

ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2011 SESSION

Open-book examination
Calculators: only authorized models
Duration: 3 hours

04-AGRIC-B8 FOOD PROCESS ENGINEERING (PART 1)

Problem 1. (5 points)

- a) How many apple juice to 8% solids can be manufactured from apple juice concentrate at 66% solids, if the flow of the concentrate is 1000 kg / h?
- b) What water flow should be added?

Problem 2. (15 points)

You have to design a cold room to store apples prior to distribution. This cold room should stock the apples needed for retailing during 5 months in winter (22 weeks from October to February). The quantity of apples to distribute each week is 25 tons, thus the total quantity of apples to consider in this cold room for 5 months is 550 tons (22 weeks x 25 tons/week).

The dimensions of the cold room are: $L \times l \times h = 30\text{m} \times 12\text{m} \times 4\text{m}$.

For design purposes, the exterior temperature can be considered constant at 16°C and the interior temperature, as 1°C .

The air change (to avoid mould and mushroom growth in the cold room) is 1 volume per hour.

The specific heat of air, C_p , (in a volume basis) is $1280 \text{ J/m}^3 \text{ }^\circ\text{C}$.

The cooling system has an efficiency of 80%, and the heat transfer coefficient of the walls and ceiling of the cold room can be considered as $0.40 \text{ W/m}^2/^\circ\text{C}$.

Heat transfer from and to the floor can be considered negligible.

Heat of respiration of apples at 1°C is $20 \times 10^{-3} \text{ W/ton}$.

Which is the cooling power needed to maintain the temperature of the cold room when it is full of apples (25 tons/week x 22 weeks) if all the heating exchanges with the surroundings (transfers from walls and ceiling), by the air change and by apple respiration are taken into consideration?

Problem 3. (10 points)

A tubular heat exchanger is used to pasteurize milk which may contain *Salmonella sp.* Operation variables are the following:

- Velocity of liquid inside the tube : 0.8 m/s
- Instantaneous rise in temperature to 85°C ;
- Instantaneous cooling.

It is known that the time for decimal reduction at 82.2 °C, $D_{82.2}$, is 0.192 sec, and the z value (increase of temperature allowing the division of D by 10) is 6.7 °C.

Please calculate the length of the tube to reduce the concentration of *Salmonella sp.* by a factor of 10^{12} .

Problem 4. (10 points)

Frozen meat is being transported to a community living in northern Canada. Three freezing/thaw cycles of the meat pieces have occurred during their transportation.

Which are the consequences of the aforementioned break of the cold chain? Explain briefly the reasons.

Problem 5. (10 points)

Please name four types of freezers commonly used to freeze foods.

Please describe briefly, for each of them, their technical characteristics and main applications in the food industry.