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Research Paper

Experimental and numerical evaluation of different vortex generators on heat transfer

M. Hosseini, D.D. Ganji *, M. Aghajani Delavar

Department of Mechanical Engineering, Babol University of Technology, P.O. Box 484, Babol, Iran

HIGHLIGHTS

- Rectangular and triangular decorated bars on cooling of a hot bar were studied.
- Experimental and numerical methods have been applied.
- Heat transfer of rectangular arrange of bars was more compared to other modes.

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ABSTRACT

Effect of Sinusoidal (Sin), Wave and Broken obstacles followed by rectangular and triangular decorated bars on cooling of a hot bar was investigated experimentally and numerically in the present investigation. Experiments were performed in a wind tunnel in which transient heat transfer were considered on the hot bar. The obtained results revealed that the heat transfer corresponding to the Sin obstacles followed by rectangular arrange of bars was more compared to other modes.

1. Introduction

Utilization of heat exchangers are growing tremendously in order to improve energy consumption issues which are classified into various types. Among these calcifications, heaters and recuperators are vastly used in industrial applications. Recuperators are a group of heat exchangers which are used to transfer heat from hot gases produced in the combustion chamber to cold air. The returned heat to the furnace results in enhanced efficiency with increased flame temperature. Therefore, it can be concluded that correct utilization of these exchangers not only modifies energy consumption but also improves the furnace efficiency.

Different types of turbulent generators including wavy fin, louver fin and slotted fin, etc, are considered effective techniques to refine the heat transfer rate of the air flow in air heating ducts [1–3]. The main role of these turbulators is increasing the heat transfer rate. Researchers have reported various types of turbulators for investigating the frictional and heat transfer characteristics in air heating ducts. Wu and Tao [4] studied the experimental and numerical heat transfer effects on four plates with a pair of delta winglet longitudinal vortex generator punched directly from the plates at attack angles of 15°, 30°, 45° and 60°. Results indicated that heat transfer through the plate with delta winglets was comparably higher. In addition, investigations on different angles also revealed that heat transfer through 60° delta winglet was larger compared to other angles. Zhou and Feng [5] experimented the effect of heat transfer on a flat plate with rectangular, triangular and trapezoidal winglets. Curved obstacles were also generated and tested. Finally, heat transfer effects of these barriers with a punched hole inside were investigated. Effects of hole diameter and positions on the performance of vortex generators were evaluated. The obtained results showed that all types of curved winglets at low and high Reynolds (laminar and turbulent flow) were better and that the triangular winglets had a better thermohydraulic effect compared to trapezoidal winglets. Moreover, the punched holes really improved the thermohydraulic performance of vortex generators and decreased the flow resistance for all cases. Wu et al. [6] experimentally studied the heat transfer effect on fin-tube surface, two kinds of novel fin-tube surfaces with two rows of

* Corresponding author.
E-mail address: ddg_davood@yahoo.com (D.D. Ganji).

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Nomenclature

T_A	ambient temperature (K)	K	heat conductivity coefficient (J/m·s·K)
ρ	air density (kg/m^3)	H_3	head loss over bar (cm·H_2O)
μ	air viscosity (kg/m·s)	$\dot{q}$	heat transfer rate (J/s)
d	bar diameter (m)	m	mass of bar (kg)
L	bar length (m)	Nu	Nusselt number ($h{\cdot}d/k$)
P_A	barometric pressure (N/m^2)	Pr	Prandtl number ($C_p{\cdot}\mu/k$)
T	bar temperature (K)	Re	Reynolds number ($\rho{\cdot}V{\cdot}d/\mu$)
A	cross section area of bar (m^2)	c	specific heat capacity of bar (J/kg·K)
M	curve slope	C_f	surface friction coefficient
V_2	downstream velocity (m/s)	V_1	upstream velocity (m/s)
L_1	effective bar length (m)	H_1	velocity head at upstream (cm·H_2O)
A_1	effective area of bar (m^2)	H_2	velocity head at downstream (cm·H_2O)
h	forced convection coefficient (J/m^2·s·K)	V	velocity over bar (m/s)
C_P	heat capacity at fixed pressure (J/kg·K)		

tubes in different diameter, arranged in staggered pattern. In this research, two laboratory samples were made, one with two rows of different sized tubes with a small triangular winglet Vortex generator placed beside the smaller tube (SA and SB models) and other with two equal sized tubes without a Vortex generator (BL model). It was demonstrated that at a velocity of 4 m/s the heat transfer coefficient in SA and SB models compared to BL model encountered 16.5% and 28.2% increase, respectively while a 10% reduction in pressure loss for SA model and a lower amount for SB was observed. Zeng and coworkers [7] performed a numerical study on the effects of attack angle, length of vortex generator, height of vortex generator, fin material, fin thickness, fin pitch and tube

