NORTHERN ARIZONA UNIVERSITY

Memorandum

Design4Practice (D4P) Program

To: Professor David Willy

From: Pipe Losses Experiment Redesign - Project 10

Date: March 16, 2018

Re: Analysis Memo - Analytical Report Roles

Introduction

As part of the Capstone project, each team member is required to produce a complete and detailed analytical report of four separate and important aspects of the design. Keith Caton is assigned a complete simulation of the selected design ideas for the pipe network, Cole Neilson is assigned a stress and material failure analysis, Mark Frankenberg is required to create a comprehensive and detailed breakdown of all sensor systems, interfaces, and use cases, and Michael Garelick is assigned pump and control systems research to controlling the flow rate within the system. Each member's assigned topic is outlined below.

Keith Caton – System Simulation
Simulation Lead

Keith Caton's analysis will have the following criteria:

- What is being analyzed?
  - Pressure Gradient
  - Head Loss
  - Flow Rates
  - Reynolds Number
- How will the analysis be performed?
  - MatLab will be the primary tool calculations
  - Hand work for deriving equations and needed parameters
  - Possible validation from third party free tools
  - Requesting NAU professors to validate model
- Assumptions
  - The flow is incompressible
  - Room temperature of 25°C
  - All analysis points assume the flow is fully developed
  - All flow will be turbulent, $\alpha \sim 1$

- Friction factor follows a logarithmic relation to the Reynolds Number, $f = \frac{0.25}{log_{10}(\frac{\epsilon}{3.7*D}+\frac{5.74}{Re^{0.9}})^2}$
- Inputs
  - Layout of the pipe system
  - Pump specifications
    i. Head
    ii. Flow Rate
  - Pipe Material
    i. Roughness
- Outputs
  - Pressure Gradient for individual segments and entire system
  - Head loss of individual segments and entire system
  - Flow rate of individual segments
- Importance?
  - Provide the necessary information needed for:
    i. Final sensor selection
    ii. Final pump selection
    iii. Pipe materials and sizes

Cole Nielsen - Materials and Stress analysis

Material and Stress Lead

For our project statement, we must redesign a pump and pipe system while remaining in our budget. A key part of this would be the materials used for the piping and the table. The research i will be doing for this aspect of the design will be:

- Choosing a pipe material that will yield meaningful head loss and can withstand the stresses and forces that will be put on the pipe fittings by the flow caused by the pump.
- The pipes will also need to have pressure taps that can be integrated into the flow system.
- A table that will have to be used to support all of the components must be strong enough to hold the system up for many years.
- The water in the system that will create a pressure in the pipe, as well as a force on the walls of bends and other fittings.
- A stress analysis will help to clarify what material pipe will be robust enough, and sealed well enough to handle the load that will be given by the pump.
- Research pressure taps and how the fit onto the selected material, how well they are sealed, and how accurate they will be for measurements.

At the end of this report I will have a chosen pipe material, and a list of possible to pressure tap systems to compare with Mark's chosen manometers from his analytical sections to find out which ones are the most reasonable for our design.

Mark Frankenberg – Sensors and Pressure Tap Research

Sensors and Measurement Lead

- Pressure taps do not connect correctly to the manometer
  - Place taps at correct distance apart to maintain a turbulent flow for the fluid
  - Once connected, flow is disrupted. Wait for flow to stabilize before cataloging data
  - When changing positions of the manometer connections, wait for flow to normalize
- Secondary Invasive sensor
  - Works well using pitot static tubes
  - Alter design but not functionality
- Non-invasive sensor is unreliable and difficult to use and move throughout the system
  - Newer technology will override the shortcomings with reliability and ease of operation
  - Clamps attached to the system will connect to the main operating device
  - The main operating device can be easily moved from varying diameter pipes to the next by unscrewing 4 simple screws

Michael Garelick – Pump and Control System Research

CAD, Pump and Control System Lead

Technical role: Pump/flow research and design

- Questions to answer:
  - What type of pump should be implemented in the design?
  - What pump specifications should the design require?
  - How will the flow rate be changed?
- Methods:
  - Head calculations to calculate the total head loss of the system and look for a pump that can produce more than the calculated value.
  - Valve calculations on the relationship between amount closed and flow rate though (If a valve is utilized).
  - Closed system calculations and logic to accept analog user input, read the flow rate, and change the voltage to the pump (If a closed system is utilized).
- Assumptions:
  - The head loss due to change in height is negelable.
  - The flow rate will never reach 0 m^3/s or the maximum flow rate of the pump.
  - The flow will be fully developed outside of the pump and after the valve (Ideally, they would be seperate from the experimental table).

- Inputs:
  - Reynolds number range (10^4 to 10^6)/Desired flow rate range.
  - Total head loss off the experimental system.
  - Voltage input of the pump (If a closed system is utilized).
  - Type of valve to be used (If a valve is utilized).
- Results:
  - What pump will be required to meet all the needs of the experimental flow.
  - How the closed system will be implemented (If a closed system is utilized).
  - How the valve will be configured for an easy flow rate change (If a valve is utilized).
  - The possibility of not meeting the Reynolds number range.
- Inform design:
  - What pump will be used in the simulation and CAD.
  - What new system constraints (Importantly, flow rate) must be added to the design.
  - The total cost of the pump implementation.
  - Maintenance and lifetime of pump (How the voltage output will change over time).