# Performance of Flame Jet Ignition for Pulse Detonation Engine

SHIMADA Hidetoshi, KENMOKU Yasuhiro, SATO Hiroyuki and HAYASHI A. Koichi

Department of Mechanical Engineering, Aoyama Gakuin University
6-16-1 Chitosedai, Setagayaku, Tokyo, JAPAN

e-mail: hayashi@me.aoyama.ac.jp

***Introduction***

Recent development of pulse detonation engine (PDE) has a remarkable progress. The main problem in this movement is a continuous operation, and mixing, and cooling. Pegg et al. (1) reports numerically that PDE may need a performance of 75~100Hz as thruster. This 100Hz has not been attained much yet for a long operation and we must overcome such hurdle. At least we must solve the problem of cutting DDT time.

The present study is to apply flame jet ignition (FJI) system (Oppenheim et al. (2), Hayashi et al. (3)) for PDE. Oppenheim et al. developed a FJI system for automobile engine and showed its better performance and combustion efficiency than plasma torch ignition and conventional plug ignition. FJI has a sub-combustor with a hole to produce a fast pulse combustion jet which contains many ions and radicals to ignite combustible mixture.

Hydrogen/air mixture is ignited using a FJI system in our PDE experiments. Its performance and effect on the engine are evaluated. A comparison of FJI with a conventional spark ignition (CSI) is performed to evaluated DDT time and distance with a Shchelkhin wire. The size of the sub-chamber and jet ejection hole diameter in FJI are also investigated along with PDE performance.

The PDE tube is about 1m long and square inner area of 40×40mm (Fig. 1). Burned gas is exhausted to a damp tank. A Shchekhin wire is set in PDE to enhance DDT process, which is 500mm long, 3.5 mm in diameter and 15 mm in pitch. Four pressure transducers are set as shown in Fig. 1 to measure pressure record, combustion wave speed, DDT time, and DDT distance. The control of the whole system is operated using a LABVIEW system.

The present experiments start by a single cycle system to study fundamental characteristics of FJI system. Initial condition (mixture injection condition) is kept to be 1.0 of equivalence ratio and 0.1MPa of pressure. The PDE tube is vacuumed in the first place to fill it up with hydrogen/air mixture up to 0.1MPa. The CSI and FJI system are set at the same position of the fore end of the tube. A combustion jet comes out to the axial direction at the center of the tube for FJI case. Parameters for the sub-chamber of FJI chamber (Fig. 2) are the sub-combustor diameter $\phi_C$, length $L_C$, and jet hole diameter $\phi_N$. The size of sub-combustor volume varies from 1.8~12.6cc and the volume ratio between sub-combustor and detonation tube is about 0.09~0.66%.

