SUMMARY

L. Trepte: Energy Conservation Measures by Natural and Mechanical Ventilation Systems. There exist a number of natural and mechanical ventilation systems which meet to a certain degree the demand for energy conservation and the requirements of comfort and hygiene. Main aspects thereby are reduction of air change to a permissible limit and heat recovery from exhaust air. The advantages and disadvantages of various ventilation systems have been assessed in an extensive r and d programme started in the Federal Republic of Germany four years ago. The programme covered investigations in unoccupied test rooms as well as in occupied buildings. Although harmonizing of ventilation with other factors influencing the energy balance of buildings, as e.g. structure, heating system, inhabitants' behaviour, etc., makes natural systems to an alternative to controlled ventilation, there is a tendency to mechanical systems. The paper presents results from the r and d programme. The possibilities and limits to save energy and to meet the requirements of comfort and hygiene by various technical systems are discussed.

RESUME

L. Trepte: Economie de l'énergie dans les habitations à l'aide de systèmes de ventilation naturels et mécanique. De nombreux systèmes de ventilation orientés vers un principe de fonctionnement natural ou mécanique répondent, dans une certaine manière, aux exigences de confort et d'hygiène en réduisant à la fois les pertes d'énergie. Ces systèmes se caractérisent principalement par une réduction de l'échange de l'air à un niveau admissible ainsi que par une récupération de la chaleur de l'air d'évacuation. Les avantages et les desavantages de plusieurs systèmes ont fait l'objet d'un programme de recherche et de développement lancé en R.F.A. il y a 4 ans. Les études ont té réalisées dans des maisons expérimentales inhabitées et des immeubles habités. D'une façon générale, la ventilation se voit adaptée à d'autres facteurs ayant une influence sur le bilan énergetique, - tels que la structure du bâtiment, le système de chauffage, le comportement des habitants etc. - présentant ainsi les systèmes de ventilation libre comme une alternative de la ventilation mécanique. Néanmoins on note la tendance vers celle-ci. Le présent discours décrit résultats obtenus par le programme de recherche et de développement mentionné ci-dessus, tout en traitant les possibilités et les limites des systèmes techniques par rapport à une économie de l'énergie et à l'assurance des exigences d'hygiène.

KURZFASSUNG

L. Trepte: Energieeinsparung in Wohngebäuden durch natürliche und mechanische Lüftungssysteme. Mit einer Reihe von natürlichen und mechanischen Lüftungssystemen lassen sich bis zu einem gewissen Grade die Anforderungen an Komfort und Hygiene erfüllen und gleichzeitig die Energieverluste vermindern. Hauptaspekte sind dabei die Herabsetzung des Luftwechsels auf ein zulässiges Mass und die Wärmerückgewinnung aus der Abluft. Die Vor- und Nachteile verschiedener Systeme wurden in einem breiten F&E-Programm (Forschungs- und Entwicklungsprogramm) beurteilt, das in der Bundesrepublik Deutschland vor 4 Jahren begonnen worden war. Die Untersuchungen fanden in unbewohnten Versuchshäusern und in bewohnten Mehrfamilienhäusern statt. Obwohl die Abstimmung der Lüftung auf andere Faktoren, die die Energiebilanz beeinflussen, wie Gebäudestruktur, Heizungssystem, Bewohnerverhalten usw., Systeme der freien Lüftung als Alternative zur mechanischen Lüftung erscheinen lassen, ist die Tendenz zur mechanischen Lüftung deutlich. Der Vortrag stellt Ergebnisse des F&E-Programms dar. Möglichkeiten und Grenzen, mit den technischen Systemen Energie einzusparen und gleichzeitig die hygienischen Anforderungen zu erfüllen werden diskutiert.

ENERGY CONSERVATION MEASURES BY NATURAL AND MECHANICAL VENTILATION SYSTEMS

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Introduction

There exist a number of natural and mechanical ventilation systems, which meet to a certain degree the demand for energy conservation and the requirements of comfort and hygiene. Main aspects thereby are reduction of air change to a permissible limit and heat recovery from exhaust air.

The advantages and disadvantages of various ventilation systems have been assessed in an extensive r and d programme started in the Federal Republic of Germany four years ago. The programme covered investigations in unoccupied test rooms as well as in occupied buildings.

