STUDY ON THE PRINCIPLE OF ENERGON, A COMBINED HEATING AND VENTILATING SYSTEM

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ABSTRACT

The Energon system is a combined heating and ventilating system which actively uses the ability of the internal building mass to store warmth. To achieve this the floor construction has ventilation air pumped through it.
The Dutch Government Buildings Agency in cooperation with DGMR Advisory Engineers bv has conducted studies, both on models and in practice, into this climate control system. It may be supposed, that bearing in mind the field of application, the appropriate secondary conditions and an advanced form of system control, the Energon system offers the possibility of achieving an amenable indoor climate and favorable energy use.

THE ENERGON PRINCIPLE

After the introduction of the Energon principle from Sweden (1980), several institutes have conducted extensive research into the possible applications of this climate control system for the Dutch climate.
The Energon system is based on the climate regulating principle which, in order to save energy and increase the thermal comfort (a more stable indoor climate), makes use of the capacity of the internal building mass to store warmth. In order to do so the floor construction, which consists of hollow channelled plates connected to each other at the ends, has ventilation air pumped through it. See figure 1.

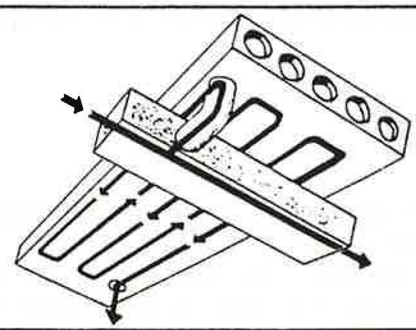
FIGURE 1. The Energon system

In addition there are important advantages to this climate control system, namely the heating and ventilation systems have smaller capacities, the limited amount of ventilation ducting which is required, and the possibility of a lower building storey (no lowered ceilings).
In countries such as Sweden, Norway, and the United States there are a considerable number of buildings furnished with this climate control system.

KNOWLEDGE ACQUISITION ABOUT THE ENERGON SYSTEM

The first building in the Netherlands to be supplied with the Energon system is the office building E.D.S. in Spijkenisse, which dates from 1982. The Technical University of Delft conducted, in cooperation with Schokbeton (Energon supplier), extensive measurements in this building, in addition to a model and system study. The Dutch Government Buildings Agency (Technique and Quality Control Department) carried out mathematical studies and kept a look-out for projects where the Energon principle could be tested in practice. The new building for the Labour Inspectorate in Nieuwegein, a medium sized office building with four floors, floor area approx. 1400 m2, and the new four storey building of the Ministry of Transport and Public Works in The Hague, floor area approx. 11000 m2, were found to be suitable. Both buildings are fitted in such a way that the Energon system attempts to compensate both for the heating losses as well as the transmission losses. This implementation deviates from the other buildings in the Netherlands, where the ventilation losses are compensated by the Energon system (by warming the ventilation air a little), and where the transmission losses are covered by a conventional heating system.
In addition to the projects mentioned the Heating and Ventilation Techniques Department of the Dutch Government Buildings Agency conducted a general feasibility study into the application of the Energon system in office buildings. Knowledge acquisition about this climate control system is considered necessary for any possible, new government building projects in the future, which are suitable for the application of this system.

RESEARCH PROJECT - LABOUR INSPECTORATE IN NIEUWEGEIN

At the beginning of 1987 the new offices of the Labour Inspectorate in Nieuwegein came into operation. In the building radiators are only used to provide additional heating. In the new building of the Ministry of Transport and Public Works additional heating was not needed due to the high level of insulation in the gable.
The offices of the Labour Inspectorate are viewed as a research project by the Government Buildings Agency. The research project has two goals:

- The evaluation of the Energon system in practice, with regard to the indoor climate and energy usage.
- The evaluation of building and installation parameters using a model, validated by measurements,simulating the building and the installation.

DGMR Advisory Engineers bv, of The Hague were commissioned by the Government Buildings Agency to develop the simulation model and conduct the parameters study.

Measurements

During the period from March 1987 until the end of October 1987 about one hundred parameters were measured, with the help of a data logger, in and around the building of the Labour Inspectorate. On the basis of the measurement results alterations have been made to the system control employed, in order to improve the indoor climate and reduce the energy consumption. The measurement results, such as the presence of people, sun intensities and outside air temperature, were also used to validate the simulation model.

The developed simulation model

A 'three room' model has been developed with the help of the temperature simulation package BFEP based on the finite elements method. The BFEP package (Building-physics Finite Element Package) is a research directed computer program for the simulation of the temperature behaviour in buildings which has been developed by the Technical University, Delft.

