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Effect of non-uniform air velocity distribution on evaporator performance and its improvement on a residential air conditioner

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ABSTRACT

The effect of non-uniform air velocity distribution on performance of a multi-circuit evaporator was studied numerically and experimentally. The non-uniform air velocity distribution on evaporator was measured experimentally, and its corresponding evaporator performance was tested and approximated numerically. The evaporator performance was also investigated numerically at the equal airflow rate but under uniform air distribution. The results showed that the evaporator capacity under non-uniform air distribution was decreased by 7.78% than that under uniform air distribution. The decrease in evaporator capacity was mainly attributed to smaller overall heat transfer coefficient of lower tubes with smaller air velocity in first row because overall tube heat transfer coefficient varied remarkably at smaller air velocity and gently at greater air velocity. Two triangle air guide plates were installed on sheet backing of evaporator to deflect part of airflow towards evaporator bottom to increase air velocity of lower tubes and to decrease the area that smaller air velocity covered. The experimental results showed air guide plates decreased blend loss of high temperature air leaving upper circuits and low temperature air leaving lower circuits, thus decreasing outlet air dry and wet temperatures. Finally, the cooling capacity and EER were increased by 3.02% and 5.1%, respectively.

1. Introduction

The non-uniform air distribution has a notable effect on evaporator or condenser performance, and many papers have been published on it. Fagan [1] numerically studied the effect of one-dimensional linear, parabolic and step airflow non-uniform distributions on single-circuit evaporator and condenser performance when the refrigerant pressure drop was neglected and the refrigerant-side heat transfer coefficient was hypothesized unchanged. The evaporator results showed the same basic trends as condenser and the magnitude of losses were similar except that the percent loss in latent capacity for evaporator coil was greater than the percent loss in total capacity. The effect of non-uniform air distribution was not negligible if the maximum magnitude of non-uniform ratio exceeded 25% of average coil face velocity. The parabolic distribution produced minimum percent loss in capacity and the step distribution did the greatest percent loss. Increasing the percentage of maximum deviation from mean velocity increased the percent loss in capacity. The percent capacity loss increased as the average face velocity increased, but decreased with increasing air velocity when the air velocity change was kept constant. Chiou [2] numerically investigated the effect of twelve typical two-dimensional airflow non-uniform distributions on performance of the automobile multi-pass crossflow flat tube condenser when the refrigerant-side convection heat transfer coefficients were considered not to be fixed and the refrigerant pressure drops were not ignored. The results displayed the deterioration of thermal performance of condenser might become significant and should not be ignored in some typical applications. The higher the degree of airflow nonuniformity was, the greater the thermal performance deterioration was. Chwalowski [3] measured the non-uniform air velocity on the surface of V-type and I-type multi-circuit evaporators experimentally and tested the evaporator performance. Both the non-uniform degree of air velocity and the tested evaporator capacity strongly depended on the angles between slab of V-type or I-type coils and duct wall. The maximum difference of tested capacity between different angles was as much as 30%. The four simulation programs with the assumption of uniform air velocity profile underpredicted or overpredicted the test evaporator capacity by as much as 80%. Beller [4] measured the non-uniform air velocity distributions on I-type and A-type air-cooled multi-row heat exchanger and studied the effect of non-

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