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SCAVENGING OF THE SUB CHAMBER OF THE ENGINE USING CNG FUEL

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Abstract

It was proposed that the sub-chamber style gasoline engine was a type of clean engine, but a significant flaw was the presence of residual gas in the sub-chamber. The CNG direct injection method was introduced to scavenge residual gas from the sub-chamber in this experimental sample. The CVC (constant volume chamber) is split into and used as the main experimental apparatus in the sub-chamber and main chamber. Since there is an injector in any CVC combustion chamber, the injector may be used freely, at the same time or individually. Therefore, by adjusting injection times for the sub-chamber, the scavenging performance can be increased. The experimental results showed that the combustion time was shortened by 30 percent relative to that of injection into the main chamber when all the fuel was injected into the sub chamber. Even though residual gas was observed in the CVC, good combustion characteristics were obtained when the number of injections into the sub-chamber increased.

***Keywords**: CNG, Sub-chamber, Combustion, Emission, Scavenging, Radical.*

I. INTRODUCTION

Owing to their significant effects on both humans and the environment, toxic emissions from automobiles using gasoline or diesel engines have been extensively studied to find strategies for mitigating emissions[1]. The primary targets in this analysis were HC, NOx and CO[2]. However, since the Kyoto protocol, CO2 has been introduced to the goal in recent years[3]. The vehicle is, therefore, the primary objective of a clean war[4]. While a number of studies involved have reached the limitation threshold for vehicle emissions, the limitation level would be further increased because the level takes circumstances into account. In fact, vehicle emissions problems, such as the Euro 5, have been fraught with considerable difficulties[5]. The reduction of toxic emissions from engines has been investigated in several studies: a report on the use of hydrogen fuel versus petroleum in engines and a study on the use of alternative fuels such as LPG and CNG have recently been incorporated into the body of current literature[6]. In order to meet Euro 3 and Euro 4 constraints, lean burn technology has been developed. This technology has been applied to the lean burn engine of Hyundai and the GDI engine of Mitsubishi. However, because of its slow combustion velocity, the lean burn technology is disadvantageous. This undesirable feature directly reduced the thermal efficiency of the engine, increased HC and affected the generation of CO2 indirectly. An engine with low emissions must also have a high combustion velocity. To build an engine that could have a high combustion velocity under a lean mixture, a feasibility study of the sub-chamber style gasoline engine was carried out[7].

Similar to a conventional sub-chamber style diesel engine, the engine combustion chamber is divided into a sub-chamber and a main-chamber[8]. The volume of the sub-chamber is 1~2 percent of the volume of the main-chamber. Sub-chamber has about 10 passage holes with a diameter of around 1.5 mm. In the sub-chamber, the spark-plug is fixed. During the intake stroke, the blend enters the sub-chamber from the main-chamber and is ignited by the spark-plug. Then, through the openings, the combustion gas and a variety of radicals are expelled into the main chamber and the mixture causes ignition. This method of ignition is radically different from the conventional gasoline engine that uses the main-chamber mounted spark plug. The ignition source is a combustion gas in this sub-chamber style RI engine, including a number of radicals that are expelled into the main chamber, like an awl. The number of ignition positions is, therefore, equal to the number of ignition positions of holes of passage.

The experimental results obtained using the constant volume chamber (CVC) showed that this method would produce a two-fold higher combustion velocity, as the RI method (radical ignition method) was referred to as the general method of combustion method and the engine was called the RI engine using this combustion method. However, applying the RI technique to a real engine causes many issues, the most notable of which is residual gas in the sub-chamber. The sub-chamber scavenging method is suggested to construct a more perfect RI engine and the effect of the RI method by scavenging must be checked. The method of direct injection of gas fuel into the sub-chamber was planned in this experiment to scavenge residual gas in the sub-chamber. Because of its low energy density, gaseous fuel has a greater volume than liquid fuel. If the sub-chamber is injected several times with a gaseous fuel such as CNG, the impact of the residual gas will be scavenged into the sub-chamber and wall wetting will be avoided. Also, the majority of the fuel flows into the main chamber through multiple holes in the sub-chamber when the direct injection method is applied to the sub-chamber via the use of a single nozzle injector. In the main chamber, this approach is supposed to improve the fluidity and mixing rate of the mixture. A CVC is used as the key experimental apparatus in this research to obtain basic data on the combustion of the air-fuel mixture according to the scavenging pattern. The strong flame flow is produced around the outside of the sub-chamber because the flame-like awl is injected into the main-chamber at all 10 holes. These vortex flows encourage the velocity of combustion as well. It is not an acceptable method to increase the number of holes to increase the ignition point, since the ejecting gas must have optimal physical and thermal energy to ensure good penetration into the main chamber.

II. METHODOLOGY

The second iteration of the RI engine is shown in Figure 1, which is an improvement on the basic model. It has two injectors and an intake manifold in the sub-chamber. Mounted in the sub-chamber, the sub-injector is used to solve the issue of residual gas. In the intake manifold, this second model has another injector mounted. Figure 2 displays the experimental apparatus. It is compatible with the CVC system, the fuel supply system, the air compressor, the intake and exhaust valves, the ECU and the pressure measurement system.

