ABE 30300 - HOMEWORK 6

FALL 2017 - Deadline November 14

Total: 120 marks

Question 1

A rheological test is carried out using a cone and plate geometry with a cone angle of 2° and a cone radius of 30mm. The following experimental data was obtained:

Ω (rad/sec)	Torque M (mN-m)
0.63	1.3
1.9	3
5.7	6.3
11	9
15	11
22	16
30	18

(a) Convert raw data into shear rate and shear stress

[5 marks]

(b) Determine the rheological parameters of the liquid

[15 marks]

Question 2

The following data was obtained for an aqueous dispersion of polysaccharide gum flowing in a capillary tube:

Pressure Drop ΔP (kPa)	Volumetric Flow Rate Q (m^3/s)
18.9	1.81×10^{-7}
24.3	5.89×10^{-7}
29.6	1.47×10^{-6}
42.8	8.34×10^{-6}
56.1	2.94×10^{-5}
70.8	8.83×10^{-5}

Internal Diameter of Capillary Tube = 0.01m
Length of Capillary Tube = 1.5m

It is proposed to pump the gum dispersion through a 65m long horizontal pipeline (ID = 6cm) from a holding tank to an open mixing vessel at a flow rate of 70 liters/min. Using a simple scale-up procedure determine the discharge pressure the pump will be required to produce (in kPa.gauge).

[30 marks]

Question 3

A liquid is pumped from a balance tank through a plate heat exchanger, where is heated to pasteurization temperature, held in a holding section and cooled, and into a holding tank. The liquid is supplied continuously to the balance tank and withdrawn continuously from the holding tank (to be packed), so that the levels in the two tanks do not change with time.

(a) Draw a diagram of the system

[5 marks]

(b) By writing an appropriate version of the overall mechanical energy balance equation between the liquid surfaces in the tanks, and using the following information, determine the electrical power drawn by the pump.

[35 marks]

Information of the piping system

1. The tank diameters are equal
2. The pressure at the liquid surface in the balance tank is atmospheric, while that at the liquid surface in the holding tank is 20 kPa gauge.
   The liquid surface in the holding tank is 3.7m higher than that in the balance tank.
3. The pressure loss due to viscous friction in the system has been calculated (from knowledge of the liquid's rheological properties and of the dimensions o the pipework and heat exchanger) to be 1250kPa.
4. The liquid's (steady) flow rate is 4000 lt./h, and its density is 995 kg/m^3.
5. Pump Efficiency = 0.8
   Pump Motor Efficiency = 0.75

Question 4

A non-Newtonian power law liquid (k=90 Pa.s$^{0.32}$, n=0.32, ρ = 870 kg/m^3) destined to further processing can be preheated conveniently by allowing it to flow by gravity through a number of vertical tubes (ID = 4cm) which are surrounded by waste hot water from another process.

The liquid is fed to the upper ends of the tubes at atmospheric pressure and flows from the lower ends into a tank at atmospheric pressure.

If the required throughput of the preheater is 380 kg/h, how many tubes will be required? Assume that there is not net change in mean velocity. In addition, you do not need to know the height of the tubes to solve this problem.

[20 marks]