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Parametric study and optimization of louver finned-tube heat exchangers by Taguchi method

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ABSTRACT

A serial studies on the effects of fin pitch, fin collar outside diameter, transverse tube pitch, longitudinal tube pitch, number of longitudinal tube rows, louver height, louver angle, fin thickness and louver pitch on fin performance of louver finned-tube heat exchanger is investigated by numerical method. The parameters of louver finned-tube heat exchangers are optimized by the Taguchi method. Eighteen kinds of models are made by compounding levels on each factor, and the heat transfer and flow characteristics of each model are analyzed. The results show that fin collar outside diameter, transverse tube pitch and fin pitch, are the main factors that influence significantly the thermal hydraulic performance of the heat exchanger. Therefore, these three factors are considered as the most important factors for an optimum design of a heat exchanger. The optimal conditions are obtained, and the results are also verified by analytical methods.

1. Introduction

Finned-tube heat exchangers are widely used in automotive and residential air conditioning heat exchangers. The dominant controlling thermal resistance is usually on the air side in practical applications, and therefore special surfaces should be employed to effectively improve the air side heat transfer performance of finned-tube heat exchangers. The commonly used enhanced fin patterns include wavy, slit and louver fins etc. The louver fin is a combination of the wavy and slit fin geometries. The louvers act to interrupt the air flow and create a series of thin boundary layers that have lower thermal resistance than the thick boundary layers on plains. For automotive applications, such as radiators, condensers, and evaporators, the louver fins are generally brazed (or soldered, mechanically expanded) to a flat, extruded tube, with a cross section of several independent passages, and formed into serpentine or a parallel flow geometry. For residential air conditioning systems, the configurations of finned-tube heat exchangers consist of mechanically or hydraulically expanded round tubes in a block of parallel continuous fins (Fig. 1).

The first reliable published data on louvered fin surfaces was in 1950 by Kays and London [1]. In the 1980s, Davenport [2] carried out smoke trace studies on a ten-times scale model of a non-standard variant of the corrugated louvered fin geometry and developed heat transfer and friction correlations for corrugated louvered fin geometry. Achaichia and Cowell [3] made a comprehensive study of performance characteristics of flat-sided tube and louvered plate fin heat exchangers. They also developed the correlations for the louvered plate fin geometry. Sahnoun and Webb [4] developed an analytical model to predict the heat transfer and friction characteristics of the corrugated louvered fin core. The investigations of heat transfer and pressure drop of standard louver fin and inclined louver fin were reported by Sunden and Svantesson [5]. Their investigations show that all the louvered surfaces are more efficient than the corresponding smooth surface, and the standard louver fin geometry reveals higher Stanton number than other inclined louver geometries.

Suga et al. [6] and Suga and Aoki [7] used a rectangular flow domain filled with overlapping Cartesian meshes to compute the flow and heat transfer over a finite-thickness fin. They carried out a computational study of the effects of louver angle, fin pitch and fin thickness on overall heat transfer performance and pressure drop. In the 1990s several researchers developed CFD codes based on non-orthogonal, boundary-fitted meshes to compute the flow over louver fins. Hiramatsu et al. [8] and Ikuta et al. [9] used a block-structured mesh with individual blocks for each louver and compared computed and measured values of overall heat transfer and pressure loss for different inlet louver designs and found good

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