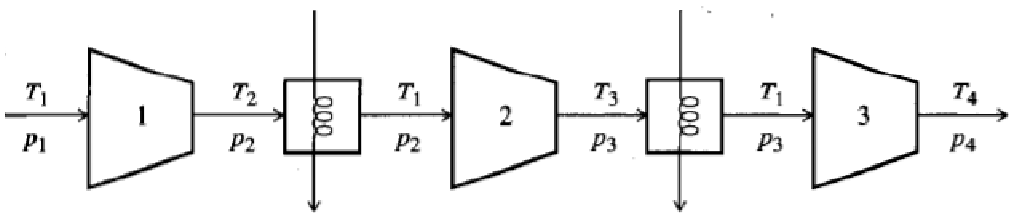
ASSIGNMENT 1 CHE 5480

DUE: January 27: Send through e-mail. Include the simulation file and a narrative explaining what was done and how.

#Problem 1

In this example we describe the calculation of the minimum work for ideal compressible adiabatic flow using two different optimization techniques, (a) analytical, and (b) numerical. Most real flows lie somewhere between adiabatic and isothermal flow. For adiabatic flow, the case examined here, you cannot establish a priori the relationship between pressure and density of the gas because the temperature is unknown as a function of pressure or density, hence the relation between pressure and



density is derived using the mechanical energy balance. If the gas is assumed to be ideal, and $k = C_p/C_v$ is assumed to be constant in the range of interest from p_1 to p_2, you can make use of the well-known relation

$$pV^k = \text{Constant} \qquad (a)$$

in getting the theoretical work per mole (or mass) of gas compressed for a single-stage compressor (McCabe and colleagues, 1993)

$$W = \frac{kRT_1}{k-1}\left[\left(\frac{p_2}{p_1}\right)^{(k-1)/k} - 1\right] \qquad (b)$$

where T_1 is the inlet gas temperature and R the ideal gas constant ($p_1\hat{V}_1 = RT_1$). For a three-stage compressor with intercooling back to T_1 between stages as shown in Figure E13.2, the work of compression from p_1 to p_4 is

$$\hat{W} = \frac{kRT_1}{k-1}\left[\left(\frac{p_2}{p_1}\right)^{(k-1)/k} + \left(\frac{p_3}{p_2}\right)^{(k-1)/k} + \left(\frac{p_4}{p_3}\right)^{(k-1)/k} - 3\right] \qquad (c)$$

We want to determine the optimal interstage pressures p_2 and p_3 to minimize $\hat{W}$ keeping p_1 and p_4 fixed.

-Solve the above problem analytically and verify if it really works for a stream of methane using the simulator.
-What would be the answer if there are elevation changes but the same (long) distance between compressors? Not the same distance? Is an analytical solution possible?
- Use simulations in pro II to get the answer.

Exercise 2: Determine what are the assumptions used to obtain the different pipeline compressible flow equations and compare it using different natural gases (different compositions, pressures,) flowing through a pipe. What does the simulator give? Prepare a one/two slides on PowerPoint and be prepared to present to others over 2-3 minutes .

Mohammed Al-Humairi: Fritzsche and Fully Turbulent. In addition, investigate about the origin of the erosional velocity relation $v=C/\rho^{0.5}$. Why does it have this form? Discuss variants and explain what type of erosion is prevented?

Armando Diaz: Panhandle A, Panhandle B AGA (American Gas Association) both partially and fully turbulent.

Bryukhanov: The Gas Processor's Association (GPSA Handbook) states that the flow equation is

$$Q = 0.018\left(\frac{T_s}{P_s}\right)E\sqrt{\frac{1}{f_f}}\left[\frac{P_1^2-P_2^2}{\gamma L_m T_{avg} Z_{avg}}\right]^{0.5} d^{2.5}$$

Investigate where this formula is coming from and why they call it a general equation? What is E? What is γ? Just some digging in the literature that might give the answer.
Also study the Ohirhian equation

Chad Duncan: Mueller, Pole.

Matthew Heckendorn: Spitzglass Low pressure and Spitzglass High pressure and Gersten (Gersten, K., Papenfuss, H.H., Kurschat, T., Genillon, P., Fernández Pérez, F. and Revell, N., 2000, "New Transmission-factor formula proposed for gas pipelines", Oil & Gas Journal, Feb. 14, pp.58-62.)

Sarah Scribner: IGT Distribution and Weymouth.

Sarah Scribner and Armando Diaz: Try to find the "Renourad" equation and analyze it.

Gregory Steelhammer: White and Colebrook-White and the following:
In several books (Gas Pipeline Hydraulics by E. Shashi Menon) elevation is taken care of by using the following equation:

$$Q = 38.77F\left[\frac{T_b}{P_b}\right]\left[\frac{\left(p_{in}^2 - e^s p_{out}^2\right)}{GT_f L_e Z}\right]D^{2.5}$$

where $L_e = \dfrac{L(e^s-1)}{s}$ and $s = 0.0375\,G\left[\dfrac{H_2-H_1}{T_f Z}\right]$

Exercise 3: The gas industry measures all gas (and performs balances) using standard volumes. Prove that this is equivalent to using mass. Start by writing the mass balance in a mixer $G_3 = G_{2+} G_2$. Convert mass flow to volume flow and see if you get $V_3 = V_{1+} V_2$