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Application of CFD Model in Analyzing the Performance of a Liquid Desiccant Dehumidifier

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Abstract

The dehumidifier of a liquid desiccant air conditioning system was the research object of present paper. A model was established on the basis of CFD. The interior heat and mass transfer processes were simulated with the model. Intensive analysis was conducted to investigate the influence of some factors, including the inlet desiccant temperature, desiccant flow rate and internally cooling.

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Keywords: CFD model; Liquid desiccant dehumidifier; Less assumptions; Intensive analysis

1. Introduction

Along with the living standards improves, more and more attention has been paid in the building environment, which relies almost on the large consumption of fossil fuels [1]. To reduce the dependency, people have always tried to improve energy utilization efficiencies of indoor devices [2] or turned to renewable energy [3-5].

For the traditional air conditioner, it was reported that about 30～50% of the total energy consumption was due to the condensation dehumidification. Thus, the liquid desiccant dehumidification unit was proposed to be integrated with the traditional air conditioner. It is the liquid desiccant air conditioning system, which can realize the separate control of temperature and humidity. Unlike the traditional air conditioner, the latent heat is controlled by removing the moisture from the air with liquid desiccant. As it needs not to reduce the air temperature to the dew-point temperature, the evaporative temperature of the

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cooler is increased so as the cooler COP in the liquid desiccant air conditioning system is higher than that of the traditional air conditioner [6].

The major component of interest in the liquid desiccant air conditioning system is the dehumidifier in which the process of heat and mass transfer occurs between humid air and liquid desiccant. Until now, several kinds of simulation models have been developed to predict and assess the performance of the dehumidifier [7-9]. However, most of the models did not take the flow into consideration. To simplify the heat and mass transfer process, lots of common assumptions have been made for the above models. Moreover, most of the study focused on the inlet and outlet parameter changes rather than the interior condition of the dehumidifier.

To fill the research gap, a model on the basis of CFD was established to study the performance of the dehumidifier under different conditions. With the model, the interior heat and mass transfer process could be obtained. Intensive analysis was conducted to investigate the influence of some factors, such as inlet desiccant temperature, desiccant flow rate and internally cooling.

2. Mathematical model

2.1. Geometric model

Numerical simulations were conducted for the unsteady two-phase flow with free liquid surface in the channel between two flat plates. The simplified geometric constructions are presented in Fig. 1.

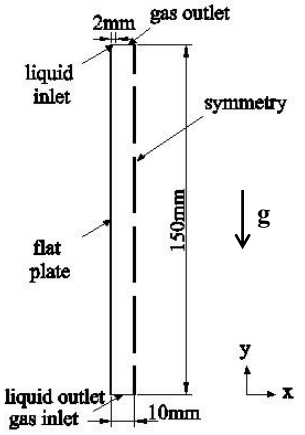

Fig. 1. simplified physical model

2.2. CFD equations

The basic principles of CFD are mass conservation, momentum conservation and energy conservation.

(1) Mass conservation

$$\frac{\partial}{\partial t}(\rho)+\nabla\cdot(\rho \boldsymbol{u})=0 \tag{1}$$

In present paper, the mass transfer source $S_{\mathrm{lg,k}}$ is the water absorbed from the humid air by the solution,

$$S_{\mathrm{lg,k}} = K_{\mathrm{g}}(W_{\mathrm{g,b}}-W_{\mathrm{g,e}})A \tag{2}$$