LOCAL THERMAL DISCOMFORT CAUSED BY FAN CONVECTORS

M. Prek, P. Novak, R. Gamberger
University of Ljubljana, Faculty of Mechanical Engineering
Aškerčeva 6, 1000 Ljubljana, Slovenia

1. INTRODUCTION

Because we spent mainly part of the day in enclosed space, is it very important to ensure as high thermal comfort as possible. Thermal comfort in closed space we achieve by heating, ventilating and air conditioning. Anyway, it is possible to occur several problems in local discomfort, specially caused by drought. This means, that people could feel drought on some parts of the body (neck, legs ...). The reason for local discomfort could also be temperature asymmetry, low floor temperature and inappropriate vertical temperature profile in room [1].

Basing on many researches, in which co-operated higher number of people, has been done a mathematical model. With this equation (1) we can predict the level of local discomfort as subsequent of drought in enclosed space [2].

$$PD = (34 - t_a)(\overline{v} - 0.05)^{0.6223}(0.3696\overline{v}Tu + 3.143) \qquad (1)$$

PD	percentage of dissatisfied
t_a	air temperature
Tu	turbulence intensity
$\overline{v}$	mean air velocity

To determine level of the local discomfort, we have to know the mean air velocity, air temperature and turbulence intensity in room. When air velocity is less than 0,05 m/s, then this value is used in equation. The latest standards (ISO 7730 - 1994, DIN 1946 - 1994) incorporate mentioned equation to determine level of local discomfort and established level PD = 15% as highest level, at which the ambient conditions are still acceptable. Because of this, the calculated values for PD in occupied zone should be less than 15% [3].

Our goal in this research work has been to analyse the discomfort level near the convector. Level of discomfort has been influenced only with the air movement; all the other parameters were constant.

2. EXPERIMENTAL PROCEDURE AND MEASUREMENT EQUIPMENT

Convector, used in our experiment, has been placed in empty room without window an the door was tight closed. All other influences on air movement were exclude Measurements were made with Bruel & Kjaer Indoor Climate Analyser Type 1213, whic is suitable for measuring low air velocities and for registrations rapid changes in a movements. Analyser was connected to air velocity transducer (MM 0038) and a temperature transducer (MM 0035). In order to comply with standards relating t environmental measurements, measurements were conducted at various heights abov ground level. Recommended measurement heights for mounting the transducers are: 0,1r 0,6m, 1,1m and 1,7m above ground (ISO 7726). Figure 1 shows measurement points. C each measurement point we obtain values for following parameters: mean air velocit standard deviation of average air velocity and air temperature. In some measurement poin we also used level recorder type 2317 in order to get time dependency of air velocit Connection between standard deviation of average air velocity and turbulence intensit which are needed for calculation predicted level of local discomfort, is defined wi following relation:

