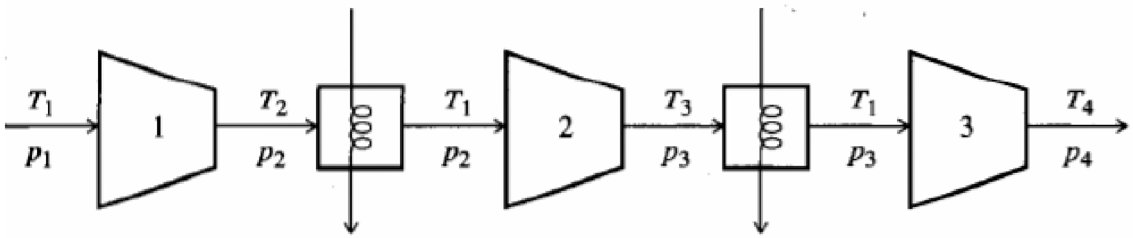
ASSIGNMENT 1 CHE 5480

DUE: February 2. 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

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

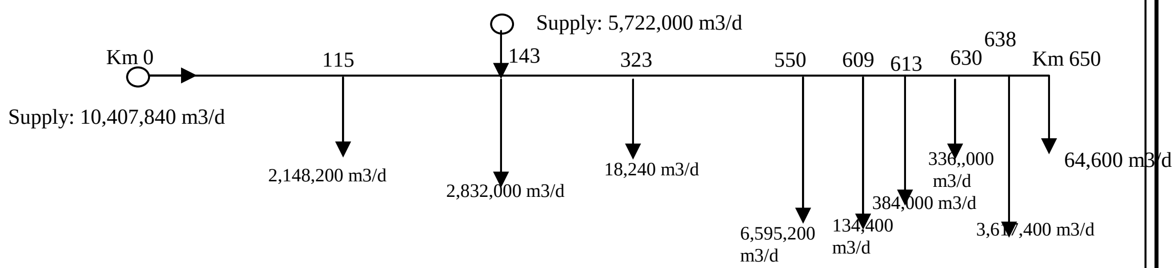
We want to determine the optimal interstage pressures p_2 and p_3 to minimize $\hat{W}$ keeping p_1 and p_4 fixed.

-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?

#Problem 2 (Exercise 1-14 in notes)

Consider the shown in the following figure



- The piping is in the ground and is not insulated. Assume a ground temperature of 25^{o}C and a ground conductivity of 0.7 W/(m ^{o}C). The gas elevation profiles are provided in the following table:

Km	Elevation (m)
0	42
115	7
143	14.93
323	60
550	10
609	120
613	122
630	235
638	470
650	890

- The gas ((1.9% methane, 5% Ethane, 2% propane, 1% n-butane and 0.1% n-pentane) is supplied at the two points indicated in the diagram at 1,367 kPa and 35^{o}C in the first station (Km 0), and 1520 kPa and 30^{o}C in the second (Km 143).
- Determine using simulations a) Piping diameter, b) Compressors at the supply station, c) cooling required. Do not use a pressure above 5,600 Kpa. Use cost data provided in class notes.
- Will new compressors be needed/beneficial?

#Problem 3

Set up a GAMS model to solve the same problem using the model by Edgar, Himmelblau and Bickel. Compare results.