

Influence of Seesaw Permanent Movement of a Person on the Performance of an Air Curtain Device



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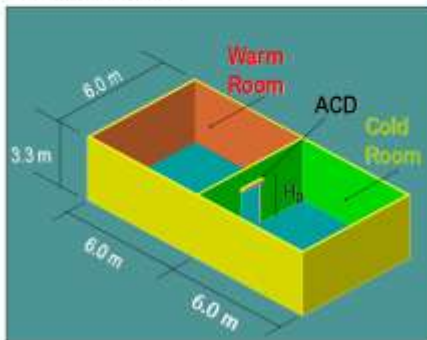
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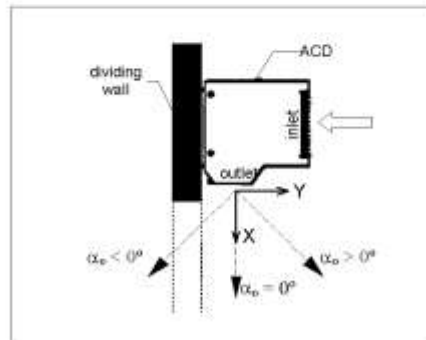
Summary: In commercial and industrial activities, there is often a need for reducing or controlling heat and mass transfer between outside environment and indoor compartments with controlled atmosphere, allowing simultaneously the easy circulation of people and equipments. In practical terms, the confinement of a given space can be achieved with aerodynamic barriers (air curtains) consisting of one or more air jets.

In the present work, an analysis is made of the loss of efficiency of a vertical downward air curtain due to the seesaw permanent movement of a person. The air curtain device was mounted over a doorway, on the wall separating two equal contiguous rooms at different temperatures, simulating a situation where a comfortable room must be isolated from a warmer outside environment.

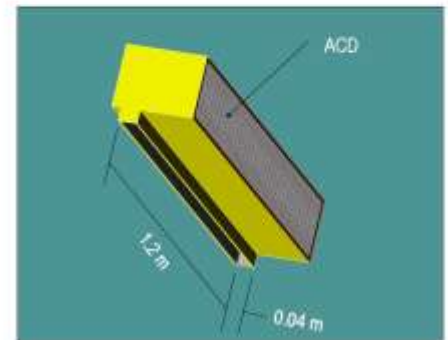
EXPERIMENTAL SETUP



Geometry of the experimental facility



Reference axes and angles used



Geometry of the studied ACD device

EXPERIMENTAL CONDITIONS

- doorway dimensions: 2.25 m × 1.12 m
- initial jet velocities of the air curtain: $U_0 = 4.3 - 7.2$ m/s
- discharge angle of the air curtain: $\alpha_o = 0^\circ, -10^\circ, -15^\circ, -20^\circ$
- temperatures of the rooms: $T_{cold} = 20^\circ\text{C}$; $T_{warm} = 25^\circ\text{C}, 30^\circ\text{C}$



"Roberta Cruise Control" software checking:

- distance to cover in each direction (4 m)
- speed of manikin when crossing the door opening ($U_{Roberta} = 0$ or 0.5 m/s)
- frequency of seesaw movement ($F_{Roberta} = 2.4$ times per minute)
- acceleration and deceleration slopes at the beginning and at the end of each movement
- time interval between movements ($\Delta t_{Roberta} = 25$ s)

The sealing efficiency provided by the air curtain for various cases (different initial velocities of the air curtain jet and different velocities and frequencies for the manikin movement) was determined through a tracer gas technique ("concentration decay method") using N_2O and an infrared photo-acoustic spectroscopic gas analyser. The main parameters derived are:

- n – air exchange rate in the "cold room", [h^{-1}]
- η_v – sealing efficiency of the air curtain
- E_v – effectiveness of the sealing process

$$n = \frac{\ln\left(\frac{C_{i,t}}{C_i}\right) - \ln\left(\frac{C_i}{C_i}\right)}{\Delta t}$$

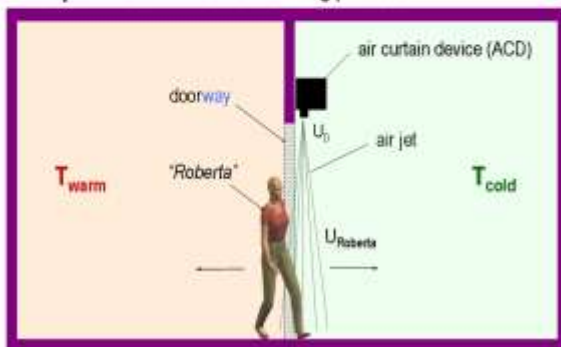
C_i – gas concentration at $t = 0$ s
 Δt – time interval between consecutive samples

$$\eta_v = \frac{n_0 - n}{n_0}$$

n_0 – air exchange rate of the reference situation ($U_0 = 0$ m/s)
 n – air exchange rate for the analysed situation ($U_0 \neq 0$ m/s)

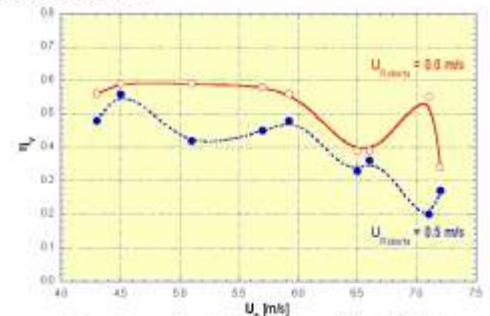
$$E_v = \frac{1}{1 - \eta_v}$$

$E_v = 1$: null sealing effect (open door with ACD switched off)
 $E_v \rightarrow \infty$: ideal sealing (door hermetically closed)

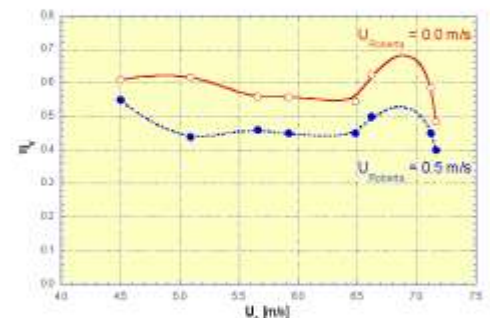


Computer controlled manikin "Roberta" making a seesaw movement across the doorway

SOME RESULTS



Air curtain sealing efficiency with and without Roberta movement for $\Delta T = 5^\circ\text{C}$ ($T_{cold} = 20^\circ\text{C}$, $T_{warm} = 25^\circ\text{C}$)



Air curtain sealing efficiency with and without Roberta movement for $\Delta T = 10^\circ\text{C}$ ($T_{cold} = 20^\circ\text{C}$, $T_{warm} = 30^\circ\text{C}$)

CONCLUSIONS

Results show that the seesaw movement of a person across the doorway leads to a 10 to 20% reduction of the sealing efficiency of a downward blowing air curtain installed to isolate two contiguous rooms.