$$Tu = \frac{SD_v}{\bar{v}} \cdot 100 \quad [\%] \qquad (2)$$

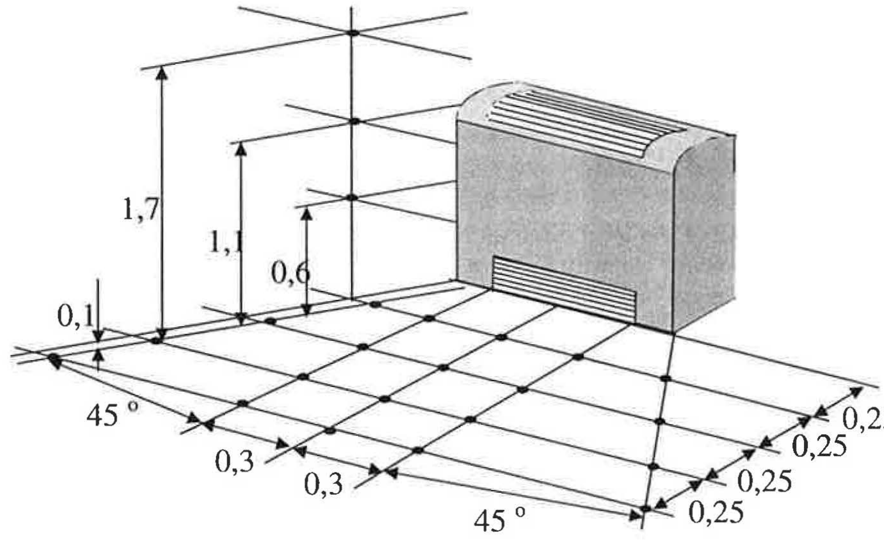


Fig. 1: Positions of measurement points

3. MEASUREMENT RESULTS

Measurement results and calculated percentage of dissatisfied are shown on figures 2, 3, 4 and 5. On these figures are shown result for measurement points, located on the horizontal plane. It was set on four different heights above ground level (0.1 m, 0.6 m, 1.1 m and 1.7 m), five different locations apart from convector and various widths.

