Class #2
Fluid Power Fundamentals
Notes

- Syllabus Questions?
- MTS Hiring
- Simulink Timing Issue
- Using Lab Time
- Using the Textbook
- Upcoming Labs:
  - Lab 3: Needle Valve
  - Lab 4: Pressure Compensated Flow Control Valve
Agenda

• Feedback: Goals
• Review: Momentum, Continuity, Constitutive
• Bernoulli’s Eqn → Valve Model
• Flow Control Valves
  – Needle Valve
  – Pressure-Compensated Flow-Control Valve
• Pressure Control Valves
  – Direct-Acting Relief Valve
  – Pilot-Operated Relief Valve
Feedback: Coarse Goals

- Learn About Industry Positions in Fluid Power
- Knowledge for Industry Job
- Experience for Fluid Power Project
- Using Matlab for Control
- Learn About “Cutting Edge” Components/Systems
- Looking for an Easy Lab
- Get Good Grade
- Have Fun
Review

• Momentum Conservation
  – $F_{hyd} = PA$

• Mass Conservation
  – Assuming Incompressible Flow  $\rightarrow$ Flow Conserved
  – $v = Q/A$

• Constitutive Relationships
  – Relating Pressure & Flow
Bernoulli’s Equation
Needle Valve as Flow Control

- Generally modeled with orifice equation:

\[ Q = C_d A_0 \sqrt{\frac{2}{\rho} (P_1 - P_2)} \]

- Needle controls effective orifice area \((A_0)\)
- Valve controls flow resistance, not flow directly
- Can be characterized by P-Q relationship either graphically or as an equation.
Needle Valve

\[ Q = C_d A_0 \sqrt{\frac{2}{\rho}} (P_1 - P_2) \]
Flow Control Valves: Needle Valve

- The goal of flow control valves is to maintain the flow rate at the specified setting.
- Needle valve is essentially an orifice.
- If pressure difference is fixed, flow will be constant.
- Sensitivity depends on $dQ/dP$.
  - You can determine from your experiment.
- Needle valve can also be used as a pressure control valve.
  - Then flow must be constant.

Is a needle valve a better flow control valve at lower pressures or at higher pressure?

How about as a pressure control valve?

\[ Q = C_d A_0 \sqrt{\frac{2}{\rho} (P_1 - P_2)} \]
Flow Control

• Better options to a needle valve?
Pressure Compensated Flow Control (PCFC) Valve

- Mechanical pressure feedback loop
1. Identify all components in the circuit.
2. What is the flow path through the PCFC valve?
3. With the compensator spool stuck open, what is the relationship between the actuator pressure and velocity?
4. What forces/pressures act on the compensator spool? What is the result?
5. How does the spring rate affect the flow accuracy?

6. Sketch the flow vs. upstream pressure, $P_A$, diagram for the PCFC valve.

7. Is this an efficient control method?
Pressure Control

• Better options to needle valve?
Pressure Control: Direct Acting Relief Valve

- Non-Passing Valve
Pressure Control: Direct Acting Relief Valve

- $P_1$ vs. $Q$ Curve
- Impact of Spring Stiffness
Pilot Operated Relief Valve
Main Spool and Pilot

Main Spool - high flow, low pressure

Pilot - high pressure, low flow
Remote Control of Pilot-Operated Relief
Ideal P-Q curve for relief valves

Which one is better? Which one is better?

How do spring rates affect this curve
- For direct acting, or
- Pilot operated relief valve?
ANSI Symbols

Direct Acting Relief Valve

Pilot-Operated Relief Valve

To Reservoir

Outlet