COMPARATIVE STUDIES OF HEATING SYSTEMS BY BUILDING SIMULATION INCLUDING CFD

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ABSTRACT

The coupling of simulation methods is an interesting way to get improved or new results concerning thermal conditions in ventilated, heated, and air conditioned rooms. Some results are given for an investigation of a room in a low energy house by building simulation including CFD and the simulation of several heating systems. Comparative studies are done in two different ways. The first way serves to get results about different heating systems concerning thermal comfort and energy consumption and the second one to study the influence of the CFD calculation on the results.

As will be shown there are clear differences as well between the heating systems and configurations as the simulation methods corresponding to the characteristics of the system and the level of approximation.

KEYWORDS

Case studies, CFD, Thermal comfort, Energy, Heating systems

INTRODUCTION

Building simulations are meanwhile established in research and industry as a powerful tool for investigating thermal conditions of a building or a part of a building. A lot of programs are available on the market. Some of them offer the inclusion of the technical equipment for instance the heating system. In this way one can get interesting results about energy consumption of a building and some facts concerning thermal comfort. However, it is impossible to give details on the thermal comfort because some information of the flow field is needed. This information is available if a flow field calculation is done and coupled to the building envelope and the HVAC system if it is installed. But a fully coupled simulation taking into account all interactions between conduction, convection, and radiation is expensive an should be restricted to only one part or one room of a building. If the room of interest is an atrium a coupled simulation is necessary to get reliable results, see Off et al. (1996). For average rooms, like in an office or residential building the situation is not so clear. Therefore we carried out building simulations for a room with several heating systems in comparison to a simulation including CFD.

COMPONENTS AND METHOD OF THE SIMULATIONS

The main simulation part is the thermal building simulation or the thermal room simulation if only one room is regarded. This part includes the thermal conduction within several types of walls, the long wave and solar radiation and the coupling to the outdoor conditions.

As heating systems we can simulate radiators with thermostatic valves, an underfloor heating or an air heating. Radiators are modelled as geometrical objects with a simplified surface. Values for the boundary conditions at the surface of a radiator are got from a thermal balance around the radiator. This leads to a correct representation of the convective and radiative heat transfer by use of a unique surface temperature of the radiator and a reference temperature within the flow field. The mass rate through the radiator is determined by means of the cha-

DISCUSSION

Evaluating the given results one should be always aware of the boundary conditions specified above. Furthermore it should not be overlooked that the values represent only a time period of 8h, from 6.00 a.m. to 2.00 p.m. The simulations are still running and shortly we can evaluate a period of 10 or 12 hours. As mentioned above the wall with the windows is a southwest wall in that case. From 2.00 p.m. until 3.00 p.m. the wheather data provide a period of intensive solar radiation. This may change the relation between the investigated systems and configurations to a certain extent. But such detailed results one can only get by a coupled simulation including CFD.

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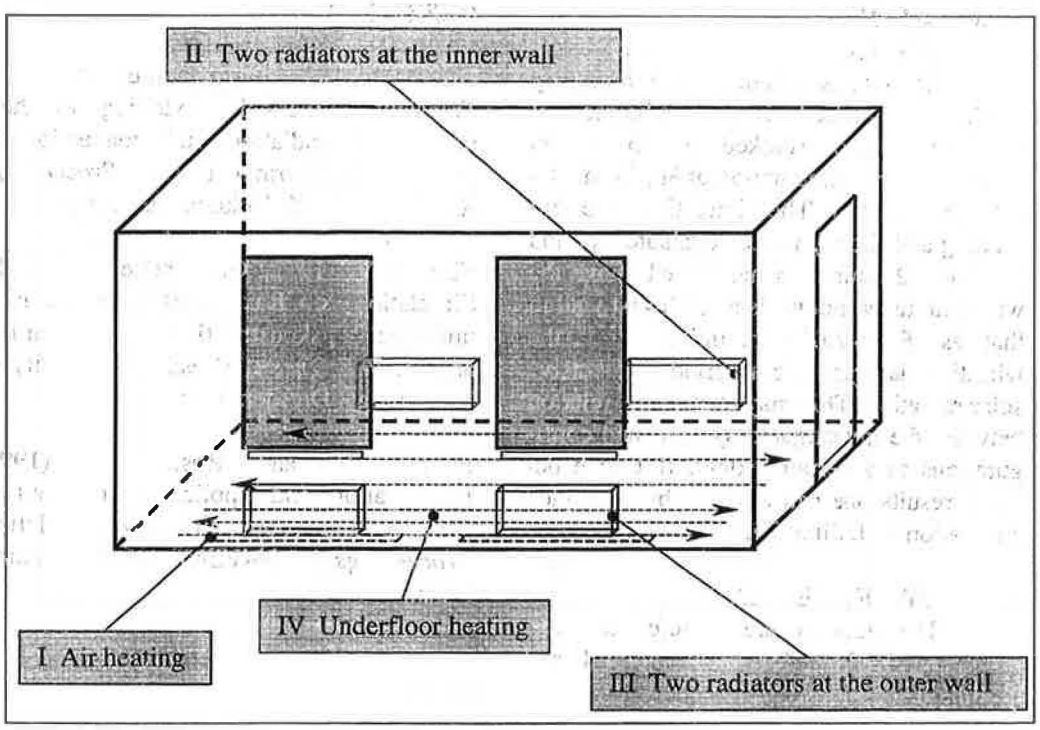