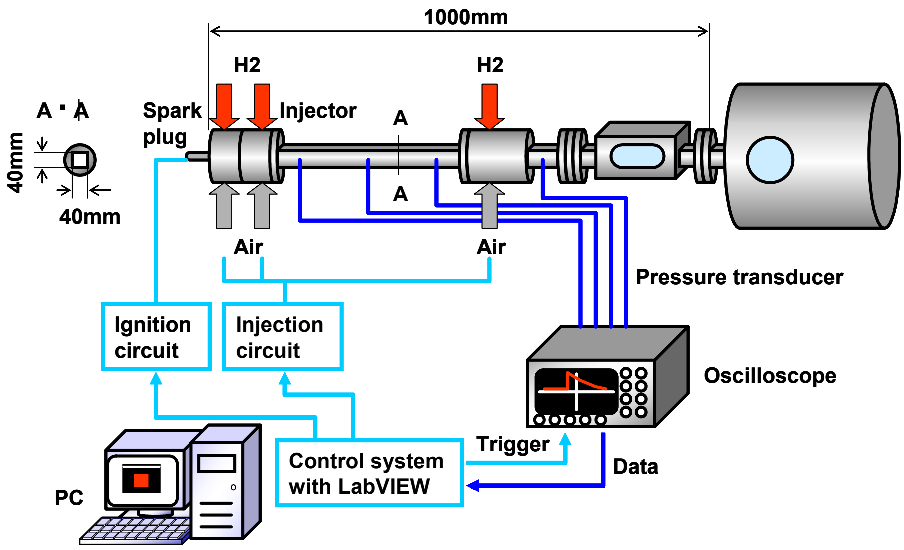



Fig. 1 Block diagram of experimental setup

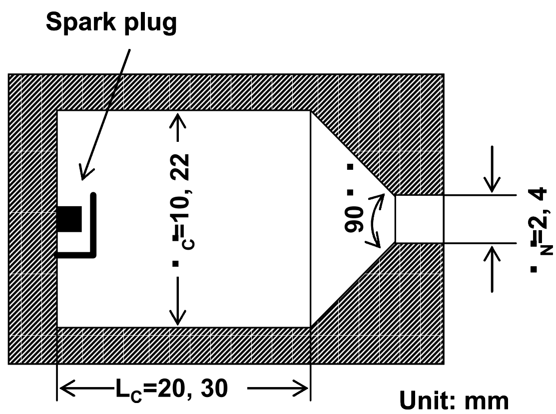
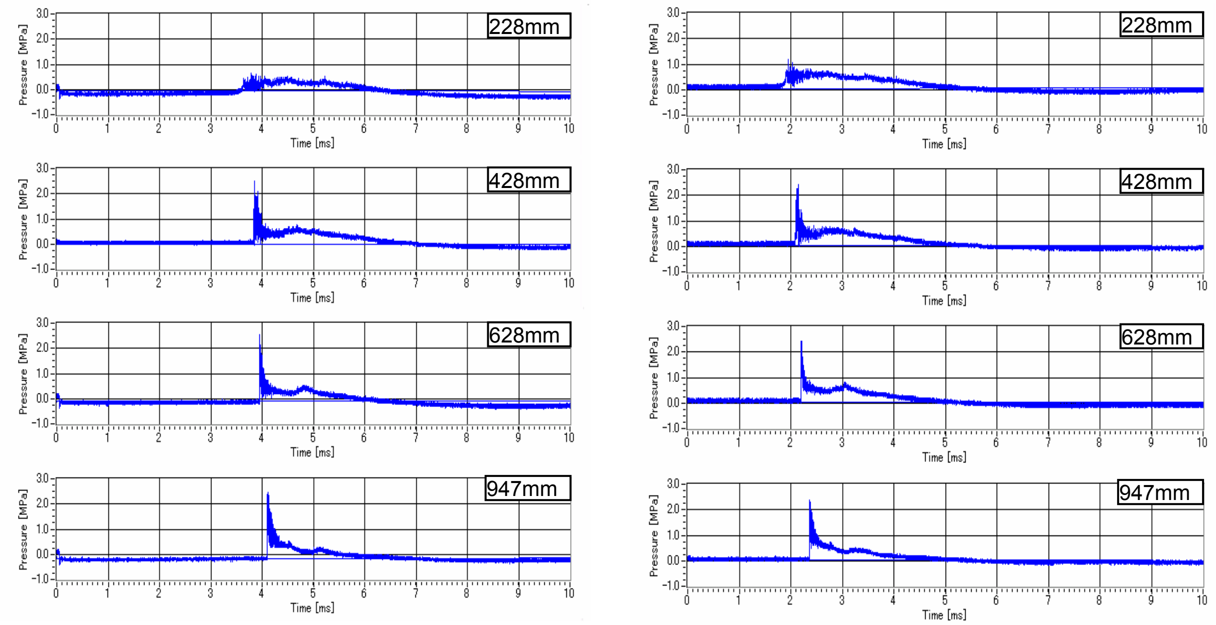



Fig. 2 Configuration of sub-combustor

Figure 3 shows the pressure history of two different ignition systems, one is (a) the CSI and another is (b) the FJI ($V_C$=1.8, $\phi_N$=4). Time 0 [ms] corresponds to the ignition. The FJI case is the case of shortest ignition time. Both cases show the ignition distance of 428mm in this moment, which has a spike pressure record. However the time when the combustion wave passed each pressure gauge is quite different between two cases. The FJI case shows the ignition time of about 2msec and that of CSI case is about 4msec. this means FJI shortened the ignition time with about 2msec.




(a) CSI　　　　　(b) FJI ($V_C$=1.8cc, $\phi_N$=4mm)

Fig. 3 Pressure history on different ignition system

At the present time eight sub-chamber configurations are tested to evaluate the best performance of DDT time. Figure 4 shows the x-t diagram where each case has a different combustion wave velocity depending on its sub-chamber configuration.

As a summery, FJI system promises the shorter DDT time to provide more mixing time for such 100 Hz operation. The details of the PDE performance will be discussed at the conference.

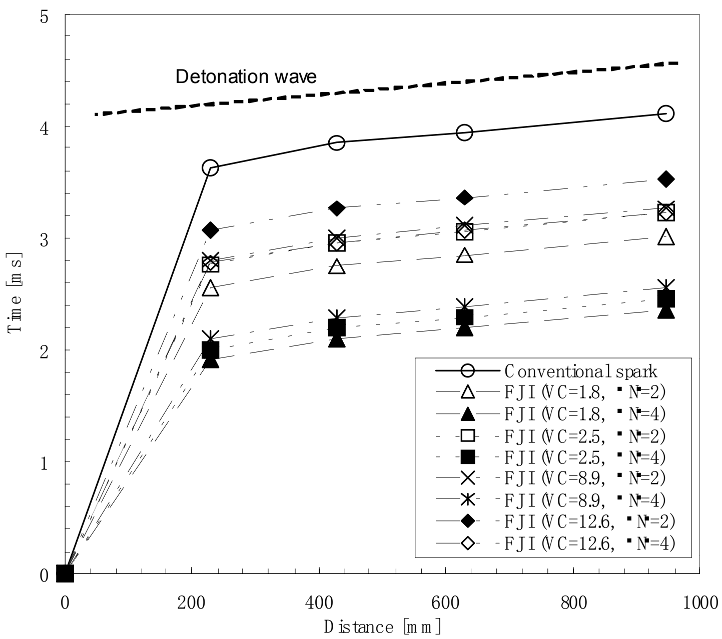



Fig. 4 x-t diagram for many different ignition systems

## Reference


1. Pegg, R. J., Courch, B. D., Hunter, L. G., AIAA paper 96-2918, July 1996.
2. Oppenheim, A. K. et al., SAE Paper NO. 890153, 1989.
3. Hayashi, K., Matsuura, K., and Baba, S., Advance in combustion, SAE Paper NO. SP-1492, 2000.