http://dx.doi.org/10.21611/qirt.1992.052

Visualizing airflow using IR - techniques

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Abstract

To visualize the air flow into a room, we used a plastic screen, placed parallell to the air flow from a supply air diffuser placed at floor level. The screen takes the temperature of the air stream and registration of the screen temperature is made with an IR-camera. This gives a picture of the temperature distribution of the air stream. The information can be used to control the technical characteristics of the supply air device and to judge the impact of the air flow on human comfort.

1. Introduction

An important part in mapping the indoor climate is visualizing the air flow and temperatures in different parts of the room. Methods currently used include:

- registration of air velocities and air temperatures by means of a thermistor anemometer;
- very light flakes, made of for example metaldehyde are introduced into the air flow; by photographing the movements of these flakes the air flow directions in the room are visualized;
- scale model with water as operating fluid; the supply air is simulated by injecting ink into the water; the diffusion of the ink is photographed and visualizes the flow.

In order to investigate how useful a tool thermography is a for visualizing airflow, tests have been carried out in the Heating and Ventilation Laboratory of The National Swedish Institute for Building Research (SIB). The work has been concentrated on measuring air temperatures and air velocities along the centreline of a low velocity diffuser and 1.5 m into the room *(figure 1)*.

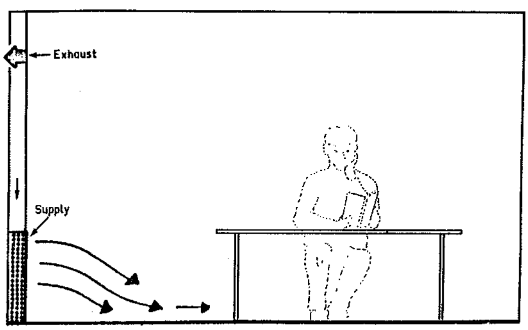

Fig. 1. A person seated at a work station in a room with displacement ventilation [4].

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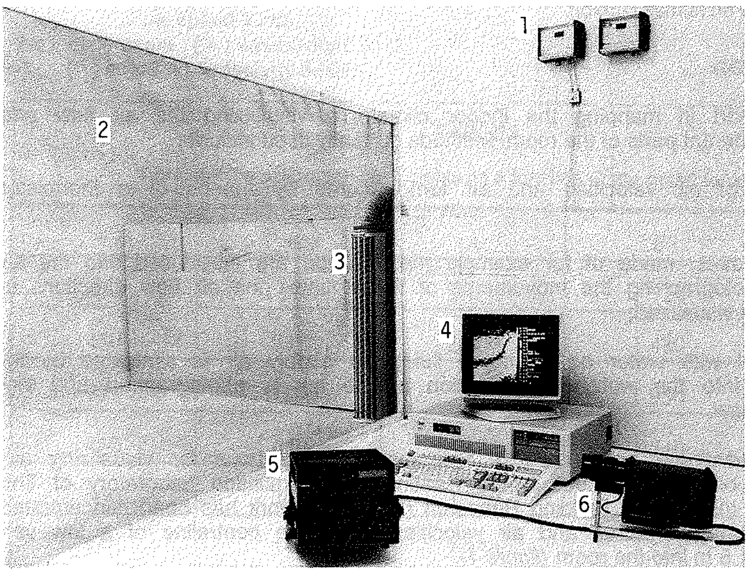
This ventilation system is known as displacement ventilation and by that we mean supply of air with a low velocity diffuser placed at floor level. The supply air is 4-6 degrees colder than the room air temperature and spreads evenly over the floor. This clean air displaces the warmer polluted air upwards and the room is divided into two zones. One layer consists of light, polluted air floating upon a layer of heavier, clean air where the breathing zone is located.

The human comfort depends on air temperatures, surface temperatures, air change rates, air velocities, etc. Thermal gradients can cause local discomfort due to the temperature difference between the level at the head and feet of a seated person. Currently recommended limits for moderate thermal environments are according to International Standards Organization, ISO 7730, 3 °C/m.

2. Measurements and results



1. Air flow control
2. Screen
3. Supply air diffuser
4. Monitor
5. Video
6. Scanner

Fig. 2. Photo of the experimental setup.

Room area	14.7 m^2
Room volume	36.8 m^3
Central room temperature	20.7 °C
Supply air temperature	15.9 °C
Supply air diffuser	Bahco Floormaster, 0.8 m high
Air flow	92 m^3/h
IR-system	Agema System 880
Screen	Plastic fibre screen, 1.2 * 2.2 m 0.8 mm thick, 74 % air.

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The tests were carried out in an office room built up in the laboratory hall of SIB. Two of the surrounding walls consists of glass, one of them may be laterally displaced. This wall was kept half open during the tests to establish a distance between the screen and the scanner, long enough to fill the display of the monitor with the thermal image of the screen. The other two walls are built against water-filled radiators making it possible to change the wall surface temperature. This system was turned off during the tests and the surface temperature was constant.

