Rocket Engine Injector Modelling

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PROTOLAUNCH

Introduction

The injector assembly of a rocket engine is responsible for delivering the correct mass flow rate of propellants to the combustion chamber, at the desired pressure. A Python tool was developed to enable the easy and accurate modelling of complicated injector systems. This included an implementation of the Omega model for two-phase flow through orifices, and a comparison of predictions with experimental data. The tool was then used to design a deep throttling injector for Protolaunch's next liquid rocket engine.

Plumbing System Solver

A tool was developed which the user could use to build 'circuits' of plumbing components. The following components could be included:

- Orifices
- Frictional pipes
- Pressure drops proportional to the dynamic pressure

The solver can use any two of the following as inputs – the third, which is unknown, is then solved for:

- The upstream pressure, P_1
- The downstream pressure, P_2
- The mass flow rate, $\dot{m}$

Example

An example circuit is shown in Figure 1, which is simulated with nitrous oxide. As the backpressure P_2 is decreased, the mass flow rate will increase until the two branches become two-phase choked.

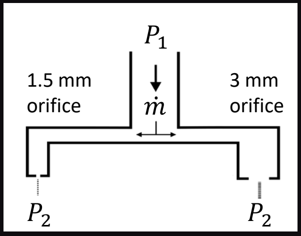

Figure 1: Example plumbing circuit.

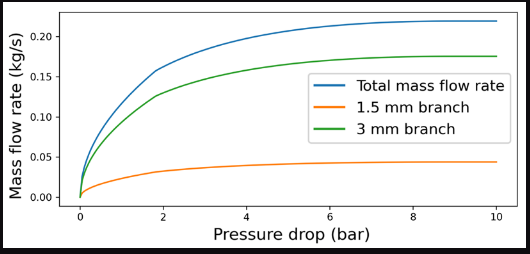

Figure 2: Solution for example circuit, with N_2O as the fluid.

Comparison with Experimental Data

The plumbing circuit tool was used to build a model for Protolaunch's HILBERT injector. The results for the fuel injector are shown below.

Figure 3: HILBERT engine hot fire.

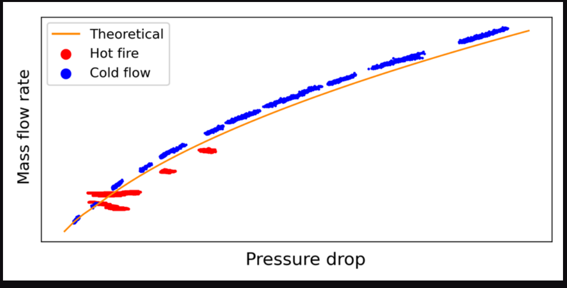

Figure 4: Comparison of model with experimental data.