Percentage of dissatisfied (PD) - **0,1 m above ground level**

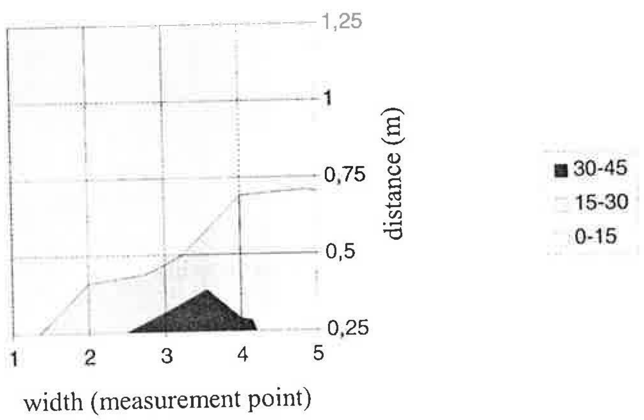


Fig. 2: Percentage of dissatisfied - horizontal plane 0,1 m above ground level

Percentage of dissatisfied (PD) - **0,6 m above ground level**

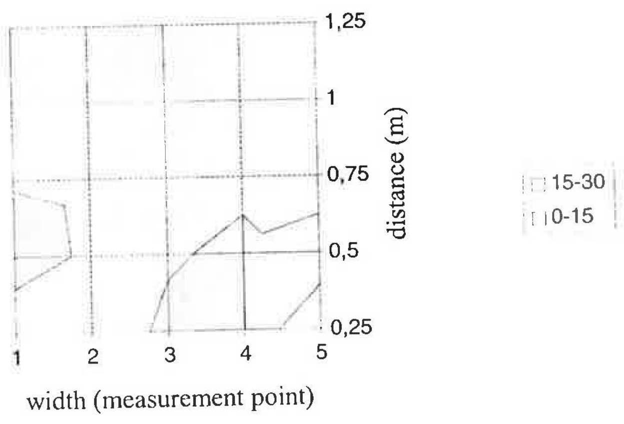


Fig. 3: Percentage of dissatisfied - horizontal plane 0,6 m above ground level

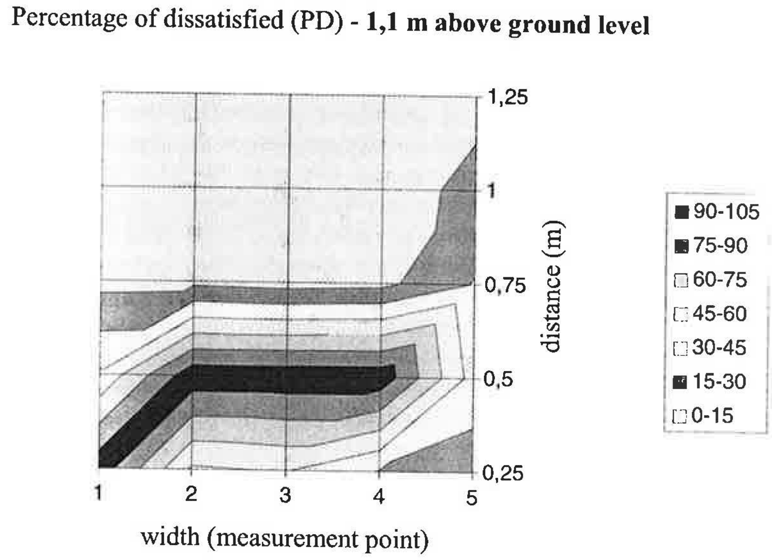


Fig. 4: Percentage of dissatisfied - horizontal plane 1,1 m above ground level

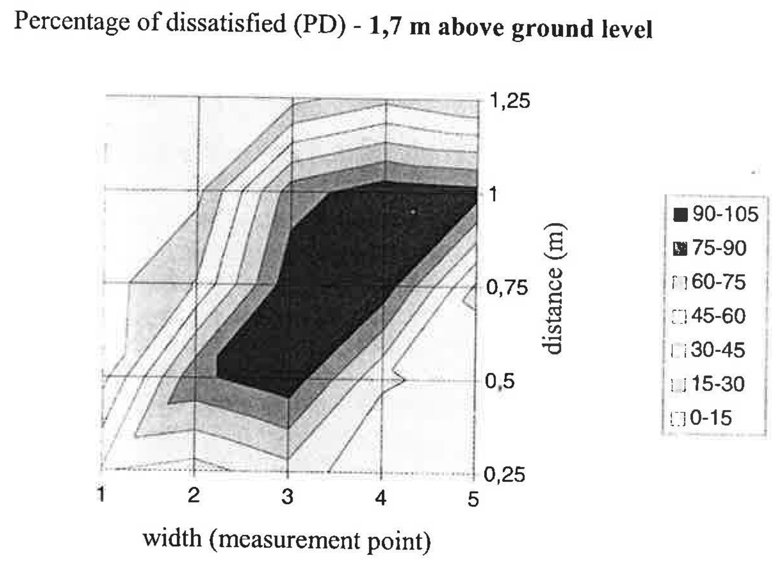


Fig. 5: Percentage of dissatisfied - horizontal plane 1,7 m above ground level

From these figures it is obvious, that most uncomfortable circumstances occur in plane 1,7 m above ground level. There is PD value over 15% for almost all area. In lover plane (fig. 4) is area with high PD value smaller (except narrow band on the right side of convector). However, near the convector the level of local discomfort has been still high. From figures, representing measurements in planes 0,1 and 0,6 m above ground (figures 2 and 3), we can see small zone with local discomfort. Even the level of local discomfort in this area is low - PD is below 30%. We can conclude that from reasons for achieving local comfort people should be at least 1 m apart from convector outlet.

Figures 6, 7 and 8 show values for mean air velocity, turbulence intensity and percentage of dissatisfied for vertical plane, located 0,5 m apart from convector. Highest value for air velocity appears on height above 1,1 m in narrow band on the right side of convector (see figure 6). Similar as values for air velocity are values for PD, shown in figure 8.

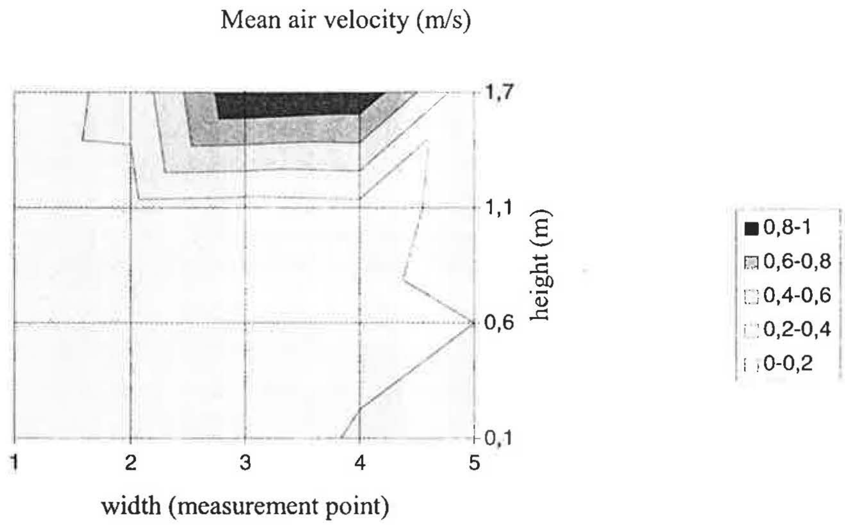


Figure 6: Mean air velocity in plane, 0,5 m apart from convector

Turbulence intensity (Tu)

