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# Comparison of fin-and-tube interlaced and face split evaporators with flow maldistribution and compensation

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ABSTRACT

Flow maldistribution in fin-and tube evaporators for residential air-conditioning is investigated by numerical simulation. In particular, the interlaced and the face split evaporator are compared in flow maldistribution conditions. The considered sources of maldistribution are the liquid/vapor distribution and the airflow distribution. Furthermore, compensation of flow maldistribution by control of individual channel superheat is studied for each evaporator type. It is shown that the interlaced evaporator is better at flow maldistribution than the face split evaporator. However, if individual channel superheats are controlled, the face split evaporator achieves the best performance, i.e. an increase of 7% in overall UA-value and 1.6–2.4% in COP compared to the interlaced evaporator without compensation.



# Comparaison des évaporateurs à tubes ailetés entrelacés et des évaporateurs splits sur le plan de la mauvaise distribution et de la compensation liées à l'écoulement

*Mots clés :* Distribution de l'écoulement ; Compensation ; Conditionnement d'air ; Tube aileté ; Modélisation ; Simulation

## 1. Introduction

For A-shaped fin-and-tube evaporators in residential air-conditioning (RAC), the chosen type of circuitry by the manufacturers changed a couple of years ago. It changed from the face split to the interlaced circuitry, see Fig. 1. The interlaced circuitry shows a significant increase in cooling capacity compared to the face split circuitry. The main reason is the

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**Nomenclature**

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| | |
|---|---|
| COP | coefficient of performance (–) |
| $F_x$ | phase distribution parameter (–) |
| $F_{air}$ | airflow distribution parameter (–) |
| $L_t$ | transverse coil length (m) |
| $U$ | velocity (m $s^{-1}$) |
| UA | overall heat transfer coefficient (W $K^{-1}$) |
| $x$ | vapor quality (–) |
| $y$ | transverse coordinate (–) |

*Subscripts*

| | |
|---|---|
| in | inlet |
| $m$ | mean |

better compensation of flow maldistribution by design. In the current paper this choice is discussed with regards to further compensation of flow maldistribution by control of individual channel superheats.

Flow maldistribution in fin-and-tube evaporators has been shown to decrease the performance of the evaporator and the system both experimentally (Payne and Domanski, 2003) and numerically (Kærn et al., 2011b; Kim et al., 2009b). Both air side and refrigerant side effects may cause flow non-uniformities, e.g. non-uniform airflow, air-temperature, humidity or frost, fouling, two-phase inlet distribution, feeder tube bending and improper heat exchanger design. In this study we only address non-uniform airflow and non-uniform liquid/vapor distribution to the evaporator.

Most efforts of compensating flow maldistribution have been addressed to the design of the evaporator circuitry. Domanski and Yashar (2007) applied a novel optimization system called ISHED (intelligent system for heat exchanger design) to optimize refrigerant circuitry in order to compensate airflow maldistribution. They measured the air velocity profile using particle image velocimetry (PIV) and used that as input to their numerical model and reported that the cooling capacity was increased by 4.2% compared to an interlaced type of circuitry.

Studies regarding the benefits by control of individual superheat have also been conducted. Payne and Domanski (2003) showed experimentally that the performance degradation due to a non-uniform airflow could be recovered to within 2% of the original cooling capacity at uniform airflow conditions. Kim et al. (2009a) studied benefits of upstream vs. downstream control of individual channel superheat on a fin-and-tube five channel R410A heat pump numerically. The study showed that the upstream control outperformed the downstream control. They found that upstream control was able to recover up to 99.9% of the penalties of maldistribution. Kærn et al. (2011a) also studied compensation by control of individual channel superheat. Here a recovery of 94.3% in COP was found at a nearly complete air blockage of half of the evaporator, keeping the total air volume flow constant.

To this point no other investigation than the current is known to the authors where tube circuitries are compared with flow maldistribution and compensated by control of individual channel superheat. The objective of this paper is to

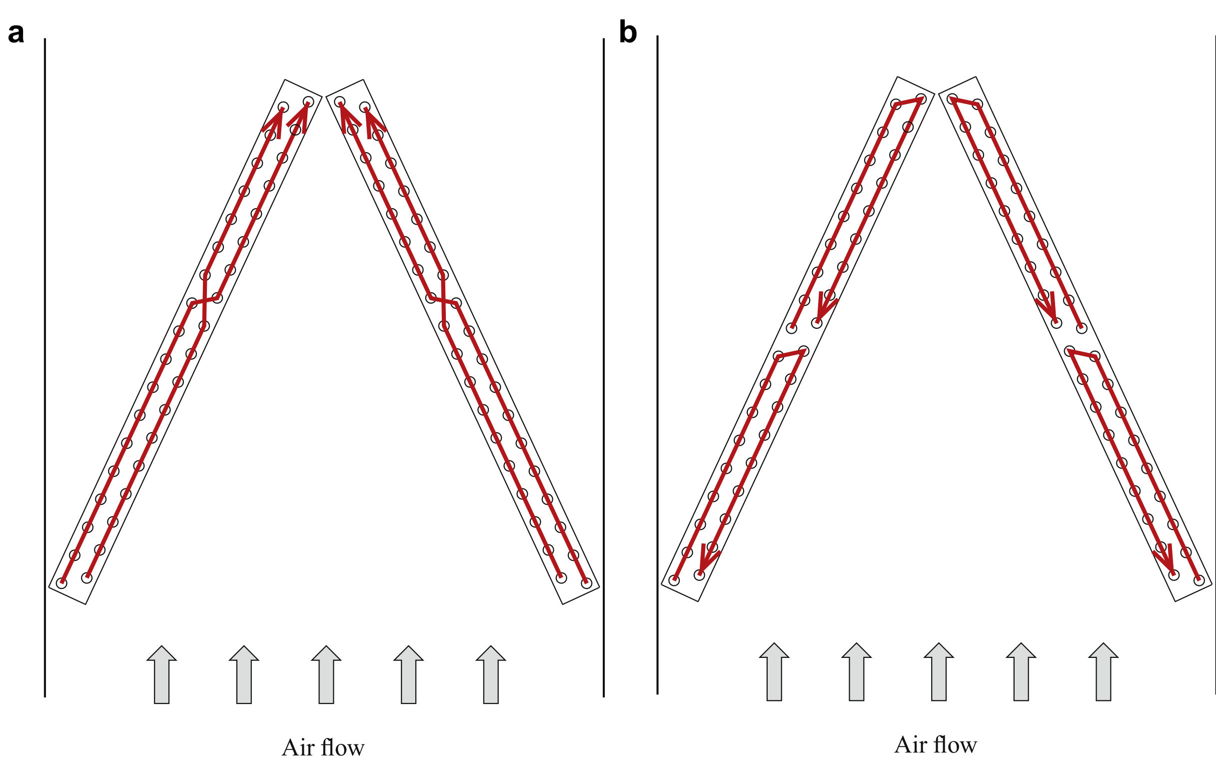


**Fig. 1 – Tube circuitries of (a) the interlaced evaporator and (b) the face split evaporator.**