VENTILATION TECHNOLOGY - RESEARCH AND APPLICATION

8th AIVC Conference, Überlingen, Federal Republic of Germany
21 - 24 September 1987

POSTER P6

DISPLACEMENT VENTILATION

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DISPLACEMENT VENTILATION

The mixing system (even called the dilution system) is normally used throughout the world to supply air to a premises.

In the mixing system you blow air at high velocity into the room at a temperature which gives you the wanted room temperature. If the system works perfectly, you will have the same temperature and concentration of contamination in the whole room. That is because the supplied air and the air in the room is mixed due to induction.

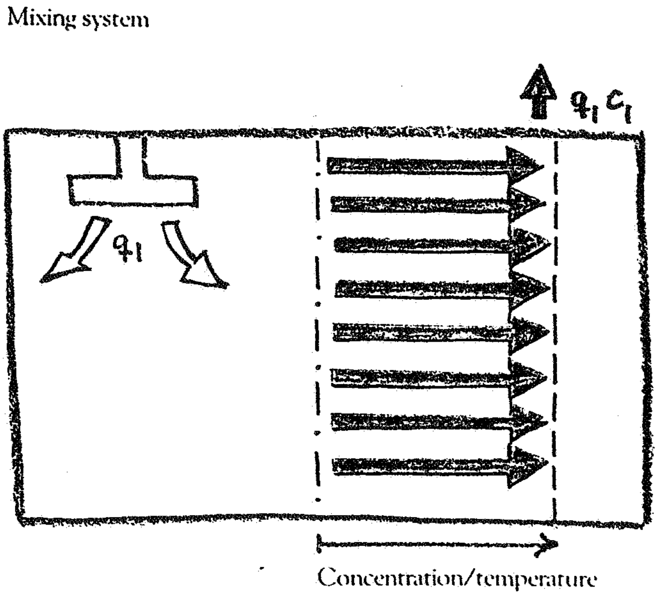

Figure 1

In Scandinavia the displacement ventilation system has had a break-through during the last years.

In this system the air is supplied through terminals with low velocity (0.2 - 0.6 m/s), which gives almost laminar flow. This together with the fact that the supplied air is slightly cooler than the air in the room gives a temperature gradient, which makes the supplied air flow out over the floor exactly in the same way as water would. The contaminated air in the room is therefore displaced towards the ceiling, where it is extracted. Warm convective air flow from different heat sources raises towards the ceiling by itself and is allowed to do this without disturbing air movements. Because of this the occupied zone is characterized to a very high degree by the supplied air rather than by a mixture of polluted and supplied air.

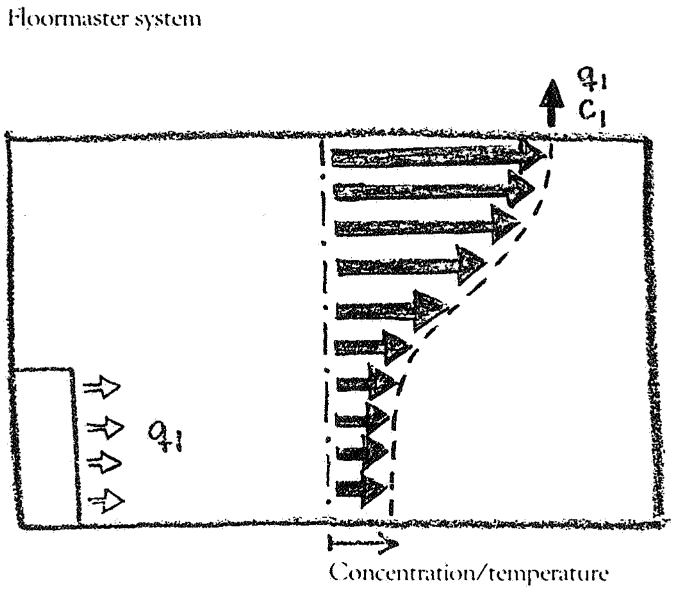

Figure 2

Let us compare a room with a given supply air flow and contamination emission. With a displacement system we will get a rather low concentration of contamination in the occupied zone and a higher concentration in the upper zone. The mixing system, however, will give this higher concentration in the whole room volume. The discussion above is valid for stationary conditions.

Result of measurements carried out in a room served by the Floormaster system.

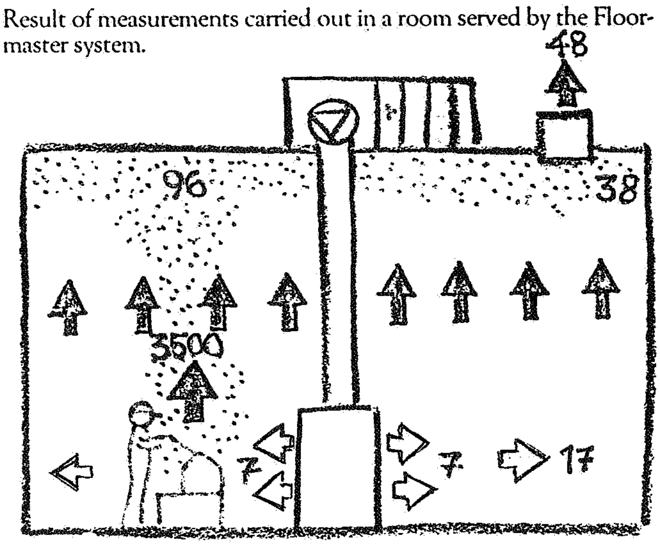

Figure 3

Figure 3 shows the result of an actual measurement in a welding workshop. The relative concentration is 48 in the exhaust air and only 17 in the occupied zone. The supply air has 7 in itself. In the same plant with a mixing system the result would be 48 in the whole room, figure 4.

