OCCUPANT INTERACTION WITH VENTILATION SYSTEMS

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VENTILATION STRATEGIES AND OCCUPANTS' BEHAVIOUR

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SYNOPSIS

Each occupant in a room should be able to control his own indoor environment. Individual control can be achieved in many ways: from simple window-opening to automatically arranged personal mini-environment.

Individual control is not utilized effectively today. This is partly caused by lack of proper information, and partly by the fact that builders pay more attention to construction than to use and operation.

Even technically complicated systems can be easy to operate -what is needed is sufficient, but not too difficult user information.

In this paper, practical examples of user-friendly ventilation in residential and office buildings will be analyzed. Information problems, technical limitations and consequences of various individual control strategies will also be discussed.

1 INTRODUCTION

The need of ventilation is primarily caused by people and their activities, secondarily by other sources of heat and pollutants. People behave in different ways, and their activities vary highly individually in space and time.

Ventilation should be designed and operated so that a proper indoor air quality is achieved whenever needed. Different people may also have different objectives for indoor air quality, thermal comfort etc. (1). So, the need of ventilation depends on occupancy. Ventilation can, in principle, be designed to be operated on full capacity all the time, but this would waste energy. Continuous minimized ventilation cannot, on the other hand, guarantee good indoor air. Ventilation should, therefore, be controllable in space and time - manually, automatically, or in a suitable combination.

2 PHYSIOLOGICAL, PSYCHOLOGICAL AND TECHNICAL BACKGROUND

2.1 Attitudes against mechanical ventilation - why?

Many complaints are today made against mechanical ventilation. The words "SICK BUILDING" are presented too often in connection with a modern office or other work environment and mechanical ventilation or air-conditioning.

In many cases, further complaints can be avoided by readjustment, minor renewal, and systematic operation and maintenance. But, complaints may occur (or remain) even if there, from the technical point of view, should be no reason to. (See e.g. (2), (3)).

The causes for the "sick building syndrome" are only partly known. The psychological aspects cannot be neglected: people feel bad if they cannot control their indoor environment: temperature, air flows, noise, lighting, (4). To be able to open a window has a great positive psychological effect! People can tolerate more draught or noise if they have got some means to control them.

2.2 Technical limitations - before and now?

"Collective" ventilation has been designed and used for the past 20 - 30 years. Simply because there have been no economical alternatives. In the Nordic countries, the main ventilation system in residential buildings is mechanical exhaust, run at full capacity for a few hours per day. In offices, especially in "landscapes", a constant temperature is set throughout the building, and ventilation is run at a constant capacity during office hours. Limited individual control may be achieved in separate rooms by using e.g. radiator thermostats or controllable fan-coil units.

In many cases, energy-efficiency has been increased, at the risk of deteriorating the indoor air quality, by using minimum outdoor air rates, minimized hours of operation (in offices etc.) or maximum percentage of return air.

Today, it is technically possible to build more individual systems and controls than was technically possible in the 1970's. Energy-efficiency is achieved easily by heat recovery systems which have become cheaper and more reliable. VAV-systems allow varying heating and cooling capacity when needed. Air quality control of ventilation is rapidly developing. New components of control systems can be programmed to provide also suitable temperature fluctuations as well.

A ventilation or air-conditioning system can be designed and balanced in a way not to be disturbed by window-opening. Pressure-controlled fans allow you to control your own air change rate without influencing ventilation in other rooms. But it may remain difficult to arrange great temperature variations - although in most cases $\pm$ 1 ^{o}C is possible in indivicual spaces, which will often be sufficient in minimizing dissatisfaction.

3 HOW TO USE INDIVIDUAL CONTROL - WILL PEOPLE LEARN IT?

3.1 Technical aspects

Technical possibilities have improved, as stated before, but they are not very well utilized today.

Attitudes among builders, designers and contractors should be changed. Now they concentrate on construction and equipment instead of occupants' needs and operation/maintenance. Traditionally, the system and its control are designed more or less separately.

3.2 User-oriented technology, examples

In other branches of technology, there are numerous examples of easy-to-operate systems, which in principle are much more complicated than ventilation.

