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ADVANCED VENTILATION SYSTEMS IN FRANCE

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1. Introduction

Ventilation of dwellings is necessary, both to insure adequate indoor air quality and to protect the building itself against condensation and mould growth. On the other hand, ventilation rates must not lead to excessive energy loads. Mechanical ventilation systems (fig. 1), which have been in common use in France since the sixties, comply with these requirements. As opposed to natural ventilation, they provide a much greater flowrate steadiness, whatever the outdoor climatic conditions:

Mechanical systems have been improved in recent years ; new systems with variable flowrates according to the prevailing indoor climatic conditions, enable energy conservation and indoor air quality to be further improved:

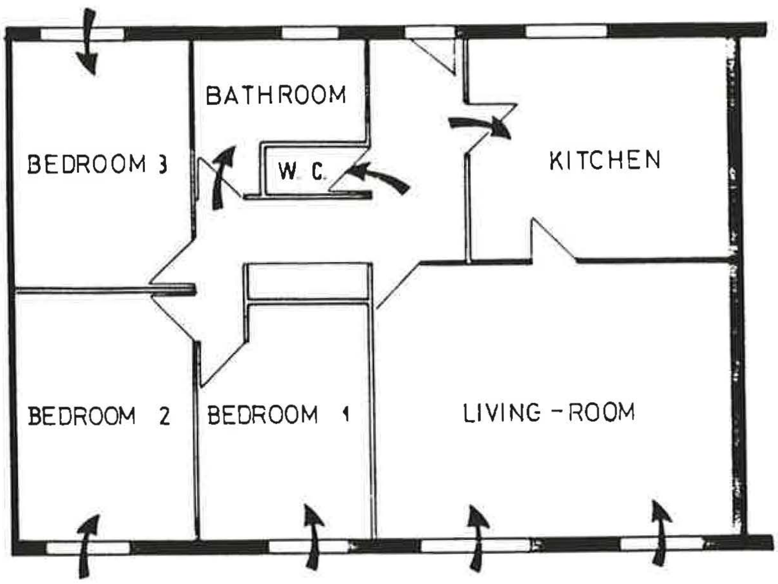

Fig.1 : Airflows in a dwelling with mechanical ventilation :
exhaust vents are located in kitchen, bathroom and WC.

2. Advanced systems. Description

All new systems marketed in France consist of air inlets or exhaust vents whose flowrate is depending on a physical parameter (temperature, pressure drop or relative humidity).

2.1. Humidity controlled devices

The air passage section of air inlets or exhaust vents is a function of the room air relative humidity, in order to increase air change when relative humidity is too high. Fig. 2 depicts an example of air inlet.

Between 5 % and 10 % of new ventilation systems in France now incorporate humidity-controlled exhaust valves, often associated with humidity-controlled air inlets.

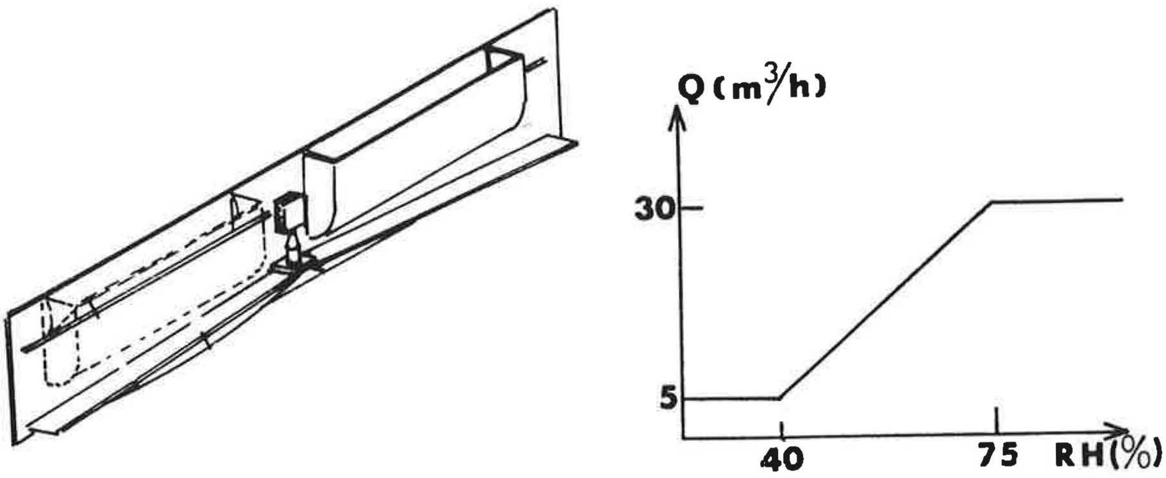

Fig. 2 : Example of humidity-controlled air inlet.
The curve depicts the flowrate as a function of the room air relative humidity when the pressure difference is 10 Pa

