EXECUTIVE SUMMARY
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Fundamental Understanding of Heat and Mass Transfer in NH_3/H_2O

An experimental investigation of heat and mass transfer in falling-film ammonia-water absorbers was conducted. A tube bank consisting of four columns of six 9.5 mm (3/8") nominal OD, 29.2 cm (11.5") long tubes was installed in an absorber shell that allowed heat and mass transfer measurements and optical access. A test facility consisting of all the components of a functional absorption chiller was fabricated specifically for this investigation. Thus, a steam-heated desorber was used to generate ammonia-water vapor over a wide range of conditions. The ammonia-water vapor was rectified and condensed, followed by recuperative heat exchange before being expanded to the evaporator pressure. The cooling load was supplied to the evaporator by a combination of resistance heating and closed loop fluid heating. The evaporated refrigerant was preheated recuperatively by the fluid exiting the condenser and then flowed to the absorber to be absorbed in the test section. A solution heat exchanger between the absorber and desorber (and in some tests, a solution pre-conditioner upstream of the absorber) completed the ammonia-water loop.

Several variations of the basic system set up were fabricated to enable testing over the wide range of conditions (nominally, desorber solution outlet concentrations of 5 - 40% for three nominal absorber pressures of 150, 345 and 500 kPa, over solution flow rates of 0.019 – 0.034 kg/s.) Heat transfer rates were measured independently for both sides of each component and energy balances were rigorously established based on mass, species and enthalpy balances for each component before test results were deemed acceptable. Care was also taken throughout the study to not only establish the desired conditions, but also to maintain the solution-side thermal resistance as the governing resistance so that absorption heat and mass transfer phenomena could be measured accurately. Component level measurements at the absorber were used to determine heat transfer rates, overall thermal conductances, and solution-side heat transfer coefficients for each test condition. The trends in heat transfer coefficients were plotted and discussed, highlighting the effect of solution flow rate, with preliminary interpretations of the effects of solution concentration and absorber pressure on the solution heat transfer coefficients. For the range of experiments conducted, the solution heat transfer coefficient varied from 558 to 1140 W/m^2-K, depending on the test condition. The solution heat transfer coefficient increased with increasing solution flow rate.

The preliminary heat transfer coefficient estimates reported here were based on approximate analyses that treat the absorber as a single, lumped component, and do not account in detail for the internal variations in heat and mass transfer coefficients. Some of the local measurements also taken during the experiments will be used in the ongoing second phase of this study, in which the development of more detailed models of the absorption process will be attempted.