SUMMARY

J. Railio: Natural Ventilation - Conditions and Means for its Improvement in Existing Buildings. In newbuilding, the requirements for indoor air quality and energy efficiency cannot be simultaneously met with natural ventilation. In renovations of existing buildings it is, however, often difficult or uneconomical to build a mechanical ventilation system. What is often forgotten is that the conditions for a functioning natural ventilation have, or will be, deteriorated even if no alterations are made in the ventilation system. Examples are given of changes in the outdoor air quality, airtightness and usage or layout of rooms, and on maintaining the conditions of satisfactory indoor air by natural, combined natural/mechanical or mechanical systems.

RÉSUMÉ

J.Railio: la Ventilation Naturelle-Conditions et moyens de l'améliorer dans les constructions existantes. Dans la construction nouvelle, les besoins relatifs à la qualité de l'air intérieur et á une gestion efficace de l'energie ne peuvent être satisfaits simultanément par la seule ventilation naturelle. Lors des rénovations de bâtiments existants, par ailleurs, la construction d'un système de ventilation mécanique reste souvent difficile, voire non rentable. On oublie souvent que les conditions qui permettent d'assurer une ventilation naturella sont, ou seront détériorées, même sans l'apport de modifications au système de ventilation. Des exemples sont fournis sur les modifications de la qualité de l'air intérieur, de sa densité, de l'utilisation ou de l'agencement des pièces, et sur le maintien des conditions permettant d'assurer un air intérieur satisfaisant au moyen de systèmes naturel, mécanique ou mixte.

KURZFASSUNG

J. Railio: Natürliche Ventilation - ihre Konditionen und Verbesserung in bestehenden Gebäuden. In neubauten können die Forderungen an Innenluftqualität und Energiewirksamkeit nich gleichzeitig durch natürliche Ventilation erfüllt werden. Bei Renovierungen in bestehenden Gebäuden ist es aber manchmal schwer oder unwirtschaftlich, ein mechanischen Ventilationssystem zu bauen. was oft vergessen wird, ist dass die Konditionen einer wirksamen natürlichen Ventilation entwerder schon schlechter geworden sind oder bald sich verschlechtern werden, auch wenn keine Änderungen im Ventilationssystem vorgenommen werden. Hier werden Beispiele gegeben über die Veränderungen in der Aussenluftqualität, Luftdichtigkeit und dem Gebrauchszweck der Räume oder dem Zimmerplan. Weitere Bespiele erläutern die Erhaltung von einer akzeptablen Innenluftqualität mit natürlichen, natürlich/mechanischen und rein mechanischen Ventilationssystemen.

NATURAL VENTILATION - CONDITIONS AND MEANS FOR ITS IMPROVEMENT IN EXISTING BUILDINGS

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Introduction

It is often said that natural ventilation should be used even in newbuilding, especially in housing, as well as in all building renovations. These statements have generally pointed out the trouble with and risks of today's mechanical systems, yet without understanding the history of natural ventilation as part of a fine integration: structure - heating - ventilation, which could work without mechanical forces.

With today's higher requirements for air quality and working efficiency, higher rates of automation, declining outdoor air quality and central heating systems etc. it could be easily testified that it is uneconomical, if not impossible, to meet those requirements with pure natural ventilation.

The Association of Finnish Manufacturers of Air Handling Equipment made a pilot study in 1984 in order to find potential ways of system and product development. It was found very difficult to make any development based on "pure" natural ventilation. But when new products are planned, the development should be based on understanding the history of ventilation, described e. g. in ref. (1).

Changes in conditions in existing buildings

There are many factors that may have influenced the function of existing ventilation systems or increased the need for ventilation. Almost in every case the conditions of functioning natural ventilation have essentially deteriorated, although these changes are not always easy to realize. The consequences are often noticed only after renovations have been made, i.e. after several simultaneous changes.

