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Thermo-hydraulic characterization of a louvered fin and flat tube heat exchanger

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ABSTRACT

In the present study, a whole heat exchanger with a hydraulic diameter of 2.3 mm is tested, which is a minichannel heat exchanger according to the Kandlikar classification. This is a louvered fin and flat tube heat exchanger currently used in car cooling systems, also known as radiator. A glycol–water mixture (60/40 in volume) circulates through the tubes at flows ranging from 100 to 7800 l/h and at a supply temperature of 90 °C. This fluid is cooled with ambient air at a temperature of 20 °C and at frontal air velocities varying between 0.5 and 7 m/s. The thermohydraulic performance of the heat exchanger is compared with the classical correlations given in the literature for the heat transfer and the friction factor calculation. On the glycol–water side the heat exchanger is characterized for Reynolds numbers from 30 to 8000. A first comparison is carried out with the correlations available in the literature with a purely predictive model by obtaining a predictive value with a systematic under prediction lower than 10%. In a second step a semi-empirical model is considered to identify the experimental heat transfer coefficients for this application.

1. Introduction

The apparition of miniaturization led, these last decades, to the realization of objects or systems remarkably innovating. Some of them have already been successfully marketed. Their principal advantage is a reduction of size and weight, which allows a better mobility and a better flexibility. Among the applications of miniaturization, forced convection in tiny channels receives an unceasingly growing interest, considering the high density of power that this mechanism could evacuate thanks to its very high surface to volume ratio. The generalization of this type of exchangers will only be possible by a better control of flows and heat transfers in those miniaturized systems.

Two different channels classifications according to their hydraulic diameters are found in the literature. The first one was proposed by Mehendale et al. [1] and it is exclusively based on the dimensions of the channels as shown in Table 1.

The second one, given in Table 2 and suggested by Kandlikar and Grande [2], is based on considerations related to gas flows. Although this classification was developed on the basis of gas flow, Kandlikar also recommends it for liquid and two-phase flows so as to standardize the classification of the channels.

The heat exchanger studied in the present work has a hydraulic diameter of 2.3 mm, so it is classified as compact passage according to Mehendale or as a minichannel according to Kandlikar. For this diameter range, classical correlations are appropriated to predict the heat transfer coefficient and the friction factor according to several studies [3–5].

The present work is carried out in a real heat exchanger unlike most of the literature study with the advantages (the real behavior of the heat exchanger) and the disadvantages (the impossibility to study separately each physical phenomenon) that this can introduce in the experimental results.

2. Experimental setup

2.1. Test bench

In this study an air cooled louvered fin and flat tubes heat exchanger is characterized. This is an automotive radiator used on combustion engine cooling systems. The fluid to be cooled is a mixture of ethylene glycol and water (60/40 in volume).

The test bench used to characterize this heat exchanger is shown in Fig. 1. It is composed of three circuits: the primary, the secondary and the air circuits. The primary and the secondary circuits are used to condition the glycol–water mixture in flow and temperature while the air circuit is used to condition the air in flow and temperature. These three circuits are equipped with several measurements of temperatures, pressures and flows in order to perform the circuit and the heat exchanger energy balances and their hydraulic analysis.

Two electric boilers are installed on the primary circuit to heat a glycol–water mixture. This heat flow is then transferred through a

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