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Title

Cold flow test of pintle injector for variable thrust combustion chamber with servo-valve method

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Abstract

From the Apollo lunar lander to the recent SpaceX's Falcon 9 rocket, the pintle injector has been useful in a variable thrust combustion chamber. This paper describes the results of the cold flow test of the pintle injector with a servo-valve method for a variable thrust combustion chamber. The pintle sleeve was designed and manufactured to move at a total stroke of 16.75 mm by using hydraulic pressure from a servo-valve to the double-acting cylinder located at the top/bottom of the pintle sleeve. The pintle core and sleeve are made of aluminum, and the head-part casing is made of transparent polycarbonate so that the behavior of the pintle sleeve can be visible. Servo-valve and power amplifier were the 550-0610 model of Star's Company (GB) and the SV-200 model of W.E.S.T.'s Company (DE) purchased and used, respectively. As the hardware of the control and data acquisition system, the USB-6211 model of NI's Company (US), which is capable of both analog input and output, was used, and as software, an in-house program was created and used based on the commercial program LabVIEW. Prior to the cold flow test, the control and operability of the servo-valve and the pintle sleeve were confirmed by supplying a working fluid (kerosene) to the servo-valve and the double-acting cylinder at the head part. In addition, a preliminary test was conducted to derive pressurization conditions for each flow rate (or each pintle sleeve stroke). The cold flow test was performed with water in a miniature rocket engine test facility (mRETF) in Daejeon. After supplying water under the pressurization conditions previously derived from the fully open state of the pintle sleeve, the pintle sleeve was moved to a position for each flow rate, and the mass flow rate and pressure drop of pintle core (oxidizer) and annulus ring (fuel) were measured. Based on the fully open state (pintle sleeve position: 16.75 mm, the total mass flow rate of water: 8.36 kg/s), it was confirmed that the mass flow rates were well matched under the conditions of 20 to 90% opening position. In addition, it was confirmed that the pressure drop can be maintained in a wide flow rate range, and in particular, the pressure drop can be well maintained at a low flow rate range.