COUPLING STUDY BETWEEN HEAT TRANSFER AND AERODYNAMIC FLOW IN SQUARE-EDGED INLET

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ABSTRACT

I. Introduction.

Multihole technique is widely used for cooling walls of combustion chamber and turbine blades. Detail understanding of the thermal behavior of the multihole wall is essential, especially heat along the surface perforations. Also, the coupling between thermal and aerodynamic aspects of the flow in the perforation is another matter of concern with extreme importance.

Since many years, this problem has been the target of numerous studies but they are focused on the determination of the average [1,2,3,4,5,6,7,8 ...] and local [9,10,11] heat exchange coefficient in the perforation or on the aerodynamic behavior [12]. The objective of this study is to consider simultaneously both heat transfer and flow aerodynamic taking place in a perforation for small length to diameter ratio (ℓ/d) by using experimental method.

In this study, the main parameters are the length to diameter ratio (ℓ/d from 1 to 8) and the Reynolds number (Re from 5000 to 35000) defined with hole diameter.

II. Experimental set-up.

Similar experimental set-up as one described by Hung & al. [9] was used for heat transfer evaluation of the stated configuration . Figure 1 presents the main scheme of the set-up:

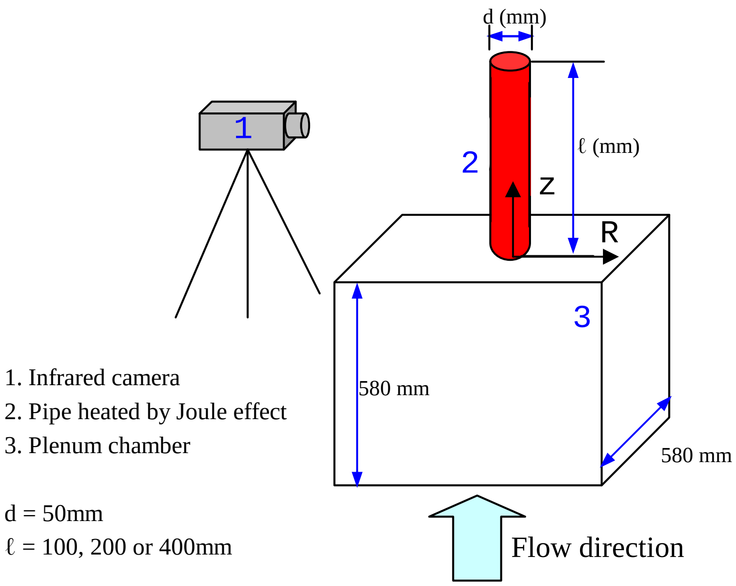

Figure 1: Experimental set-up

For aerodynamics study, the experimental set-up is almost the same as, it was describe for thermal aspect. Despite few modification which were made to carry out aerodynamic study of the flow inside the perforation. It includes the horizontal positioning of the test bench, replacement of heated tube with a transparent tube to permit the introduction of the optical technique LDA (Laser Doppler Anemometry), and the implement a smoke evacuation system guiding outside the experimental room.

III. Results:

The present experimental results highlight the influence of studies parameters (Reynolds number, length to diameter ratio of the hole...) on the coupling between thermal and aerodynamic aspect of the flow in a hole.

The results of thermal experiment are presented by variation of the local convective coefficient taking place within the hole (or variation of the local Nusselt number). An example of distribution of exchange coefficient h is shown in Figure 2. These results allow determination of the takeoff zone and the flow tie point for each particular Reynolds number.