For example, at home you can switch your lights on and off, whenever needed, very simply and without any technical expertise. You get your tap water almost as easily, or open your radio, TV etc. A little more is required for adjusting the tap water temperature, or colours in your TV but you still can do it without technical skill, and your operations have no influence on your neighbours. Why not also in ventilation? Why not have a constant duct pressure (as voltage!), why not simply adjust your individual air supply and exhaust whenever needed?

A more complicated comparative example is the motor car. In order to use it you need education and a license. "A license for living in your own home" does not sound reasonable at all, but some education on one's indoor environment should be given, already at school. For the rest (the technical part) you should get instructions from the manufacturer or designer!

3.3 Windows

Windows have been used for centuries as a means of basic or additional ventilation. Because they generally can also be tightly closed (at least in the Nordic climate for all winter), other means of air supply should be used for basic ventilation. There are still periods when extra ventilation is needed or wanted: for cooling in summer, for airing if the room is exceptionally crowded etc.

Attempts to change people's window-opening habits have generally failed. People feel dissatisfied if they cannot open their windows.

3.4 Information

You cannot change people's habits, but people can be educated! The only way to do this is proper information. Both natural and mechanical ventilation need careful operation and maintenance - good, simple and clear information is necessary. Always tell people <u>why</u> (air quality, comfort), and <u>how</u> (short-period window opening, use of forced ventilation in kitchen, filter cleaning periodically). Information should not, however, mean a technical manual with hundreds of pages!

4 CASE STUDIES

4.1 General

The following examples show both positive cases of user-oriented ventilation (including limitations in application), and cases where lack of (or wrong) information has caused problems in air quality and even structural damage.

4.2 Detached and row houses

Extreme examples have been measured: air change rates of about 0.01 ac/h (!!), CO_2 concentrations of more than 5 000 ppm, i.e. beyond hygienic limit values, high humidities allowing mould growth. These observations concern tightly-sealed bedrooms in houses equipped with natural or closed-off mechanical ventilation and without any supply air arrangements. The occupants had wanted to save energy or been disturbed by draught or noise, generally they had not received any information on how to use their ventilation.

Generally, in houses with mechanical ventilation, the fan is on only during cooking, bath etc. Major problems can be avoided if the ventilation cannot be completely closed off.

In one experimental area, the manufacturers informed the residents on ventilation. In those houses, most people learned the proper use immediately, but still in some cases the fan is (especially in winter) closed off if the air change due to infiltration satisfies the minimum need for ventilation. Generally, people considered personal instruction by the manufacturer or contractor more useful than instruction manuals.

The importance of good adjustment, and noise reduction, is obvious. Measures required for maintenance should also be as simple as possible; even cleaning or changing the cooker-hood filter is likely to be forgotten if it is considered difficult.

4.3 Renovated block of flats: exhaust fan for each flat

This three-storey block of flat was built in 1951, and need for renovation became obvious in early 1980's. The existing ducts for natural ventilation were in a poor condition, and therefore the owner decided to build a new mechanical exhaust system with one small controllable fan for each flat.

Technically, this system worked, but the information was not sufficient. The advantages of good ventilation, when needed, were not pointed out to the residents clearly. The slight increase in the electricity bill caused by the exhaust fan was estimated into its maximum, some 200 FIM per year. With the consequence that, in order to save a little money, people closed off the fans in many flats. This caused frost damage due to condensation in the exhaust air duct tops and in rooftop fans. New information was soon distributed to the occupants, and now, some years later, the ventilation is satisfactory and properly operated. Supply air is taken in via cracks in the building envelope, which in some winter weather conditions causes draught.

4.4 Experiences from full speed - half speed, operation of exhaust ventilation in blocks of flats

In blocks of flats mechanical exhaust ventilation with one central exhaust fan is predominant. The full speed is generally on for one-two hours in the morning and two-three hours in the afternoon, i.e. when people are assumed to do their cooking. The rest of the day and all the night ventilation is run at half speed.
This arrangement has not worked satisfactorily. In hundreds of buildings, the exhaust fan is closed off for nights (energy, noise...), although this should not be allowed. In many cases, the timer clock is not accurate and may switch full speed on even at midnight.