Figure 1: Sketch of the investigated room with several heating systems

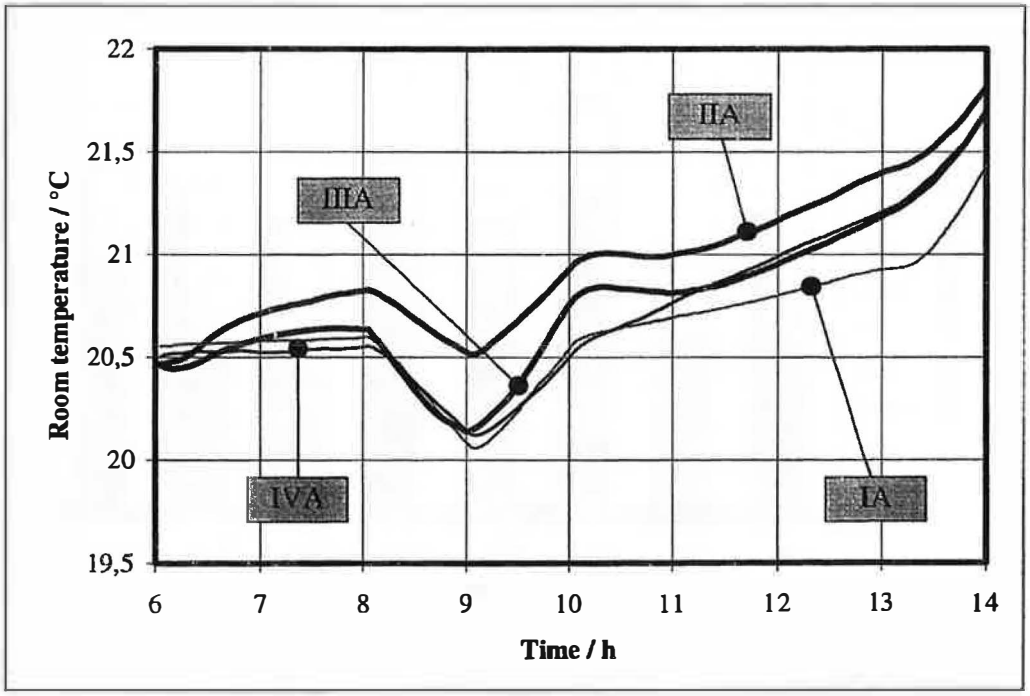

Figure 2: Time dependent progression of room temperature (calculations including CFD)

