ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2009 SESSION

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

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

Problem 1. (20 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 6 months in winter (26 weeks from October to March). The quantity of apples to distribute each week is 20 tons, thus the total quantity of apples to consider in this cold room for 6 months is 520 tons (26 weeks x 20 tons/week).
The dimensions of the cold room are: L x l x h = 30m x 10m x 5m.
For design purposes, the exterior temperature can be considered constant at 15°C and the interior temperature, as 0°C.
The air change (to avoid mould and mushroom growth in the cold room) is 1 volume per hour.
The specific heat of air, Cp, (in a volume basis) is 1280 J/m^3 °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 $W/m^2/°C$.
Heat transfer from and to the floor can be considered negligible.
Heat of respiration of apples at 0°C is 20 x 10^{-3} W/ton.

Which is the cooling power needed to maintain the temperature of the cold room when it is full of apples (20 tons/week x 26 week) 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 2. (15 points)

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

- Velocity of liquid inside the tube : 1.0 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 0.018 sec, and the *z* value (increase of temperature allowing the division of *D* by 10) is 5.6 °C.

Please calculate the length of the tube to reduce the concentration of *Mycobacterium tuberculosis* by a factor of 10^{13}.

Problem 3. (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 4. (10 points)

Please name four types of evaporators commonly used to concentrate liquid foods.

Please describe briefly, for each of them, their technical characteristics and their impact on the properties of concentrated liquids.