

Puu-23.3000 Chemical Engineering in Pulp and Paper Processes

Calculation part 17.04.2007:

Please, each answer on individual sheet of paper.

Question 1

The dimensions of softwood chips are as follows: length 25 mm, width 15 mm and thickness 10 mm. The moisture content of the chips is 40 w-%. The Basic Density of the pine wood is 400 kg/m³. The chips are steamed by means of saturated steam at pressure 0.14 MPa(abs).

Estimate how long it takes to increase the temperature of the chips from 20 °C to 108 °C. You can use the enclosed diagram in the calculations and assume that the chip particle is a sphere having the same volume as the above mentioned real chip particles.

Question 2

Pulp suspension from a tank open to atmosphere is pumped at flow rate 3000 l/min. The consistency of sulphate mass is 3 % and temperature 80 C. The inlet pipe diameter is 250 mm, length 5 m and there are two bends of 45 degree. The level of the tank is at the highest 5 m and smallest 1 m measured from the center of pump impeller.

- Calculate the linear velocity of the flow.
 - Is the pump cavitating in the above cases if the $NPSH_{req} = 6$ m?
 - How large error in calculations the pulp density causes, if liquid water density at 80 °C or assumption 1000 kg/m³ is used?
- Show the answer with calculations.

Question 3

The production of a pulp mill is 1500 ADT/d. The dry matter amount to be evaporated in the black liquor evaporation is 1,8 tons/ADT pulp. The evaporation plant has 6 effects, the dry matter concentration of the feed liquor is 15 % and the dry matter concentration of the evaporated strong liquor is 75 %. The pressure of the saturated primary steam is 0.35 MPa(abs) and the temperature of the saturated steam leaving the last effect is 60 °C. Calculate:

- The evaporated water amount/evaporation effect. It can be assumed that the evaporated water amount is the same in each effect.
- Estimate the total Boiling Point Rise (the sum of individual boiling point raises of each effect) and the effective temperature difference of the evaporation plant.

Question 4

Two air streams and one steam stream are mixed. The first stream is 5 kg dry air/s, temperature 20 °C and relative humidity 40 %. The second stream is 10 kg dry air/s, temperature 80 °C and relative humidity 10 %. The flow of saturated steam at 100 °C is 0.05 kg/s. Define the temperature, wet bulb temperature and the relative humidity of the air mixture by using the Mollier diagram and steam tables. (You can also use the corresponding humid air correlations if you want).