Energy Consumption and Control Performance

Challenge 1

The job of the Blend Chest pumping system described in Figure 1 is to maintain a relatively constant level in the Machine Chest. There is a wide grade range on this 400 tpd fine paper machine. The Blend Chest to Machine Chest flowrate varies by grade as shown below. During the field tour of the process, it was noted that the control valve was cavitating strongly at 1200 gpm and 1600 gpm.

The pump, valve and pipe friction loss curves for this system are shown in the figures below.

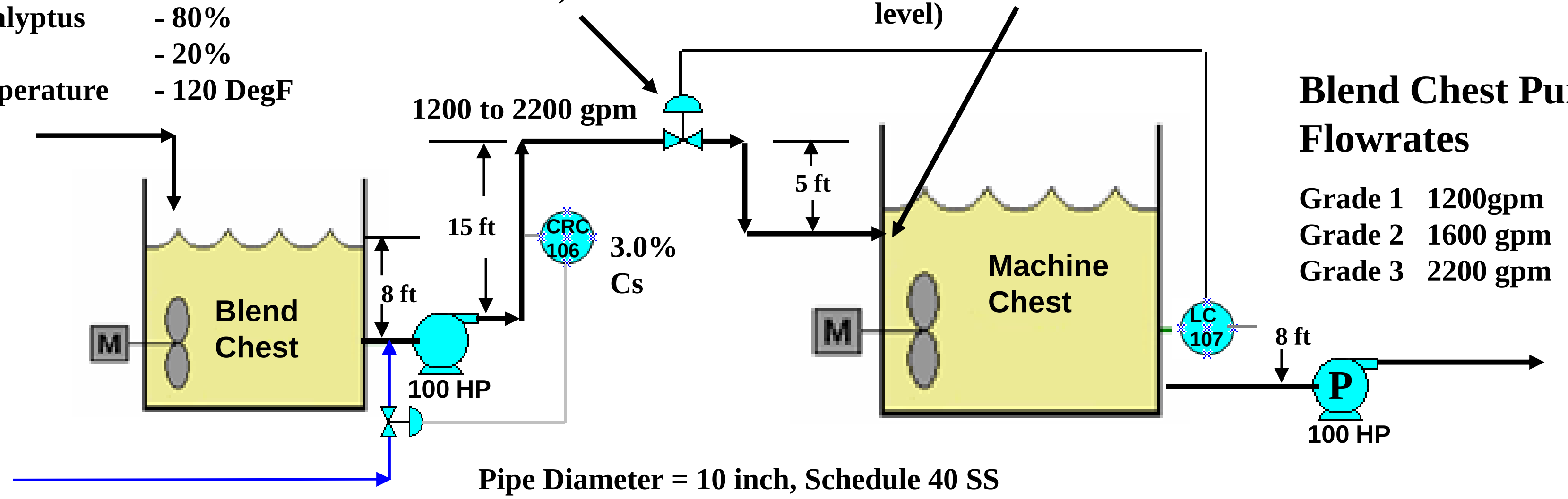
Fiber Data

Eucalyptus	**- 80%**
NK	**- 20%**
Temperature	**- 120 DegF**

Control Valve Data

Fisher V-150, 8 inch diameter

Discharge Pressure = 0.9 psig (approx. 2 ft below operating level)



Blend Chest Pump Flowrates

Grade 1	1200gpm	20%
Grade 2	1600 gpm	70%
Grade 3	2200 gpm	10%

Pipe Diameter = 10 inch, Schedule 40 SS

Eq. Length Pump to Valve	**- 70 ft.**
Eq. Length Valve to Tank	**- 20 ft**

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The equations needed to answer the challenge questions are shown below.

Assume SG = 1 for 3% stock

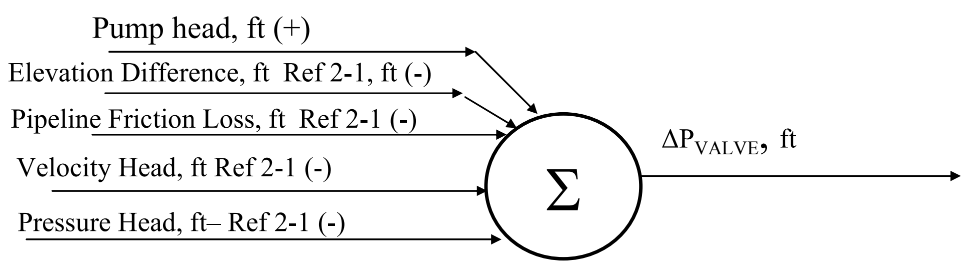
$$\text{Motor Power (BHP)} = \frac{\text{SG} * \text{Head (ft)} \times \text{Flow (gpm)}}{3960 \times \text{Efficiency}/100}$$

