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ABSTRACT

The main purpose of the present work is to develop and test a mathematical model using an operating computer program for two case studies. The first is to predict outlet concentration of water vapor streams for dehydration beds of natural gas and the temperature profile along the bed, the second is to study the effect of feed air velocities on nitrogen purity by using a pressure swing adsorption (PSA) unit.

These models were developed on the basis of dehydration of a natural gas unit and production of nitrogen gas from air by pressure swing adsorption (PSA) located in Amerya LPG Recovery Plant of Egyptian Natural Gas Company (GASCO).

The present work also predicts the breakthrough time for the dehydration beds at several inlet concentrations of water vapor at different superficial velocities of the feed gas. The theoretical part in this thesis focuses on the different methods of gas dehydration process and PSA. The present manuscript also provides a testing of the developed model.

Nomenclature

C	=	Solute concentration
C^*	=	concentration in equilibrium with average loading $\bar{q}\,(\mathrm{mol\,m^{-3}})$
C_f	=	Volumetric heat capacity of fluid
$C_{v,g}$	=	Molar heat at constant volume for gas phase (J/kg K)
$C_{p,g}$	=	Molar heat at constant pressure for gas phase (J/kg K)
D_L	=	axial dispersion coefficient (m2 s^{-1})
d_p	=	Adsorbent particle diameter (m)
d_{int}	=	bed diameter (m)
D_e	=	Effective diffusivity (m^2 s^{-1})
$D_{i,j}$	=	Diffusivity of component, i, in component, j (m^2 s^{-1})
h_f	=	film heat transfer coefficient between the gas and the adsorbent (W/m^2 K)
h_w	=	internal heat transfer coefficient between the gas and the column wall (W/m^2 K)
K	=	Overall mass transfer coefficient (m s^{-1})
K	=	Adsorption equilibrium constant (dimensionless)
k_c	=	External mass transfer coefficient (m s^{-1})
k_B	=	Boltzmann constant (1.3805 x10^{-23} J/K)
$M_{w,i}$	=	Molecular weight of component, i (kg/kmol)
$M_{w,j}$	=	Molecular weight of component, j (kg/kmol)
$\dot{m}$	=	mass flow rate (kg/s)
P_e	=	Peclet number
P	=	Total Gas mixture pressure (kg/cm^2)
Q	=	Adsorbed concentration(mol/kg)
q^*	=	Equilibrium adsorbed concentration (mol/kg)
q_m	=	Equilibrium parameter for extended Langmuir equation (mol/kg)
R_p	=	Adsorbent particle radius (m)
R_e	=	Reynolds number (dimensionless)
Sc	=	Schmidt number (dimensionless)
Sh	=	Sherwood number (dimensionless)
T	=	temperature (^oC)
T_∞	=	Furnace external air temperature (K)
T_g	=	gas temperature (K)
T_s	=	solid temperature (K)
T_w	=	wall temperature (K)
u_s	=	superficial velocity of vapor (m/s)
Z	=	Bed length (m)

Greek symbols

μ	=	dynamic viscosity (pa.s)
ρ	=	density (kg/m^3)
υ	=	Kinematic viscosity
$\nu_{i,j}$	=	Collision diameter (Å)
$\Omega_{Di,j}$	=	Diffusion collision integral
λ_L	=	Effective axial thermal conductivity
τ_p	=	Tortuosity of the pores in the micro void
ε_p	=	particle void fraction