2.2. Exhaust vents for flue gases

When gas appliances are linked to the exhaust duct, for instance in the kitchen, the exhaust flowrate must take a minimum value (often 90 m^3/h) in order to evacuate properly the flue gases. Special exhaust vents are used to reduce the flowrate as the gas heater stops. Their aperture area is minimum when the air temperature is low (for instance below 70°C) and maximum when above this value.

2.3. Self-regulated air inlets

Fig.3 depicts a typical flowrate curve of a self-regulated air inlet. These air inlets, which are in widespread use for more than ten years, help to prevent uncomfortable draughts when the wind pressure is too high. As a side effect, they contribute to lower heat losses due to cross ventilation.

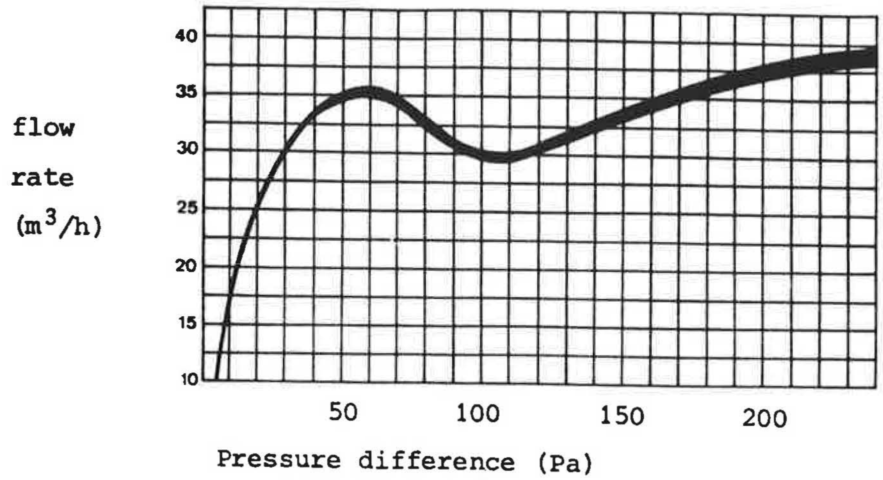

Fig. 3 : Self-regulated air inlet : flowrate curve

2.4. Miscellaneous

Others solutions, which for the moment have not been developped in France, may be devised :

- Exhaust flowrates controlled by outdoor air temperature : the principle is to automatically increase the exhaust flowrates when the outdoor temperature increases. This leads to a heat loss drop during cold weather when condensation hazards are low.

- Control of exhaust flowrate by carbon dioxide concentration in the air: This kind of component has not been developped because cost and reliability of existing meters do not seem to be adequate for domestic applications

3. Performances assessment

The performances of the ventilation systems may be easily assessed using a computer model :

3.1. Modelling

The model developped in C.S.T.B. is a 5 min. time step model; it is used to calculate throughout the entire heating season (about seven months) the airflows in a dwelling (fig.1) fitted with a mechanical ventilation system.

The meteorological data used are actual records given for different locations in France: values of wind speed and orientation, temperature and relative humidity. Each air inlet or exhaust valve is characterized by its flowrate curve as a function of the pressure difference, and also, when relevant, of the temperature or relative humidity.In order to keep the model simple enough, we considered some assumptions. For instance, stack effect was neglected and humidity concentration was assumed to be homogeneous inside each room.

The proper calculation of the relative humidity in each room required to take into account the moisture transfer between the air and the room materials (furnishings, ...). The governing equation (1, 2) was assumed to be :

$$\frac{dm}{dt} = b.RH-a.m$$

where : m is the moisture mass stored at instant tin the room furnishings

RH stands for relative humidity of the air

a,b are coefficients which account for the room behaviour with regard to humidity.