Conversion : 1HP=0.746 kW

Flow Across a Valve- Estimating the control valve differential

Reference point 1 - Top of Blend Chest

Reference Point 2 – Discharge into Machine Chest



$$\text{VelocityHead, ft} = \frac{v^2}{2g_c}$$

$$\Delta P_{Valve}, PSI = \frac{\Delta P_{Valve}(\text{ft}) \times \text{SG}}{2.31}$$

Flow Across a Valve - Estimating the flowrate

$$\text{Flow (gpm)} = \text{Cv} \times \text{F}_P \sqrt{\frac{\Delta P_{Valve,\,psi}}{\text{SG}}}$$

$$\Delta P_{Valve} = \left(\frac{Flow}{CvFp}\right)^2 * SG$$

Where:

Cv – Valve flow coefficient

Fp – Valve Flanging Coefficient (Assume = 1)

ΔP_{Valve} – Valve Pressure Drop, psi

SG - Specific Gravity

$$\text{Wasted EnergyAcrossValveHP} = \frac{\text{Flow}_{gpm} \Delta P_{Valve\,ft} \text{SG}}{3960}$$

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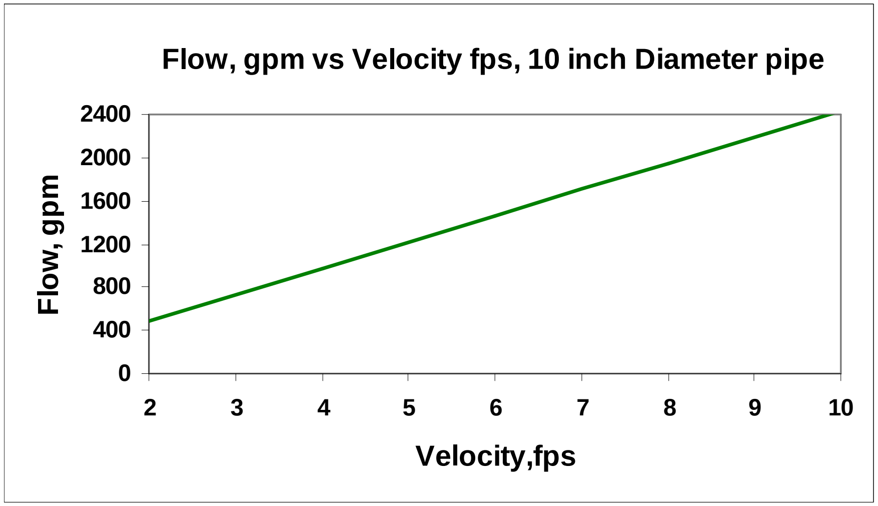

