Technical base for separated rooms climate automatic control

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Abstract: *In this paper the problems of separated living rooms climate automatic control and the technical set for the data acquisition are discussed, also as the operational processes, which deal to solve such problems.*

Keywords: smart home, climate control, energy consumption optimization, buildings automation.

1. INTRODUCTION

In accordance with political and economical tendencies there are few possibilities to solve followed problems, which affected a country:

1. Optimization of the energy consumption (exploitation of the potential to save energy as an act against monopolies of the energy traders)
2. Improvement of the old types of produce and Introduction of new possibilities to satisfy the old not released problems as a way to increase the potential of markets.

One of such possibilities is a separated rooms climate automatic control.

Separated control of living rooms by system of heat and ventilation regulation rests itself essentially at new technical possibility, which have emerged owing to the progress in information technique and measurement technique. Problems of the instrumentation application and needs in new research are discussed in the following.

Fig.1 - Front view of the Building in the University of armed forces Munich. Research lab is part links.

There are presented examples from the real house (research lab figure 1) in the text. The single-family house has been built on the area of the University of the federal armed forces Munich in 2000.

2. PHYSICAL CONDITIONS FOR THE SEPARATED THERMAL ROOMS CONTROL

A physical model considers the thermal conditions in the room will be discussed here and as a result the condition requirements for the technology.

The physical models of thermo dynamical processes are based on the energy balance. Equation of the energetic balance in a room can be presented as :

$$Q_H + Q_G \equiv Q_{Gewinne} = Q_{Verluste} \equiv Q_T + Q_L \qquad (2)$$

there:

Q_H - Heat flow to the room from the Heating devices

Q_T - Heat flow due to different surface wall temperature and Air temperature

Q_L - Heat flow due to Air exchange (Heat flow for ventilation)

Q_G - Heat flow due to internal Heat yields (Yields heat flow) $Q_G = Q_S + Q_P + Q_M + Q_C + Q_B$

Q_S - Heat flow due to the solar heating Q_P - Heat flow due to persons, Q_M - Heat flow due to machines, Q_C - Heat flow due to chemical reaction, Q_B - Heat flow due to lighting.

The leading control value Q_H depends essentially on $Q_{Verluste}$ and on the variable disturbance Q_G. The variation of $\Delta Q_{Verluste}$ and ΔQ_G should be compensated through ΔQ_H.

Earlier all Buildings has been conceived so, what $Q_G << Q_{Verluste}$ was. Although an energetic contribution of heat yields flow was important, under the technique devices of control such fact leads to the conditions presented in the formula (3).

$$Q_H >> Q_G \Rightarrow \Delta Q_H + \Delta Q_G \approx \Delta Q_H \qquad (3)$$

Thus one could produce a relatively stable climate in a room during a winter [5], just by control of the whole building depends on slowly changeable outdoors air temperature, and in the same time it can keep down the costs of the construction.

In our time there is a big progress in energy save due to passive reducing of heat leakage (Figure 2). But further passive reducing of heat leakage is not simple, because of consequence, when the formula (3) is not valid.

New boundary condition for the control is the following:

$$Q_{Verluste} \approx Q_G \Rightarrow \Delta Q_H + \Delta Q_G \neq \Delta Q_H \qquad (4)$$

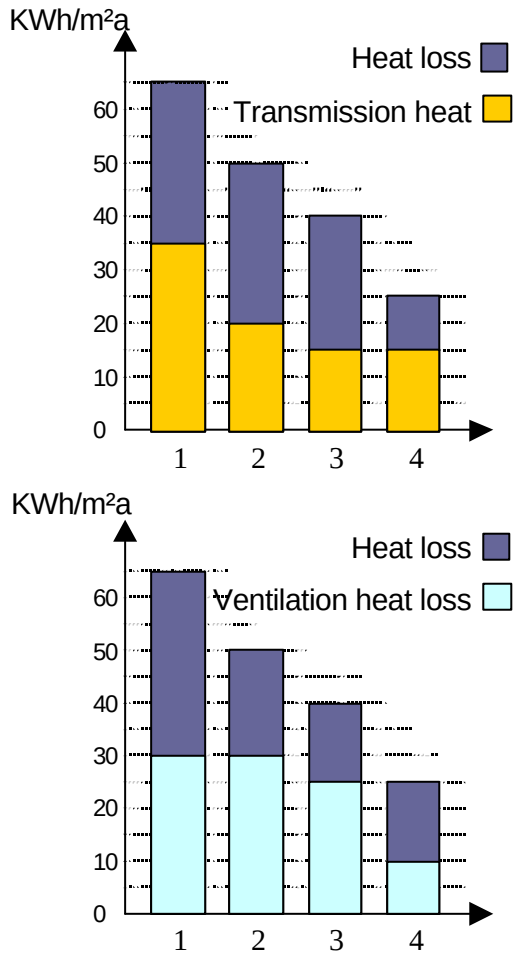

Fig.2 - Energy loss for single family house with ca.130m² useful area.

1. **After Warmeschutzverordnung in Germany 1995 [1]**
2. **After Warmeschutzverordnung in Germany 2000 [2]**
3. **Low energy building (research lab) with standard ventilation (bad rooms-climate condition)**
4. **Low energy building with separated smart heating and ventilation as well as use of heat exchangers.**

According to the formula (4) the heat yields should not be ignored any more. Their value depends on several rooms parameters e.g. from the position of the room, fenestration square, occupancy of the room with electric machines and presence of people etc.