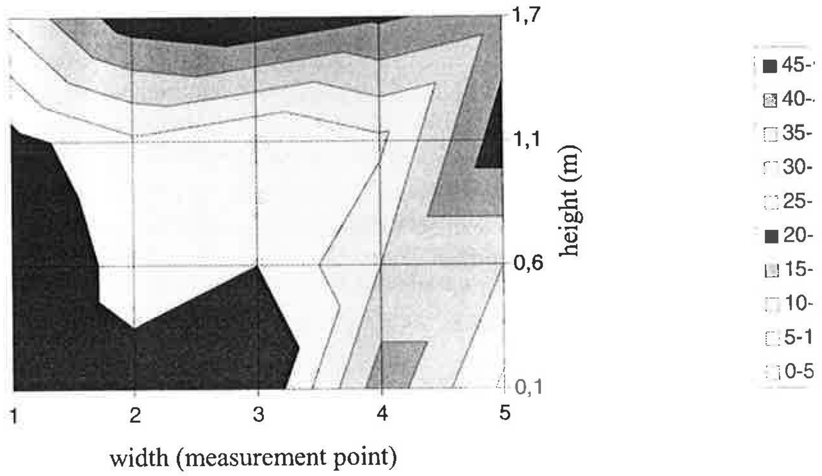


Figure 7: Turbulence intensity in plane, 0,5 m apart from convector

Percentage of dissatisfied (PD)

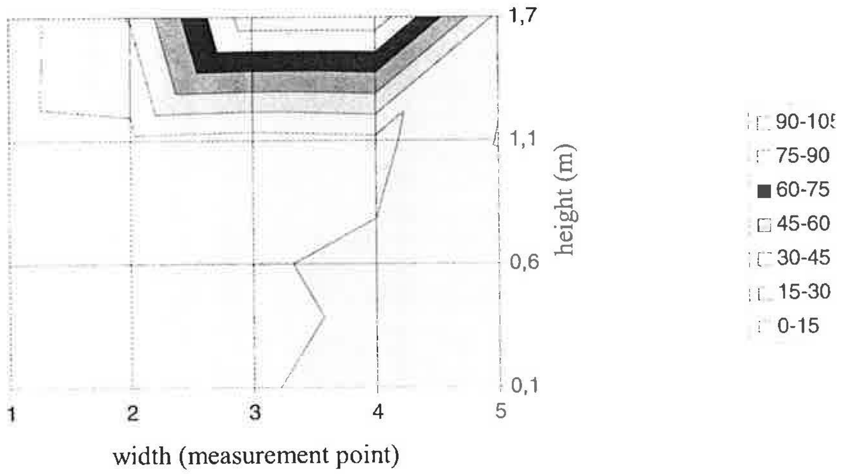


Figure 8: Percentage of dissatisfied in plane, 0,5 m apart from convector

In addition to the basic measurements we try to determine influence of human presence to the relations in observed plane. We placed obstacle (human body) on measurement point number 3, 0,5 m apart from convector. Results are presented in figures 9, 10 and 11.