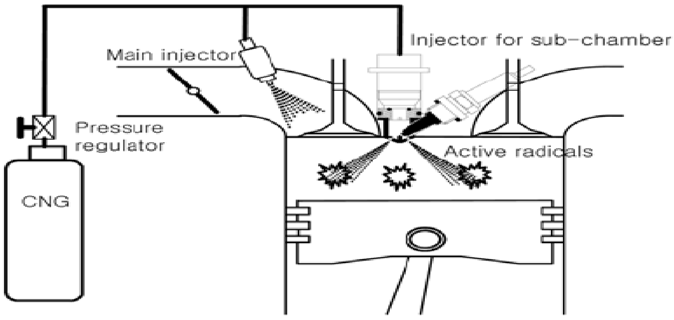
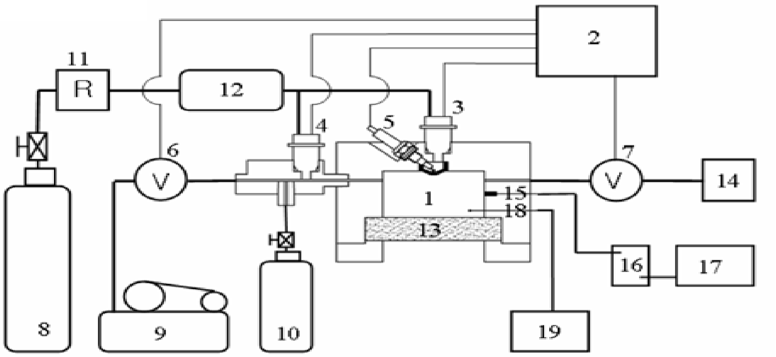


Fig. 1: Shows the gasoline engine of the sub-chamber type with the injector



1. CVC
2. ECU
3. Injector for main-chamber
4. Injector for sub-chamber
5. Spark plug
6. Intake valve
7. Exhaust valve
8. CNG bomb
9. Air bomb
10. CO_2 bomb
11. Pressure regulator
12. Surge tank
13. Quartz window
14. Vacuum pump
15. Pressure transducer
16. Amplifier
17. DAQ system
18. Thermocouple
19. Temperature controller

Fig. 2: Experimental setup

A. Scavenging in the sub-chamber by the injector

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According to the injection pattern, figure 4 shows the p-t diagram. As shown in Figure 3, the CO2 concentration is set at 6.0 percent, 7.9 percent, etc. As described above, the CNG is supplied in different patterns and, regardless of any adjustment in experimental conditions, is divided into eight injection times by two injectors. The S0+M8, written in the legend, therefore reflect 0 injections of time into the sub-chamber and eight injections into the main-chamber. The data shown in Figure 8 is also an average of five experiments. Figure 4 indicates a higher combustion velocity as well as a more robust combustion due to fast scavenging of residual gas in the sub-chamber when compared with Figure 4 and Figure 3. This happens because the efficiency of scavenging increases due to the rise in injection frequency towards the sub-chamber.

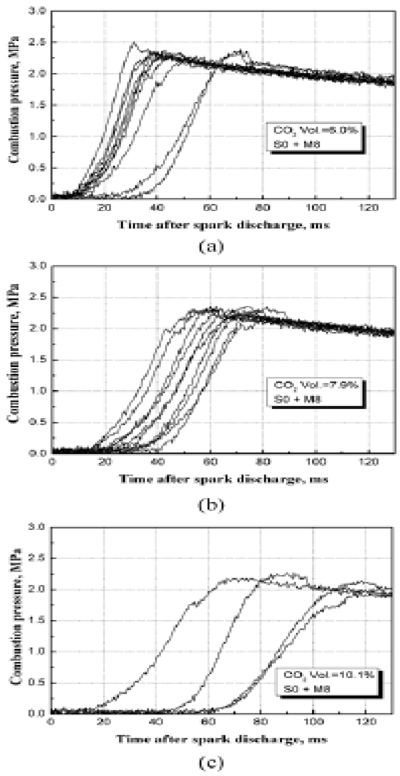

Fig. 3: P-t diagram in the case of the existence of residual gas

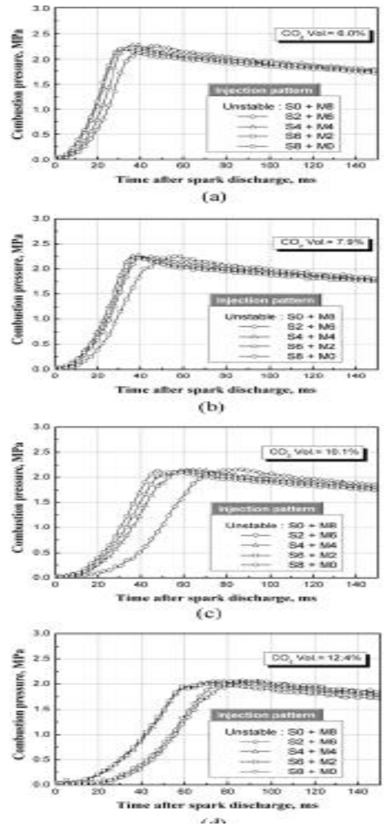

Fig. 4: Change of the p-t diagram by injection pattern.

III. CONCLUSION

The following findings were obtained in this analysis.

i. The combustion properties of the CVC are largely altered as the injection pattern shifts.

ii. The combustion velocity increases as more fuel is pumped into the sub-chamber.

iii. By means of CNG direct injection into the sub-chamber, the issue of residual gas in the sub-chamber can be solved.

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