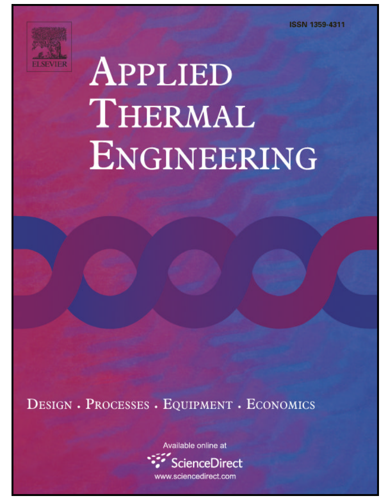

Research Paper

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STUDY OF THE ADIABATIC ABSORPTION PROCESS IN POLYMERIC HOLLOW FIBER MEMBRANES FOR AMMONIA/WATER ABSORPTION REFRIGERATION SYSTEMS

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Abstract. This paper presents a theoretical and experimental study of the adiabatic absorption process of ammonia into an ammonia/water solution using a polymeric hollow fiber membrane module (Liqui-Cel G501 2.5x8 Extra-Flow) as a contactor. An experimental test bench was designed and built and the effect of the subcooling conditions of the inlet solution and the mass flow rate on the ammonia absorption flux was studied. The experimental conditions were those of an absorber and a resorber in an absorption-resorption refrigeration system but in this case working under adiabatic conditions. A two-dimensional model was also developed and validated with the experimental results and two case studies were made at different solution mass flow rates to determine the evolution of the ammonia solution concentration, ammonia absorption rate, bulk solution temperature, gas temperature and solution subcooling throughout the hollow fiber membrane module. The two-dimensional model enables us to study the evolution of the main operation parameters in the axial and radial direction of the membrane module. Agreement was very good between the model predictions and the experimental measurements of the ammonia absorption rate (J) and the temperature of the solution at the outlet of the membrane module. The Mean Absolute Error of the model predictions with respect to the experimental data was $\pm 3\cdot 10^{-5}$ kg/m^{2}s and ±0.3 °C, respectively. The model opens up the possibility of designing enhanced absorbers for the ammonia/water absorption refrigeration cycle.

Keywords: Membrane, Hollow fiber, Absorption-Resorption, Refrigeration, Ammonia/Water

NOMENCLATURE

dA	[m^2]	Discretized membrane area
D	[m^2/s]	Diffusion coefficient
D_k	[m^2/s]	Knudsen diffusion coefficient
d_0	[m]	Outer diameter of the hollow fiber
d_i	[m]	Inner diameter of the hollow fiber
dp	[m]	Pore diameter
D_s	[m]	Inner diameter of the shell of the module
D_t	[m]	Outer diameter of the central tube
dx	[m]	Length of the discretization element in the axial direction
dy	[m]	Width of the discretization ring in the radial direction. Also gap between the fibers
h	[J/kg]	Specific enthalpy
J	[kg/(m^2·s)]	Mass flux
K_{BL}	[m/s]	Mass transfer coefficient in the liquid phase
K_m	[kg/(Pa·s·m^2)]	Mass transport coefficient in the pores of the membrane
L	[m]	Membrane module length
n	[-]	Segment n
N_f	[-]	Number of fibers
Nu	[-]	Nusselt number
m	[-]	Segment m
m_{abs}	[kg/s]	Mass flow rate of the ammonia (vapour) absorbed
m_{BL}	[kg/s]	Solution mass flow rate
m_{BG}	[kg/s]	Gas mass flow rate
M_{NH3}	[g/mol]	Ammonia molecular weight
p	[Pa]	Pressure
R	[J/(K·mol)]	Gas constant
Re	[-]	Reynolds number
Sc	[-]	Schmidt number
Sh	[-]	Sherwood number
T	[K]	Temperature
U	[W/m^2·K]	Overall heat transfer coefficient