The temperature of the supply air is lower than the ambient air and effects the temperature distribution of the screen. This cooling effect of the screen is registered with the IR-system and presented as a black/white or coloured thermal image on the monitor. The image signals are recorded on video tape for processing later *(figure 2)*.

Radiation emitted by the background and transmitted through the screen is also part of the total image. By subtracting the radiation from the background wall, the actual temperature distribution of the screen is obtained.

The air is introduced with low velocity and falls rapidly to the floor effecting the screen to a characteristic temperature pattern. Each colour represents an area within 0.4 °C and the temperature of the area represented by the screen is between 17.3 and 19.3 °C *(see colour Fig. A)*.*

3. Comparison with a conventional method

A comparative measurement using a thermistor anemometer was carried out in order to control the agreement with temperatures in the thermal image. Three spot temperatures, 0.1 m above the floor, and 1.1, 0.6 and 0.1 m from the diffuser, have been compared *(table 1)*.

Table 1 Spot temperatures.

Spot	Thermal image of screen (°C)	Thermistor anemometer No screen (°C)
1	18.5	18.8
2	18.2	18.7
3	17.4	17.6

According to this test, the temperatures obtained by thermography of the screen correspond well with the ones using a conventional method. Note that the temperature difference between the air stream and the room air is about 5 °C.

When surveying the whole cross section of a room, considerable time must be spent on measurements using conventional equipment. Example of equipment used and results are shown in *figure 3*.

* *The colour plates of this article 52 are located on page XVI of the colour gathering, at the end of the book*

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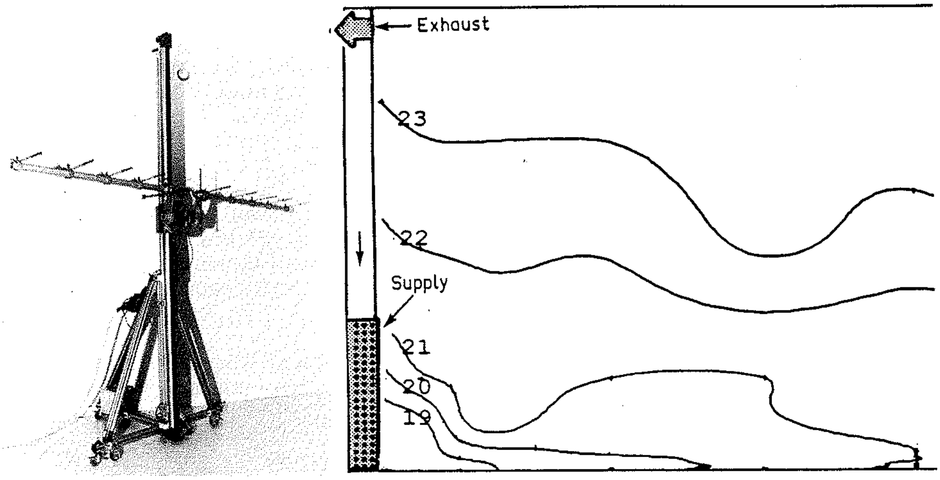

Fig. 3. Result from a cross-section measurement showing the profile of air temperatures along the centreline of the supply air diffuser when using a 8-channel thermistor anemometer.

Using a 8-channel thermistor anemometer, about 90 min is needed for registration of the air temperatures along the cross-section of a 15 m² room. The time for thermography is estimated to a couple of minutes.

4. Conclusions

These tests demonstrate that the use of IR-techniques is a useful tool when visualizing the air flow and measuring the temperatures in front of a low velocity supply air diffuser. In order to locate high air velocities, the method is suitable for rapidly visualizing critical areas where an anemometer can then be used to register air velocities.

To compare repeated measurements it is important that:

- a stiff frame is used, making it possible to stretch the screen material;
- the position of the screen is fixed.

If the screen is rotated 180 ° around an axis perpendicular to it, the thermal image may be different if the screen is unsufficiently stretched. The thermal image may also vary if the viewing angle is changed. The best result is obtained if the viewing angle is zero.

Studies will continue to evaluate the thermography recording of air flows for configurations other than these described in this paper.

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Future work will include:

- thermography of a screen in a vertical position, parallel to the air flow, systematically varying supply air temperatures and flows;
- thermography of a screen in a horizontal position, to register the temperature distribution in a horizontal plane of the air stream;
- thermography of a screen in a vertical position, perpendicular to the air flow;
- use of different kinds of screen material, for example aluminium;
- use of wide angle optics so one can get closer to the screen, for applying the techniques in small rooms;
- compare temperature registrations using thermography and conventional methods to study the influence of the presence of the screen.

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