Theoretical comparison with a mixing system.

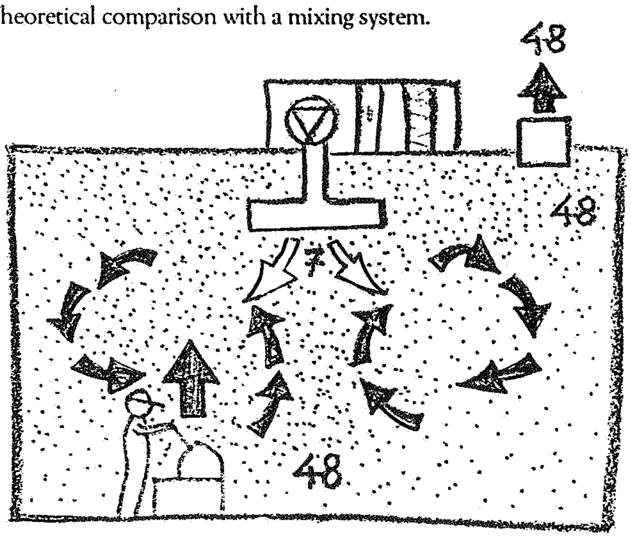

Figure 4

An adequate definition of ventilation efficiency is

$$\varepsilon = \frac{C_e - C_s}{C_o - Cs}$$

where

ε = stationary ventilation efficiency

C_e = concentration in the exhaust air

C_s = concentration (if any) in the supply air

C_o = mean concentration in the occupied zone.

The result for mixing system is a ventilation efficiency of 1. The result for the displacement system is 4.1 using the figures in fig. 3. This means that you would need 4.1 times more air with the mixing system to achieve 17 ppm in the occupied zone. Just think about the installation costs!

The reason for two systems to give such different results is that in the mixing system a particle in the room is recirculated several times to the occupied zone before it is exhausted. In the displacement system it raises towards the ceiling and is prevented from returning because of the thermal forces provided by the system.

In principle the temperatures in a room with a displacement system are as shown in fig. 5.

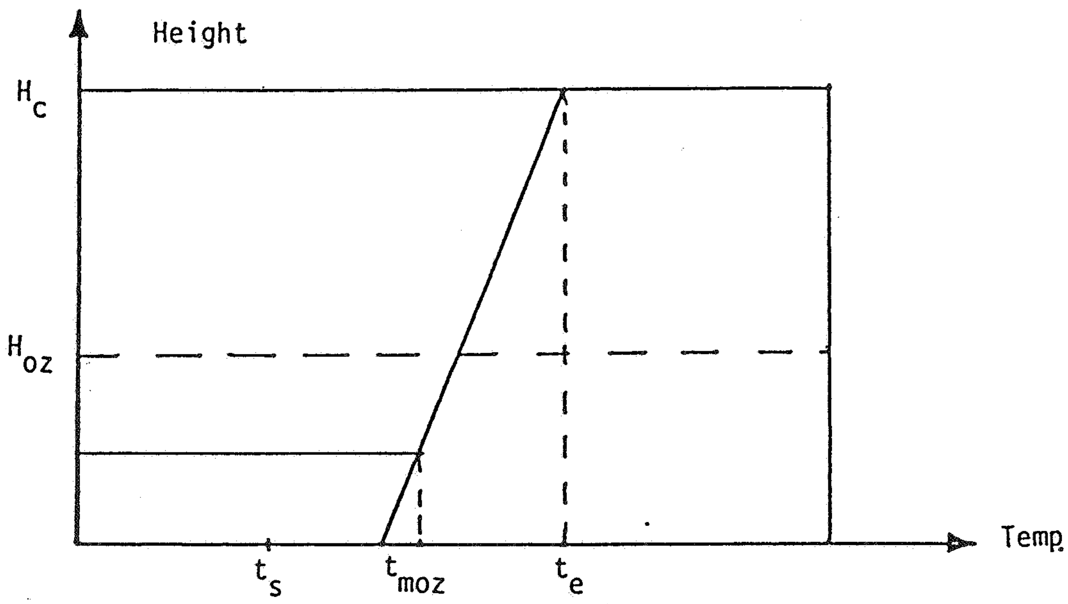

Fig. 5. Temperature profile of a displacement system. (In reality the profile is not always a straight line.)

Explanations to fig. 5.