3.2. Results

3.2.1. Performance expression modalities

The comparison between different ventilation systems relies on calculation of the heat load and of a so-called Air Quality Indicator designed to assess ventilation efficiency:

Many different indicators have been considered (mean concentration of carbon dioxide, frequency of condensation on the windows, mean relative humidity, which is expected to be correlated with mould growth hazards, ...). As will be shown here after, results proved to be somewhat sensitive to the indicator choice. In this paper, we present results obtained by using the meteorological data of PARIS, to examine the vapour condensation frequency on the main bedroom windows.

3.2.2. Results

Each ventilation installation can be represented by a point on a graph where the losses by air renewal are given on the x axis, and the selected indicator of the air quality on the y axis. By making the dimensioning characteristics (for example the value of extracted flow) of the system vary, one can then obtain a cluster of points representative of all of the installations of this group. The envelope of this cluster of points located (see fig.4a) farthest to the left and the bottom of the graph represents the best dimensioning that can be obtained using the principle under consideration.

3.2.2.1. Systems with humidity-controlled exhaust vents

Fig.4 depicts the performances of different humidity-controlled systems compared with a standard system : for a similar level of air quality, the best heat load reduction that can be obtained with humidity-controlled exhaust vents is in the range of 400 kWh/year, depending on the indicator selected.

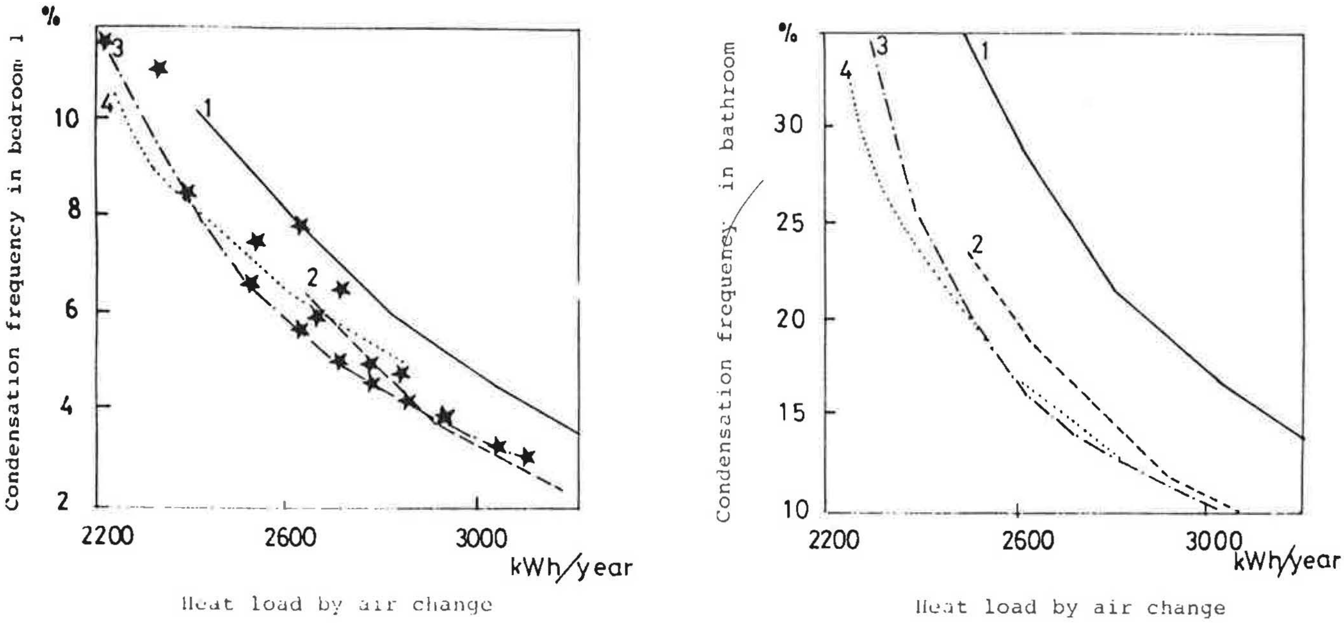

fig.4 :comparison between ventilation system with humidity-controlled exhaust vents, and standard system:
1 : standard mechanical ventilation system
2 : humidity-controlled exhaust vents ; humidity range : 35% to 55%
3 : humidity-controlled exhaust vents ; humidity range : 45% to 65%
4 : humidity-controlled exhaust vents ; humidity range : 55% to 75%

Fig. 5 depicts similar results considering both a building with the standard air leakage value (40 m^3/h when pressure difference is 1 Pa) and a building without any air leakage. It may be observed that air leakage suppression leads to a significant improvement.

