#6211

DETERMINATION OF THE BOUNDARY LAYER LEVEL IN A LARGE DISPLACEMENT VENTILATED FACTORY BUILDING

Lars Dyreborg Christoffersen and Thomas Lund Madsen
Thermal Insulation Laboratory
Technical University of Denmark
Lyngby, Denmark

SUMMARY

A large factory building of 1,200 m^2 is equipped with a ventilating plant which acts on the principle of displacement ventilation. Because the machinery generates a lot of heat and air pollution the ventilating plant is supplemented with fume-hoods at each machine.

In order to control the displacement ventilation is used a tracer gas measuring equipment from Brüel & Kjær - Denmark, to measure the age-of-air in different levels in the building.

The measurements show that the age-of-air in the occupied zone is about 20 min rising to 38 min in the upper zone. The result indicates that the boundary layer between the lower zone and the upper zone is at the same level all over the building and over the occupied zone.

DETERMINATION OF THE BOUNDARY LAYER LEVEL IN A LARGE DISPLACEMENT VENTILATED FACTORY BUILDING

Lars Dyreborg Christoffersen and Thomas Lund Madsen
Thermal Insulation Laboratory
Technical University of Denmark
Lyngby, Denmark

INTRODUCTION

Knowledge of air movement in buildings is important for solving problems with the spread of indoor pollution.
Displacement ventilation in industrial buildings with high level of indoor air pollution needs control and regular supervision to secure that the boundary layer between the upper zone and the lower zone has the necessary level, so that the lower zone is identical to the occupied zone.

Measuring equipment for defining air movement in buildings almost always uses tracer gas technique. In this investigation is used a new developed tracer gas equipment to measure the age-of-air in different levels in a large factory building with displacement ventilation.

THE FACTORY BUILDING

The factory building covers an area of 1,200 m^2 and has a volume of 8,500 m^3. The building has a shed-roof with a minimum height of 5.3 m and a maximum height of 9.0 m.

The building is equipped with 22 injection moulding machines and 8 presses. Production, check out and sort out of plastic components takes place in this building. The machinery generates a lot of heat which gives the occasion of powerful convective air flow. After each moulding process the machinery tools are cleaned with compressed air. This operation causes a tremendous spread of pollution.

The building is equipped with a ventilating plant to remove polluted air. The ventilating plant acts on the principle of displacement ventilation. This principle is very well fitted in rooms with a lot of excess heat and in rooms were pollution not effectively can be removed by the source.

The ventilating plant blows supply air into the building through 6 outlets placed near the floor. In the top of each shed the exhaust takes place 8.5 m above the floor. The powerful convective air flow over the machines is lager than the air flow in the shed-exhaust. The ventilating plant is therefore supplemented with fume-hoods at each machine.

The air flow in the ventilating plant is 29,000 m^3/h. Of this flow 8,450 m^3/h comes from the fume-hoods and 20,550 m^3/h comes from the shed exhaust.

MEASURERING EQUIPMENT

The tracer gas measurering equipment that has been used in this investigation is from the danish company Brüel & Kjær. The equipment consist of one Multi-gas Monitor Type 1302 and two Multipoint Sampler and Doser Type 1303. The system is remote controlled by the Application Software Type 7620.

Multi-gas Monitor Type 1302 is the center in this measurering equipment. The monitor is used for quantitative analysis of up to 5 components and water vapour in gas mixtures.
The measurement principle is based on the photoacoustic infra-red detection method. The lower detection threshold depends on the gas, but the upper detection threshold is 10^5 times the lower detection threshold.

The Multipoint Sampler and Doser Type 1303 is designed to air sampling and temperature measurements in up to 6 different locations and to deliver tracer gas to 6 different locations.
From the Multipoint Sampler and Doser the air samples are delivered to the Multi-gas Monitor for analysis.

Application Software Type 7620 is designed for remote controlling of 1 Multi-gas Monitor and 1 or 2 Multipoint Sampler and Doser units. This software enables ventilation and air exchange measurements and multi-gas monitoring in up to 12 locations.
This software synchronizes measured tracer gas concentrations and the tracer gas dosing which makes it possible to keep a constant concentration in several rooms. By the use of 2 Multipoint Sampler and Doser units it is possible to make advanced measurements using 2 different tracer gasses.
Application Software Type 7620 represent data in table or by graphic representation and it is possible to make advanced calculations.

MEASUREMENT METHODS

The age-of-air

By displacement ventilation, clean air with subtemperature is supplied to the occupied zone, and the thermal air flow in the room are utilized to separate the clean air in the occupied zone from the polluted air above. With a correct ventilation according to the principle of displacement the boundary layer level between the clean and the polluted air only lies a little above the occupied zone. By measuring the age-of-air at different levels in the room the boundary layer level can be found.

