Measurement Error in a Venturi Flowmeter

Introduction

Venturi flowmeters use the height of a liquid column to measure the pressure drop (and hence the flowrate) of fluid in a pipe. However, errors in reading the column height will affect the calculated value of the flowrate.

Methane (at 1 bar and 40°C) enters a venturi meter with a water manometer (with a measurement error of ± 1 mm). The upstream pipe area is 0.05 m^2 and the venturi throat diameter is 0.025 m^2.

The water displacement across the manometer is 3 cm. Given the measurement error, this application calculates the potential range of flowrates.

This application uses several Maple packages, including ThermophysicalData, ScientificConstants, and Tolerances. The Tolerances package is particularly important because it allows measurement error to be carried through a series of calculations.

```
> restart :
  with( ThermophysicalData ) :
  with( ScientificConstants ) :
  with( Tolerances ) :
```

Calculations

```
> h := 0.03 ± 0.001m :
> temp := 40degC :
> press := 1bar :
> A_1 := 0.05m^2 :
  A_2 := 0.025m^2 :
> g := evalf( Constant( 'g', units ) )
```

$$9.80665 \ \frac{m}{s^2} \qquad \textbf{(2.1)}$$

> $\rho_{water} := \text{Property}(\text{density}, \text{water}, \text{pressure} = \text{press}, \text{temperature} = \text{temp})$

$$992.2157713 \ \frac{\text{kg}}{\text{m}^3} \tag{2.2}$$

> $\rho_{methane} := \text{Property}(\text{density}, \text{methane}, \text{pressure} = \text{press}, \text{temperature} = \text{temp})$

$$0.6170449654 \ \frac{\text{kg}}{\text{m}^3} \tag{2.3}$$

Pressure difference across the venturi

> $\Delta P := \rho_{water} \cdot g \cdot h$

$$(292. \pm 9.73) \ \text{Pa} \tag{2.4}$$

Hence the flowrate range is

> $Q := A_1 \cdot \sqrt{\frac{2}{\rho_{methane}} \cdot \frac{\Delta P}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$

$$(0.888 \pm 0.0148) \ \frac{\text{m}^3}{\text{s}} \tag{2.5}$$

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