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Procedia Engineering 157 (2016) 19 – 28

Procedia Engineering

www.elsevier.com/locate/procedia

IX International Conference on Computational Heat and Mass Transfer, ICCHMT2016

# Heat transfer enhancement of laminar flow of ethylene glycol through a square channel fitted with angular cut wavy strip

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**Abstract**

The numerical friction factor and Nusselt number data for laminar flow through a square channel fitted with angular cut wavy tape has been presented. Fixed angles of 45o angular cut wavy tape were used as swirl flow generators inside the square channel. The angular cut wavy tape inserts with different wave ratio (y = 1.0, 3.0, 4.5), have been investigated for different inlet velocity. The computations were conducted with Reynolds number ranging from 100 to 2000 using ethylene glycol (Pr = 150) as the working fluid. The thermohydraulic performance has been evaluated. Use of angular cut wavy tape leads to considerable increase in heat transfer when compared with no angular cut wavy tape. The overall enhancement ratio has been calculated in order to discuss the overall effect of the angular cut twisted tape. This result is useful for the design of solar thermal heaters and heat exchangers.


Peer-review under responsibility of the organizing committee of ICCHMT2016

*Keywords:* Swirl flow, angular cut, wavy tape, heat transfer enhancement, Thermal enhancement efficiency.

## 1. Introduction

Laminar flow is being confronted in different industrial applications. A major thermal resistance in the bulk flow in addition to the dominant thermal resistance in the thin boundary layer adjacent to the flow is present in laminar flow. So to mix the gross flow effectively wavy strip inserts are used in laminar flow to reduce the thermal resistance in the core flow through the channel.

Angular cut wavy strip as shown in Fig. 1(a) make the flow wavy nature along the channel length. Early works on wavy tapes have been reported by Saha [1]. Fig. 1(b) shows the layout of a square channel having full-length angular cut wavy tape.


Peer-review under responsibility of the organizing committee of ICCHMT2016
doi:10.1016/j.proeng.2016.08.333

Saha et al. [2–6] had done experiment on laminar flow through different types of channel having different vortex generator inserts. Goldstein and Sparrow [7] reported experimentally on wavy-walled channel on laminar, transitional and low Reynolds number turbulent flow. Sriromreun et al. [8] investigated the heat transfer and flow friction characteristics in a channel fitted with Z-shape baffles as a turbulator. Designing various tube shapes, the thermal boundary layer disrupted by swirl to enhance heat transfer performance. Some researchers uses different tubes to enhance heat transfer like; transverse groove tubes as a enhancing tools [9], spiral grooved ducts [10], converging–diverging channels [11], corrugated tube with twisted-tape insert [12,13], sinusoidal tubes [14], and finned ducts [15,16] are all effective designs for improving the heat transfer surface in the boundary flow.

**Nomenclature**

| | |
|---|---|
| $A_o$ | plain channel flow cross-sectional area |
| D | internal diameter of the plain duct |
| d | Width of the tape |
| f | dimensionless friction factor |
| g | acceleration due to gravity |
| Gr | Grashof number |
| Gz | Graetz number |
| H | wavy strip pitch |
| hz | axially local heat transfer coefficient |
| L | axial length, length of the duct |
| m | mass flow rate |
| Nu | Nusselt number |
| ∆P | pressure drop |
| P | wetted perimeter |
| Pr | Prandtl number |
| Re | Reynolds number |
| Ra | Rayleigh number |
| y | wave ratio |

Greek symbols

| | |
|---|---|
| β | angular cut |

Subscripts

| | |
|---|---|
| f | bulk fluid |
| i | inlet |
| m | mean |
| o | outlet |
| w | tube wall |

It has been observed from the literature that the angular cut wavy tape inserts has not been reported in the past. In this paper, therefore, the laminar flow numerical heat transfer and pressure drop results of full-length angular cut wavy-tape inserts in square channel are presented.