGR technique is effective method to reduce NOx emission. In our research, the increase of residual gas in combustion chamber led to increase HC emission and decrease CO (Fig. 12) and NOx emission (Fig.13).

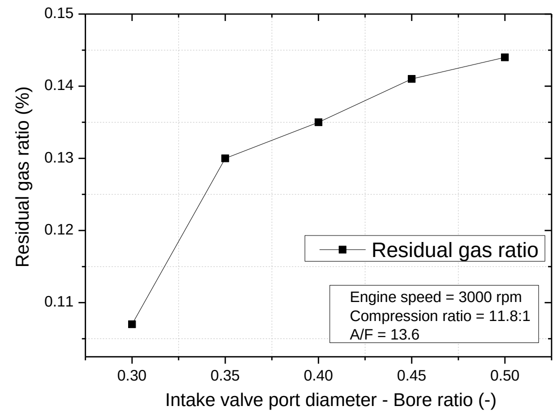

Fig 8 Residual gas ratio versus IPD/Bratio

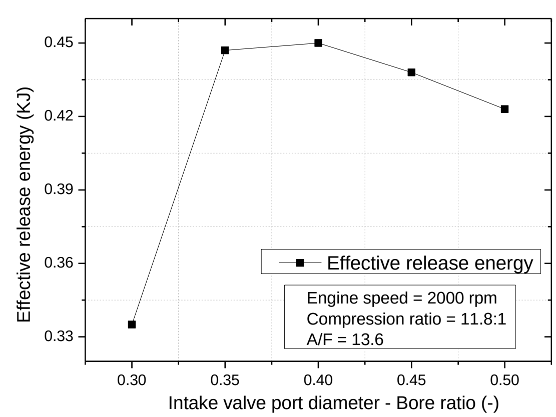

Fig 9 Effective release energy versus IPD/Bratio

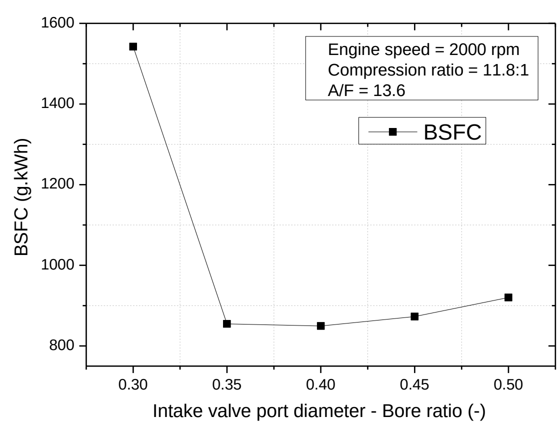

Fig 10 BSFC versus IPD/Bratio

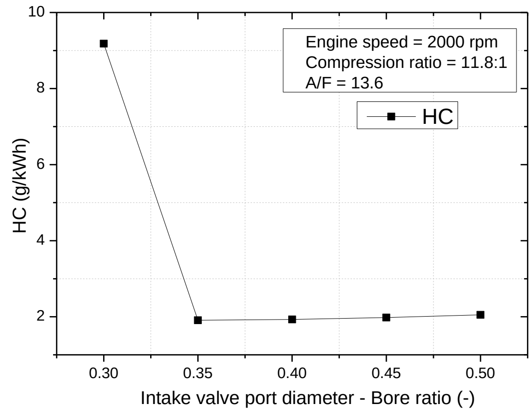

Fig 11 HC versus IPD/Bratio

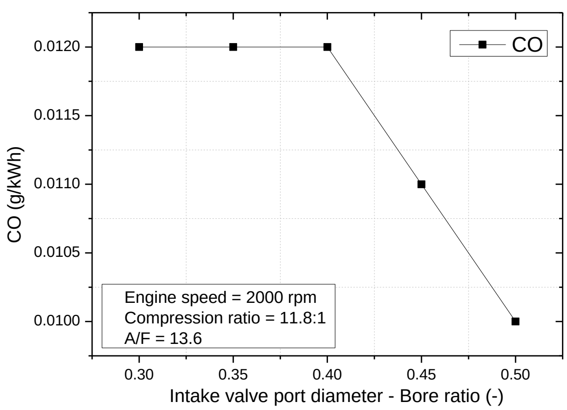

Fig 12 CO versus IPD/Bratio

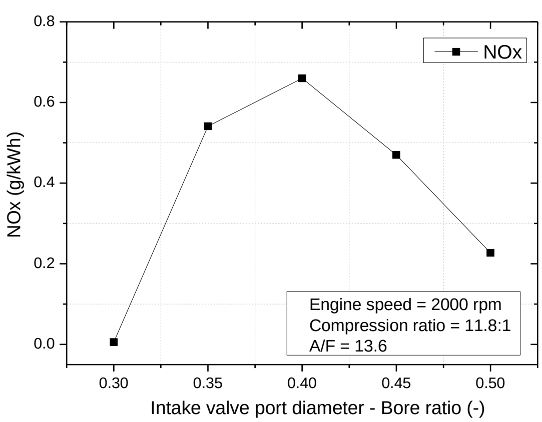

Fig 13 NO_x versus IPD/Bratio

2.6 Conclusions

The effect IPD/B ratio on residual gas, effective release energy and engine emission characteristics of Motorcycle engine are studied.

The results show that:

1) The IPD/B ratio gets quite effect on residual gas, effective release energy and engine emission characteristics. As the increase of IPD/B ratio from 0.3 to 0.5 the residual gases increase from 0.11 to 0.14%.

2) The trend of residual gas is adverse effective release energy (Fig 8 and Fig 9). It means the residual gas also gets effect on effective release energy. If residual ratio increases then the effective release energy was decreased and reverse direction.

3) The optimal value of effective release energy, BSFC was achieved at the same IPD/B ratio value. At IPD/B ratio value was 0.4 the maximum effective release energy was 0.45 KJ and the minimum BSFC was 849.5 g/kWh.

4) The results point out that: the engine operates not well with IPD/B ratios value are smaller than 0.35 because the missing firing will be happened in this band of IPD/B ratio.

5) The HC and NOx emission decrease as increase of IPD/B ratio, the CO emission had a downtrend but not much. At IPD/B ratio value was 0.4 the maximum NO_x emission was 0.66 g/kWh and minimum HC emission was 1.91 g/kWh.

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