Energy and Buildings 125 (2016) 161–170

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Experimental analysis on dehumidification performance of an indoor passive falling film liquid desiccant moisture receptacle

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ARTICLE INFO

Article history:
Received 3 November 2015
Received in revised form 14 March 2016
Accepted 23 April 2016
Available online 4 May 2016

Keywords:
Dehumidification
Passive
Falling film
Indoor
Liquid desiccant

ABSTRACT

Vases or spheres with flowing water on the surface are common in buildings as indoor decoration or art work. The flowing water can have an impact on the indoor humidity environment, like humidification. By substitute of water with liquid desiccant, the vase or sphere with falling film on the surface can act as a moisture receptacle which removes moisture at high humidity and releases moisture at low humidity. In this paper, a passive falling film liquid desiccant moisture receptacle to be installed in indoor environment directly is proposed. Dehumidification performance of this indoor passive system is investigated by experiments. Impacting factors on the indoor passive falling film liquid desiccant moisture receptacle are studied by using an L_{16} (4^5) orthogonal experiments, including solution type, indoor air temperature, indoor relative humidity and solution flow rate. The effect trends of indoor air temperature and indoor humidity on static dehumidification capacity are also verified. Meanwhile, dynamic dehumidification processes are recorded to obtain the results under different initial working conditions. The results show that the factors impacting dehumidification capacity of this indoor passive falling film liquid desiccant moisture receptacle rank in the order as: solution type, indoor relative humidity, indoor air temperature, solution flow rate. Under given operation conditions, with the specific passive falling film liquid desiccant moisture receptacle design parameters, the dehumidification rate of LiBr solution is 88 g/(12 h) larger than that of LiCl solution. And the dehumidification rate of LiBr solution is 314 g/(12 h), which is much higher than that of $CaCl_2$ solution. In a chamber, the indoor relative humidity below 70% is achieved in the first two hours with the indoor passive moisture receptacle adopting the four solutions.

1. Introduction

Humidity, one of the six primary factors that must be addressed in thermal comfort environment [1], has attracted considerable attentions in the field of Heating, Ventilating, Air Conditioning, and Refrigeration. Many criteria regarding indoor humidity have been implemented in recent years [2,3]. Like Leadership in Energy and Environment Design has clarified that designers must limit indoor relative humidity that would cause dampness-related problems such as mold and microbial growth [4].

Many designers and researchers have done a lot of work to improve indoor humidity environment. In the early times, conventional air-conditioning system was widely applied in real situations to coupling control the indoor temperature and humidity. However, in the conventional air-conditioning system, the dehumidification is achieved by cooling the temperature of supply air below its dew-point which is deemed to be energy waste. Therefore, combined liquid desiccant dehumidification and vapor compression system, defined as hybrid liquid desiccant air-conditioning (HLD) system, is proposed to control indoor temperature and humidity independently. Up to 40% of the energy consumed by conventional air-conditioning system can be saved [5]. The aqueous solution used in HLD system can also remove aerial pollutants and sterilize the bacteria and virus to improve indoor air quality effectively [6].

Various experiments and theoretical researches regarding HLD systems have been carried out, such as: the evaluation of liquid desiccant dehumidification/regeneration [7–9], performance analysis in different HLD configurations [10–13], the utilization of low grade heat in regenerating the desiccant [14,15].

Yin et al. [16] introduced a liquid desiccant evaporation cooling air conditioning system to study the effects of heat source temper-

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http://dx.doi.org/10.1016/j.enbuild.2016.04.061
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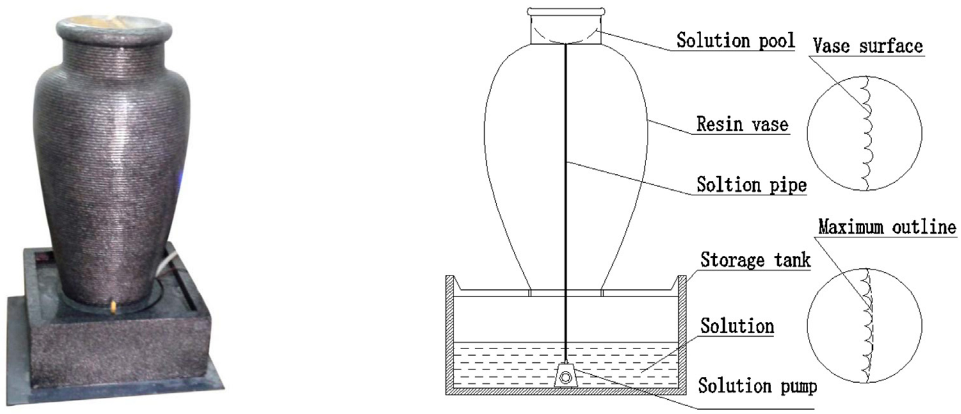

Fig. 1. Perspective view of falling film liquid desiccant prototype.