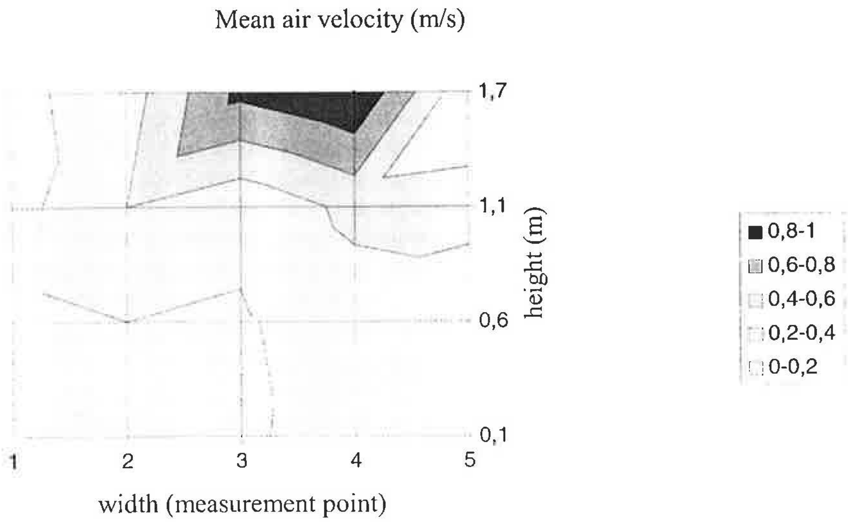


Figure 9: Mean air velocity in vertical plane 0,5 m apart from convector.

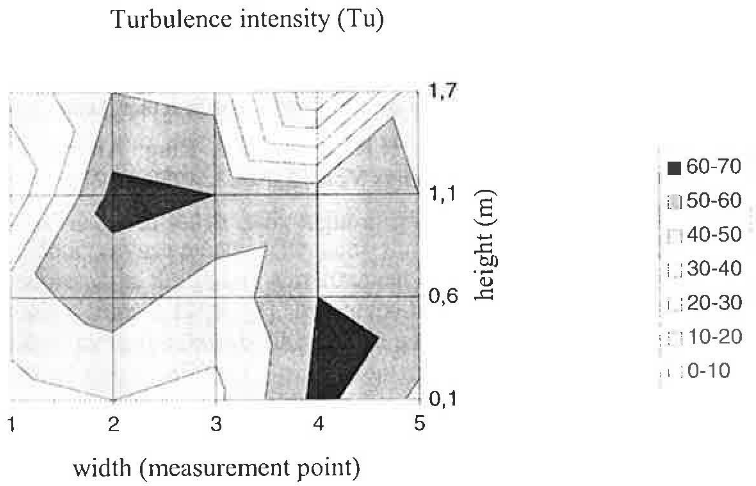
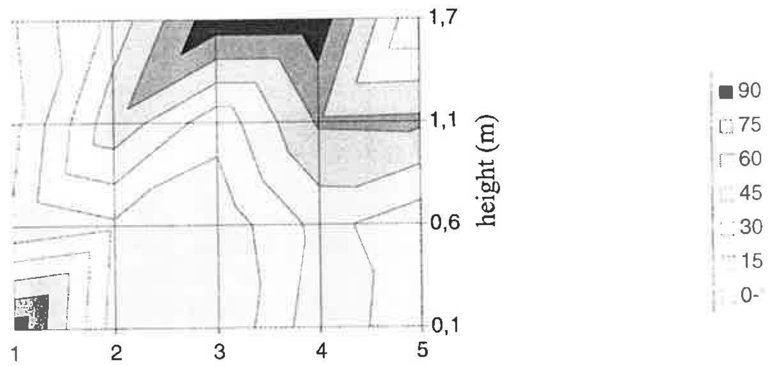


Figure 10: Turbulence intensity in vertical plane 0,5 m apart from convector.

Percentage of dissatisfied (PD)



width (measurement point)

Figure 11: Percentage of dissatisfied in vertical plane 0,5 m apart from convector.

Comparing results, shown in figures 9, 10 and 11 when a human body is present in fr of convector, with measurements without obstacle, we can observe different conditio Influenced by human presence are increased: mean air velocity, turbulence intensity a percentage of dissatisfied. Zone with local discomfort is also increased.

LITERATURE

[1] B.W.Olesen: Local thermal discomfort; Brüel & Kjaer Technical Review No. 1 - 198

[2] P.O.Fanger, A.K.Melikov, H.Hanzawa in J. Ring: Air turbulence and sensation drought; Energy and Buildings Vol. 12, No. 1, 1988, p. 21 - 39.

[3] A. K. Melikov: Quantifying drought risk; Brüel & Kjaer Technical Review No. 1988.