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# Control of the free convection flow within the breathing zone by confluent jets for improved performance of personalized ventilation: Part 1 – Thermal influence

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## SUMMARY
A new method for improvement the performance of personalized ventilation (PV) by control of the free convection flow based of confluent plane jets was studied. The confluent upward plane jets were generated close to the front of human body by openings at the front edge of a desk. The inner jet supplied controlled air while the assisting outer jet supplied room air. The mixing between the two jets was minimized by control of the shear stress between the two flows. Thus the air of the inner jet was transported upward to the face. In this paper, manikin-based equivalent temperatures were analyzed under the condition with this PV method and there was no thermal influence by the flow except for the back of neck.

## KEYWORDS
Personalized ventilation, confluent jet, thermal comfort, equivalent temperature

## INTRODUCTION
One of the aims of ventilation and air-conditioning is supplying air to each occupant to make the comfortable environment. Mixing and contamination are inevitable in the any methods of ventilation such like total volume ventilation and displacement ventilation. Personalized ventilation can bring supplied air to occupant effectively because it targets only personal space and supplies the air from close to the human body. However, there is upward flow around the human body caused by the skin temperature and it prevents the supplied air from reaching to breathing zone without mixing.

## METHODS
The experiments were conducted in the climate chamber at Danish Technical University, measuring 4.70 m × 2.40 m × 2.60 m. The PV air was provided through boxes which were installed below the desk and they sucked air from the room and out of the room. Sucked room air was used as outer jet, and the other was inner jet fitting to stomach of thermal manikin. Air temperature was adjusted 26 °C, however, the fans which driving jets heated the air somewhat. Thermal manikin wearing 0.5-clo clothes was put in the chamber and its surface temperature was controlled by Fanger's neutral equation.

The air terminal device of PV was consisted of two boxes which connected the fans respectively. Each airflow rate was controlled by dumper and monitored by pressure manometer.

Skin temperature of each body parts and each jets' temperature were measured and equivalent temperature was calculated from the measurement results. Manikin-based equivalent temperature, $t_{eq}$, was used to assess the performance of the PV in regard to occupants' thermal comfort. The manikin-based equivalent temperature is defined as the temperature of a uniform enclosure in which a thermal manikin with realistic skin surface temperature would lose heat to the environment at the same rate as it would in the actual environment. In this study, the manikin-based equivalent temperature, $t_{eq}$, was calculated by the following expression:

$$t_{eq} = 36.4 - CQ_t \quad (1)$$

where 36.4 is the deep body temperature ($^oC$), $Q_t$ the measured sensible heat loss ($W/m^2$), $C$ the thermal resistance offset of the surface temperature control system of the thermal manikin equal to 0.054 ($K\ m^2/W$).

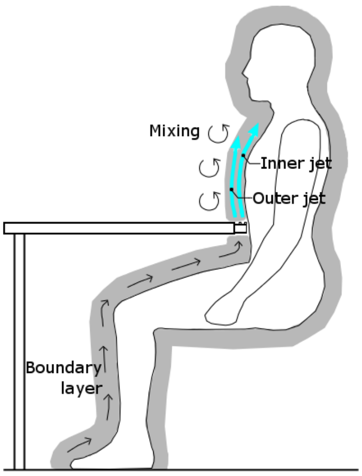


Figure 1. Human body and boundary layer


Figure 2. Measurement set-up

Table 1. Measurement cases

| | |
|---|---|
| Case 0 | No jets |
| Case 1 | 2jets 60 mm 10L/s both |
| Case 2 | Inner 60 mm 4L/s |

**RESULTS AND DISCUSSION**

Airflow velocity was measured with anemometer at the opening of outer jet in case of 14.4 L/s as flow rate which was the maximum value in the entire conditions of preliminary experiment. The measurement points were middle of the opening's depth which was 60 mm for inner and outer jet. The velocity profiles are shown in Figure 3. In this result, the highest velocity was 0.6 m/s at the middle of the opening, and the minimum was 0.2 m/s as three times less than the middle.

Three different cases have been studied. The results are shown below (Figure 4). It shows the equivalent temperature at each body parts which exposed to the flow and the total mean value, besides room temperature and PV temperature. Equivalent temperature at the back of neck in case 0 was higher than the other cases. It resulted from supplied air going along with neck and reaching the back side.

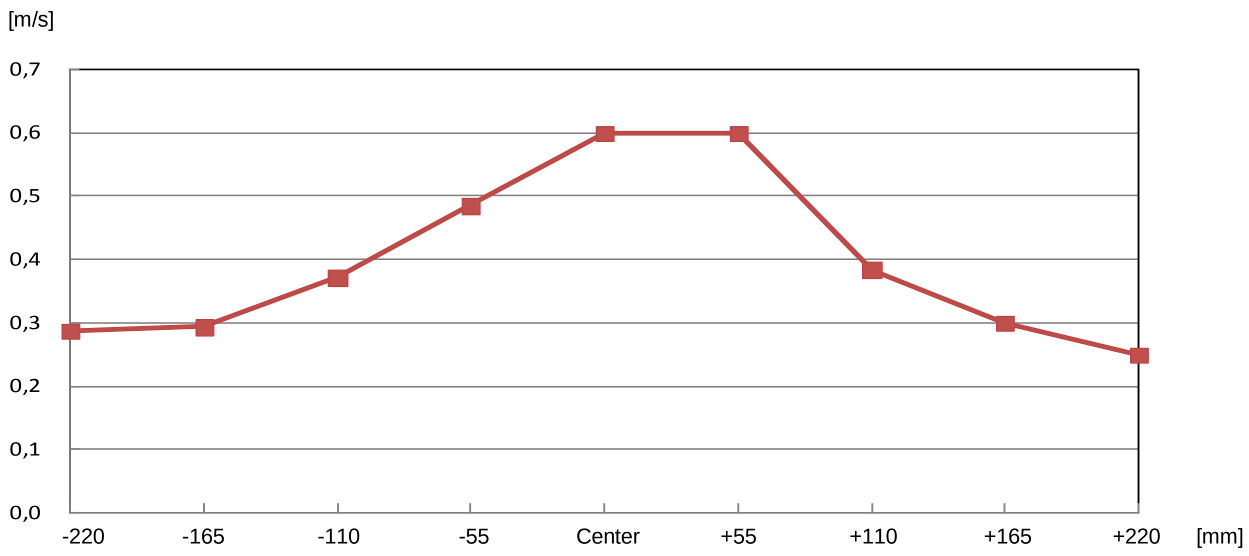


Figure 3. Airflow velocity profile


Figure 4. Equivalent temperature

## CONCLUSIONS

The measurements were made with new PV systems and the thermal influence was investigated with thermal manikin. This PV system could not have any thermal impact to equivalent temperature of human body. Future studies will focus on inhaled air quality and flow interaction.

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