Air curtains – present status and perspectives

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The presented paper deals with air curtains. The air curtains constitute of separation devices adopted in order to isolate two adjacent air volumes with different climatic characteristics one from each other. The curtain is based on the discharge of an air stream, which can be horizontal or vertical, with or without recirculation. In many cases, the geometrical aspect ratio of the rectangular discharge nozzle is that which defines an air curtain and it may be considered as two-dimensional plane jet or plane turbulent impinging jet [1, 2, 3].

Curtains realize fluid insulation against heat, moisture and mass transfers between the separated areas without holding up traffic of people, vehicles, materials, objects and etc. Thus, the air curtains are particularly useful in situations where conventional physical barriers become unacceptable for practical, technical, economical or safety reasons. Some of their applications are: thermal barriers for conditioned space insulation; wind resistance; interior separation for particle and dust control; fly and insect control; refrigerated counters; clean rooms, testing chamber apparatus, industrial oven openings, etc…[2,3,4]. Some basic applications are shown in Figure 1 [5].

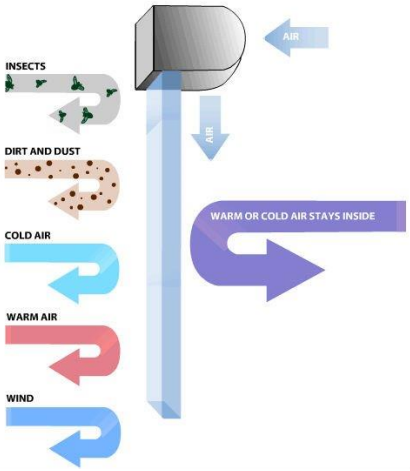

Figure 1, Air curtain applications

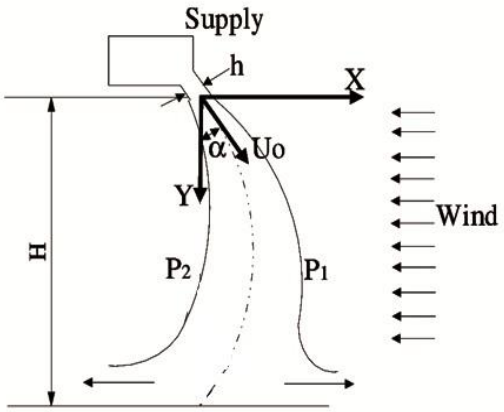

Figure 2, Schematic representation of air curtain

In the technical dimensioning of an air curtain it is necessary to determine the pressure difference across the opening ($P_2 - P_1$). Other important parameters are the nozzle width (h), jet velocity exit (U_0), discharge angle (α), volume flow rate (Q), critical velocity (U_c), height (H) and width (W) of the opening [6] – Figure 2 [7].

Despite there are many studies presented in the literature, still air curtains need further investigations in terms of energy efficiency of the curtains. The use of recirculation on air curtains according to the energy efficiency should be further studied. Still the change of the nozzle of the air curtain with a system of nozzles and how this will affect on the energy consumption and the sealing efficiency of an air curtain has not been investigated. Considering the sealing efficiency Loubier and Pavageau [8] reported that it is directly related to the amount of ambient fluid particles entrained into the main flow and carried across it by convection and diffusion and that it can never reach 100%. In this respect, the Kelvin-Helmholtz-like instabilities that develop in the shear layers along the lateral boundaries of the jet flow (Figure 3 [8]) play a relevant role. However, LES simulations [9] have shown that it is in the impingement region where mass transfer across the jet stream preferentially occurred. The flow in that zone is complex and still not yet very well known [10].

Particularly, depending on the height and the stream of an air, a jet shows two, three or four different regions. It is possible to distinguish a potential core zone, a transition zone, a developed zone or impinging zone - Figure 4 [10].

