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State-of-the-art in liquid desiccant air conditioning equipment and systems

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A B S T R A C T

The air conditioning market has witnessed a significant development in liquid desiccant air conditioning (LDAC) technologies over the past few decades. Many previous studies have confirmed that technical and economical deficits associated with conventional air conditioning systems can be eliminated using LDAC technologies. As a result, LDAC technologies – both equipment and systems – have become hot topics for research, which has resulted in hundreds of research papers in the scientific literature. The objective of this paper is to present a comprehensive overview of LDAC equipment and systems, and to identify gaps in the literature to be considered by future research.

Contents

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1. Introduction

A proper amount of fresh air should be delivered to a conditioned space in order to achieve acceptable indoor air quality levels according to the ASHRAE 62.1 and 55 standards [26,27], and to increase occupants' productivity. Fresh air should be conditioned to acceptable conditions in order to cover the required sensible and latent loads (i.e. could be space, ventilation or total loads depending on if the system is all-air or 100% outdoor air). Sensible loads can be met using conventional air conditioning equipment (e.g. vapor compression system) in an energy efficient manner. On the other hand, it is energy intensive to meet the latent loads using conventional air conditioning equipment. This is because latent loads are met in a vapor compression system by cooling the humid air stream below its dew point temperature. The overcooled air stream then needs to be reheated to an acceptable supply air temperature in order to avoid the thermal discomfort of occupants.

Many research studies have shown that the limitations associated with vapor compression systems in dealing with latent loads can be eliminated using liquid desiccant air conditioning (LDAC) systems. In addition, LDAC systems can improve indoor-air quality (IAQ) while saving energy [44], and they have some merits compared to solid desiccant air conditioning systems as follows [4]: (1) The dehumidification of a humid air stream using a solid desiccant air conditioning system results in over heating the dry air stream; on the other hand, simultaneous cooling and dehumidification can be achieved using a LDAC system. (2) Liquid desiccants have higher capacities to hold moisture than solid desiccants. (3) The temperatures required for the regeneration of dilute liquid desiccant solutions are lower than those required for the regeneration of solid desiccants [74]. (4) Energy storage is possible in LDAC systems by storing concentrated desiccant solution in storage tanks, while this is not possible for solid desiccants [75].

The basic components of a LDAC system, as shown in Fig. 1(a), are the dehumidifier, regenerator, cooling coil, heating coil and solution heat exchanger. The major operating fluid in a LDAC system is the liquid desiccant solution, which is used to absorb/desorb water vapor from/to an air stream by adjusting its moisture content and surface vapor pressure as can be seen from Fig. 1(b). In the dehumidifier, a cool and concentrated desiccant solution stream (state 1 in Fig. 1(a)) is used to absorb water vapor from the humid air stream in order to cover 100% of the latent load required to be removed by the air stream. Depending on the inlet temperature of air and solution streams, the air stream may be either heated or cooled. The concentration of the solution leaving the dehumidifier (state 2 in Fig. 1(a)) is lower than the inlet solution concentration. Thus, the dilute solution (state 2) is regenerated by being heated to a specific set point temperature (state 4 in Fig. 1(a)) and then being