Changes: What they are and how they work

Improved airtightness. Additional insulation, and especially the vapor barrier, makes the building envelope more airtight. In order to avoid draught, the windows are often re-sealed. In natural ventilation, improved airtightness always means a reduced air change rate and need for new supply air arrangements. In a mechanical exhaust system, these arrangements are needed as well because of less efficient ventilation the so-called "bedroom problem"(2). The air always finds the easiest flow routes!

Removal of old local fireplaces. The integration of heating and ventilation (see the introduction) is broken if the old fireplaces are removed. Central heating with water radiators causes, of course, less work and is more comfortable, but who has paid any attention to the other part of this integration? The exhaust air ducts, have often bee closed off and even the still existing ones have lost most of their driving force previously created by the warm adjoining chimney.

Closing off the supply air vents. Vents in outer walls were earlier common as the supply air parts of natural ventilation. But since they are draughty in winter, the closing them off was a very na tural consequence, leaving infiltration and airing the only ways of getting supply air in.

New building and furnishing materials (especially taken into use in renovations): The best-known of the several consequences is the increased emission of formaldehyde.

Changed usage or layout of rooms. This means almost always increased need for ventilation. In central Helsinki, for example, many dwellings have been changed into offices. A large room may have been divided into four small offices - three of them without any ventilation arrangements.

Modern working environment. This change often goes together with the previous one - more people, more machines. But increased office automation in itself has increased the load. In addition, the emissions from copying machines etc. must be taken into account.

Closed, leaky or otherwise useless ducts. The old ductwork, mainly masonry, may have been deteriorated in the course of time. E.g. during radical changes in usage (from residential to commercial) of a flat, many old ducts may have been cut off.

Deteriorated outdoor air quality. Most of the old buildings equipped with natural ventilation (except for the majority of one-family houses) are located in urban areas with highly polluted outdoor air. Therefore, air supply arrangements often must include air filtering and also noise reduction, which increase the flow resistance so that natural ventilation hardly can work properly under any conditions. In city centers, air intake from street facades should prefarably be completely avoided.

Increased energy prices. There is no return to cheap energy, and the health aspects do not allow any further reduction in ventilation rates. In the Nordic climate (and maybe also in milder climates), a good indoor air quality can be guaranteed in an energy-efficient way only if the ventilation is controlled and if heat recovery is included in the system.

How to achieve a functioning natural system?

Ideas of functioning natural ventilation have been presented on many occasions. Wind rotors and other wind-utilizing devices on the roof, heated exhaust air ducts and controllable (or rather one-way) air intake devices can all help the natural ventilation to work properly, but they should be used together in the actual building (not necessarily at the same time). With self-controlling devices we can limit the air flows in wintertime, etc. But these techniques are not cheap or service-free.

"But you can simply open your window"

Airing via open windows has its advantages. You may have a party at home, a meeting of six persons in your small office, or other exceptional loads which the ventilation system is not (and should not be) designed for. The openable window has also positive psychological effects (you can have a way of controlling your indoor environment)

An openable window cannot be regarded as part of a modern ventilation system for two reasons. One is comfort: just as you rather let your radiator system take care of heating without everyday troubles with your fireplace. The other is air quality, because the openable window can also be closed tightly!

Facts about air change rates

The British Standard BS 5925 (3) states that it is almost impossible to predict the air change rate in actual weather conditions. Although the ventilation rate in and around average outdoor climates rate may be rather constant or steady, wide variations or fluctuations occur. Some calculations are presented in (4), and they show clearly that air change rates depend very much on wind, temperature, and location of leakage paths.

Measurements, e g in (2) and (5) show also that the air change rates in various rooms vary very much and cannot be predicted. According to some calculations and field observations, the monthly average air change rate can in certain special cases be almost constant throughout the heating season, but high deviations from this average are common.

The problem has so far been worst in rather new airtight single-family houses where natural ventilation is still widely applied. Local air change rates below 0,1 ac/h are quite common (5).

Towards systematic renovation

Before starting building renovations, a careful analysis must be carried out, with examining both the existing structures and building services (e.g. pressure tests of the ductwork), and the demands of the planned use of the building after renovations (generally various alternatives are to be evaluated). A systematic analysis method is being developed by the Nordic Ventilation Group.

