Study of mass transfer in liquid desiccant for dehumidifiers packed by using conventional wooden slats

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Abstract. To reduce electricity consumption, heating ventilation from the air-conditioning sector focuses on developing alternative solution electrically-driven vapour-compression system. The liquid desiccant air-conditioning system represents energy efficiency. It is more environmentally friendly as an alternative technology for the dehumidification process, especially in cases with high latent loads to maintain air quality under reduced conditions for comfortable. This technology is more efficient than the vapour compression system in hot and humid climates like Indonesia. This study carries out an experimental investigation to find out how much moisture removal with using a liquid desiccant to absorb humidity in the air and to know general types of correlations for heat and mass transfer in the contactor for the air solution. In this experiment, liquid desiccant will be passed through wooden slats to determine the physical and thermophysical properties of the air. The general equation will be verified by the experimental results using a curve that fits this expected. The result is a decrease in the humidity in the air. It is known from the amount of moisture absorbed by the drying liquid, and the highest is 336.49 g / s and the lowest is 19 g / s. So it can be concluded that the drying liquid that is exposed to air and passing through wooden slats effective removes moisture.

Keywords: Humidity, Liquid desiccant, Moisture removal, Wooden slats

1. Introduction

The energy consumption to operate the A/C system is very large, especially in dealing with hot and humid air. It has taken about 20% - 40% of energy consumption for the HVAC system. In general, the lower the fresh air ratio of a building, the smaller the energy consumption required. HVAC dehumidifiers generally use a vapour compression system, based on the development of the ASHRAE 62 and 90 standards, and conventional vapour compression systems have become less efficient at handling latent loads in buildings with high moisture content. This is because when the coil is turned off, the moisture content in the evaporated air is condensed again, which causes the air in the room to return to moisture, making it inefficient. In addition, at the end of this decade, a lot of attention was shown to improve Indoor Air Quality (IAQ) since there was a large-scale outbreak of the SARS and SBS (Sick Building Syndrome) viruses in a building’s air conditioning system, which requires an effective
system to create a proper air ventilation system. can balance low energy needs and (IAQ) high [1]. In addition, heat is captured by the solar collector, which is used to regenerate the liquid desiccant, which is used to increase system efficiency. So that the Liquid desiccant technology was developed which is one of the promising alternative technologies for efficient dehumidification and heating or cooling, and uses solar energy to regenerate this liquid desiccant [2].

Apart from the conventional dehumidification method (cooling the air to below its dew point temperature), air can also be dried with a liquid desiccant. The impact of the air conditioning system using a liquid desiccant to dry the air is getting a lot of attention [3], this method uses a liquid desiccant to dry the air by absorbing water vapour in the air. The drying method using a liquid desiccant does not need to be cooled down below the dew point temperature like using a vapour compression cooling system. Meanwhile, compared to using CFCs and HCFCs, liquid desiccants are not harmful to the environment. In addition, because it means that it only requires a little energy for the regeneration of the cooling air system using a liquid desiccant, solar energy can be used to run this system [4]. Thus, an air conditioning system using a liquid desiccant is a promising option for the cooling process.

LiCl and LiBr solutions had been used for cooling systems by using a liquid desiccant [5, 6]. LiBr solution has a higher density and lower specific heat capacity. By using the same flow rate, the dehumidification process of the LiCl solution is better than the LiBr solution, but the regeneration performance of the LiBr solution is slightly better or almost the same as the LiCl solution. Apart from using liquid desiccants (LiBr, LiCl and CaCl2), a new type of liquid desiccant that can be used in air conditioning systems has also attracted many researchers to research this theme. Many researchers are concerned with the nature of concentrated bittern solutions as a byproduct resulting from salts acting on sunlight, due to their potential use as a liquid desiccant in liquid desiccant systems in cooling systems. The relative humidity balance of bitterns expresses a function of the relative concentration of seawater.

The vapour pressure of bitterns solution was found to be similar to that of solutions containing only magnesium chloride but having the same mass fraction of total salt. Davies and Knowles [7] explored the scope for exploiting the hygroscopic salts that occur in these byproducts - such as magnesium, calcium and sodium chloride - as liquid desiccants in greenhouse cooling systems. The result of the exploration is that the six salts that are considered can be used for liquid desiccant in greenhouse cooling systems, except for sodium chloride. Apart from research on the characteristics of liquid desiccants, there is a lot of literature [8] which includes experimental and theoretical research data from air conditioning systems using liquid desiccants [9]. Presented experimental tests and theoretical analyzes of heat and mass transfer in a dehumidifier/regenerator that had been trimmed. Experimental tests and theoretical analysis have shown that the dehumidification process of air by using a solution containing.

2. Experimental setup

A detailed schematic diagram of a cross-flow dehumidification system with liquid desiccant is shown in Figure 1. Ambient air is pushed into a square duct (30 cm x 30 cm) by a centrifugal blower placed at the beginning of the duct. The wet and dry bulb temperatures were measured just before the packing wooden slats. The wooden slats packing pad is wet with liquid desiccant that flows from top to bottom at set flow rates, the concentration liquid desiccant stored in the solution tank. The solution sprayed through the solution distributor wets the packed tower and removes moisture from humid air. All measurements for all the thermocouples were recorded in a data logger.
Figure 1. Schematic diagram of the experimental for the liquid desiccant dehumidification system.

In the experimental setup, the temperature sensor put inside the contactor, and the temperature sensor will send temperature data to NI 9213 via NI cDAQ 9174. Temperature data converted in digital form and the temperature data will be sent to the computer.

3. Result and Discussion

Figure 2 shows the influence of the desiccant solution flowrate on the humidity ratio from humidity ratio inlet to outlet.

Figure 2. Influence of the solution flow rate and humidity ratio of the liquid desiccant.

Humidity ratio at outlet lower than input each time flowrate increasing. Humidity ratio increases rapidly with the solution flow rate. This may be because increasing solution flowrates ensure good contact between the air, the liquid desiccant and wooden slats also increase the mass transfer coefficient.
Conclusion

An experimental study was carried out to evaluate wooden slats performance on liquid desiccant dehumidification system. Difference Humidity ratio was used as the performance indicators.

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