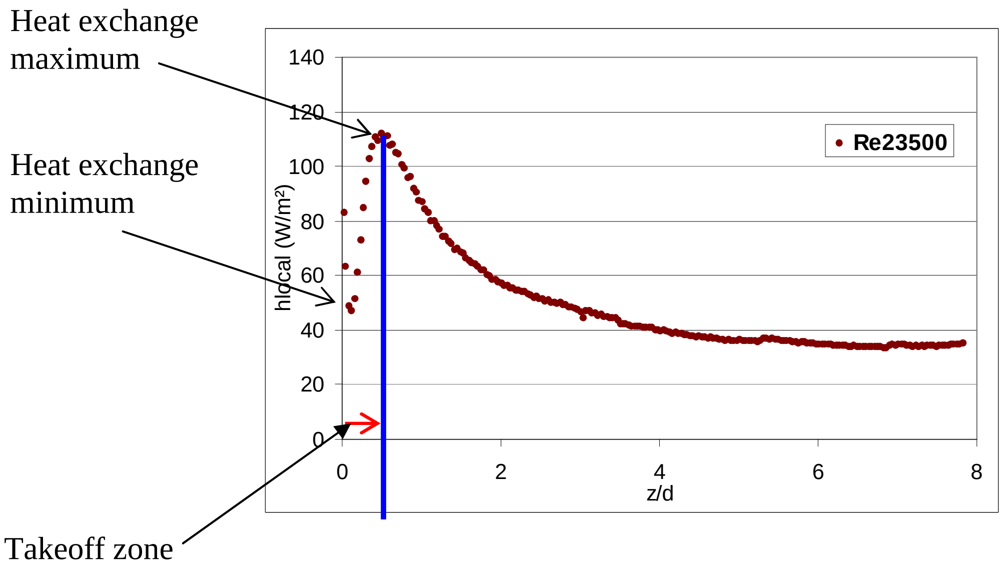

Figure 2 : Distribution of the local convective exchange coefficient in the perforation with Re =23500 and ℓ/d = 8

On the other hand, we have also obtained the takeoff zone and the flow tie point (attachment point), thanks to aerodynamic measure. The coordinate system and measurement positions are described in Figure 3.

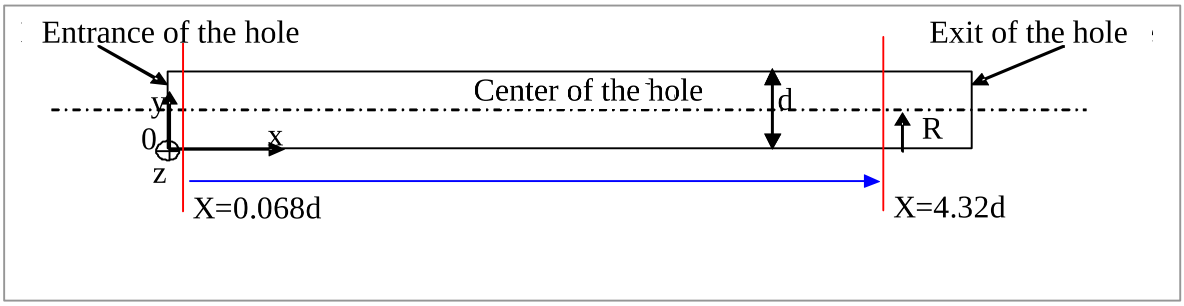

Figure 3 : Ccoordinate system and measurement positions of the aerodynamic study.

An example of measured velocity profile and method of determination of point attachment is presented in the figure 4. Further, influence of ℓ/d and Re parameters on aerodynamic structure within the hole is also studied.

