Experimental Study on Upwards Blowing Air Curtain Jet

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Introduction

Upwards blowing air curtain includes usually a shaped inlet, a fan, an outlet duct, sound attenuators, an underground plenum and a nozzle. Warmed air or outdoor air is blown from the nozzle forming a jet which travels the width of the doorway and run into the upper edge of the doorway. Upwards blowing air curtains are normally used in doorways to protect workers and processes from cold outdoor air and to reduce energy and maintenance costs of the industrial buildings (1,3). Design requirements of the upwards blowing air curtain are substantially different from those of the air curtains in entrance doors of the commercial buildings (1,2,4). Achieving the required momentum, the nozzle exit velocity can raise up to 40 m/s. To prevent the penetration of cold outdoor air through the air curtain, it is important that the air flow from the nozzle is evenly distributed through the full width of the doorway (1,3). In this study the main objective of the experiments was to develop an underground air plenum and the nozzle which would achieve an evenly distributed nozzle exit velocity using as low pressure loss as possible.

Methods and Results

A full-scale air curtain with variable nozzle width (figure 1) was built inside a laboratory hall. Cross-sectional area of the air plenum was close to 1 m^2. The diameter of the air plenum inlet was 800 mm. The blowing air flow rate was adjusted within 2 m^3/s to 8 m^3/s range. The nozzle exit velocity meas-urements were per-formed in isotherm conditions by a measuring robot using several ther-mo anemometer probes.

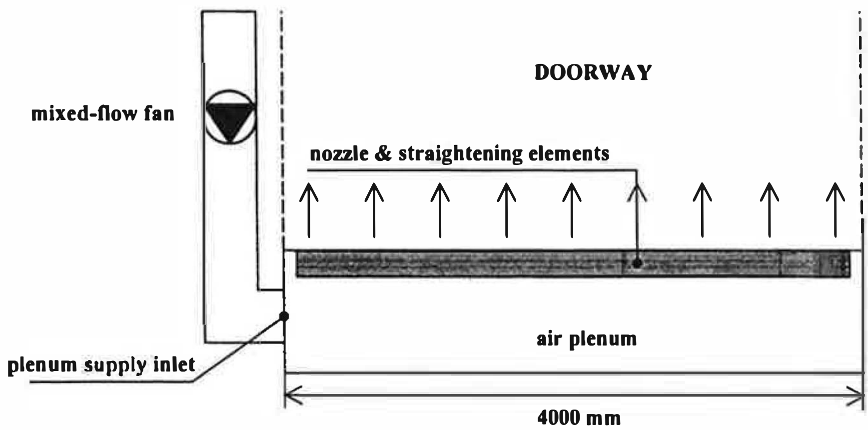

Figure 1. Schematic drawing of the air curtain of the laboratory hall.

As figure 2 shows, the plenum supply inlet had a significant effect on the nozzle exit velocity and the direction of the jet. Increasing the straightening elements within the nozzle did not remove the disturbances. Experiments indicated that the even nozzle exit velocity over the full length of the nozzle is difficult to achieve without a low enough velocity in the plenum supply outlet.

