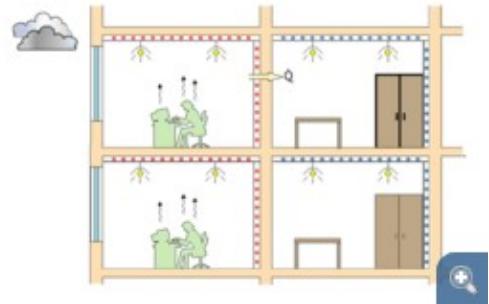


Low-exergy systems in heating and room ventilation technology




Even slight temperature differences can be used for heating or cooling buildings. This involves spatial and temporal temperature potentials. The temperature differences between different areas of a building can be used for heat transfer between rooms which are too warm and rooms which are too cool, so that thermal homogenisation of the building structure can be achieved, even if there are differences in room usage and heat loads. For the utilisation of temporal temperature potentials, latent heat storage systems are being examined by means of computer simulation. Materials with a phase-change temperature similar to the room air temperature can store energy (heat) without large exergy losses. Here, decentralised and centralised systems are being examined, developed, and tested.



Low-exergy systems utilise even slight temperature potentials. Here, the temperature differences between different building areas are used for heating and cooling.

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Technology summary

Term of project	09/2004 bis 08/2007
Technology status	 Prototype Phase
Key aspects	Facade systems, Active cooling, Regenerative + passive cooling, Thermo-active building element systems, Heat / cold storage, Control technology, operational management, building automation

Project description

The objective is to heat and cool rooms using as little exergy as possible. In so doing, conventional chillers are to be avoided, and as-yet unused heat sources and heat sinks are to be used instead. This requires large surfaces which transfer heat, even when temperature differences are slight (capillary tube mats) and heat storage tanks which can effectively store heat at temperatures similar to the room temperature.

Capillary tube mat: A key technology in this regard is the capillary tube mat, as this allows thermal activation of large surfaces within a room (ceilings, walls, floors). Due to the resulting large heat transfer surfaces, the temperature difference between the heat transfer medium and the indoor air can be reduced, whereby as-yet unused heat sources or heat sinks can be used.

Heat transfer: One approach is heat transfer within a building structure. By means of capillary tube technology, heat can be transferred from a room which is too warm (e.g. a conference hall, or a south-facing room) to a room which is too cool (e.g. a north-facing room). In this way, both the energy requirement for cooling, and for heating, could be reduced.

Overnight cooling: Another system approach used is the cooling of rooms with the aid of heat storage tanks. In order to prevent rooms from overheating on warm sunny days, heat can be extracted from the indoor air and transferred to a heat storage tank by means of capillary tube mats installed in walls, ceilings, or floors. For final dissipation of heat to the environment, the natural temperature drop between day and night is used. Thus, the storage tank can be regenerated overnight by means of an outdoor heat exchanger, so that it can again absorb excess heat on the following day.

Latent heat storage tanks: As the heat storage tank also must be operated with slight temperature differences, latent heat storage tanks based on paraffins are used for this application. By means of storage material phase change, latent heat storage tanks absorb very large amounts of heat while remaining at an almost constant temperature. The material's temperature increase when absorbing energy is only very slight, due to the phase-change process, in which the energy is applied as melting enthalpy to melt the paraffin. Only once the paraffin volume within the storage tank has become completely liquid, does the material become noticeably warmer if additional energy is absorbed.

The overnight dissipation of heat into the environment also occurs at an almost constant temperature. Once the solidification point is reached, the paraffin's solidification enthalpy becomes free, and is released into the environment via the outdoor heat exchanger.

Focus

At the Hermann Rietschel Institute at the Technical University of Berlin, the interplay between the room and the system components is represented in a computer, within combined simulations which encompass the building

and the system technology, and is thus adjusted and optimised. Simultaneously, the above-mentioned system approaches are being tested in practice. To this end, two equivalent model rooms were constructed, with an equivalent structure, geometry, and orientation to the sun. The rooms were equipped with capillary tube mats, outdoor heat exchangers, and comprehensive sensor technology. On this basis, detailed examination of the heat transfer between two rooms is possible.

Trox GmbH developed a latent heat storage tank, which is suitable for temperature control of rooms. One model room was equipped with a heat storage tank and capillary tube mats, and hydraulically coupled to the outdoor heat exchanger. The second model room serves as a reference, and has no heat storage tank or thermo-active building systems. Various prototypes were tested and optimised with regard to long-term performance, and production costs. The development goal is a storage tank which is as compact as possible, with high energy density and minimal maintenance requirements, which can be built into parapets, walls, and ceilings. To supplement the latent heat storage systems, compact ventilation devices are being developed, which only require an electrical connection, and which thus enable flexible implementation in existing buildings, and in new buildings. The outdoor air apertures have very compact internal heat recovery and an internal controller.

Imtech Deutschland GmbH developed a facade ventilation device with a latent heat storage tank. Alongside design calculations based on the programming language Modelica, several prototypes of the PCM storage tank module, and of the facade ventilation device, were examined in testing facilities and in a test room. The recorded thermal and flow-related properties of the new facade ventilation device are now the foundation for the development of a suitable control strategy. The overall concept is being assessed in an office construction, numerically, and on the basis of measurements. The 50 PCM modules were developed as hybrid, decentralised ventilation devices for implementation with a centralised air extraction system. The cool night air is channelled into the interior space via ventilation devices, which serves to regenerate the latent heat storage tanks, and to cool the building. On hot summer days, the supply air is cooled, and the rooms warm up much more slowly. The cooling function can operate with circulating air, and supply air.

Success

Comprehensive simulation libraries for the combined simulation of building, system, occupant, and weather were compiled. The construction of the comparison rooms, and of the complicated hydraulic systems, is almost complete. A special testing facility for latent heat storage tanks was built.

Simulations which have already been conducted indicate, on the basis of calculations from the model rooms, that this system approach can potentially reduce the temperature by three to four kelvins (hottest week of the test reference year, location: Berlin). At the same time, the entire system works without conventional chillers, and requires only electrical energy for operation of the circulation pump and control equipment.

The decentralised facade ventilation devices with PCM modules are also proving themselves in a demonstration building in Hamburg.

Milestones

Inauguration of the Imtech building in Hamburg in August 2006, with 50 decentralised facade ventilation devices with PCM modules.

In 2007, Emco Bau- und Klimatechnik GmbH is commencing sale and distribution of the decentralised PCM facade ventilation module, which was developed in cooperation with Imtech GmbH.

Application

A decentralised facade ventilation module with latent heat storage tank is being distributed by Emco Bau- und Klimatechnik GmbH.

This project is funded within the framework »Energy Optimized Building« (EnOB) by the German Federal Ministry of Economics and Technology, on the basis of a decision by the German Bundestag. Get further information at www.enob.info.