International Communications in Heat and Mass Transfer 38 (2011) 668–671

Contents lists available at ScienceDirect

International Communications in Heat and Mass Transfer

journal homepage: www.elsevier.com/locate/ichmt

Experimental research on heat transfer of water in tubes with conical ring inserts in transient regime ☆

A.R. Anvari [a], R. Lotfi [a,*], A.M. Rashidi [a], S. Sattari [b]

[a] Nanotechnology Research Center, Research Institute of Petroleum Industry (RIPI), West Blvd. Azadi Sports Complex, P.O. Box 14665-1998, Tehran, Iran
[b] Sharif University of Technology, Azadi Avenue, P.O. Box 11365-8639, Tehran, Iran

ARTICLE INFO

Available online 21 March 2011

Keywords:
Heat transfer enhancement
Conical turbulator
Nusselt number
Transient regime

ABSTRACT

Forced convective of water in horizontal tubes with conical tube inserts has been studied experimentally. The transient flow regime has been used for the tests. Experimental results are validated with existing well established correlation. The turbulators were placed in two different arrangements: converging conical ring, referred to as CR array and diverging conical ring, DR array. Two correlations for the Nusselt number based on the experiment are introduced for practical use. It is found that the insertion of turbulators has enhanced the Nusselt number for the DR arrangement up to 521%, and for the CR arrangement up to 355%, although using the turbulators cause a significant increase in pressure drop.

1. Introduction

In the recent years limited availability of energy resources has created different techniques to augment the heat transfer in heat exchangers. These techniques can be categorized into passive (without supply of external energy), active (with external energy supply) or being a combination of both. Some methods such as extended surfaces, rough surfaces, additives for the fluid, displaced enhancement devices, coiled tubes and swirl flow devices are famous ones of the passive techniques. The use of turbulators in pipes is one of the most commonly used passive heat transfer enhancement method.

Recently, many researches have been conducted to assess the heat transfer enhancement of different types of turbulators located in the tubes by evaluating their effect on the heat transfer coefficient and also pressure drop [1–5]. Turbulators produce more momentum transfer and heat fluxes by the concept of reverse flow and boundary layer disruption. The reverse flow can improve convection of the tube wall by decreasing the cross section area, and increasing the axial Reynolds number and temperature gradient. Decrease of entropy generation, which increases the second law efficiency, is another advantage of the turbulators.

Junkhan et al. [6] compared the heat transfer enhancement with several types of turbulators inserted in a tube. Conical turbulators, among different kinds of the turbulators, have concerned a great deal of attention. As an early work, Ayhan et al. [7] studied the heat transfer in a tube by means of truncated hollow cone inserts both numerically and experimentally. Yakut et al. [8] experimentally evaluated the effect of conical-ring turbulators on the heat transfer and pressure drop of the turbulent flow. Their experimental data were analyzed in terms of the thermal performances of the heat transfer promoters with respect to the heat-transfer enhancement efficiencies for a constant power. In another work Yakut and Sahin [9] studied the flow-induced vibration characteristics of conical turbulators used for heat transfer augmentation in heat exchangers. They resulted that the Nusselt number increases with the rising Reynolds number. Also it was mentioned that the smallest pitch arrangement leads to maximum heat transfer. Durmus [10] studied the heat transfer and exergy loss in cut out conical turbulators, placed in a heat exchange tube, with four different conical-angles.

Promvonge and Eiamsa-ard [11] experimentally studied the effects of a combination of the conical turbulator with the snail entrance on heat transfer rate and flow friction in a heat exchanger. Promvong [12] investigated the use of conical ring turbulators with different ring to tube diameter ratios with different arrangements (converging conical ring, referred to as CR array, diverging conical ring, DR array and converging–diverging conical ring, CDR). In a more recent work Kurtbas et al. [13] used a novel conical injector type swirl generator in a pipe and examined the effect of the device on the performance of heat transfer and pressure drop.

In almost all of the works addressed above, laminar or turbulent regimes have been used for the experiment. However in industrial world a large number of heat exchangers operate in the transition regime between laminar and turbulent flow. The need for information for the proper design of these devices has motivated for creating algebraic relationships for the prediction of heat transfer coefficients

☆ Communicated by W.J. Minkowycz

* Corresponding author.
E-mail address: lotfir@ripi.ir (R. Lotfi).

0735-1933/$ – see front matter
doi:10.1016/j.icheatmasstransfer.2011.03.016