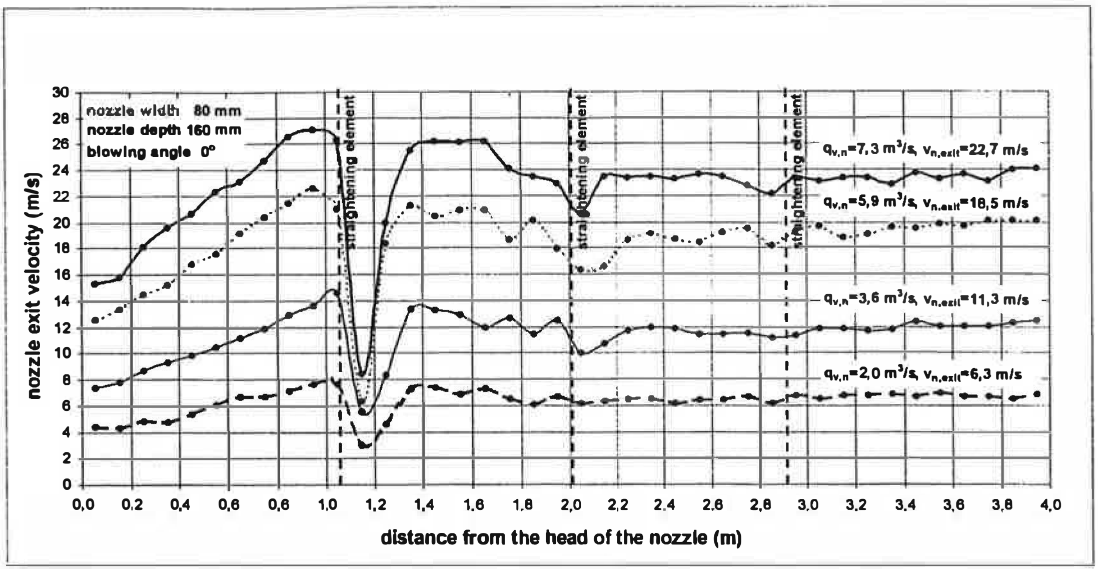

Figure 2. The nozzle exit velocity 80 mm above the nozzle centreline.

Visualisation of air flow by smoke or yarns showed, that there were strong swirls of the air flow just above a head of the nozzle. In addition, experiments showed that disturbances were spread when the distance from the nozzle was grown, as consequence cold outdoor air was penetrating more easily through the air curtain. In practice, however, low velocities can not be used, because the air plenum becomes too large to install into the ground in the doorway. To eliminate fluctuations and swirls of the air flow, different components inside the air plenum were tested. Finally, by installing an adjustable plate inside the air plenum and a bend in the plenum supply inlet, the nozzle exit velocity was evened, figure 3. By means of these components, the air flow rate could be raised up to 8,0 m3/s when the nozzle width was chosen along the range of 40 mm to 120 mm.

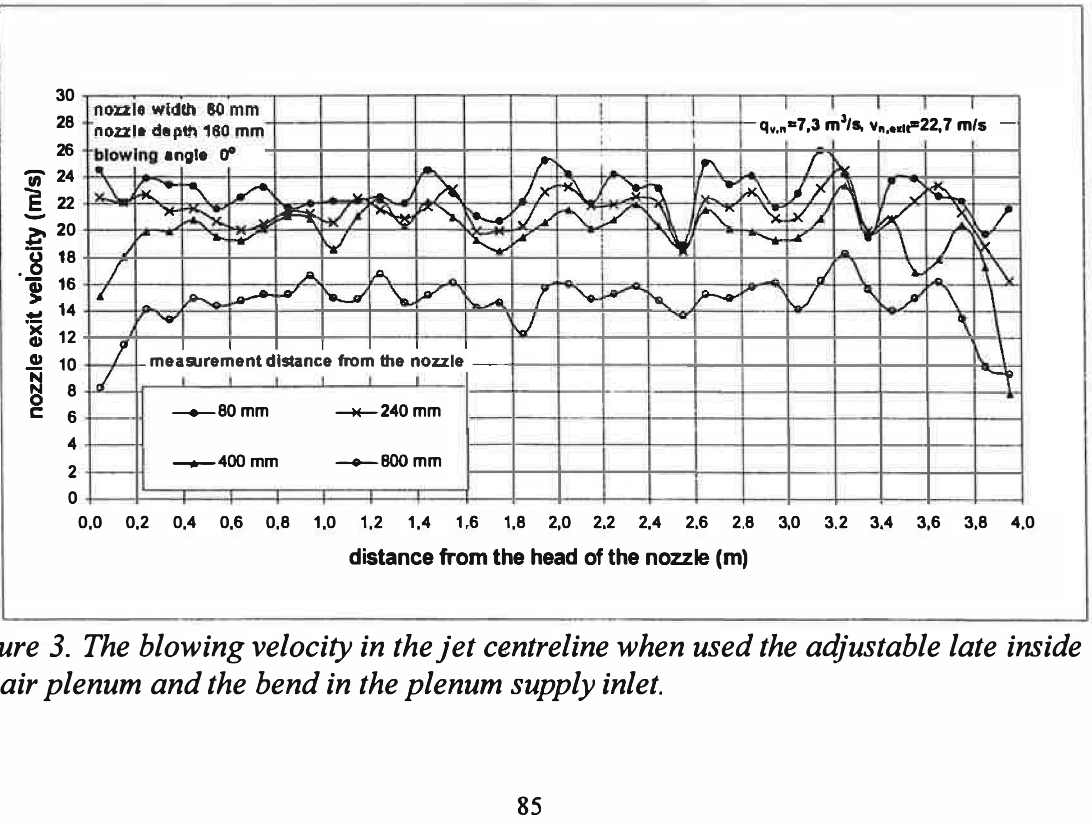

Figure 3. The blowing velocity in the jet centreline when used the adjustable late inside the air plenum and the bend in the plenum supply inlet.