Although harmonizing of ventilation with other factors influencing the energy balance of buildings, as e.g. structure, heating system, inhabitants behaviour etc., makes natural systems to an alternative to controlled ventilation, there is a tendency to mechanical systems.

The paper presents results from the r and d programme. The possibilities and limits to save energy and to meet the requirements of comfort and hygiene by various technical systems are discussed.

Ventilation Systems Investigated in Dwellings and Test Houses

Within the German r and d programme "Ventilation and Air Infiltration in Buildings" different ventilation systems have been investigated during several heating periods in a number of occupied multiple unit dwellings and under natural climatic conditions in unoccupied test houses of single-family dwelling floor plan (1). The spectrum of investigated technical systems covers

natural ventilation (2): windows and devices for "controlled" natural ventilation, in which supply or exhaust air flows result from natural pressure differences due to wind or temperature differences. Usually these decentral devices are installed near or in connection with the windows

as well as

mechanical ventilation (3): decentral or central systems for exhaust fan ventilation or for both supply and exhaust fan ventilation, in some cases combined with heat recovery.

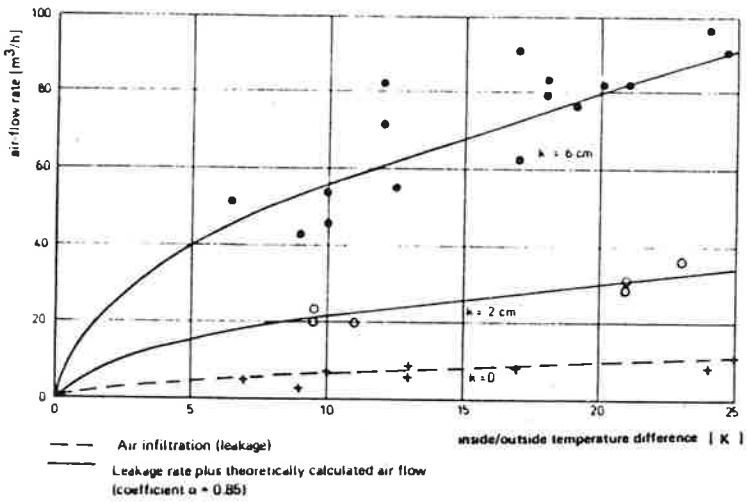
Main objectives of these investigations had been to measure and to assess the systems concerning ventilation function, influence on dwelling's heat balance and operation.

Ventilation Function

Systems for Natural Ventilation

For bottem hung windows the air-flow rate's functional dependance on opening width, inside-outside temperature difference and wind velocity can be shown. Figure 1 illustrates the influence of temperature induced ventilation.

Fig. 1: Temperature induced ventilation of bottem hung windows, dependence on inside-outside temperature difference, wind velocity below 1,5 m/s, k: opening width



The extremly tight common-type window systems available on the German market result in very low air change rates which do not meet the hygienic demands. In principle the control of the air-flow rate within tolerable ranges would be possible by installing adjusting devices which admit defined opening widths. But then the users have to operate these devices depended on the climatic conditions.

Also with "controlled" natural ventilation systems problems in controlling air flows can arise. Usually installed for permanent ventilation at wind velocities above 4 m/s the air change rate can rise up to rates similar to those measured for tilted windows (4). If temperature difference is the only driving force, in tight buildings additional measures must be taken

against insufficient air changes, e.g. installation of a second device.

Systems for Mechanical Ventilation

In general mechanical ventilation systems ensure independent from temperature differences sufficient supply and exhaust air flows also at very low wind velocities. The dependence of the air-flow rate on wind velocity and direction is much more better than for natural ventilation systems.

Decentralized single supply or exhaust systems usually meet the requirements for ventilation of a single room but for satisfying ventilation of the dwelling additional measures, e.g. window ventilation, are needed. Drought can not be avoided. Especially mechanical ventilators in distances of about 1 m still show flow-velocities above 40 cm/s (4).

Central supply ventilation systems are very sensitive to disturbing influences as wind pressure or untightnesses, e.g. of front doors. Also for other reasons, e.g. insufficient collection and removel of the exhausted air this type of system has some disadvantages, thus the installation should be an exception. With central exhaust or supply and exhaust ventilation systems, inclusive forced air ventilation, most of the problems can be avoided. In addition to this they offer the advantage of heat recovery and demand adapted ventilation.