Improvements by simple mechanization

Low-pressure exhaust air ductwork. If the existing ductwork does not have any major leakages or if the leakages can be easily repaired, there is a simple and cheap way to convert the system into mechanical exhaust, as shown in Fig. 1.

Small ventilation units. In this alternative, further technical development is still needed, e.g. for small standard packages to serve a flat or a group of rooms. This kind of package, generally equipped at least with air filter, noise reduction, heating coil and fan can be integrated for example with an ordinary airing panel.

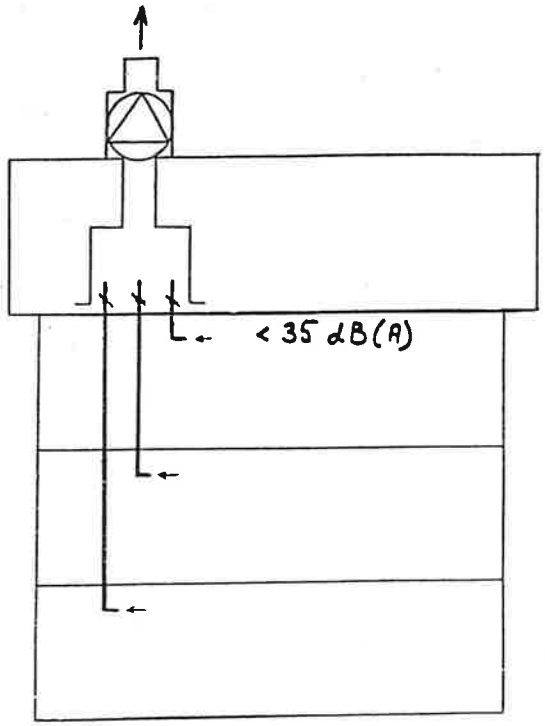

Fig.1 Simple mechanization of natural exhaust. Existing ducts are cut and provided with adjustable dampers. An exhaust fan is installed and the new ductwork is provided with noise reduction.

Careful with mixed systems!

It is possible to combine natural and mechanical ventilation, e.g. with a small ventilation unit for one room or one flat. If this unit has both supply and exhaust fan with (about) equal air flows, it can work with appropriate pressure conditions without disturbing the natural exhaust. But if exhaust only is applied, the natural exhaust ducts act as supply air ducts, spreading e.g. odors from toilets when the kitchen hood fan is on! In that case, serious problems can be avoided by using one-way dampers.

In some old renovated office buildings in Helsinki the natural ventilation system has been preserved in office rooms. Larger meeting rooms, cafeterias etc. have been separately equipped with balanced mechanical air supply and exhaust. This can be a satisfactory solution if the outdoor air is not highly polluted, and if the old ductwork can be successfully repaired and if radical; changes in loads and layout of rooms and radical improvement of air-tightness in structures are avoided.

Conclusions

It is important to understand the principles of natural ventilation, what are its driving forces, how the air supply is arranged, and the exhaust as well, so that the air flows can be controlled. A single duct from a room onto the roof is not a natural ventilation system, but only a duct with varying air flows into varying directions depending on wind speed and directions and outdoor temperature, almost totally uncontrollable.

It is still possible, although very difficult,to design a functioning natural ventilation system. With ducts heated to a temperature continuously above the outdoor temperature, with one-way self-controlling devices in both supply air intake and exhaust, its performance can be improved but not completely guaranteed. The energy demand (also because of limited air flow control) and space requirements of natural systems generally exceed those of well-designed mechanical systems.

Generally, care should be excercised in converting the existing natural ventilation system into a mechanical one. This can be done without complicated "over-mechanical" space-requiring arrangements. Combinations of natural and balanced supply and exhaust systems can be applied and further developed e.g. for residential and public buildings.

Building renovation often requires compromises. Yet we should bear the air quality in mind. A good solution will mostly also satisfy the builders and architects.

References

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