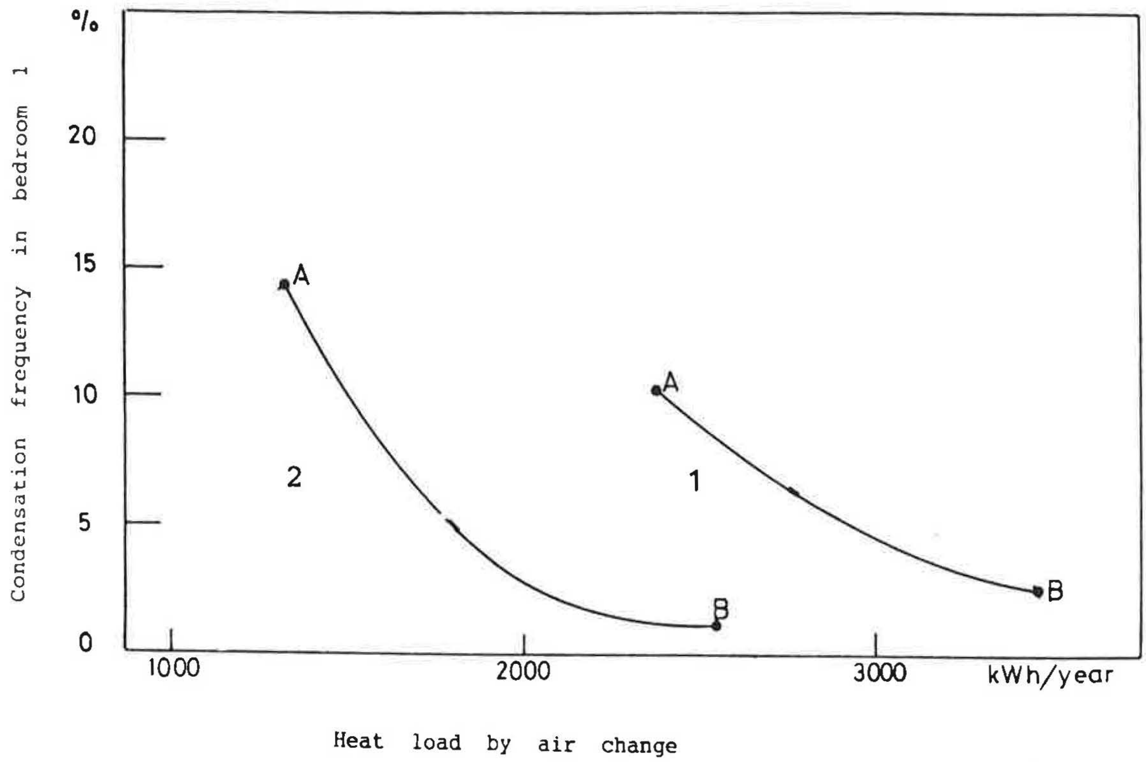

fig. 5 : comparison of a standard mechanical ventilation system
for two different air leakage values :
index 1 refers to a building with a standard air permeability. Index 2 refers to a perfectly airtight building

3.2.2.2. Miscellaneous

Other configurations have been investigated :

- use of humidity-controlled air inlets
- use of exhaust vents with flowrate controlled by outdoor temperature.

The results were that these systems lead to a significant improvement of ventilation efficiency : the supplementary heat load reduction is for each principle in the range of 200 kWh/year.

3.2.2.3. <u>Results enlargement</u>

The foregoing results have been obtained by using certain input data (climate of Paris, moisture generation equal to 6 kg/day, ...). Fig.6 depicts results obtained with other input data : a large variation may be observed. However if similar air quality levels are considered, the heat loss difference between the two ventilation principles is less sensitive to the choice of input data than it would have been without any provision being made for air quality level.

