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Investigation to Set the Type of Pre-Chamber Fuel System in Heavy Gas Engine HIMSEN 35/40

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ABSTRACT: Following concerns about air pollution and global warming in recent years, the use of heavy duty gas engines has become favorable in major industries such as the marine industry, power plants, etc. Heavy duty diesel engines designed for similar applications were used and made by modifying their structure or adding new parts or a combination of the two approaches, because of the fact that heavy duty gas engines are more similar to diesel engines with similar emissions. They have less emission and also less power. Various technologies can be used to increase the power of the gas engines. One of these new technologies is the pre-combustion chamber, which results in an increase in power output. The pre-chambers are categorized into two types of refueling in terms of how the refueling is shared with the main chamber and refueling independent of the main chamber. The pre-combustion chamber should be used to increase the efficiency of the pre-chamber and overall engine efficiency, which is suggested after considering the use of the pre-combustion chamber with a stand-alone fuel system.

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1. Introduction

Heavy gas engines are often developed by diesel engines, which includes changing different parts of diesel engines or adding new parts to them or a combination of the two, resulting in a new engine that fits the gas. One of the most effective technologies used in this field is pre-chamber technology, which leads to a significant improvement in the combustion process. There have been many studies on preoperative performance, which will be discussed below.

Toulson et al. [1] studied SI ignition and ignition systems with PCI pre-ignition on natural gas and propane fuels. Shah et al. [2] using simulation of prefabricated jet mixing features in a heavy-duty gas engine using Computational Fluid dynamics (CFD) method to investigate the effects of pre-chamber and nozzle dimensions on ignition caused by turbulent jet in the two-ratio format. Gentz et al. [3] used combustion imaging and modeling of CFD to examine the performance of a pre-chamber ignition system by the TJI turbulent jet in a high-density motor for different nozzle diameters. Khan et al. [4], using three-dimensional computational modeling, examined the ignition jet in a methane-hydrogen-air-mixed mixture in a fixed volume combustion chamber. Thelen et al. [5] conducted a computational analysis of the effect of nozzle size on the performance of the TJI turbulent jet ignition system. The turbulent jet ignition system is provided on a high-density machine. Alvarez et al. [6] conducted a comprehensive study by reviewing pre-chamber ignition systems as poor combustion technologies in ignition spark motors. Qin et al. [7] examined the pre-mixed combustion of methane-air mixture in the prefabricated system and main chamber using precise numerical simulation, which is suitable for use in internal combustion engines.

In this article, by selecting the HIMSEN 35/40 gas engine made by Hyundai Korea with a cylinder diameter of 350 mm and a course length of 400 mm, this issue is examined: What should the pre-chamber fuel system look like, shared with the main or separate chamber refueling system?

2. Methodology

Dimensions and dimensions of the HIMSEN 35/40 engine are available from Hyundai's website [8]. This study is performed by numerical solution with the help of simulation in CONVERGE commercial software. The computational network is shown in Fig. 1.

3. Results and Discussion

The pressure trace from the experiment and the results obtained from the simulation for pre-chamber based on time for pre-chamber mode with a cylindrical nozzle ("straight") is shown in Fig. 2.

In this paper, the results are validated in the CONVERGE software on a fixed volume combustion chamber, while the engine is intended for the analysis of a larger gas engine with larger dimensions. The first stage is the independence of the grid in the simulation of the fixed volume combustion

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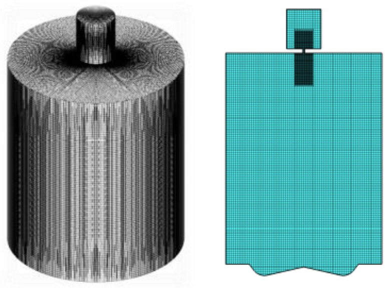

Fig. 1. 3D and 2D view of the solution domain and the generated grid

chamber (Fig. 3(a)), and the second stage is the independence of the grid in the simulation of a heavy gas engine as shown in Fig. 3(b) (40/35HIMSEN gas engine).

