Analysis of Real Pressure Drop Data

DUE: Monday, October 1

ALLOWED COLLABORATION: You may collaborate and divide labor within your group however you choose. One report is required per group. No collaboration outside of your group is permitted.

Most industrial systems use two-phase, one-component flow (steam-water, refrigerants), but many experiments use two-component flow to keep down costs and separate the fluid dynamic effects from those rooted in heat transfer. There is no phase change in two component flow ($dx/dz = 0$).

A databank of two-component, horizontal flow data has been provided on the website. In horizontal flow, there is no gravitational pressure loss. Total pressure drop data are provided for all flows, along with estimates of film thickness. Assume a temperature of 11 °C for all flows.

In this assignment, you will look at modeling of pressure drop for annular flow, including the film roughness concept that uses film thickness measurements to estimate pressure drop.

Much of your work will involve applying correlations – from lecture or otherwise – to these flow conditions. The following error statistics are particularly relevant *and must be included in your analysis*. Consider dp/dz as the metric of comparison.

You will want to use the data analysis slides/notes on the course website.

This assignment must be submitted as a type-written report, including equations to show your optimized correlations. EES outputs, spreadsheet outputs, etc. may be included as appendices.

1 Assignment

1. Apply the following general-purpose correlations to the given data:

   (a) HEM, assuming gas compressibility is negligible

   (b) Lockhart-Martinelli, assuming gas compressibility is negligible

   (c) Friedel, assuming gas compressibility is negligible

   For each correlation, provide at least one meaningful scatterplot to show the accuracy of your correlation with changing flow rates *and* provide error statistics and R^2 values. Analyze the correlation and provide a recommendation regarding the suitability of that correlation for these data. Using multiple series in your scatterplot – for example, for different liquid or gas flow rates or diameters – may be useful in determining the limitations of the correlations.

2. Identify the primary empirical parameter in the Lockhart-Martinelli correlation and re-optimize the functional forms to the provided data.

   For this optimized correlation, provide at least one meaningful scatterplot to show the accuracy of your correlation with changing flow rates *and* provide error statistics and R^2 values. Analyze the correlation and provide a recommendation regarding the suitability of that correlation for these data. Using multiple series in your scatterplot – for example, for different liquid or gas flow rates or diameters – may be useful in determining the limitations of the correlations.

3. Develop your own model for pressure gradient for these data, based on the following equation:

$$\left(\frac{dp}{dz}\right)_{fric} = f\frac{GU_{sg}}{D} \quad (1)$$

$$f = f(Re) = C_1 Re^{C_2} \quad (2)$$

Where C_1 and C_2 are optimization parameters. The Reynolds number used may be Re_g, Re_f, or Re_{fo}. Discuss the strengths and weaknesses of your correlation. How does it perform with variations in flow rates (gas and liquid) and tube diameter?

2 Grading

Technical Content – 34 points

- Analysis of data using existing, basic correlations (HEM, L-M, Friedel) – correct and complete (10 points)
- Reoptimization of existing, basic correlations – correct and complete (8 points)
- Quality (accuracy of prediction) of your own correlation (8 points)
- Discussion and critical evaluation of your correlation (8 points)

Document Quality – 10 points

- Overall quality of the writing (5 points)
- Quality of graphical presentation of information (5 points)

Peer Review – 2 points

By the end of the day (2359 Eastern) on the due date, you are required to assess the productivity of each of your group members. Here are the rules for the peer review:

- The peer review must be submitted by the deadline – no extensions or partial credit.
- The peer review must be provided as plain text, in the body of an e-mail, to the instructor.
- The assessment of each team member will be as a percentage.
- The percentages must add to *exactly* 100%.
- Each assessment must be a whole number (0, 1, 2, 3... 100).
- You must include yourself.
- You may only submit your review once; if you violate the rules above, you get no credit.
- The peer review is graded either 0 or full credit

Document Standards – 4 points

The following specific standards are enforced on all projects:

- Figures/tables must have numbers.
- Figures/tables must be referred to in the text by number (not "above", "below", etc.)
- Figures/tables must not appear before the first reference to them.
- Figures/tables must have a caption.
- All running text must have the same font/spacing/justification, as must each level of heading.
- The use of Greek symbols and other mathematics in running text must not break line spacing. Doing so makes a professional document look rather like scratch paper for notes. As a rule of thumb, any math requiring either a fraction bar or superscripts AND subscripts really belongs in an equation. In particular, "smelly text" is not allowed. (It looks like that line of text smells bad and others are inching away from it.) To achieve this in Microsoft products, you may need to use "exact" paragraph spacing.
- Your document must have a title page with the prescribed content and nothing else.
- Nothing may be hand-written.
- In tables and narrative text, a serif font (such as Times, Palatino, or Computer Modern) must be used. Documents in a sans serif font (Arial, Calibri [ew!]) may be returned unread.

Any additional document formatting requirements given in the project descriptions are included in this category. Violations of document standards will lead to a reduction in points, typically 1 at a time. Multiple points may be deducted for a particularly heinous violation. Multiple instances of the same violation can lead to multiple deductions and even to negative scores in this category.

The list of standards, above, is not intended to be all-encompassing. For example, a document where all the text is inexplicably in bright green with the pages out of order will have points deducted.

Document standards do not apply in appendices, although you are still expected to generate material that is not painful to read/use.

Note that the default settings in popular office software are completely unacceptable for presentation of technical reports to engineers and scientists. Considerable effort must be spent either changing these settings or changing your choice of software.

3 Procedures on Projects

- **Group Composition/Interactions** The groups were selected by the instructor. The order of students in each group is meaningless. If there are severe difficulties in working together, please contact the instructor. A rule of thumb: if the conflicts are severe enough or the division of labor is uneven enough that you would alert your boss on a job, then contact the instructor. Less severe disparities in workload should be discussed on the peer evaluation. See also the material in the syllabus regarding collaboration on projects, including restrictions with respect to on-call policies and real-name social networking.

- **Executive Summary** You must provide a brief outline of your solution to the problem on the first page of your report, along with all of your names and the title. It should cover approximately one-half of the page if single-spaced and given a normal font size. There should be no other material on the summary & title page. The executive summary should be the *only* place where student names are provided (that is: *do not* put your names on the top of every page).
- **Format** The body of your report must be type-written. *You may use any program you wish to accomplish this, but your choice of program and whatever its defaults are will not affect professional document standards being applied to your work.* Information from anything other than lectures must be cited. If you take information from the text that was not discussed in lecture, that must be cited. Use a serif font such as those from the Times, Palatino, or Computer Modern families (not a sans serif font, like those from the Arial, Helvetica, or Calibri [ew!] families).
- **Submission** Your document narrative must be submitted by the class time on the due date as hard copy or electronically via Canvas as a PDF.

4 Groups

1. Cockram, Emma
   Rice, Alexander
   Sapp, Scott
   Lehotay, Sarah
2. Flanders, Matthew
   Rivas, Andy
   Guilbe, Jonathan
   Smith, Charlyne
3. Fu, Zhenyu
   Merrow, Justin
   Bruenderman, Rachel
4. Field, Ryan
   Kepner, Vincent
   Berglund, Matthew
5. Del Valle, Pablo
   Peet, Christopher
   Clements, Kayla