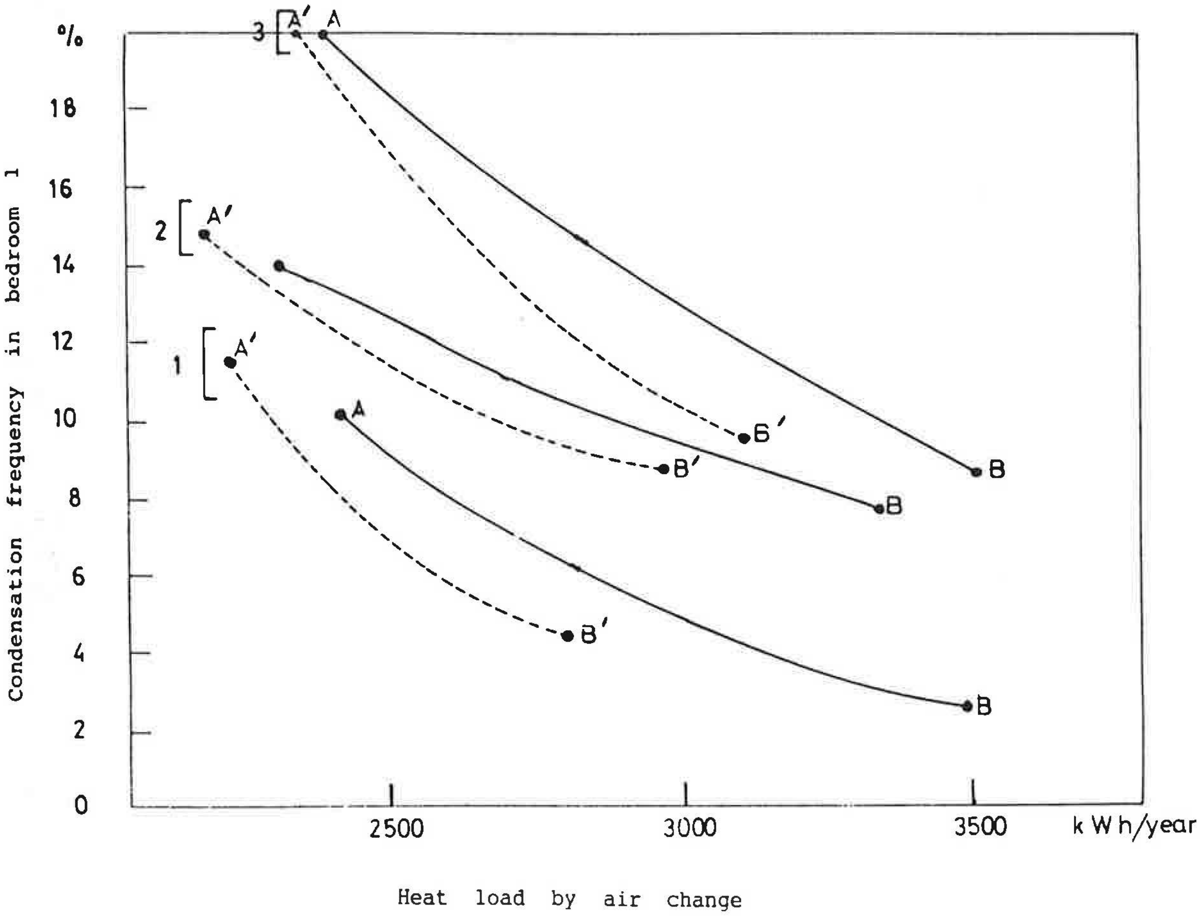

fig.6 : comparison between ventilation system with humidity-controlled exhaust vents and standard system :
1 : climatic data of Paris ; moisture generation : 6 kg/day
2 : climatic data of la Rochelle ; moisture generation : 6 kg/day
3 : climatic data of Paris ; moisture generation : 9 kg/day.

4. Conclusions

A computer model was used to assess the performances of different mechanical ventilation systems in dwellings.

Heat loads by air renewal were calculated with reference to a standard mechanical ventilation system. For this calculation, the flowrates'dimensioning was adjusted in order to achieve a similar air quality level for each system. On this basis the load reduction, using advanced systems which have recently been released on the French market, was found to be appreciable.

The calculated values of this reduction were somewhat depending on the air quality indicator chosen, which therefore should be carefully selected.

It should be added that achievable values of energy savings may prove to be more important than the theoretical values reported in this paper : for instance, the way humidity - controlled ventilation systems are sized in current practice, leads (when humidity production is not too high) to a slight diminution of the air quality level (with respect to a standard mechanical system), which makes it possible to increase energy savings. This slight diminution is acceptable because, in this case, condensation hazards are not critical.

Further work with a model taking into account phenomena which, so far, have been neglected (windows opening, stack effect, ...) is needed in order to confirm the results presented in this paper.

5. References

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