Abstract

The enhanced tube is a kind of the passive technique for improving the thermal performance of the heat exchangers with a little increase of the friction penalty. The literatures have stated that the use of enhanced tube instead of the common smooth tubes for designing of boilers heat exchangers. The size of these heat exchangers can be reduced considerably by using the enhanced tubes instead of smooth tubes.

The numerical and experimental investigation on the enhancement of turbulent convective heat transfer inside dimples tubes were performed in this study. An experimental rig was constructed and instrumented to evaluate the enhancement of heat transfer and pressure drop at this surface. Air was used as working fluid, and steam was used as a heating source where constant wall temperature condition of ($135C^{\circ}$) was achieved. Heat transfer and pressure drop data were obtained from six different dimples tube geometries with diameter of *35 mm* and *1.2 m* length. These tubes were designed and fabricated to study the effect of longitudinal dimples pitch to diameter ratio *X/d=2,4 & 6*, tube arrangement (staggered, inline and spiral) and radial pitch to diameter ratio *S/d=1.8 & 3.6* in addition to plain tube which was used to verify the data of the present test facility and used as a reference for comparison. The test facility was capable for providing turbulent flow with Reynolds number varied from *4000* to *20000*.

Thermal and hydrodynamic flow pattern associated with six dimples tube was numerically studied using commercial code FLUENT14. The turbulent model utilized in this analysis is the two- equation k-Epsilon model. The flow pattern, local and average heat transfer coefficient of turbulent flow over dimples surface for six models were obtained. The numerical results showed that the flow pattern of

inline arrangement performs better than staggered arrangements, where the horseshoe vortices flow has low effect on flow reattachments. The local heat transfer on dimples surface was higher than the plain surface by *30-80%*, depending on the Reynolds number and dimples pitch ratio. The average heat transfer of the numerical results was in good agreement with the experimental ones.

The experimental results showed that the heat transfer and pressure drop of staggered arrangement are increased when dimples pitch ratio *X/d* is decreased, and high heat transfer and pressure drop are obtained at *X/d=2.* The same behavior was obtained for radial dimpled pitch ratio *S/d*, whereas the heat transfer and pressure drop are increased as the *S/d* decreased from *3.6* to *1.8*. The inline arrangement performed better heat transfer and pressure drop than staggered arrangement whereas the heat transfer is of inline was *10%* higher than the staggered arrangements and *30%* lower for pressure drop. The heat transfer of dimples tubes was *2 to 2.7* times the plain tube, while pressure drop of the dimples tube was *2.5 to 4.5* times the plain tube. The overall enhancement of the present dimples over the plain tube was approximately *1.17 to 1.4*, reducing the heat transfer area by *20-40%.* Comparison of the present technique with the conventional passive technique of (twisted tape, static mixer, bend tape, and spiral corrugated tube) showed that the dimple tube is competitive and performs better for inline dimples arrangement with *X/d=4*.