But even if the system is operated correctly, people often are far from satisfied. In recent experimental projects it was found out that people's cooking habits vary so much that collective fan operation would not satisfy everyone unless the full speed were on from 7.00 to 21.00 hours.

The full speed-half speed operation also causes problems in pressure conditions. At half speed, the pressure differences are about one fourth of those at full speed (e.g. fan pressure 100 Pa vs. 400 Pa), for which the system is generally balanced and adjusted. This means that in winter, especially in high-rise buildings, or at high wind speeds, the natural forces will disturb the balance of ventilation. Problems with pressure conditions may occur even if the ventilation systems can be operated individually - floors and partition walls should be built as airtight as possible!

4.5 Modern and renovated offices

A new generation of office interiors have been recently introduced. Flexible, integrated furniture systems including lighting and air distribution are already available. This allows an individually controllable mini-environment for each occupant. Unfortunately, no experimental data is available yet concerning indoor air conditions and system performance.

In renovated offices, originally equipped with natural ventilation, many people like to keep the ventilation "as natural as possible". Very often this is not possible: the office environment is more loaded than before (office automation!), old ductwork is partly damaged, outdoor air quality requires air filtering etc. "Soft" and flexible mechanization, with as little influence on interior architecture as possible, generally brings the best result. If changes in architecture are allowed (or have already been made), then providing modern air-conditioning is possible even in an existing building. In any case, it is important to listen what the end user wants! Even mechanical systems can be "natural" - adjustable and noiseless. Lack of space for new ducts sets its own limitations; VAV or fan-coil systems are often suitable and user-friendly.

5 CONCLUSIONS AND FUTURE TRENDS

In the design of ventilation, it is necessary to pay much attention to traditions and people's habits. People want to adjust their own room temperature, and they want to open windows. Why not let them? Modern air conditioning technology allows individual control, and technical solutions can be made based on the occupants' needs and wants.

Correct information is necessary, e.g.:

- Opening a window in your office causes draught in winter and brings in dust, so if you still want to open it, just a few minutes' airing is enough, in summer do just as you like, but remember that airing when wind speed is high may cause discomfort to your neighbours (OFFICE).

- Closing off your fan makes the air bad. The minimum speed is needed even when there is nobody at home. Half speed is recommended except during cooking, when you also should open the kitchen hood damper (HOMES. The positions needed must be marked clearly).

- In summer, if it gets too warm indoors, you can run your fan at full speed or open your windows late in the evening, at night, in the morning, when it is cooler outdoors. (HOME). In offices mechanical night cooling is recommended.

People are very sensitive to draught and noise; odours are often much more easily tolerated. In order to achieve good indoor air quality, special attention should be paid to proper air distribution and noise insulation/reduction.

The future ventilation would probably be designed as follows:

1 In residential buildings: individually controlled ventilation in each flat, maybe in each room. Total air flow is controlled by fan or damper, room control by terminal devices. Window opening is, naturally, possible. If higher quality is needed, each room would be equipped with controllable air supply. To avoid problems with pressure differences, combinations of natural and mechanical ventilation (e.g. natural exhaust plus kitchen hood fan) are not allowed, supply and exhaust should be well balanced for a slight underpressure, and floors and partition walls should be built airtight.

2 In offices, schools, theatres, hotels etc, an air-conditioned individual mini-environment where you can adjust the temperature (e.g. within $\pm$ 1 ^{o}C) or its fluctuation (e.g. morning - 21 $\pm$ 1 ^{o}C, afternoon-upper limit 24 ^{o}C, "natural" rise), the amount of fresh air (constant or between minimum-maximum), direction of supply air flow. In sophisticated systems, the indoor environment can be controlled by central air conditioning (basic control) plus mini-air-conditioning (individual variations) - maybe with opening a window as a temporary addition! Rooms with temporary occupation, e.g. conference rooms are controlled separately (for example, by timer-controlled on-off dampers and air quality-controlled VAV-terminals). Integrated furniture - lighting - air distribution systems will probably be soon introduced also in office renovations.

