



Effect of the $\text{NH}_3\text{--LiNO}_3$ concentration and pressure in a fog-jet spray adiabatic absorber

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ABSTRACT

This paper presents the effect that both the ammonia concentration in an ammonia–lithium nitrate solution and the absorber pressure have on the adiabatic absorption of ammonia vapour by droplets generated by a fog-jet injector. The injector ensemble is located at 205 mm from the bottom of the absorber. The solution has an ammonia mass fraction varying from 0.419 to 0.586 and the absorber pressure varies from 429 to 945 kPa. This is representative of the operating conditions for conventional absorption chiller cycles, but also for advanced cycles such as those with a booster compressor located in series between evaporator and absorber. This leads to a higher than common pressure in the absorber. Results show approach to equilibrium factors higher than 0.83, being the mean value of the experiments 0.9. The absorption ratio obtained was between 0.008 and 0.07. The increase in pressure and inlet subcooling increases the absorption rate, whilst the increase in the ammonia mass fraction increases the approach to equilibrium factor, decreasing the absorption rate.

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1. Introduction

Currently the absorber size significantly impacts the overall size of single-effect absorption machines due to transferring heat and mass at the same time between two phases with a small difference in temperature and concentration [1]. There are several configurations of the absorber, being the falling film the most common type in commercial absorption chillers. The main problem with this configuration is the bad liquid distribution/surface wetting, e.g. [2], hence not using efficiently the available interchange surface of the absorber. Other types of absorbers are bubble absorbers and adiabatic absorbers [3].

The adiabatic absorber separates the processes of heat and mass transfer. Before the poor in refrigerant solution enters the adiabatic absorber, it is subcooled in an external conventional heat exchanger operating with a single-phase flow, which allows reducing its size and cost [4]. The mass transfer process takes place adiabatically inside the absorber [5]. Usually liquid molecular diffusion limits the absorption rate [4]. In order to reduce the penetration length of the absorbed vapour into the liquid, the solution can be dispersed as small drops. When the drops start absorbing vapour their temperature rises, slowing the absorption rate. If the residence

time in the absorber is large enough, the adiabatic equilibrium is reached at the outlet of the absorber. In order to increase absorption, part of the rich in refrigerant solution at the outlet of the absorber is mixed with the solution coming from the generator, downstream it is subcooled and recirculated through the absorber, so that the adiabatic absorption is repeated. This way, the equilibrium concentration corresponding to the inlet temperature of the external cooling flow can be approached, namely, the diabatic equilibrium. The ratio of mass flow rates of recirculated solution and of solution that goes to the generator, namely the recirculation ratio, can be in the range of 4–6 using the ammonia–lithium nitrate solution, for a reasonable approach to the diabatic equilibrium conditions [6].

The absorption of vapour by a sprayed liquid drop can be considered adiabatic. It has been studied theoretically for individual and independent spherical droplets by different authors [7–12], among others. All of them consider resistance to heat and species flow only inside the droplet. Some of them [7–9] are analytical models, starting from the Newman model [7] where the mass transfer of a spherical droplet is considered with no surface heat release by absorption and no motion inside the droplet, coinciding with null Peclet number. Ref. [8] included the internal liquid recirculation driven by the viscous shear from the external vapour flow under free falling conditions, resulting in infinite Peclet number. Ref. [9] added the absorption heat dissipating inside the

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