Applied Thermal Engineering 49 (2012) 106–117

Contents lists available at SciVerse ScienceDirect

Applied Thermal Engineering

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

Influence of turbulence on heat transfer upon a cylinder impinged by a slot jet of air

Fabio Gori, Ivano Petracci*

University of Rome "Tor Vergata", Department of Mechanical Engineering, Via del Politecnico 1, 00133 Rome, Italy

ARTICLE INFO

Article history:
Received 29 October 2010
Accepted 15 August 2011
Available online 27 August 2011

Keywords:
Slot jet
Heat transfer
Metallic grid
Turbulence
Nusselt number

ABSTRACT

The present work deals with the enhancement of heat transfer on a cylinder due to the turbulence of the impinging jet. Experiments are carried out to cool a smooth cylinder, electrically heated, with a submerged slot jet of air at Reynolds numbers equal to $Re = 4180$ and $Re = 7630$. The increase of turbulence is obtained by the introduction of a metallic grid and by the natural evolution of the jet with the distance from the slot exit. Turbulence, velocity and heat transfer measurements are presented in order to show the relation with the slot-to-cylinder distance. The metallic grid is set in two positions: just on the slot exit or at a constant distance in front of the cylinder. In the natural evolution of the free jet the turbulence increases with the distance because of the interaction with stagnant air, reaches a maximum and then decreases. If the grid is on the slot exit the turbulence increases at first, then decreases according to the degeneration law, and finally increases again due to the interaction with the stagnant air. Turbulence at a distance of 10 times the slot height is about the same whether is present or not the grid. Heat transfer measurements are presented as local and mean Nusselt numbers. Without grid local and mean Nusselt numbers increase with the distance from the slot exit reaching the maximum at a distance of about 8 time the slot height. With the grid on the slot exit the local Nusselt number has a maximum immediately after the grid and a minimum at 4–5 time the slot height. With the grid in front of the cylinder at the distance of the slot height the local Nusselt number has the maximum immediately after the grid and then is about constant up to 10 times the slot height. The mean Nusselt number with the grid in front of the cylinder is greater than without the grid only at the higher Reynolds number experimented.

1. Introduction

Techniques to enhance heat transfer are classified passive or active if they do not or do require external power respectively, as proposed in [1]. Turbulence promoters can modify the flow characteristics representing a passive technique. Turbulence can be increased by screens, grids and perforated plates [2–4], but is followed by a downstream decrease according to the degeneration law.

The experiments of heat transfer upon an impinged body are called "full flow" when the fluid section is much larger than the dimension of the impinged body. The effect of the free-stream turbulence in a "full flow" impinging a cylinder was investigated in [5], where an empirical equation was proposed to correlate the Nusselt number on the stagnation point with the turbulence level and the Reynolds number. The stagnation-region heat transfer was also studied in [6] as function of free-stream turbulence, Reynolds number, and leading-edge velocity gradient for four elliptical leading edges models downstream of five turbulence-generating grids. A wake-generator and turbulence grid were employed in [7] to determine the combined effects of high turbulence, unsteady wake, and Reynolds number on the heat transfer around the cylinder. The role of turbulence was investigated in the heat transfer on a cylinder in axial turbulent flow and an empirical expression was proposed [8]. The level of turbulence on the heat transfer upon the stagnation point of a cylinder was taken into account in [9] by the same type of relation proposed in [5] for low Reynolds numbers.

The main conclusion of the literature review for "full flow" is the proposal of empirical expressions of Nusselt number as function of Reynolds number and turbulence level.

Impinging jet has a higher efficiency than "full flow" because of the fluid concentration and the limited fan expenses necessary to move the smaller amount of fluid. The main fluid dynamics difference is that velocity and turbulence are also dependent on the

* Corresponding author. Tel./fax: +39 0672597129.
E-mail addresses: gori@uniroma2.it (F. Gori), ivano.petracci@uniroma2.it (I. Petracci).

1359-4311/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.applthermaleng.2011.08.023