THERMAL COMFORT STUDIES IN A COMMERCIAL KITCHEN ENVIRONMENT

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ABSTRACT

Thermal comfort issues in a commercial kitchen were studied in a laboratory test series. A commercial instrument was used to predict the thermal comfort of the kitchen personnel working near the hot cooking surfaces. The effect of variables like supply air type and personal nozzles were studied using a thermal comfort meter showing PMV and PPD indeces. The results show that the thermal satisfaction was greatly improved with the help of supply air through the hood with low velocity, especially when directed downwards, and using personal nozzles for local cooling, which can be adjusted by the user.

KEYWORDS

Thermal comfort, full-scale experiments, case studies, kitchen ventilation, local exhaust

INTRODUCTION

It is very difficult to reach thermal comfort in a commercial kitchen environment using just general ventilation, whether it is mixing or (better solution based on earlier studies) displacement or low- velocity ventilation blowing vertically downwards. The personnel are exposed to very high radiated temperature, in addition to the convective air flows and humidity which can escape from the hood unless effectively exhausted from the hood. It is a major challenge for hood manufacturers to develop products that capture the convection flows efficiently and at the same time can provide local cooling.

There are different types of hoods, which differ in their operation. One classification is presented in ASHRAE, 1995. The simplest hood type is just a box (exhaust-only hood). It is very sensitive to flow disturbances and thus needs very high air flow rates to operate satisfactorily. Another type of hood is so called shortcircuit hood, which has internal induction. The total exhaust rates of air are normally quite large since it was originally developed to satisfy the high (nominal) exhaust air flow rates that exist in some US-based building codes. The third type of hood is a capture jet hood, which has only about 10% of total exhaust as capture jet, the purpose of which is to enhance the capture of convection flows and minimize the effect of disturbances etc. The tests were carried out with this type of hood. All of these hood types can also have integrated supply air (also called as make-up air in some connections).

In addition to the hoods, many other parameters affect the thermal comfort and ventilation efficiency. The type of supply air diffusers, total air flow rates, supply air temperature etc have also influence on the conditions reached in the kitchen. The primary task of kitchen ventilation should be to guarantee sufficiently good working conditions for the personnel with as little energy consumption as possible.

The main task of this study was to investigate how selected parameters (different types of arranging local cooling) affect the thermal comfort in a commercial kitchen environment.

METHODS

A laboratory test series was arranged to test the assumptions made of improving the thermal comfort in a kitchen environment using different types of local cooling methods. A real commercial kitchen was simulated with real cooking equipment and hood. The thermal comfort was measured with a thermal comfort meter in different situations.

The concepts of PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied) are very well known by the experts of ventilation and thermal comfort. The first one is presented in the scale from –3 to +3 ; from cold to hot, consequently, 0 being neutral (comfortable). The second one predicts the percentage of dissatisfied with the thermal environment, and it is closely linked with PMV. These parameters take into account many variables, like air velocity, temperature, humidity, radiative temperature, and also the levels of activity and clothing. They are specified also in the international standard ISO 7730. They also exist in the proposed European pre-standard for design criteria.

There exist some requirements for thermal comfort in kitchens in some countries, but not in all countries. As an example, the German VDI, 1995, specifies some requirements, for example maximum allowed temperature in the kitchen. More typically efficient exhaust and adequate ventilation are tried to be reached by specifying either supply or exhaust air flow rates, eg per square meter or per person. This is quite a rough method and does not take into account the specific features of kitchen equipment or hoods.

In this study, a commecial instrument for specifying PMV and PPD indices was used. A test dummy was used to represent the cook. The measurements were made at the arm level. Four different cases were tested, see figure 1.

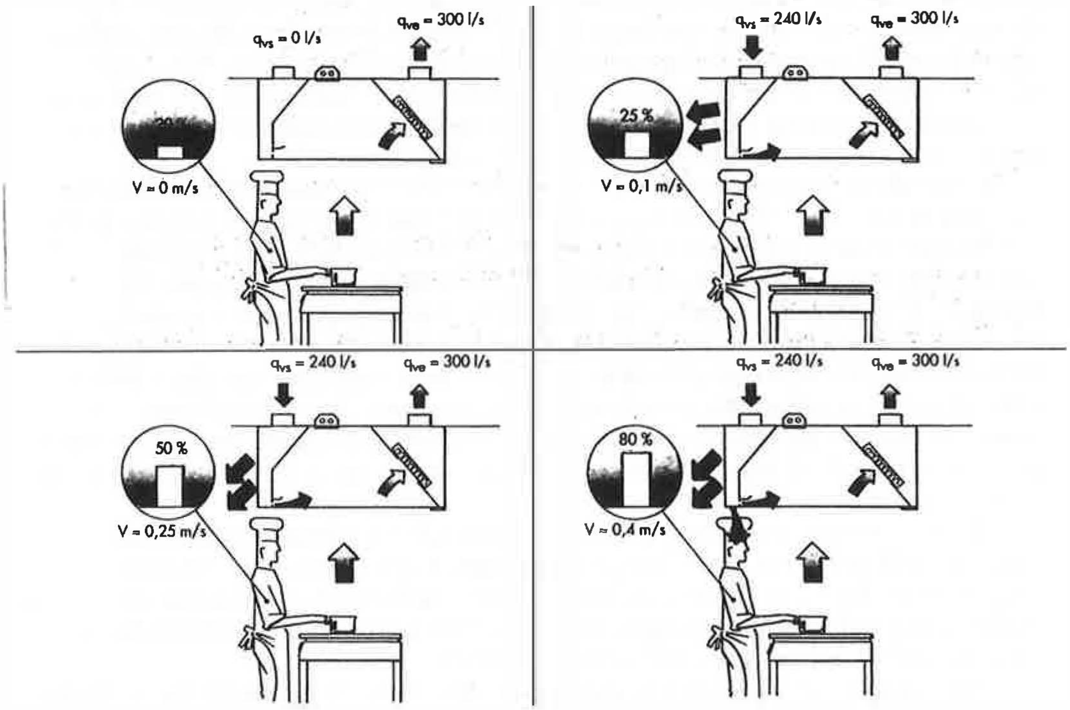

Figure 1. Four different tested cases.

RESULTS

The results verified the assumptions of improving the thermal comfort by introducing supply air through low velocity devices integrated in the hood. The PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied) were improved remarkably.

The four different cases that were tested are shown in figure 1. In the very basic case of having no special supply air or capture air through the hood (upper left case in figure 1), the PPD was 80% (in the figure 'the amount of non-dissatisfied' = 100%-PPD is presented). PPD improved slightly to 75% using capture air and low velocity supply through the front face of the hood blowing horizontally (upper right case).

A more remarkable improvement was reached when the front face supply was directed downwards (lower left case). The PPD was 50%.

The best results were achieved with the personal nozzle installed in the front face of the hood in addition to the supply air flow (lower right case). The PPD improved to the level of 20%, which is considered to be a quite high figure taking into account the high thermal load in the test kitchen.

DISCUSSION

This study has shown that thermal comfort can be remarkably improved in a commercial kitchen environment by using a hood with air supply through the front face, and by using personal nozzles, through which supply air can be directed to the face of the personnel working in the kitchen.

It is a challenge for hood manufacturers to develop better hoods with adequate local cooling, since without it it can be impossible to reach good thermal comfort without usimg unnecessary amounts of cooling energy (if all necessary cooling has to be brought with general ventilation). It can be that the possibility of having personal (adjustable) nozzles increases the satisfaction also from the psychological point of view. However this has not been proved by scientific tests.

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