**ABE 557 F 18**  **Due \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

DRYER DESIGN Part 2

Design a Through-Circulation conveyer dryer to produce a non-porous product.

1. Design a continuous through-circulation conveyer dryer to produce 2000 kg/hr of a dense extruded couscous product from 40% to 5% wb moisture content. The initial diameter 5 mm. The dryer has to be as energy efficient as possible. The dryer is composed of several sections at different air temperatures and air humidities to produce the desired texture. Drying air can be transferred to the outside or between sections. Air is heated by passing over banks of finned coils containing steam available at 100 psig.
2. Fresh air is assumed to be 25C and 50% RH. Approximate drying rates with using Eq 9.9-7 of CJG (substitute x with r) with Deff from Part 1 for each 5% change in moisture. Determine the equipment cost and operating costs. Determine the annualized cost from your determined operating and fixed costs.

Dryer Design Requirements

1. Electrical and steam loads,

b) air temperature and RH for each section,

c) length of each section,

d) fan size for each section –airflow, pressure drop, Hp,

e) heat exchanger design for each section.

Equipment and utility costs are as follows:

1. Fan: Cfan = $ 103[V(m3/min)/84.9]0.54
2. Air-cooled HX: Chx = $50 [BareArea(m2)][BareArea(m2)/464.5]-0.6
3. Conveyer: Ccon = $2x104[L(m)/61]0.85
4. Steam: $1.75/1000 lb.
5. Electricity: $0.04/kWh

1. Dryer Design Requirements

1. Electrical and steam energy requirement
2. Air temperature and relative humidity for each section
3. Belt width for entire dryer 8ft
4. Length of each section
5. Fan size for each section
6. Heat Exchanger design for each section

2. General Requirements

1. Minimize the energy consumption
2. Maximize product quality. Comment on the expected quality changes (shrinkage, and gelatinization of pasta during drying)

References:

1. Perry's Chemical Engineer's Handbook
2. Geankoplis
3. Conveyer Dryers in Handbook of Industrial Drying, Chap. 15

**Dryer Design Part 2 F 2018**

DRYERSolution Suggestions

**Drying Conditions in Each Section**

1. Based on the results of Part 1, divide the dryer into sections at different temperatures and humidities. Assume that each section is maintained at constant average temperature (uniform mixing). Conduct material/energy balance for each section.
2. Using the inlet and outlet moisture content of the product for each section from Part 1, determine the residence time in each section. Procedure: From the effective diffusivity values from Part 1 calculate the drying time at a given average moisture content. Determine the residence time in each section with using Eq 9.9-6 of CJG (substitute x with r) with Deff from Part 1 for each 5% change in moisture in a dryer section.
3. Check the product quality in each section and ensure that it is within the prescribed bounds. There are two variables to be determined: temperature and equilibrium moisture. Note that they are not independent of one another and an implicit constraint is that the equilibrium moisture should be less than the desired final product moisture content for each section but not below the glass transition.

**Fan and Heat Exchanger Design**

1. Using the inlet temperature and relative humidity of air for each section, calculate the gas flow rate through the bed in each section to insure negligible external resistance and air circulation should not have more than a 10% change through the bed of product. Determine pressure drop through bed. (Use equations in Geankoplis). Use the isotherm to relate equilibrium moisture content to relative humidity.
2. Using the pressure drop, density and flow rate of air, determine the fan hp and electric power requirements.
3. Determine the air moisture pick-up, overall gas flow rate, and temperature drop for the drying air in each section.
4. Based on your calculated inlet and outlet temperature and relative humidity of the drying air, determine fresh air or exhaust air requirement for each section. Do an energy balance also to determine the heating required for each section.
5. Determine the velocity of the conveyer and hence length of each section from drying rate values.
6. Design a finned tube heat exchanger for heating the air in the dryer. Use Geankoplis.
7. Discuss in detail techniques to decrease energy use (present conceptual designs).
8. Discuss your design assumptions. Is your design realistic? What parameters are important when consider a design that minimizes cost.