UNIT OPERATIONS LABORATORY 1

METHOCEL (PIPE VISCOMETER) LAB

ChEn 475 – Knotts

Introduction

There are two main purposes of this lab. One is to review the concept of non-Newtonian fluids and give you hands-on experience with such a fluid. The second is to reinforce statistical tools that should have been learned in other courses and to introduce new statistics that are useful in engineering. Engineers use many types use statistics. For example, process engineers use statistics to keep processes running smoothly and maintain quality, research engineers use them to identify if observed phenomena are significant, and safety engineers need them to develop inherently-safe operations. Students learn many of the basics of statistics in other courses, but it is often difficult to see how these techniques are used in engineering. This lab presents you with an opportunity to make the connections between powerful statistical methods and engineering practice.

Day 1 Tasks

To motivate the work, you have been given a memo from me requesting that your team perform design calculations to pump a solution of methocel from a mixer to a packaging station. Your first task in this assignment is to demonstrate that you know how to solve the problem.

1. Study the concept of power law fluids. Use whatever resources are available to you.
2. Learn the basics of methocel (what is it, what is it used for, etc).
3. Familiarize yourself with the experimental apparatus. Determine what you can measure, what you can change. After learning about the equipment, familiarize yourself with the startup and shutdown procedures and the safety procedures. Pass off your "Permission to Start" sheet before starting any experiments.
4. After learning the needed background, think about how you will respond to my design request. Basically, you need to answer the question: "How can I use the experimental apparatus to size a pumping system to move a methocel at a flow rate of 100 gal/min over a distance of 1000 ft?"
5. Write a short email to the instructor outlining your approach to solving the problem. I want to know what data you will take and how you will use it to solve the problem. You will be able to attach one PowerPoint slide to the email where you can put in equation, graphs, etc. Make sure to effectively communicate to me that you know how to solve the problem.

Deliverables-Statistics

Remember that one purpose of this lab is to improve your understanding of statistics that are often used by engineers. As such, I will give you several workshops on statistics techniques. The topics include: the basics of statistics, confidence intervals, linear regression, Igor (a program to perform linear regression), and propagation of error. You will have one homework assignment to give you practice with these statistical methods. You will also have a quiz on the statistical techniques.

Finally, in regard to statistics, you should be able to obtain a significant amount of data over multiple days during this lab. This is especially important for the regressions that you will do. You should plan on performing experiments each day and obtaining data at many conditions. Also, don't delay analyzing the data. This will help you see gaps in the data and determine if more experiments should be performed.

Deliverables-Technical

Remember that the other purpose of this lab is to perform experiments to solve the design problem. A large portion of your time with this lab will concern taking and analyzing data to accomplish this. You will report your findings at the end of the lab in an Oral Presentation. The audience of the oral presentation will be me *and*, your peers in the other team doing the choked flow experiment. The choked flow experiment is also a "statistics" experiment and this other team is learning the same statistical techniques that your team is but with a different design problem. Make sure to plan your remarks accordingly so that you presentation is neither too basic nor too complex for the audience. Also remember that the statistical techniques learned in this lab are crucial to answering your design problem with confidence, so make sure to include these in some form in your oral report.

Summary of Deliverables

In summary, you have 4 deliverables for this lab as outlined below. Please check your calendar for due dates. Also check the calendar for the times of the statistics lectures and *suggested* activities for each day.

Deliverables

1. Theory email (Individual)
2. Statistics homework assignment (Individual)
3. Statistics oral report (Team)
4. Statistics quiz (Individual)
5. Leadership report (Individual)
6. Lab notebook (Team)

To: Engineering Development Team

From: Thomas Knotts

Date: 6 September 2017

Subject: Methocel Delivery System

The Plant Design Division is working on the preliminary design of a new plant that uses a dilute solution of methocel (cellulose ether) in water. A delivery system for bringing the solution in from the railway terminal to the plant must be part of the design. However, a pipeline already exists from the terminal to a location near the new site, with a safety rupture disk at the railway end of the pipeline. Please determine if the existing system is adequate to deliver the methocel-water solution to the plant at the desired rate without blowing out the rupture disk (this would save us considerable money). If not, please recommend a pipe system that would be adequate for the job. In either case, please indicate the discharge pressure needed for the pump that must be installed at the railway end of the system. Compare with a similar system that pumps only water.

We have a tank of the methocel solution in our laboratory that is the same concentration as we need to deliver. As you know, methocel-water solutions are non-Newtonian, but you will need to determine the exact rheology.

We will be waiting for your recommendation.

<u>Specifications:</u>
Methocel concentration: 1.00 wt%
Delivery distance from railway terminal to site: 1500 ft
Required flow rate to the plant: 100 gal/min
Rupture-disk rating: 130 psig
Characteristics of industrial pipe: 2-in schedule 40 steel pipe