Numerous experiments were performed with 40 mm, 80 mm or 120 mm wide nozzles to find out the advisable distance between straightening elements. Installing the straightening elements in conjunction with the nozzle with a spacing not greater than 1-2 times the nozzle width, the magnitude of swirls reduced and the nozzle exit velocity was uniform enough. In addition, the parallel straightening elements assured that the direc-tion of the air flow was perpendicularly upwards from the nozzle. Experiments showed that the blowing air is distributed evenly even for the 8 m wide doorways by installing fans on both sides of the doorway and using two separate underground air plenums.

To assure even air flow distribution over the full length of the nozzle, the underground plenum , the nozzle exit velocity and the nozzle width should be selected according to figure 4. The required momentum of the jet, which is depending on the density of the blowing air, the nozzle exit velocity and the blowing air flow rate, is determined in accordance with pressure difference in the doorway.

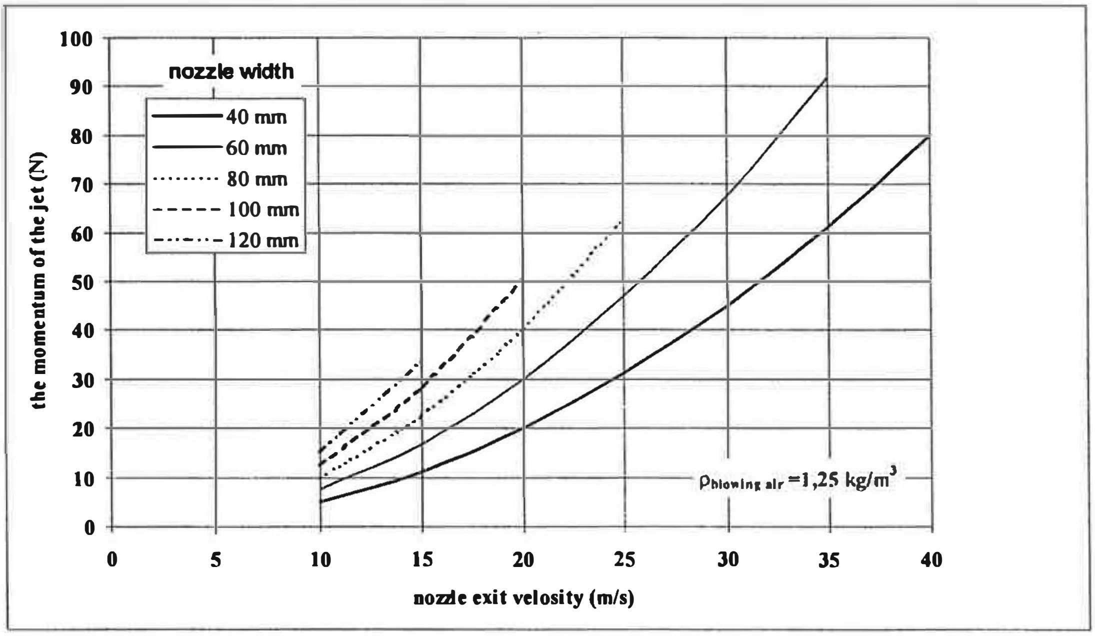

Figure 4. The momentum of the jet depending on the nozzle exit velocity and the nozzle width.

Figure 4 shows that a low nozzle exit velocity can be used, when the pressure difference in the doorway is low. Otherwise the required momentum of the jet is achieved only by using a high nozzle exit velocity and a narrow nozzle.

Conclusions

A low velocity should be used in the air plenum supply inlet and the plenum itself. With a wide nozzle, an evenly distributed jet is difficult to achieve. A perpendicular direction of the air flow upwards from the nozzle is assured by using straightening elements within the nozzle.

References

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