Available online at www.sciencedirect.com

ScienceDirect

International Journal of Heat and Mass Transfer 51 (2008) 3683–3692

International Journal of HEAT and MASS TRANSFER

www.elsevier.com/locate/ijhmt

Numerical study on laminar convection heat transfer in a channel with longitudinal vortex generator. Part B: Parametric study of major influence factors

J.M. Wu [a,b], W.Q. Tao [a,*]

[a] State Key Laboratory of Multiphase Flow in Power Engineering, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an City 710049, China

[b] School of Environment and Chemical Engineering, Xi'an Polytechnic University, Xi'an City 710048, China

Received 12 October 2006; received in revised form 17 March 2007
Available online 24 May 2008

Abstract

This paper presents the influences of main parameters of longitudinal vortex generator (LVG) on the heat transfer enhancement and flow resistance in a rectangular channel. The parameters include the location of LVG in the channel, geometric sizes and shape of LVG. Numerical results show that the overall Nusselt number of channel will decrease with the LVGs' location away from the inlet of the channel, and decrease too with the space between the LVG pair decreased. The location of LVG has no significant influence on the total pressure drop of channel. With the area of LVG increased, the average Nusselt number and the flow loss penalty of channel, especially when $\beta = 45^\circ$ will increase. With the area of LVG fixed, increasing the length of rectangular winglet pair vortex generator will bring about more heat transfer enhancement and less flow loss increase than that increasing the height of rectangular winglet pair vortex generator. With the same area of LVG, delta winglet pair is more effective than rectangular winglet pair on heat transfer enhancement of channel, and delta winglet pair-b is more effective than delta winglet pair-a. Delta winglet pair-a results in a higher pressure drop, the next is rectangular winglet pair and the last is delta winglet-b. The increase of heat transfer enhancement is always accompanied with the decrease of field synergy angle between the velocity and temperature gradient when the parameters of LVG are changed. This confirms again that the field synergy is the fundamental mechanism of heat transfer by longitudinal vortex. The laminar heat transfer of the channel with punched delta winglet pair is experimentally and numerically studied in the present paper. The numerical result for the average heat transfer coefficient of the channel agrees well with the experimental result, indicating the reliability of the present numerical predictions.
© 2007 Published by Elsevier Ltd.

Keywords: Vortex generator; Heat transfer enhancement; Flow loss; Field synergy principle

1. Introduction

In the companion paper [1] of the present article, the longitudinal vortex generator was introduced and the major related studies [2–14] were reviewed in detail. Thus, for the simplicity of presentation, the present article will not repeat such contents. From the review of [1], it is concluded that even though a large amount of researches, both numerical and experimental, have been conducted, following two aspects need further study for a deeper understanding of the LVG performance and the essence of heat transfer enhancement by LVG. First, in engineering practice the LVG is punched from the base sheet with a finite thickness, hence, there is a corresponding hole under the LVG. However, in most of the existing literatures, either the LVG thickness or the hole was not the taken into account. And it is also very limited for such parametric

* Corresponding author.
E-mail address: wqtao@mail.xjtu.edu.cn (W.Q. Tao).

0017-9310/$ - see front matter © 2007 Published by Elsevier Ltd.
doi:10.1016/j.ijheatmasstransfer.2007.03.031

Nomenclature

a	transverse space between the winglet pair defined in Fig. 1 (m)
b	thickness of vortex generator (m)
B	width of channel (m)
h	height of vortex generator (m)
H	height of channel (m)
f	fanning frictional factor
l	chord length of vortex generator (m)
Nu	Nusselt number
s	streamwise coordinate of LVG defined in Fig. 1 (m)