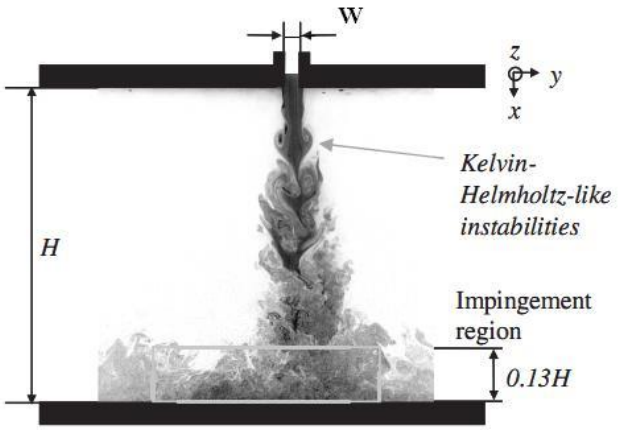

Figure 3, Illustration of a plane turbulent jet profile

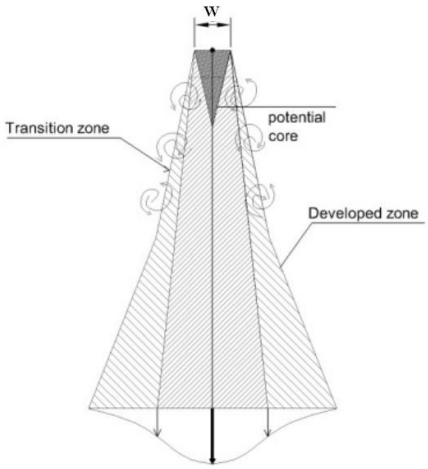

Figure 4, Zones of a free air jet

Nowadays Computational Fluid Dynamics gives a good possibility for numerical studies of air curtain operating parameters [11].

The main task in the PhD study is to develop and propose a numerical study of an adequate numerical model of air curtain. This includes geometrical model, selection of proper turbulent model, development of computational grid which provides Grid Independent Solution (GIS), implementation of adequate boundary and initial conditions.

In order to assess energy efficiency, the investigated regimes will cover the change in some parameters like jet exit velocity; the discharge angle; the pressure difference across the opening; the change of the air curtain nozzle with a system of nozzles; the impact of recirculation of the air blown from the air curtain on the energy efficiency.

We expect that, the different combinations of the mentioned parameters will have the potential to decrease the energy consumption of the investigated air curtains.

In order to verify the achieved results from the numerical simulations, an experimental study is planned.

REFERENCES:

1. Enrico Nino, Roco Fasanella, Rocco Mario Di Tomaso, Characterization of a two dimensional air curtain, Journal of Engineering and Technology (2012) pp 9-18.

2. Juan E. Jaramillo, Carles D. Perez-Segarra, Detailed numerical Study of turbulent flows in air curtains, V European conference on Computational Fluid Dynamics ECCOMAS CFD, 2010.

3. J.I. Simper, New uses for air curtains, BSE 43 (1975) A16–A18.

4. Leading Edge a Marley Engineered Products Brand, Design&Application Guide, 2008.

5. Berner International Corp. Catalogue, No. II- 300, 2012.

6. Julian E. Jaramillo, Assensi Oliva, Carlos D. Perez-Segarra, Application of Air Curtains in Refrigerated Chambers, International Refrigeration and Air Conditioning Conference, paper 973, 2008.

7. Awbi, H. B., Ventilation of Buildings, Chapman and Hall, 1991.

8. Kariene Loubiere, Michel Pavageau, Educing Coherent Eddy Structures in Air Curtain Systems, Chemical Engineering and Processing, vol. 4, 2010 pp 435-448.

9. F. Beaubert, S. Viazzo, Large Eddy simulation of plane turbulent impinging jets at moderate Reynolds numbers, Int. J. Heat and Fluid Flow 24 512-519, 2003.

10. Grzegorz Krajewski, Grzegorz Sztarbala, Air curtains used for separating smoke free zones in case of fire, 12th Conference of Internal Building Performance Simulation Association, Sydney, 2011.

11. H. K. Versteeg, W. Malalasekera, An introduction to Computational Fluid Dynamics, Longman Scientific&Technical, 1995.

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