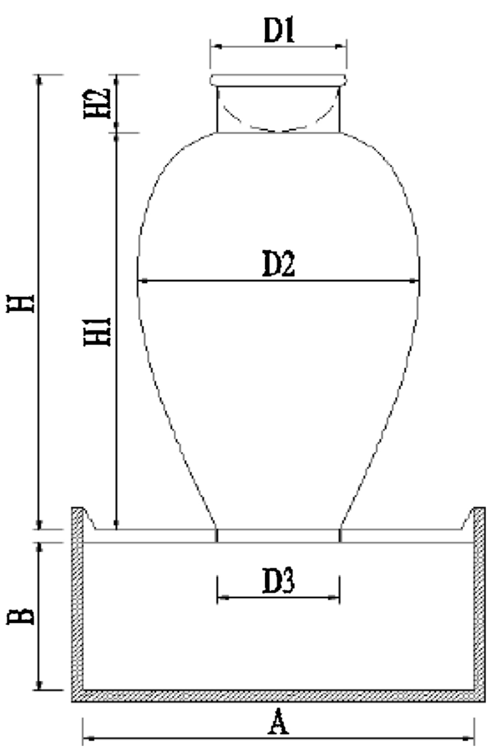

Fig. 2. Geometry of the falling film liquid desiccant prototype.

Table 1
The dimension of the prototype.

A(mm)	530
B(mm)	200
D_1(mm)	350
D_2(mm)	450
D_3(mm)	320
H(mm)	1020
H_1(mm)	880
H_2(mm)	140

ature, air and solution parameters on the rates of dehumidification and regeneration. Hamed et al. [17] constructed a new rotating absorption disk adopting lithium chloride and found that this configuration could absorb an amount of 95 g of water in the absorption cycle per hour. Jain and Bansal [18] carried out a comprehensive comparative parametric analysis of packed bed dehumidifiers with three commonly used liquid desiccants. Xiong et al. [19] proposed a two-stage liquid desiccant dehumidification system using calcium chloride solution and lithium chloride solution in the first-stage and the second-stage dehumidifier, respectively. Huang et al. [20] conducted an experiment for a counter flow dehumidifier with random packing and lithium bromide solution when solution flow, inlet concentration and temperature varied.

Falling film liquid desiccant air-conditioning system, as an effective alternative to achieve indoor humidity control in a variety of applications, also plays a vital role in this field. Its advantage lies on high heat and mass transfer efficiency [21]. The researches of falling film liquid desiccant air-conditioning systems have been effectively

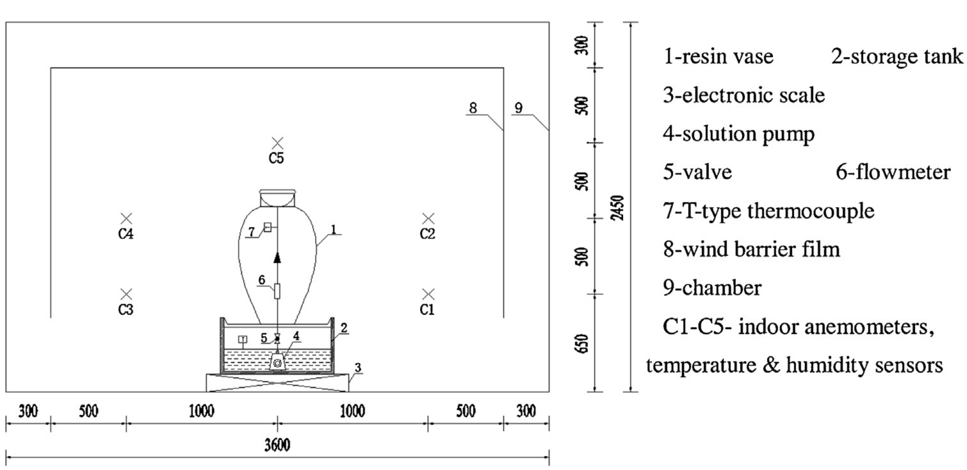

Fig. 3. Steady-state orthogonal experimental setup.