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Experimental study on heat and mass transfer characteristics of louvered fin-tube heat exchangers under wet condition ☆

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ABSTRACT

An experimental study was conducted to investigate the effect of a tube row, a fin pitch and an inlet humidity on air-side heat and mass transfer performance of louvered fin-tube heat exchangers under wet condition. Experimental conditions were varied by three fin pitches, two rows, and two inlet relative humidities. From the experimental results, it was found that the heat transfer performance decreased and the friction increased with the decrease of a fin pitch, for 2 row heat exchanger. The effect of a fin pitch on heat transfer performance was negligible with 3 row heat exchanger. The change in a relative humidity was not affected heat transfer and friction. However, the mass transfer performance was slightly decreased with the increase of a relative humidity and with the decrease of a fin pitch. The mass transfer performance decreased with the decrease of a fin pitch. The mass transfer performance of the louvered fin-and-tube heat exchanger was different according to the number of a tube row.

1. Introduction

The fin-tube heat exchangers are widely used in a variety of air-conditioning system and refrigeration. If the heat exchanger operates at wet condition of a moist air by a cold surface (that is, cooling condition), the temperature of a fin-tube surface of the heat exchanger is below the dew-point temperature of a surrounding air, and then the condensate occurs on the fin-tube surface. This condensate grows along with the flow direction and is extracted downstream. Some is stayed between neighbor two fins and at tube surface. That is, at wet condition, the heat and mass transfer by condensate is observed on the fin-tube surface, unlike dry condition (heating condition). As a result, significant changes of the heat and mass transfer by condensate are observed. Due to the intrinsic nature of a two-phase flow by the moist air and condensate, the fluid flow and the thermal phenomena of the heat exchanger are very complicated. So, the correct understand on the condensation phenomena occurring at the fin-tube surface of the heat exchanger are not easy.

The efficient and compact heat exchanger with a louvered fin has been attracted attention both in industry and academia. But, the performance of the louvered fin-tube heat exchanger has been not completely resolved. Experimental data at wet condition for the optimization of the louvered fin-tube heat exchanger design are not enough.

Wang et al. [1] studied a louvered fin-tube heat exchanger for dry condition and shown that the heat transfer performance is insensitive to change of inlet relative humidity. They also reported that the effect of the number of tube row on heat transfer performance and friction factor is relatively small. Fu et al. [2] shown the heat transfer performance increases and friction factors increase for a higher relative humidity, and the heat transfer performance decreases as fin pitch decreases, for below Reynolds number 2000. Korte and Jacobi [3] reported that the heat transfer performance decreases and friction increases, since the retention of condensate increases with the decrease of fin pitch. These results have a different trend along with the experiment objective. The results of Fu et al. [2] are different to Wang et al. [1] results. These results on the fin-tube heat exchanger do not show the consistent state at wet condition. This is because the experimental data of existing studies are obtained within a limited experiment condition and range.

Although the definite explanation on a wet process of the heat exchanger is difficult, more comprehensive and systematic study for the fin-tube heat exchanger at wet condition is required to develop the high efficiency air-conditioning system. Especially, to develop a compact and high performance heat exchanger, the study on heat and mass transfer characteristics of the fin-tube exchanger should be necessary. In the present study, thus, we investigate the air-side heat and mass transfer characteristics at wet condition. The effects on the fin pitch, the tube row, and the inlet relative humidity are introduced.

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