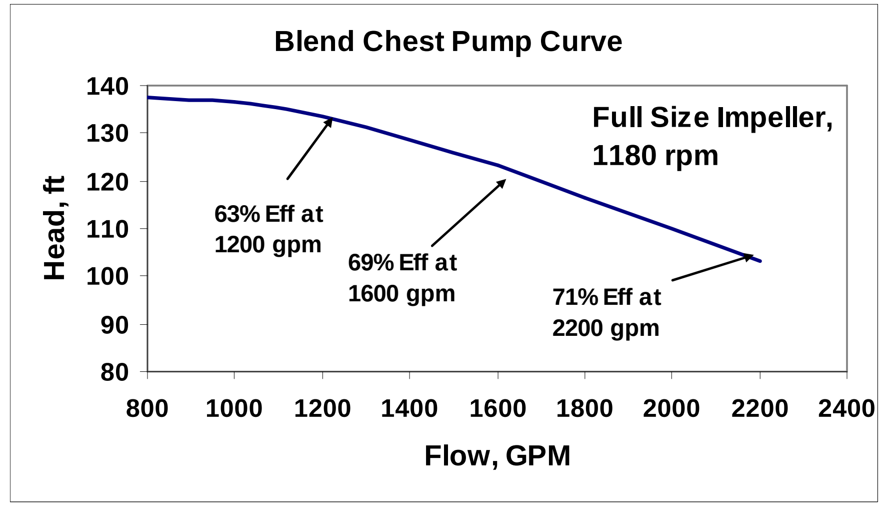

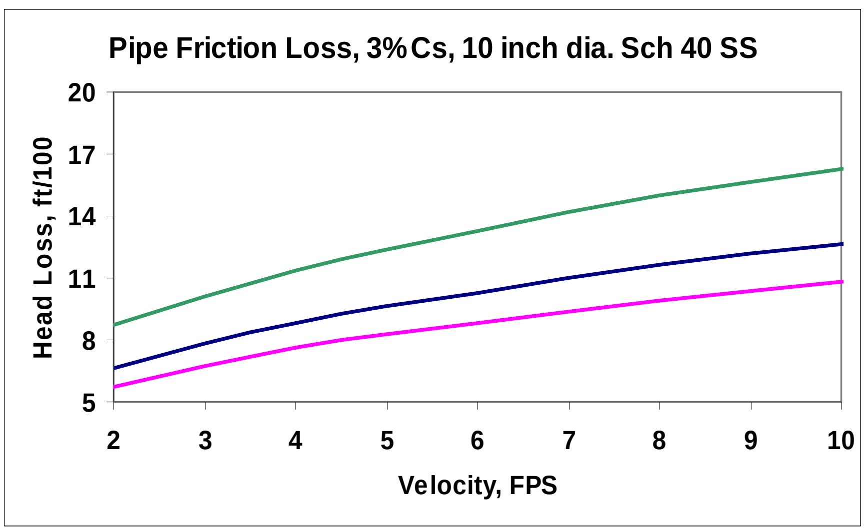

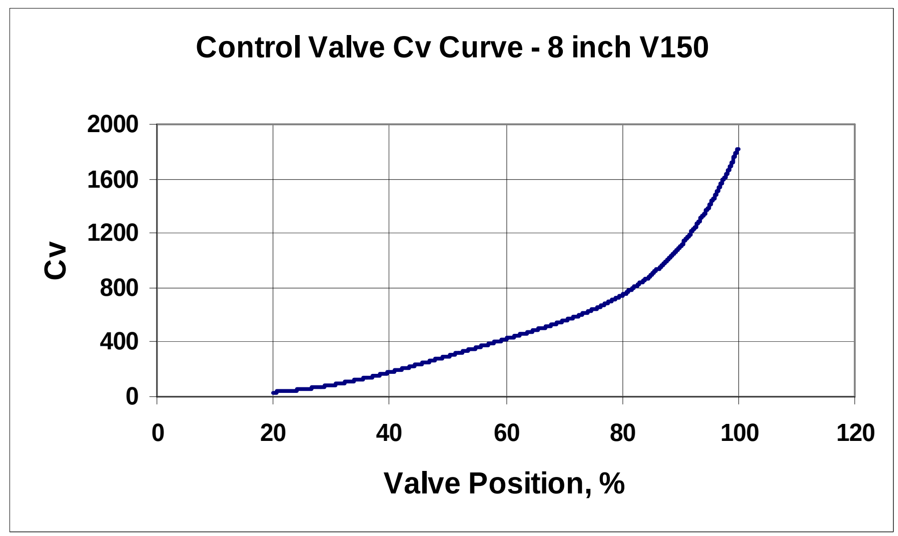

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Questions:

1. Estimate the annual Blend Chest Pump power consumption in HP and kW. What is the annual energy cost of this pump at $650/kw-yr.
2. Estimate the pressure loss due to pipe friction. How much power is consumed in overcoming pipe friction at each flowrate? What is the annual cost of pipe friction?
3. Estimate the pressure drop across the control valve at 1200, 1600 and 2200 gpm. How much power is wasted across the by the control valve at the three flowrates? What is the annual cost of control valve friction?
4. What is the expected position of the control valve at 1200, 1600 and 2200 gpm. Estimate the total range in the control valve position. Is this an acceptable operating range for good control and low variability? Explain.
5. What will be the average steady state flow change in response to a 1% control valve step at 1200 and 2200 gpm?
6. Estimate the impact of 1% stiction in the level control valve. Will this result in a level cycle, a consistency cycle or both?