The 'three room' model describes a hallway and a north-facing and a south-facing room in the office building. In addition to the physical description of the structural geometry the system control is also simulated in the simulation model. The system control defines with the help of preconditions, the desired temperature of the air blowing in and the quality and quantity of the air channelled through the Energon floor. Preconditions are, for example, the installation capacity, concrete temperatures, the outside air temperature and the air temperatures in the rooms.
The air temperatures calculated in the north- and the south-facing room of the simulation model are compared with the measured air temperatures in two reference rooms. From this comparison it appears that for 93% of the period an accuracy of 1 Kelvin is achieved between the calculated and measured air temperatures in the north- and the south-facing room. For 100% of the period an accuracy of 2 Kelvin is realised between the calculated and measured temperatures.

The expected indoor climate and energy use in the building of the Labour Inspectorate were computed, on the basis of the average climate data for the Netherlands (climate year 1964), using the validated simulation model. In addition a number of important quantities, which are of influence in the choice and functioning of the Energon system and the alternative system controls, have been assessed with regard to the expected indoor climate and energy use. Important quantities are the level of insulation in the gable, the active mass in the rooms, the orientation and internal heat loads as a result of people, lighting and equipment. Research was also carried out in the alternative system controls into important control parameters such as the heating line and the test temperature at which the Energon floor would be cooled with outside air.

Test criteria

The assessment of the indoor climate is expressed in the investigation as a excess and shortfall weighted time per room. The weighted time is a period of time, weighted according to the thermal load, in which the comfort norms are in shortfall or in excess, and in which a PMV value (predicted mean vote) of -0.5 and 0.5 is used as the comfort criterium. It is assumed that the excess weighted time is weighted as heavily as the shortfall weighted time. For the energy use a distinction was made in the investigation between heating energy and ventilator energy.

Some conclusions

In addition to the conclusions reached regarding the applied system control in the building of the Labour Inspectorate in Nieuwegein, the investigation has also led to more general conclusions being drawn with regard to the indoor climate and energy use when using the Energon system. It can be concluded that in the Labour Inspectorate building, large differences in comfort occur between the north- and the south-facing room. The heat exchange between the connecting floors is thus limited. An individual arrangement for the various rooms is really not (yet) possible within the Energon system.

Study into building parameters has shown that:
- When the level of insulation is low or the building skin has a high air permeability then use of the Energon system is not advisable.
- For buildings equipped with the Energon system the surface area of glass in the gable, in combination with the glass quality and the orientation, is also an important aspect in influencing the indoor climate. The Energon system is not capable of compensating for an extreme sun load in a room.
- In order to make more use of the accumulating capacity of the Energon floor, because of the radiation exchange effect, the use of a thermally impermeable lowered ceiling is rejected.

From the research it seems that with a small symmetrical internal heat load, in contrast to a large load, a smaller absolute difference occurs (and larger relative difference) between the north and the south facing rooms in both the comfort norm excesses and shortfalls. See figure 2.

By symmetrical load is meant an identical load in the north- and in the south-facing room. A greater internal heat load has a positive effect on the indoor climate (the total of comfort level excesses and shortfalls) and the energy use. With asymmetrical loading the conclusion can be drawn that, for both the indoor climate and the amount for heating energy, the greatest internal heat load should preferably be released in the north-facing room. It should be noted, at this point, that for the non-individualised system control, with reference to test criteria, use is sometimes made of the north-facing room and sometimes of the south-facing room.

Because the ventilation air is continually being channelled through the Energon floor, it is possible that at the moment the stored coolness or warmth is required, it has,for the most part, either warmed up or cooled down. The storage of the energy can in these situations lead to extra energy usage instead of energy saving.
The complexity of the control and adjustment of the Energon system has become apparent from the study.

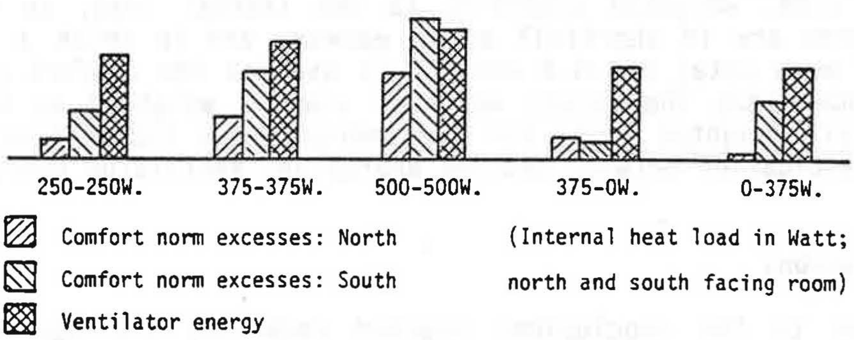

FIGURE 2. Influence of the internal heat load.

