

CM3215 ChemE Transport Lab:

Frictional Losses in Straight Tubing

Pre-laboratory Assignment

Read through the section on friction losses in laminar and turbulent flow in your transport book (see syllabus). Create a plot in Excel or some other computer program of friction factor versus Re for a smooth tube for $10^3 < Re < 10^6$; affix this plot to a page in your notebook. Design your plot to mimic the Moody diagram (log-log, even decades, log minor tic marks).

Calculate the Reynolds number and expected pressure drop in psi for 1.0, 2.0, 3.0, and 4.0 gpm for each of the three tubing sizes we have in the lab. Place a table of these calculations in your lab notebook (with units). Compare your answer with classmates to be sure to arrive at the right answers. Answer this question in your lab notebook:

- For which tubing sizes and at what flow rates will you be able to obtain accurate pressure-drop readings?*
- For which tubing sizes and at what flow rates will you be using the Honeywell DP meter? The Bourdon gauges?*

Prepare data tables in your laboratory notebook for recording data. Prepare a safety section in your laboratory notebook detailing all safety issues associated with this laboratory.

Introduction

Flow through pipes or tubes is always accompanied by a resulting pressure drop due to frictional losses. When designing chemical processing and heat

transfer equipment, characterization of the fluid frictional losses is critical to specifying equipment of the correct size.

Theory: See lecture.

Overall Objectives:

Measure friction losses in copper tubes of three different sizes (1/4", 3/8", 1/2" nominal, type L copper tubing) and *quantitatively* and considering uncertainty compare the results with data reported in the literature. Address all other objectives as discussed in the **Data Analysis** section.

Experimental Procedure

(To be determined by each lab group)

Tasks:

Measure friction factor versus Re on each of the three long sections of tubing in our laboratory station. Use as wide a range of flow rate as you can with the instruments available ($10 \leq R(\%) \leq 90$ or the maximum possible). Take sufficient data sets to span the available range of Reynolds number and friction factor.

Data Analysis

- Evaluate the accuracy of the pressure drop data you obtained. What is the lowest pressure drop you can accurately measure for the DP meter? What is the highest? What are the lowest and highest accurate pressures for the Bourdon gauges? Justify your numbers.
- Identify and discard all data that are below the known measurement accuracy of the

- device on which it was measured. Explain your decisions.
3. Compute Fanning friction factors from measured tubing pressure-drop data. Use only accurate points. Use actual inner tubing diameters, not nominal values, in your calculations. **The copper tubing is type L.**
 4. Compute Reynolds numbers for your data.
 5. Plot measured Fanning friction factor versus measured Reynolds number (log-log plot). On the same graph, plot what this curve should be, according to the literature, using calculations like those you performed in your prelab. Compare these two curves quantitatively, using appropriate uncertainty analysis. Please design your comparison graph to look like the Moody plot. Include error bars on your data points.
 6. Do you observe distinct $f(\text{Re})$ curves for each tubing size or is a single $f(\text{Re})$ curve obtained (within experimental uncertainty)? Should you get distinct $f(\text{Re})$ curves for different tubing sizes according to the literature? Discuss quantitatively any discrepancies between your measurements and the correlations from the literature. Discuss possible reasons for any discrepancies; consider possible systematic errors.
 7. Attach raw data tables and calculated results as an appendix (do not include raw data tables in the report). Please pay attention to significant figures when preparing your tables. Use scientific notation, if necessary, to

reduce the number of digits shown. Always include units when presenting data.

Appendix: Procedures

Shut Down Procedure

1. Close needle valve WV-5.
2. Turn off pump P-01.
3. Close valves WV-1, WV-2, and WV-3.
4. Close WV-10 and drain T-02 by opening DV-02.
5. Disconnect measurement devices from the pressure taps; turn off the DC power for the DP meter (south wall).
6. Dry off any wet surfaces with paper towels.
7. Turn off all the electronic devices and properly store them.