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1. (35 points) Raw cotton is supported on a tray with 60 cm square and 1 cm thick. The drying occurs only on the top surface of the cotton because the tray bottom is insulated. Air at 75°C with 50°C wet – bulb temperature circulates across the pan surface at a mass flow rate of $2,500 \text{ kg/hr.m}^2$. It is assumed that the cotton density is 0.7 g/cm^3 , the equivalent diameter (D_e) is 15 cm, and the critical free moisture is 40%.
 - 1.1. (25 points), Determine a constant rate of drying in $\text{kg/m}^2.\text{hr}$.
 - 1.2. (10 points), Calculate time period used to dry the cotton from initial free moisture content of 80% to 10% (dry basis)



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2. (25 points) Adsorption of zeolite 5A is used to adsorb methane (CH_4) in H_2 gas. The stream gas contains 40% CH_4 in feed with total feed pressure 25 atm and temperature 30°C . The ideal adsorption time is 300 min and the beds are 85% loaded (used bed) with total length of beds is 11 m. The bulk density of bed is 795 kg/m^3 .
- 2.1. (12 points), Estimate saturation capacity in mole/kg if feed velocity is 1,000 m/hr.
- 2.2. (3 points), Find break point time in min.
- 2.3. (10 points), Estimate the amount of zeolite 5A in kg if 10% CH_4 in the exit gas is required and the outlet pressure, exit velocity are 2 atm and 250 m/hr.

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3. (25 points) A solution consisting of 35% MgSO_4 and 65% H_2O at 160°F is cooled to 120°F in a batch crystallizer. During the cooling 5% of total H_2O evaporates.
- 3.1. (15 points), Determine lb of crystals obtained per 2,000 lb of feed solution.
- 3.2. (10 points), Find heat removed from the solution per ton of crystals in Btu