Energy Aspects

With view to energy conservation, exhaust and supply exhaust ventilation system are most promising, especially in combination with heat recovery. For all other systems the spectrum range of air changes in most cases results in higher heat losses.

In Fig. 2 common systems on the German market are compared. Reference is "normal ventilation by windows" with 1 ac/h.

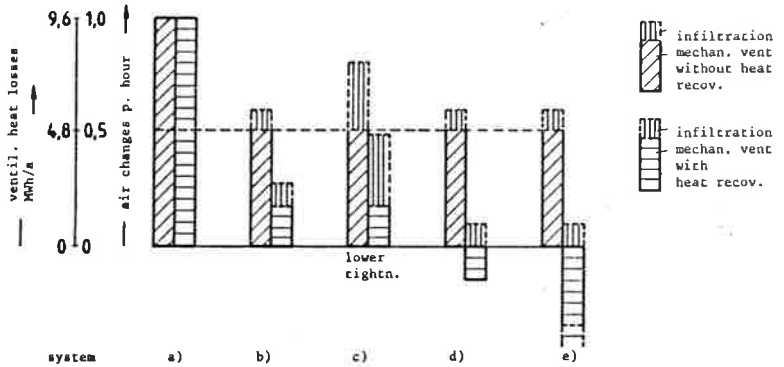
If the buildings's envelope is tight (infiltration rate about 0,2 ac/h) heat recovery by heat exhangers will reduce the heat losses to about 50 % (Fig. 2,a)). At higher infiltration rates of e.g. 0,3 to 0,4 ac/h also the heat losses are higher (Fig. 2,b)). Regarding energy conservation this means, for an efficient heat recovery the buildings's envelope has to be as tight as possible.

By an exhaust/supply heat pump more heat can be recovered from the exhaust air than is needed to warm-up the supply air (Fig. 2, d)), with the exception of very low outdoor temperatures. By way of calculation there is even a small "ventilation gain".

More advanced technologies, as e.g. heat recovery from exhaust gas of gas-heaters will raise this gain (Fig. 2. e)), dependent on the efficiency of the boiler.

Fig. 2: Typical air change rates and heat losses by ventilation, central supply and exhaust ventilation system (single-family dwelling, volume ca. 450 m^3)

a) reference, "normal" ventilation by windows
b) +c) supply and exhaust ventilation, heat exchanger
d) supply and exhaust ventilation, air/air heat pump
e) supply and exhaust ventilation, heat exchanger, heat recovery exhaust gas



Inhabitants Behaviour and General View

Whilst measurements in unoccupied test houses for supply and exhaust fan ventilation with heat recovery did result in energy savings up to 20 %, in occupied dwellings this effect could be shattered by the inhabitants behaviour. As the investigations showed, the installation of mechanical ventilation systems in some cases the inhabitants did not hinder from opening windows. Thus disadvantageous behaviour regarding ventilation may raise the air change rates with negative effects similar to untightnesses of buildings some times the heating demand of a building differed from another identical one by a factor 2, without any imperfections in the buildings fabric, installations etc. in one of them. The inhabitants contribute substantically by their behaviour to the heating demand of the building.

On the other side the inhabitants' acceptance of technical systems is a factor of importance in energy conservation. The inhabitants need a certain freedom of choice in the approach to ventilation, and sometimes still a wide-spread suspicion against mechanical installations could be noticed. Therefore proceeding to ventilation techniques for energy conservation which meet indoor air quality requirements should be attended with information and motivation.

References

(1) Lüftung im Wohnungsbau, Ventilation and Air Infiltration in Residential Buildings
Ed. Projektleitung Energieforschung (PLE) der Kernforschungsanlage Jülich GmbH (KFA),
Verlag TÜV Rheinland GmbH, Köln 1984

(2) Bestandsaufnahme von Einrichtungen zur freien Lüftung im Wohnungsbau,
Forschungsbericht T 84 - 028,
BMFT-Schriftenreihe, February 1984

(3) Bestandsaufnahme zur Ausführung von Lüftungsanlagen im Wohnungsbau,
The report will be published in BMFT-Schriftenreihe

(4) Werner H., Lüftungstechnische Untersuchungen in unbewohnten Versuchshäusern,
in Lüftung im Wohnungsbau,
Verlag TÜV Rheinland GmbH, Köln 1984