



Experimental investigation of heat transfer and pressure drop in serrated finned tube banks with staggered layouts

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ABSTRACT

An experimental study was performed to investigate the heat transfer and pressure drop characteristics of serrated finned tube banks with staggered layouts. The influences of varied fin densities, transversal tube spacing and longitudinal tube spacing were presented. For a constant fin height, an increase in the fin density resulted in an increase in the Euler number, and a gradual decrease in the Nusselt number was observed as the Reynolds number increased. An increase in the transversal tube spacing corresponded to a significant reduction in the Euler number, whereas the Nusselt number essentially remained unchanged. The longitudinal tube spacing had an insignificant effect on the Nusselt and Euler numbers, and the optimum ratio of the transversal tube spacing to longitudinal tube spacing increased with an increase in the transversal tube spacing. Scaling of the tube spacing had little effect on the Nusselt number but had a significant influence on the Euler number. Finally, predictive correlations for Nusselt and Euler numbers were developed based on the data presented here, and comparisons between the test data from this paper and the predictive values from previously published correlations were performed.

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1. Introduction

Helical finned tubes are widely used in large-scale heat transfer equipment with flue gas emissions, such as combined cycle heat recovery steam generators (HRSGs) in power plants and waste heat boilers in chemical industries. For high-temperature applications, tubes and fins are normally made from carbon steel, and the fin assembly is welded to the tube surface. Due to restrictions in the required technical level of welding, early helical steel-finned tubes had an L-shaped fin-root (known as an L-foot fin) that was used to increase the welding area. With recent technical developments in high-frequency electric resistance welding techniques, strip-shaped fins (called I-foot fins) can now be directly welded to a tube surface. Due to the poor ductility of steel, the manufacturing of solid steel fins consumes a large amount of energy in the winding process, and the fin height must be within the limits of radial deformation and fin-end rips. Hence, serrated helical steel-finned tubes emerged in industrial applications in the 1960s to overcome these defects related to solid fins. Compared to solid fins, serrated fins are easier to manufacture and have a larger finned ratio. Serrated fins can also exhibit a higher fin efficiency and heat

transfer coefficient as a result of the better penetrability and turbulent condition of the fin-side gas. However, the number of published experimental studies on the heat transfer and pressure drop characteristics of serrated helical finned tube banks is very limited.

Among the available studies on serrated helical finned tube banks, many experiments have focused on comparisons between solid fins and serrated fins tube banks, such as Sparrow and Myrum [1], Zhuo et al. [2], Chen et al. [3] and Kawaguchi et al. [4,5]. In general, these studies found that serrated fins could increase the fin-side heat transfer coefficient by approximately 10–25% relative to solid fins, whereas the pressure drop is enhanced by approximately 10–15%. Moreover, Reid [6] compared two types of finned tubes while also considering the cost of finned tubes, and recommended to choose serrated finned tube when fin heights are greater than 12 mm.

Early in the 1940s, Schryber and Brooklyn [7] presented heat transfer data for 3 L-foot serrated copper-finned tube banks. Subsequently, I-foot serrated steel-finned tube received widespread attention. For example, Weierman (1977) [8] reported pressure drop data for 6 tube banks and later compared the effects of square and equivalent triangle tube layouts on heat transfer and pressure drop through 2 tube banks [9]. Later, Hashizume [10], Zhuo et al. [2], Chen et al. [3] and Kawaguchi et al. [4,5,11,12] reported heat transfer and pressure drop data for I-foot serrated

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