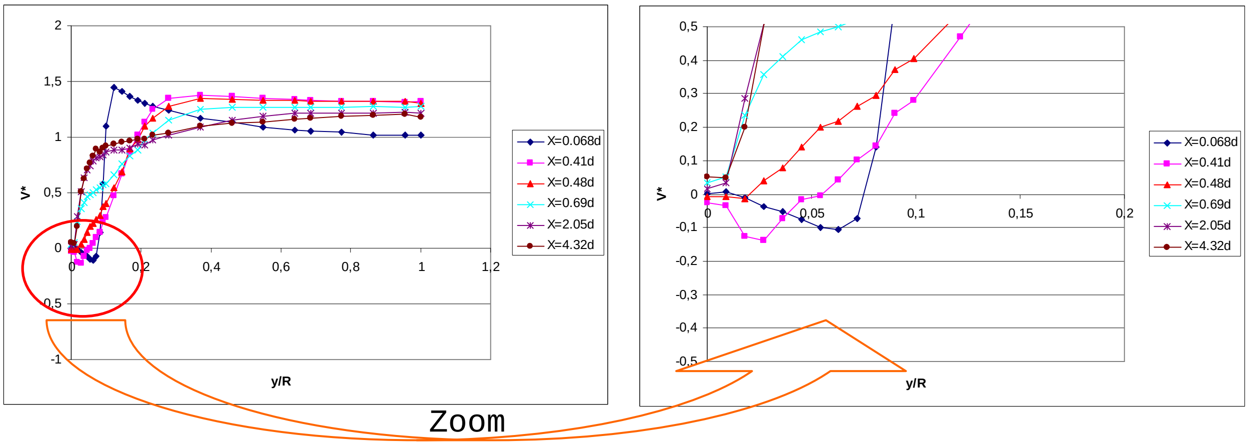

Figure 4 : Determination of the point of attachment - case Re = 13000 and ℓ/d =8

The comparison of thermal and aerodynamic results allows us to build a scheme, which presents the coupling between heat transfer and aerodynamic flow (Figure 5):

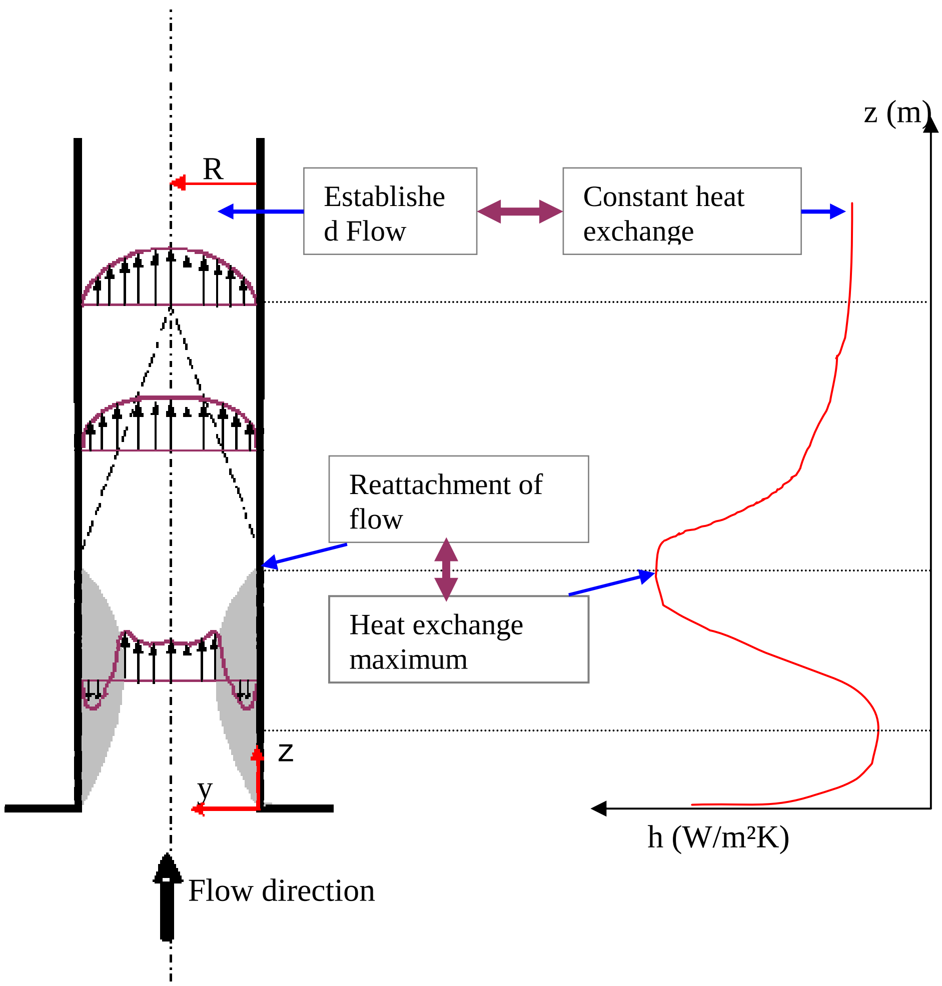

Figure 5 : Coupling between heat transfer and aerodynamic flow inside the hole of sharp-edged type.

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