As shown in Fig. 5, the pressure inside the main chamber increases during the time, while the increase in pressure inside the pre-chamber is very small so that it can be ignored. This means that the pressure inside the pre-chamber is not affected by the increase in pressure inside the main chamber, because unlike light gas-fired engines [9], the nozzle dimensions are very small compared to the main chamber and pre-chamber, so it can be ignored when the pre-chamber pressure is still low during ignition. There is no mixture of fuel and air into the pre-chamber, so the pre-chamber pressure at the time of ignition will be lower than the desired value, and even after ignition and combustion.

4. Conclusion

In general, it can be stated that in the HIMSEN 35/40 gas engine, the pre-chamber refueling system must be independent of the main chamber's refueling system, which is true for all large-scale heavy-duty gas engines, based on the reasons stated in result section the flame jet does not flow efficiently from the pre-chamber to the main chamber, so there is no effective combustion inside the main chamber.

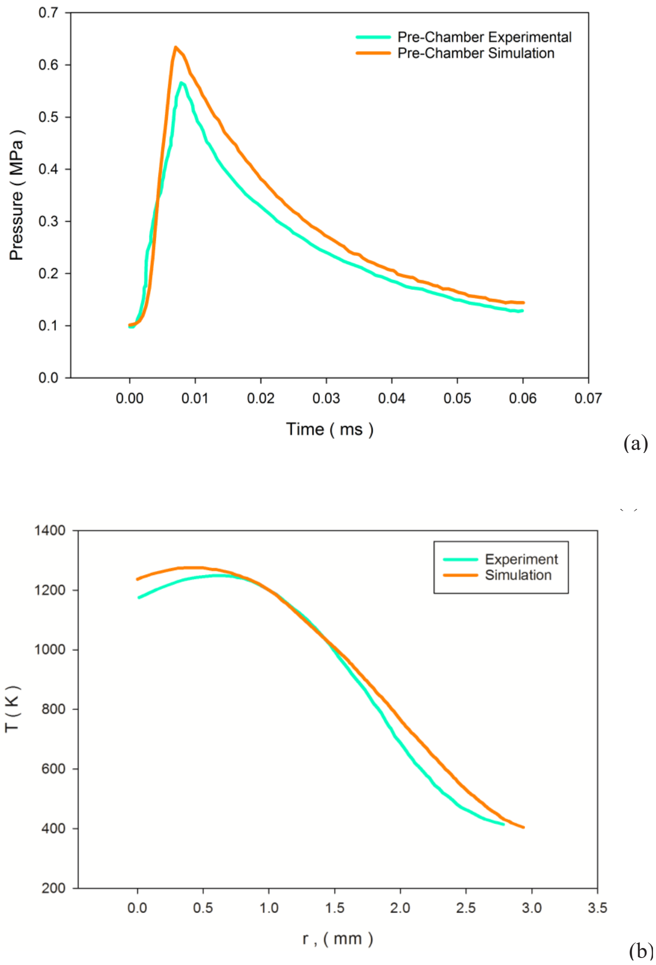

Fig. 2. Comparison (a) of pre-chamber pressure trace and (b) cylinder temperature along radial distance from the cylinder axis, for experimental results and simulation results in CONVERGE software

