

Puu-0.3010, Separation Technologies in Biorefineries

Exam, 9th December 2013

Answer in three questions, 4 points per each question, 12 points in total.

Please, each answer on separate paper, it makes the checking easier. You can make the drawings into appendixes and return them inside your answering sheets.

Duration: 4 hours, RETURN the question paper

Allowed material: Lecture notes (book style text in 12 chapters), lecture slides (PowerPoint style), steam tables (for example Keskinen, K. I., Kemian laitetekniikan..., or similar book), book in chemical engineering (for example Geankoplis or similar), mathematical tables (MAOL taulukot or similar), pocket or scientific calculator (the memory of the calculator is not needed to erase because all the material is available)

NOT allowed material: homework assignments, solved calculation exercises

Question 1

a) Explain shortly what kind of initial states and boundary conditions are needed in heat transfer problems and why.

b) The chip particle (size 30 mm * 20 mm * 6 mm) is heated in saturated steam of 1.2 bar(abs). The initial uniform temperature of the chip particle is 25 °C. The chip moisture is 30 w-% and its basic density is 480 kg/m³.

Calculate the average temperature of the chip particle after 60 seconds of the start of steaming. Calculate the chip as an infinite slab. (infinite plate). The analytical solution is given below

$$\frac{T_s - \bar{T}}{T_s - T_0} = \frac{8}{\pi^2} \left(e^{-a_1 Fo} + \frac{1}{9} e^{-9a_1 Fo} + \frac{1}{25} e^{-25a_1 Fo} \right)$$

$$a_1 = \left(\frac{\pi}{2} \right)^2$$

where \bar{T} average chip temperature

T_s constant average temperature of the surface, i.e. temperature of saturated steam

T_0 initial temperature

Fo Fourier number, $Fo = \frac{\alpha t}{s^2}$

α thermal diffusivity

s half thickness of the slab