Experimental Research about Combustion of Multi-hole Pintle Injector Using LOx/GCH4

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Pintle injector can control injection velocity optimally at any combustion conditions with moving pintle parts. In addition, pintle injector can replace many injector elements to single element. For this reason, Pintle injectors have recently been adopted in rocket engines due to the advantages of combustion performance and weight savings[1]. Methane is researched as liquid rocket fuel in Europe recently[2]. Methane has advantages of higher specific impulse and cocking temperature compared to kerosene. Furthermore, NASA [3] is researching about Mars in-situ resource utilization technology for in-situ production. For this reason, LOx/GCH4 combustion has been researched in DLR recently [4].

The objective of this work is to analyze the combustion efficiency depending on geometric parameter, like number of pintle hole and pintle opening distance. The experimental system was designed for 500N of thrust and 20 bar of chamber pressure. Cryogenic liquid oxygen and gaseous methane was adopted as main propellant, and gaseous oxygen and methane was used for torch ignitor. The cross-section view and dimensions of a pintle injector are shown in Table 1. The designed mass flow rate of propellants are 133.2g/s for liquid oxygen and 33g/s for gaseous methane.

Combustion experiments were performed with two types of pintle tips. The hole diameter is the same, but there are 16 holes in one pintle tip and 24 holes in the other pintle tip. Pintle opening distance was controlled in the range of 0.4 to 1.6 mm. representative combustion experimental result is shown in fig. 1. Pintle opening distance was set to 1.6 mm, The mass flow rate of LOx is 66 g/s, that of methane is 12.3 g/s. As the result, the characteristic velocity efficiency was measured as 92.5%.

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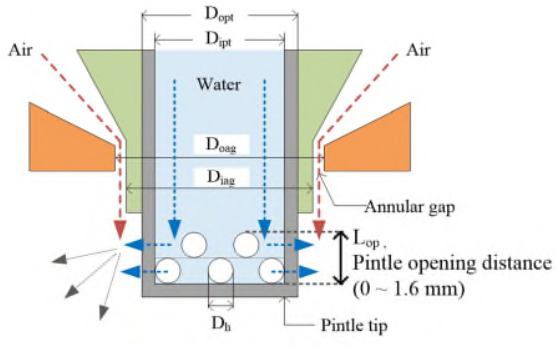
Table 1: Schematic and dimensions of a multi-hole pintle injector



Design Variables	Acronym	Value
Pintle opening distance	L_{op}	0-1.6 mm
Pintle tip inner diameter	D_{ipt}	4.35 mm
Pintle tip outer diameter	D_{opt}	6.35 mm
Annular gap inner diameter	D_{iag}	8.0 mm
Annular gap outer diameter	D_{oag}	9.5 mm
Pintle tip hole diameter	D_h	0.8 mm
Pintle tip rod diameter	D_{pr}	2.5 mm
Pintle tip Thickness	L_{pt}	1.5 mm
Number of Hole	N_h	16, 24

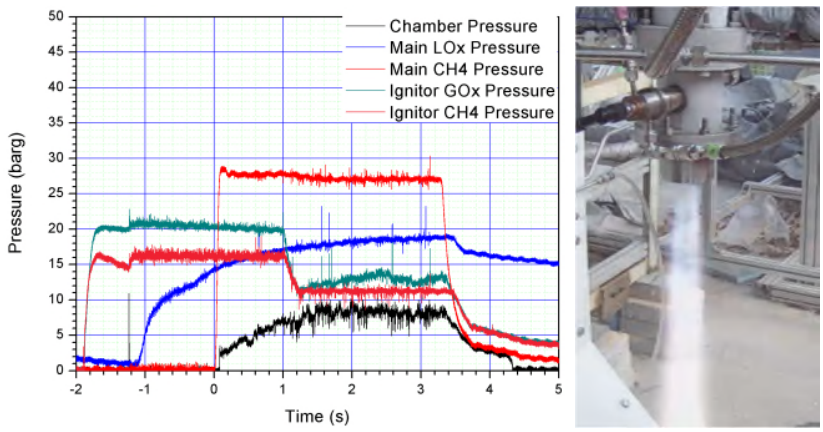


Figure 1. Combustion experimental result

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[3] Muscatello AC, Santiago-Maldonado E. (2012) Mars In Situ Resource Utilization Technology Evaluation. In: Proceedings of 50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, AIAA 2012-0360.

[4] Preuss A, Preclik D, Mading C, Gorgen J, Soller S, Hadin O, Oschwald M, Clauss W, Arnold R, Sender J. (2008) LOX/Methane Technology Efforts for Future Liquid Rocket Engines. In: Proceedings of 5th International Spacecraft Propulsion Conference.