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Heat transfer and pressure drop comparison of louver- and plain-finned heat exchangers where one fluid passes through flattened tubes

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ABSTRACT

Louvered fins constitute a major methodology for heat transfer enhancement. Of critical significance in evaluating the worthiness of such fins is the comparison between the heat transfer and pressure drop for a thus-finned heat exchanger with the baseline case of a counterpart plain-finned heat exchanger. Up to the present, it appears that such comparisons are confined to heat exchangers in which one of the participating fluids passes through circular tubes. In another basic geometry in which louvered fins have been employed, the aforementioned participating fluid passes through flattened tubes which are virtually rectangular in cross section. The focus of the present paper is to obtain results for the latter basic geometry for both louver-fin-based heat exchangers and counterpart plain-fin-based heat exchangers. The results were obtained by means of numerical simulation over a range of Reynolds numbers spanning approximately a factor of five. Over this range, enhancements of the heat transfer rate ranged from factors of approximately 2.2–2.8. Over this same Reynolds number range, the pressure drop increased by factors of 2.3–3.6. This outcome is attributable to the fact that the rate of heat transfer is less sensitive to the velocity than is the pressure drop.

1. Introduction

Louvered fins are a widely used means of improving the thermal performance of heat exchangers. On the other hand, it is widely acknowledged that the periodic interruption of an otherwise orderly flow and the concomitant mixing extracts a major toll in increased pressure drop. The increased pressure drop is not necessarily a sufficient deterrent to negate the use of louvered fins. That judgment depends on the application in question. For example, if the louver-fin-related pressure drop is one of many pressure drops encountered by a flowing fluid along a series flow path, the increased pressure drop may well be acceptable.

Among the broad range of louver-fin heat exchanger configurations, it is possible to identify two general categories. One of these, designated here as Type I, is an array of circular tubes, with the tubes deployed perpendicular to an assemblage of parallel louvered fins. In the other category, Type II, the tubes are flattened so that they resemble flat rectangular ducts with rounded edges.

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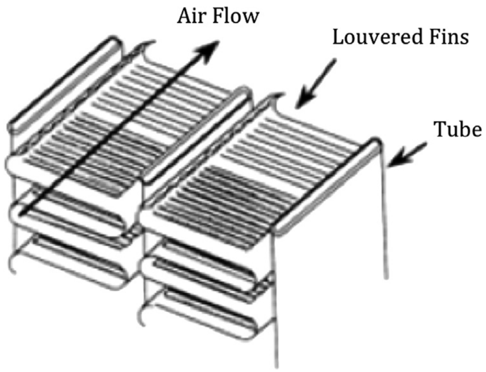

Fig. 1. Schematic diagram of a louver-finned heat exchanger of Type II.

The information essential to truly evaluate the performance of a *louver-finned heat exchanger* must include not only its heat transfer and pressure drop characteristics but also those of the *plain-fin heat exchanger* that is the counterpart of the louver-fin exchanger in question. A literature search was performed to identify publications in which results for both counterpart louver-fin and plain-fin heat exchangers are available. It was found that papers which convey this type of comparative information were limited to Type I heat exchangers [1–6]. In the present paper, it is Type II heat exchangers that are of particular interest in accordance with the motivating application. No literature comparing counterpart louver-finned and plain-finned heat exchangers for Type II was found.

2. Physical situation

A schematic diagram of a Type II louver-finned heat exchanger is displayed in Fig.1. One of the two participating fluids passes through the flattened, near-rectangular tubes. A louvered plate, periodically folded and then bonded to the surface of the flattened tube, forms the flow channels through which air passes over the louvers. For the plain-finned heat exchanger, the same material and thickness are used as for the counterpart louver-finned heat exchanger.

Inspection of Fig. 1 suggests the existence of an intrinsic periodicity of the geometry. Away from the outboard ends of the heat exchanger, there is no reason that any one fin and its adjacent airflows differ fluid-wise and temperature-wise from any other fin and its fluid. This observation suggests that there is no need to investigate the fluid flow and heat transfer in the entire heat exchanger. For the case of the louver-finned heat exchanger, the solution may be confined to one fin and to half of the respective flow channels on each side of the fin. Since the plain-finned case is symmetric, the solution domain may be limited to half of the fin thickness and half of one of the adjacent flow channels, either above or below the fin.

To supplement the schematic representation of Fig. 1, a photograph of an actual Type II louvered heat exchanger is displayed in Fig. 2.

A schematic diagram showing the front face of the louver-finned heat exchanger is exhibited in Fig. 3 to facilitate the

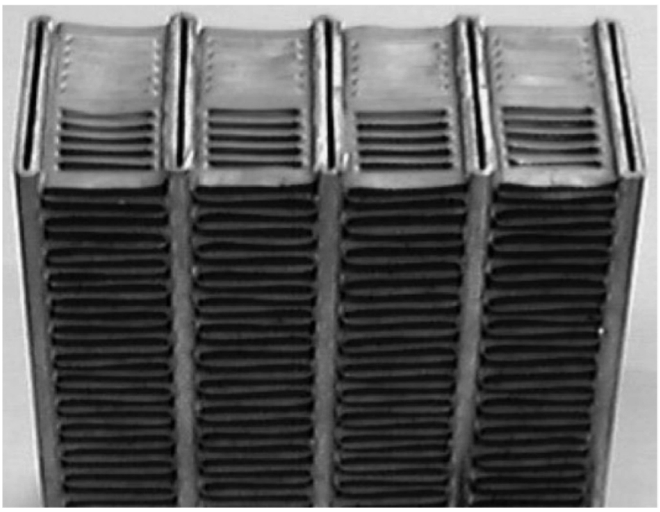

Fig. 2. Photograph of an actual Type II louver-finned heat exchanger.