

# Liquid - Liquid Pintle injector design and manufacturing

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## Abstract

Pintle injectors are characterized by their ability to maintain spray properties such as spray angles and droplet size during throttling. This allows for unique control of thrust and the ability to completely shut off the propellant flow, making them attractive for various applications that require easily adjustable thrust. In addition, pintle injectors have been known for several decades and have proven their combustion stability during operation and while throttling. This is made possible by maintaining properties such as the Total Momentum Ratio (TMR) between the flows and additional properties related to the physical size of the injector, such as the skip distance and chamber-to-pintle diameter ratio.

This study presents the design and manufacturing of a liquid-liquid pintle injector. The injector is intended to produce 500 N of thrust. It uses 120 g/s of LOX and 48 g/s of kerosene at a combustion chamber pressure of 70 bar.

The injector developed here is a fuel-centered pintle. It uses a movable rod to vary the radial flow cross-sectional area. This allows control of the fuel mass flow rate while maintaining a fixed annular flow area.

Detailed analytical modeling established the relations between pintle stroke, flow velocity, and pressure drop. These findings guided the selection of preliminary design parameters.

Following the design phase, the injector was manufactured from AISI 316 stainless steel for cold testing. In these tests, both propellants were replaced with water.

The experimental setup features independent pressurization of the water tanks using nitrogen gas. Control is achieved through an NI card with a LabVIEW interface.

Experimental validation was not completed within the project time frame. However, test procedures were prepared to evaluate spray characteristics, calibration maps, and throttling behavior under constant TMR.