Two Phase Flow in Short, Vertical Tubes

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Motivation

The fuel emulsion tube in a carburetor is a region of complex physical phenomena that are difficult to predict. Carburetor models to date have used over-simplified two-phase flow models for the emulsion tube that almost completely fail to capture the actual pressure drop behavior. Since fuel flow through the carburetor is sensitive to the pressure drop in the emulsion tube, it is important to develop an accurate model of this behavior.

Objectives

1. To formulate a correlation that predicts pressure drop as a function of air flow, fuel flow, geometry, and fluid properties.
2. To obtain visualization of representative flows in order to identify the physical behaviors that govern the pressure drop behavior.

1. Pressure Drop Correlation

To mimic the fuel emulsion tube in a typical small engine carburetor, manifolds were machined from polycarbonate with air injection holes and pressure taps. These manifolds can be seen in Figures 1 and 2.

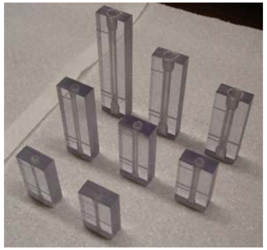

Figure 1. Machined polycarbonate manifolds

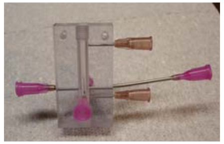

Figure 2. Manifold fitted with air injection and pressure tap needles

Data were collected for various air and fuel flows; the pressure drop was measured using a differential pressure transducer. Nine geometries were tested – three diameters and three L/D ratios per diameter. Figure 3 shows the experimental results, as a function of the kinetic and potential energies of the mixture.

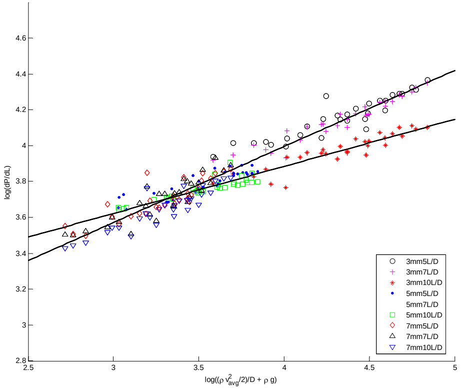

Figure 3. Experimental pressure gradient results, as a function of energy

Fitting the experimental data yielded a correlation that can be seen in Figure 4:

$$\frac{dP}{dL} = C\left(\frac{1}{2}\rho_{mix}\bar{v}^2\frac{1}{D} + \rho_{mix}g\right)^k$$

For all cases except 3 and 5mm, 10L/D:

C=200, k=0.424

For the 3 and 5mm 10L/D cases:

C=684, k=0.262

Figure 4. Correlation, based on experimental results

2. Visualization

A video camera was included in the data collection, and still images were obtained at each test point. The images were compiled into a matrix for comparison with the test results. Figure 5 shows the experimental setup with video equipment; Figure 6 is an example of the visualization obtained.

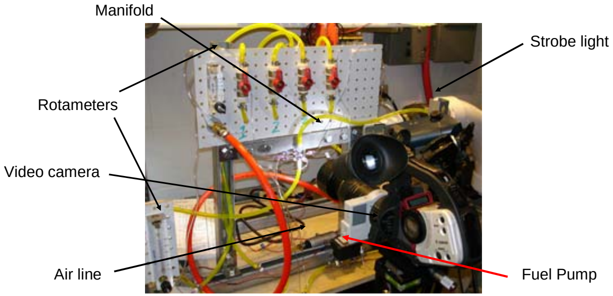

Figure 5. Experimental setup

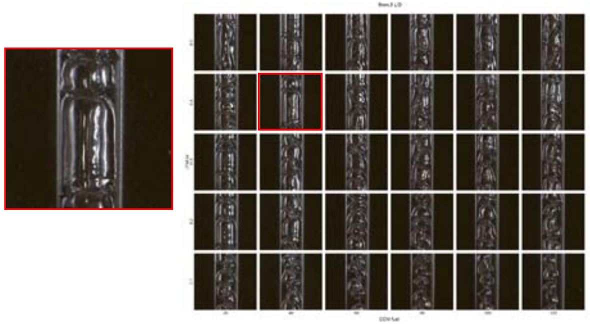

Figure 6. Visualization matrix for 5mm, 5 L/D manifold

Although the analysis is incomplete, these videos are being studied to try to understand the reason for the change in behavior for the 3 and 5 mm 10 L/D data. This may lead to a more complex, but more accurate model.

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