Preliminary Investigation of Mini Pulse Detonation Engine (PDE)

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1. Introduction

Supersonic and hypersonic aircrafts must pass wide range of speed to reach high speed region. But for existing engines the most efficient operating speed ranges are decided according to their flying speed, so an engine which mixes several engines like TRJ (Turbo Ramjet) and ARJ (Air Turbo Ramjet) has been planed. This mixed type engine has inefficiency that more than two engines must be installed simultaneously, but the pulsed detonation engine that uses detonation combustion has a strong point that it can operate in all speed range with single engine.

In our experiments using a small model, we confirmed that the specific impulse of PDE is superior to other engines.

2. Experimental Equipment

We manufactured a small size PDE of laboratory scale for development and concept design of pulse detonation engines that use periodic detonation waves and carried out experiments in which detonations were induced in chamber using detonation waves induced in the detonation tube.

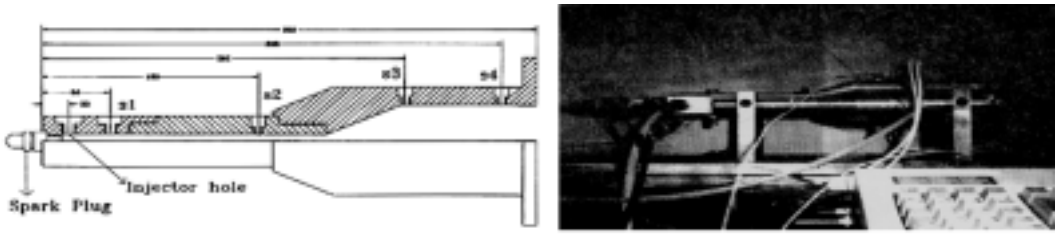

Fig. 1 Schematic and Picture of the PDE Model

About 30 degrees of diverging angle from the detonation tube to detonation chamber was suitable considering the thrust characteristics and specific impulse characteristics.

3. Experimental Method

Those experiments were carried out with two steps; single cycle experiments and multi cycle experiments.

In the case of single cycle experiments, detonation wave was induced when we ignited providing acetylene-oxygen mixture into the detonation tube through a solenoid valve intermittently and injecting acetylene-air mixture into the detonation chamber changing mixture ratio between 2.5%-20%.

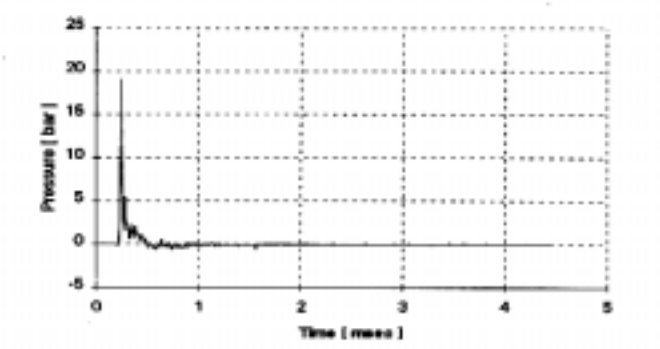

Fig. 2 Single Cycle Test

In the case of multi cycle experiments, periodic detonations that had operation frequency of 10Hz were generated for 3-4 minutes when we provided acetylene-oxygen mixture into the detonation tube with the similar method as single cycle case without certain cooling system, and injected acetylene-air mixture into the detonation chamber periodically.

Specific impulse based on the following equation,

$$Isp = \frac{1}{Mg} \int_A \int_0^t (P - Pa) dt dA$$

where,

M = Mass of fuel and oxidizer
P = Pressure in tube or chamber
Pa = Ambient pressure
A = Cross sectional area of tube or chamber

4. Result

Representative of detonation tube is shown in Fig.3 where maximum can be obtained about 1320 sec. But for main detonation chamber is shown in Fig.4, where even 3200 sec maximum could be obtained. However, there values should be considered only for the reference.

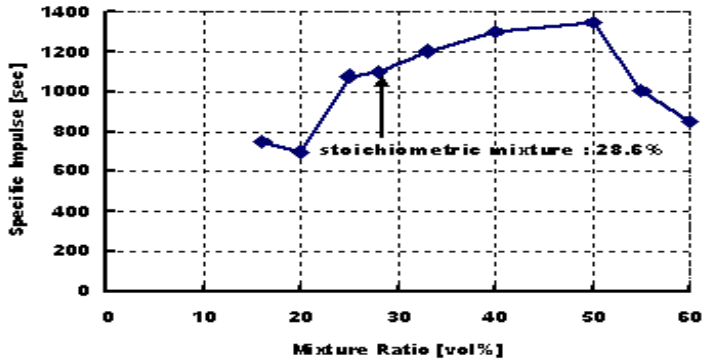

Fig. 3 Isp in Detonation Tube

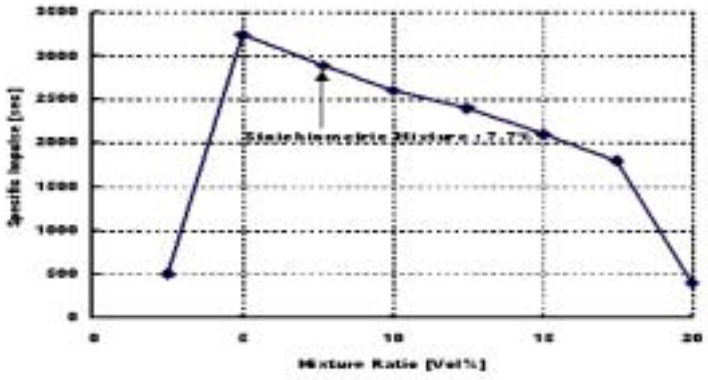

Fig. 4 Isp in Detonation Chamber

In order to utilize the pulse detonation engine as the propulsion engine for aircrafts, we have to consider more about the cooling system, and must develop more efficient ignition system and injecting system which has better mixing characteristics and has ability of high pressure, high speed fuel injection.

References

[1] Lloyd H. Back, Warren L. Dowler and Giulio Varsi, “Detonation Propulsion Experiment and Theory”, AIAA Journal Vol.21, No.10, oct.1983.