The age-of-the air is an expression of the time in which the air remains at a certain point.

Tracer Gas Dosing and Sampling

As tracer gas sulphur hexafluoride (SF_6) is used.

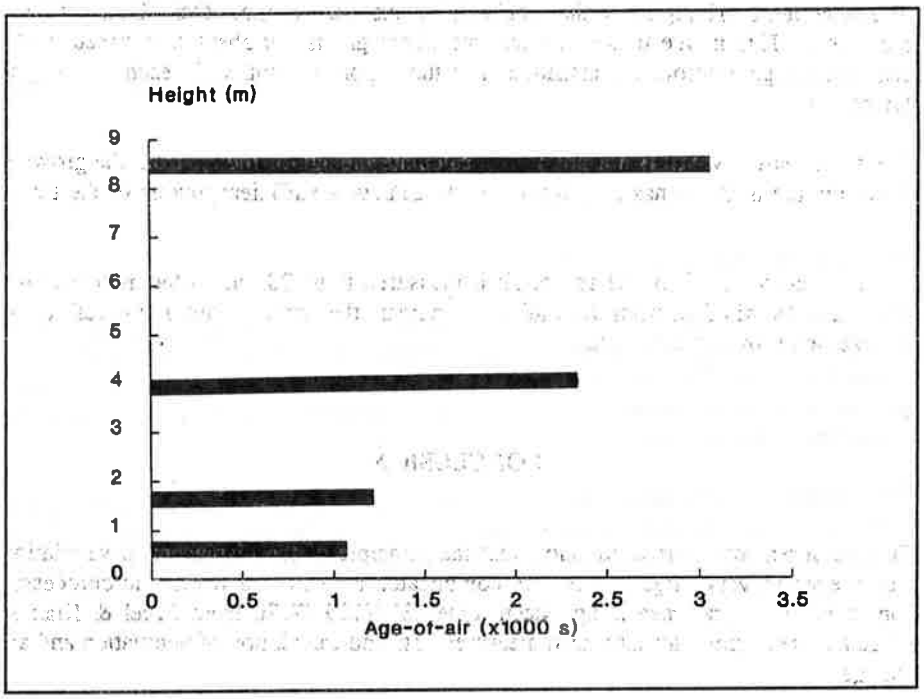
The tracer gas is dosed in the intake of outside air of the central aggregate by constant dosing. The dosing is stopped when a constant concentration is achieved in the measuring points. The measurements continue on the concentration decay. The age-of-air can then be calculated from the growing concentration curve and from the concentration decay curve.

The measurements are carried out in the center of the factory building: 0.6, 1.7, 4.0 and 8.5 m above the floor and in a single measuring point 1.7 m above the floor, 3 m from the wall. The concentration of the tracer gas of the intake air is measured in one of the supply air outlets.

RESULTS

It was only possible to calculate the age-of-air during the concentration decay because the fluctuations were too great in the measured tracer gas concentration during the constant dosing.

From the figure appears the age-of-air at different levels of the room.



The age-of-air in a vertical column.

From the figure appears that the age-of-air rises from $1.2x10^3$ to $2.3x10^3$ s (20 - 38 min) in the zone from 1.7 to 4.0 m above the floor.

The age-of-air in the single measuring point 1.7 m above the floor is $1.1x10^3$ s (18 min).

Consequently, the measurements show that the principle of displacement ventilation is working, and that the baundary layer level between the clean and the polluted air lies over the occupied zone.

DISCUSSION

The tracer gas technique is a good and necessary method to carry out advanced investigations of airflow in all sorts of rooms, but it is important to be aware of the risks of wrong measurements caused by external conditions.

Some tracer gasses can, for instance, occur in certain industrial environments.

In the actual measurement, the concentration with the dosed amount of tracer gas, ought to be constant of 18 mg/m^3 in the supply air outlets, but not more than 10 mg/m^3 were measured. This is due to the fact that the tracer gas is not absolutely mixed in the central aggregate before the distribution to the supply air outlets in each side of the factory hall.

The main reason why it is not possible to calculate the age-of-the air from the growing concentration is that it has been a problem to achieve a sufficient mixing of the tracer gas.

At 1.7 m above the floor the age-of-air is measured to be 20 min in the middle of the floor, and 18 min 3 m from the wall. This indicate that the distribution of fresh air is acceptable all over the building.

CONCLUSION

The measurements carried out show that the principle of the displacement ventilation works even in very large rooms with complicated air flows, and the microprocessor controlled tracer gas measuring system type 1302/1303/7620 from Brüel & Kjær is especially well suited for advanced measurements and calculation of ventilation and air change.