Greek symbol

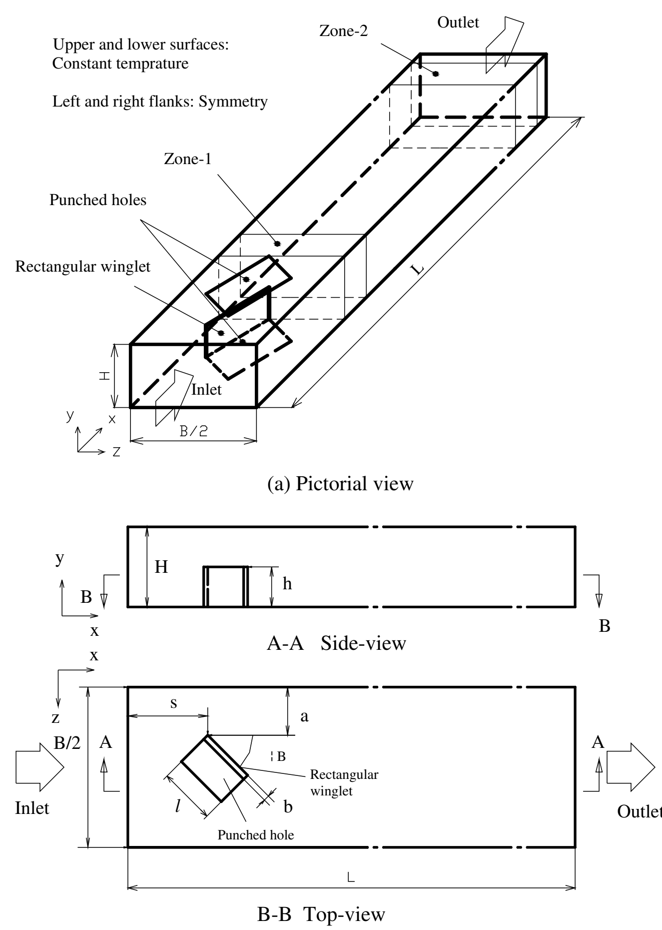
β	attack angle (°)

Subscripts

m	average
0	channel without vortex generator

study, which took both the LVG thickness and the hole into account. Second, the heat transfer enhancement by LVG was usually explained by the traditional enhancement mechanisms, including the re-development of a boundary layer, the mixing caused by swirling of the LVG and the LVG-induced disturbances. From our preliminary study shown in [1], the fundamental mechanism of heat transfer enhancement by the LVG is the improvement of the synergy between velocity and temperature gradient. The major purpose of this paper is to present our numerical results of a parametric study for the influences of the major parameters and reveal the fundamental mechanism of the LVG enhancement. To describe the performance of LVG, we take the comparison of the heat transfer and friction factor results between the duct with LVG and that without LVG at the same other conditions. It should be noted that there are a number of comparison criteria for the enhanced heat transfer surfaces as can be found in [16]. For such comprehensive comparison it needs another full paper, and is not the task of the present study. It may be useful to indicate that the field synergy principle is a new idea or concept of the heat transfer enhancement mechanism, it is not the comparison criterion for which a number of comparison criteria can be found in [15]. From the results presented later, it can be found that any heat transfer enhancement by the LVG is always accompanied by a better synergy between velocity and temperature gradient, thus un-doubtfully demonstrated that the fundamental reason for LVG enhancement is in the improvement of the field synergy.

For the readers' convenience, the computed channel is shown in Fig. 1. The governing equations and boundary conditions have been described in detail in [14], and for the simplicity of presentation they are not shown in this paper. The numerical results will be presented in detail in this paper. The mechanism of heat transfer by LVG will be discussed from the field synergy principle, and the domain average synergy angle will be used to show the degree of synergy between velocity and temperature gradient. A brief introduction to the field synergy principle has been provided in the companion paper [14], and for the simplicity of presentation, it will not be re-stated here. In the following, the numerical predicted effects of the LVG's location, size and shape will first be presented, followed by a comparison between experimental measurement and numerical prediction. Finally, some conclusions will be drawn.



(b) Plane view of the RWLVG in channel

Fig. 1. Rectangular channel with a pair of LVG.

Download English Version:

https://daneshyari.com/en/article/660422

Download Persian Version:

https://daneshyari.com/article/660422

Daneshyari.com