In all cases, the best result can be achieved with a combination of manual and automatic adjustment + control. Some principles are presented in the Figures 1 and 2.

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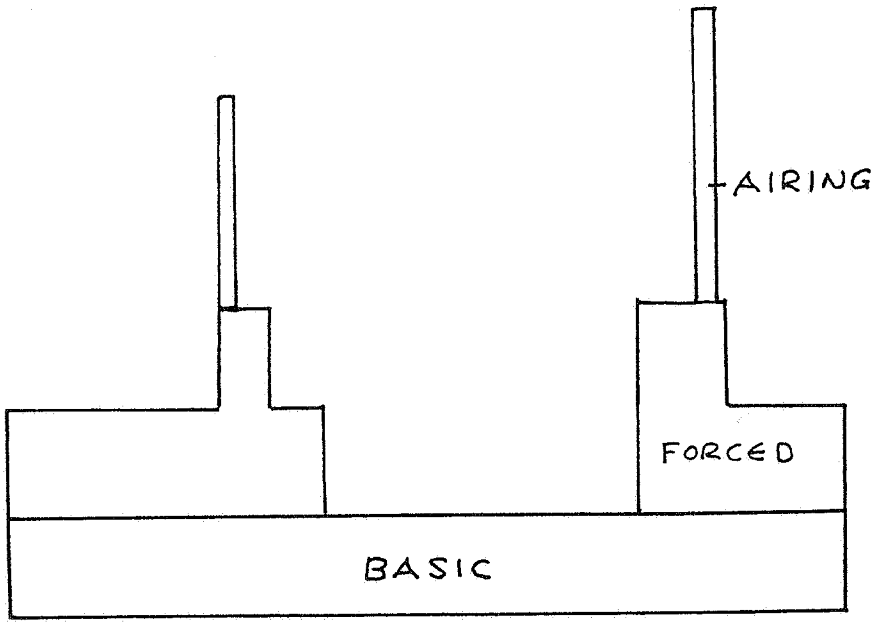

Fig. 1. How to use ventilation in residential buildings. Basic ventilation is always on, forcing is due to occupancy, cooking etc. Airing only for extra need or exceptional loads.

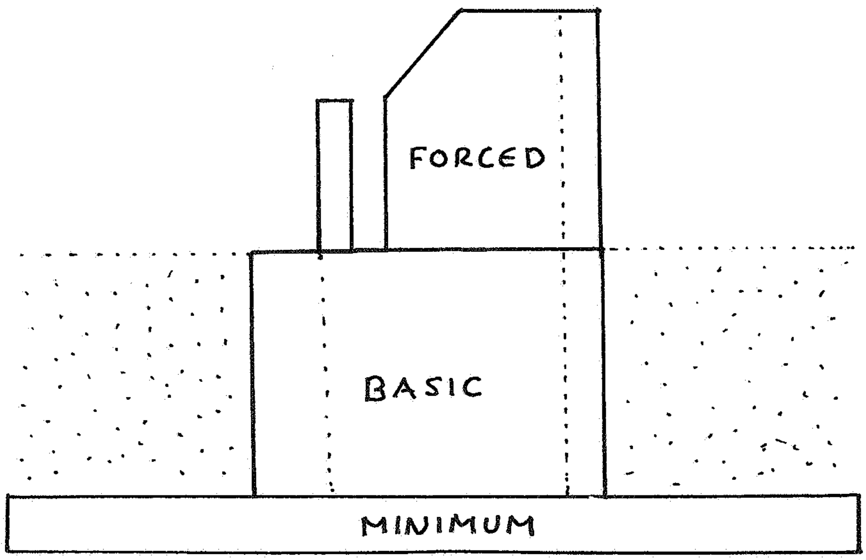

Fig. 2. Use of ventilation in offices.
Minimum = continuous exhaust from toilets etc.
Basic = ventilation due to expected occupancy (Variable if demand-controlled) forced = extra ventilation due to thermal loads .