The heating line can also be used, in addition to heating, in those situations where no heat is supplied, but only an unheated air mixture of outside and return air. The study has demonstrated that by improving the heating line the greatest reduction in the comfort norm excesses and shortfalls can be realised in the winter period. In addition it appears that having one heating line during the whole year, as is the case in the Labour Inspectorate building (and also in the new building of the Ministry of Transport and Public Works) does not lead to an optimal result. A combination of a number of heating lines, dependant on the outside air temperature or differentiated for summer and winter periods, produces better results.

In order to prevent the concrete temperature being too high in the morning, whereby the room air can transfer too little warmth to the concrete, the floor is cooled out of office hours with outside air. The importance and sensitivity of the test criterium at which the floor is cooled has emerged from the study. A lower warmth storage resulted, in the variants calculated for the Labour Inspectorate building, in a reduction in the number of comfort norm excesses and in an increase in both the comfort norm shortfalls and the ventilator and heating energy. See figure 3.
With other test temperatures in the spring and autumn periods than those of the summer months an improvement of the indoor climate and the energy use can be expected.

In addition to the parameters in the applied system control, such as the heating line and the test temperature at which the floor is cooled, extensions of the system control were also evaluated. Furthermore an attempt was made to adjust the system control within the applied concept in such a fashion that the Energon system could function, as required, without radiators. It was concluded that the Labour Inspectorate offices, both with the applied system control and with the alternative system controls, cannot conform to the requirements with regard to the indoor climate without additional heating being provided by radiators. The causes of this are the large percentage of glass in the south-facing gable (55% of the interior surface, double plain glass with outside sun blinds) and the minor heat load in the rooms. In addition it is doubted whether the walls are truly airtight. Alternative system controls which would improve the indoor climate and energy use when compared to the present control can, indeed, be implemented in the building management system for the Labour Inspectorate.

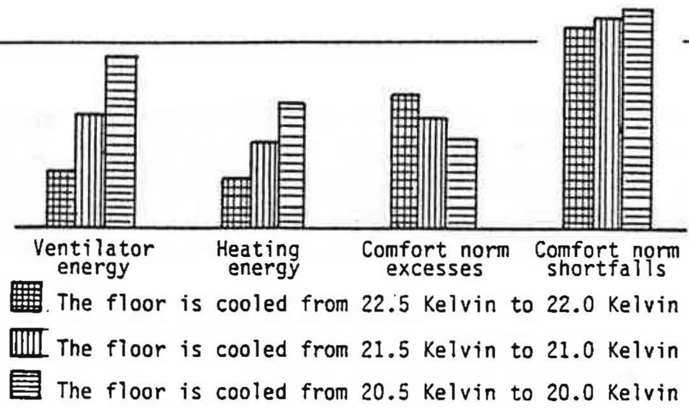

FIGURE 3. Influence of the concrete temperature.

FINAL WORD

The Technical University, Delft has concluded, on the basis of studies, that by using the Energon system for rooms with a high insulation level, a saving in the energy requirements of up to 40% must be possible (this does not include ventilation energy).

From the feasibility study conducted by the Department of Heating and Ventilation Techniques of the Government Buildings Agency it has been shown that energy and cost saving, through the application of the Energon system, can vary greatly from building to building and can even be more unsuitable than a conventional system. The Energon system is therefore not always suitable for every office building. This system is more suitable in countries where there are large temperature differences between day and night, such as Sweden, than it is for the Netherlands where this is not the case.

In the present implementation of the Energon system the air is entirely channelled through the floors. It is possible to imagine situations where it is not desirable that the mass of the floors is used. This has also been noted in Sweden where experience has been gained with a by-pass, which allows the user to channel some of the air directly into the room. The advantages of this by-pass are that the indoor climate can be carefully adjusted and there is an individual control. This development should be further investigated. For this purpose the simulation model which has been developed offers good possibilities because of its demonstrated reliability.

In spite of the results obtained in the new building of the Ministry of Transport and Public Works it could be presumed, on the basis of the practical and model studies conducted by the Dutch Government Buildings Agency, DGMR Advisory Engineers bv and the Technical University, Delft, that the Dutch Government Buildings Agency regards the Energon system in its applied state somewhat critically. Taking into account the field of application, the correct preconditions and a good system control, the Energon system offers the opportunity of achieving a comfortable indoor climate and a reasonable energy use. Other aspects such as the acoustics in the rooms, the flexibility, the maintenance and the investment costs should also be taken into consideration.

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