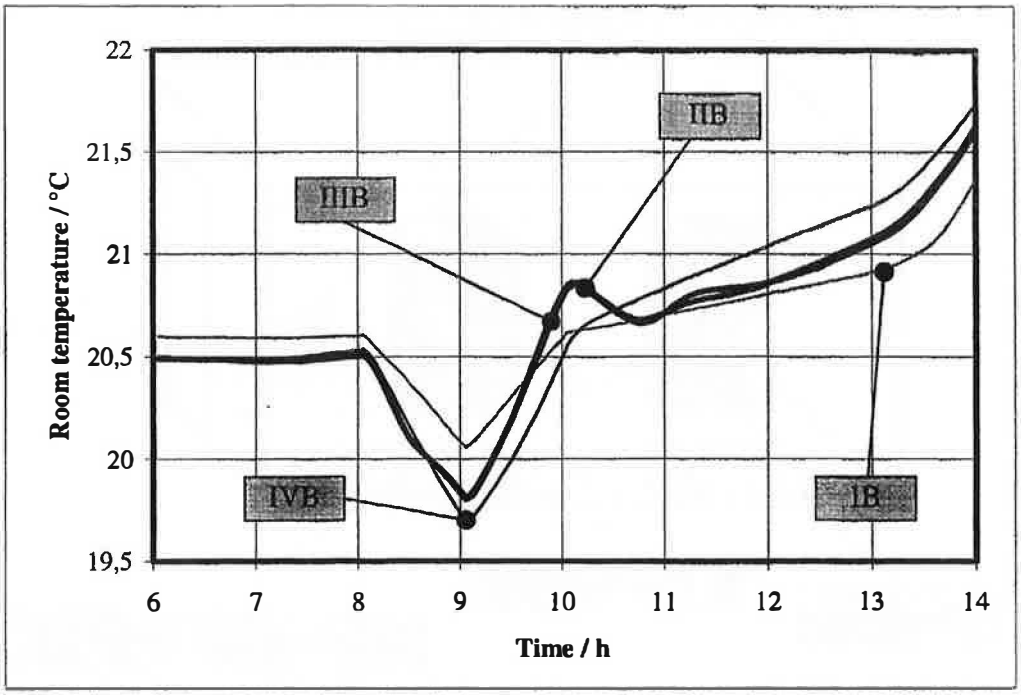

Figure 3: Time dependent progression of room temperature (calculations without CFD)

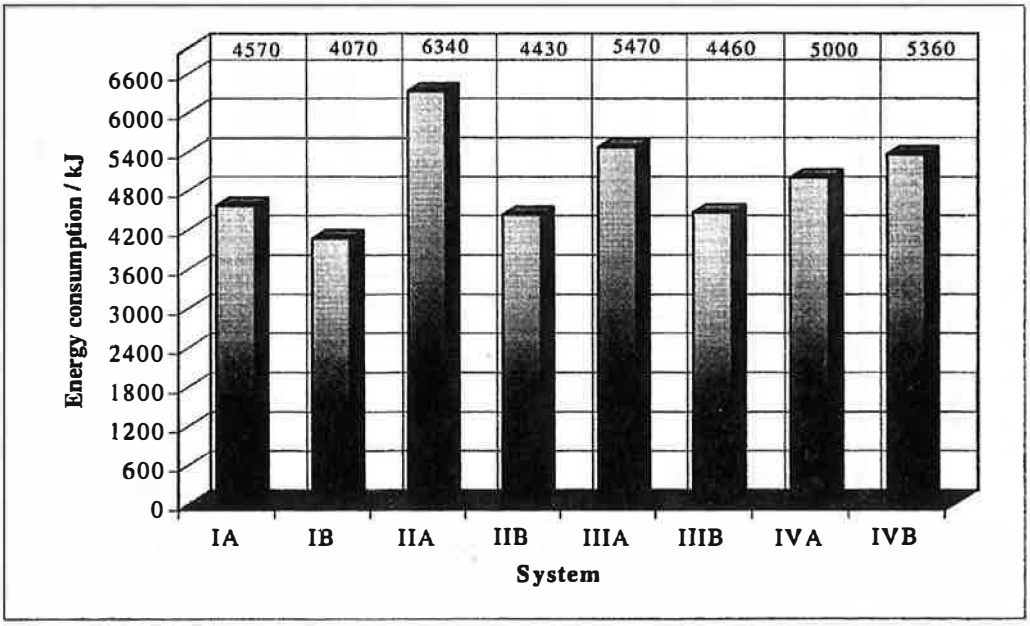

Figure 4: Energy consumption of the heating systems over a period of 8 h