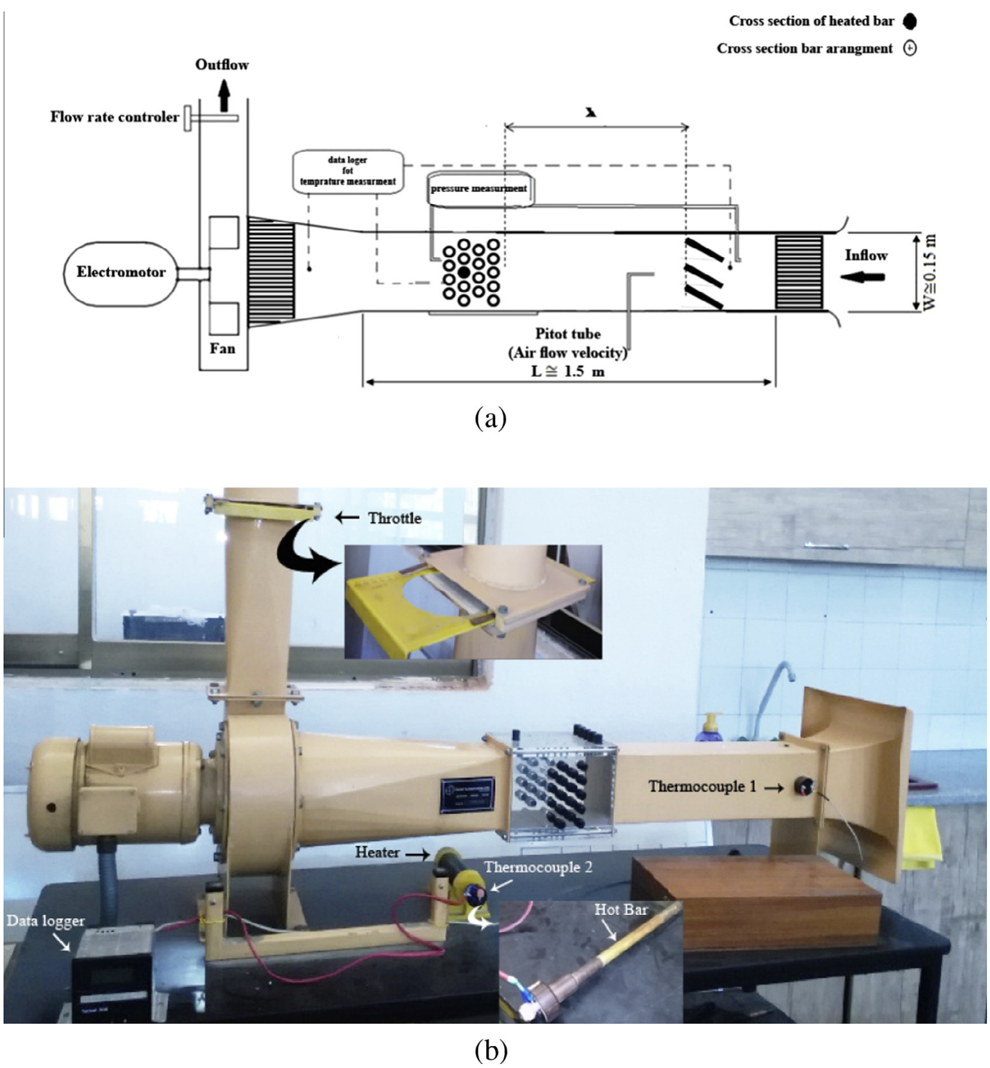

Fig. 1. (a) Schematic figure of the setup (b) experimental apparatus.