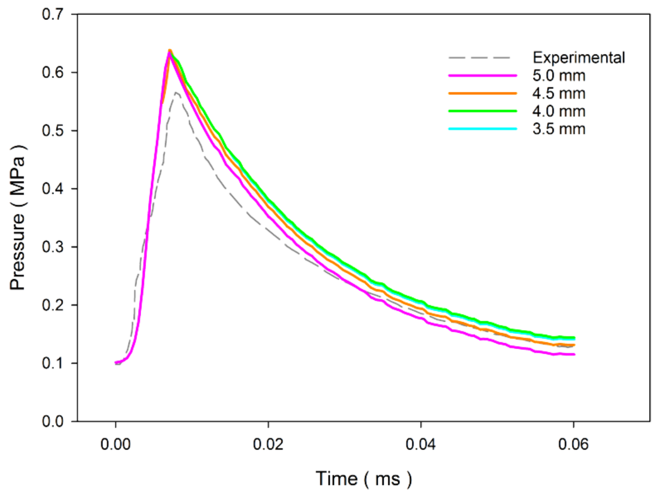

Fig. 3. Pre-chamber pressure trace for mesh sizes 5.0, 4.5, 4.0 and 3.5 mm in constant volume combustion chamber

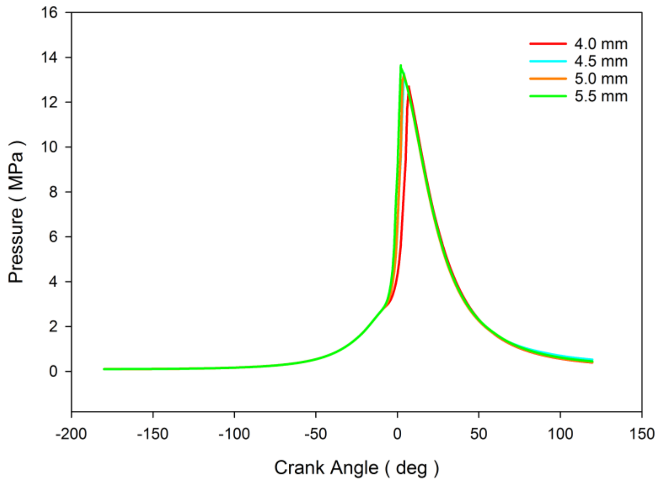

Fig. 4. Main chamber pressure trace for mesh sizes 5.5, 5.0, 4.5 and 4.5 mm in HIMSEN 35/40 engine chamber

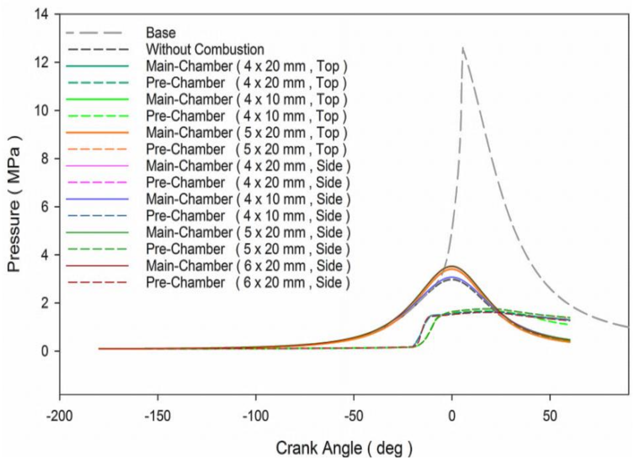

Fig. 5. Main chamber pressure trace for common main and pre-chamber fuel system

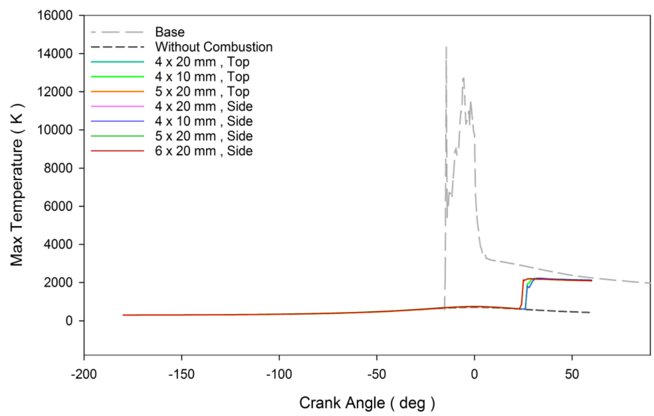

Fig. 6. Maximum temperature trace for the common main and pre-chamber fuel system

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