H_c = height to the ceiling

H_{oz} = height of the occupied zone

t_s = supply air temperature

t_{moz} = mean temperature in the occupied zone

t_e = exhaust air temperature = temperature at the ceiling.

The surplus heat in the room is taken care of by a certain supply air flow and temperature difference between exhaust air and supply air (t_e - t_s). In this case there is no difference between a mixing system and a displacement system. Both systems get the same value of (t_e-t_s) provided that the air flow and surplus heat are the same.

What differs between the systems though is the supply air temperature (t_s) needed to get the same temperature in the occupied zone. This is illustrated in figure 6.

A well functioning mixing system has the same temperature from floor to ceiling (at least almost so) and also the same exhaust air temperature. A typical example is shown in fig. 6.

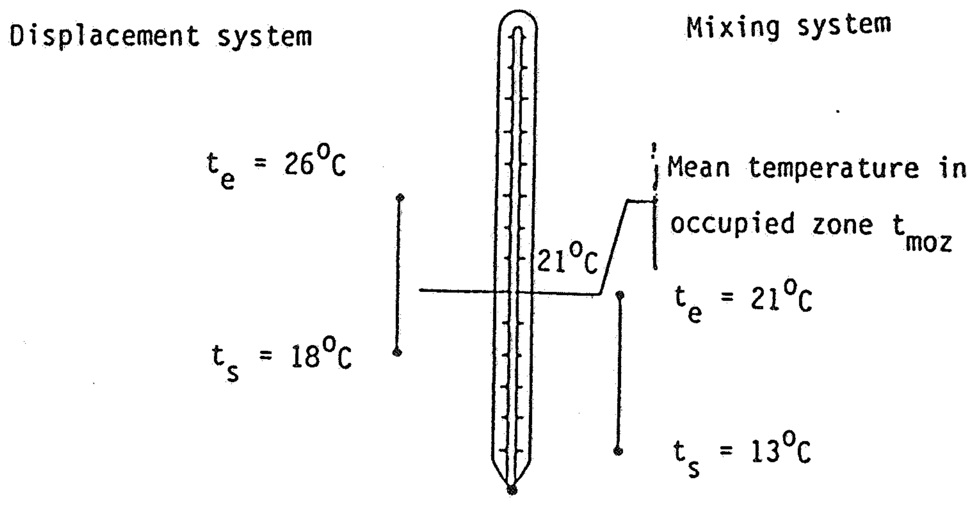

Fig. 6. Example of normal supply air and exhaust air temperatures for displacement system and mixing system.

The example shows that a mixing system demands a supply air temperature of 13 °C, while the displacement system needs 18 °C to achieve a suitable temperature in the occupied zone. This means, of course, that a displacement system needs less cooling during the warm season.

An other way to put it is that the displacement system gives a comfortable temperature in the occupied zone during a longer time in a plant without cooling.

The air movements, created by the two systems mentioned above are quite different. If we supply 1 000 m^3/h at 10 m/s in a mixing system, the result will be an air movement in the room of 50 000 m^3/h at a velocity of 0.2 m/s. For the displacement system the corresponding value is only 2000 m^3/h. This gives a much lower air movement which allows the temperature gradient we want to develop. It also eliminates a lot of the traditional draught problems.

One often hears that exhaust hoods do not work very well. The reason for this is often that the convective airflow from a stove is disturbed by the air movements created by the mixing system. This means that a lot of the fume will pass outside the hood.

With a displacement system the air movements are restricted to a minimum. The flow from the stove goes directly into the hood. This will create a good environment in institutional kitchens which is difficult to match.

In traditional mixing systems it is common to use recirculated air.

As the task for the outdoor air is to assure air quality, the task for the recirculating air is to provide heating, cooling and air movements when the outdoor airflow is not big enough. The reason for the need is closely connected with the demands of the existing technique e g the mixing system itself.

The inlet diffusors need a certain airflow to work correctly. If the flow is reduced, the undertempered supply air will not mix and therefore create draught. Consequently, by using recirculating air you can meet varying demands without changing the airflow.

Changing the flow is no problem in the displacement system. If you decrease the airflow due to decreasing demands, the system works equally well. From the systems' point of view there is no lower limit as to how far the flow can be reduced. As the supplied air is distributed over to the floor due to its weight and not due to velocity, the whole room will be ventilated.

As a result when designing a displacement system, you will discover that the need to use recirculated air is virtually non-existing.

The criteria that speak for displacement system are:

Need of ventilation

Modern, that is well insulated, tight buildings

Surplus heat and limits for pollution

With the displacement system you can not cover transmission losses. This is virtually the only system limitation. On the other hand the system gives

* a high ventilation efficiency
* a high temperature efficiency that gives superior cooling capacity
* no draught
* it ventilates the whole room
* it is very flexible and normally reduces ducting.

In short, with displacement system you will get better ventilation at the same price and often even cheaper.

Displacement systems are installed in a lot of different premises from tough foundries, welding shops and laundries over department stores and sport halls to concert halls, conference rooms, offices, ward rooms and operating theatres.