Therefore it is near to impossible to realize a quality climate control in a lot of separated rooms with only one device. The installation of such systems leads to control of one (worst to the determined moment in sense of thermal conditions) room. All other rooms have in this case higher air temperature, which is a reason of energy waste and worse comfort.

Consequently it should be attempted to save energy by means of building shell improvement with separated thermal rooms control.

3. DATA ACQUISITION AND PROCESSING SYSTEM

Comfortable climate [3] is the only one valid criterion for the separated thermal rooms control. In new rooms condition the registration of physical values important for the thermal comfort (not only an air temperature) is an essential task.

This means that a new control system should work as a network between a lot of sensors and actors. A new concept of such system for the private living house has been developed.

The measurement instrumentation in the test house has three main aims:

- Demonstration of the energy saving;
- Determination of the parameters for the physical room model and
- Optimal thermal rooms control.

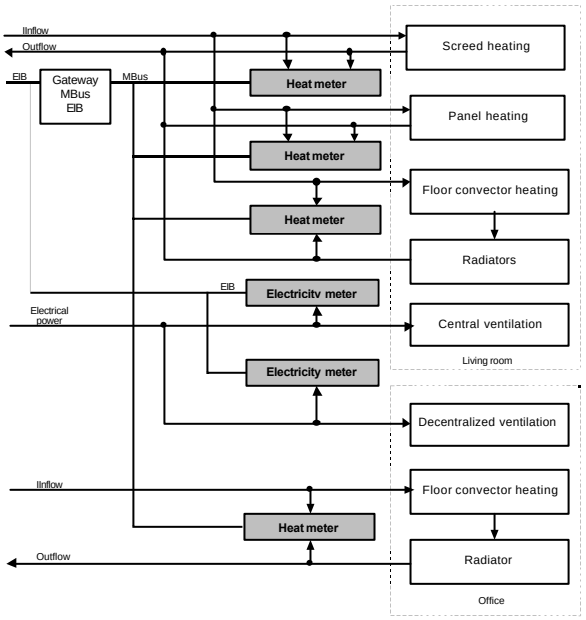

Fig. 3 – Measurement instrumentation for the demonstration of the energy saving.

The consumption of energy in house consists of two big parts – heat energy and electrical energy consumption. The consumption of electrical energy is measured only for the ventilation system and for other devices is calculated as a sum of mean energy

consumption of the single devices. The consumption of the heat energy is measured both for single heating circuit and for whole heat system in the test house. The measuring data is transferred from the heat meters via European Installation Bus (EIB) and M-Bus (Fig 3).

The weather data are very important for the heat flow balance calculation. Therefore the weather station was installed on the test house roof . The following weather parameters are measured:

- Air temperature;
- Air relative humidity;
- Wind speed;
- Wind direction;
- Sun radiation (global and diffuse);
- Precipitation.

For an analysis of the physical room model have been selected two rooms in the test house: the living room and the office with different geometry, location, heat and ventilation systems:

- The office: north side, with radiator and floor convector heating and decentralized ventilation system;
- The living room: south side, with screed heating, panel heating, radiator and floor convector heating and central ventilation system.

The aim of the optimum control is to guarantee the comfort in room. To reach the comfort conditions in a room the following parameters should be consider:

- Mean air room temperature;
- Relative air humidity;
- Mean air velocity;
- Concentration of the carbon dioxide;
- Radiation temperature.

About 200 sensors have been installed in the office on the area of 50 m^2 in order to measure the radiation temperature. It was possible with Dallas Semiconductors DS18B20 temperature sensors. These sensors can be integrated to the network with unique 1-Wite™ interface. On the strength of marketing requirements all instrumentation should be installed either in the building cover or in the standard technical room equipment. Thus, the sensors have been installed in the inlet and outlet pipes of the ventilation system (Fig. 4).

The following parameter are measured:

- Air temperature;
- Air humidity;
- Air flow rate;
- Air CO_2 concentration.

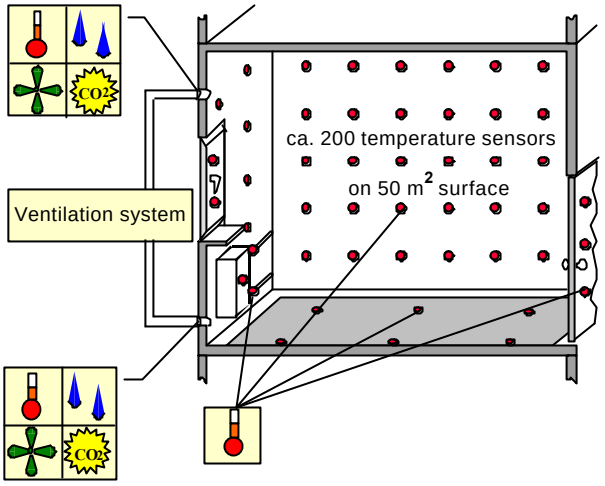

Fig. 4 - Measurements in the office.

The measuring data acquisition and processing system consists of two data loggers for reading data from sensors, control computer, where the data is processed, and backup computer for saving measure database. All this computers are connected to local network with Internet access (Fig. 5).

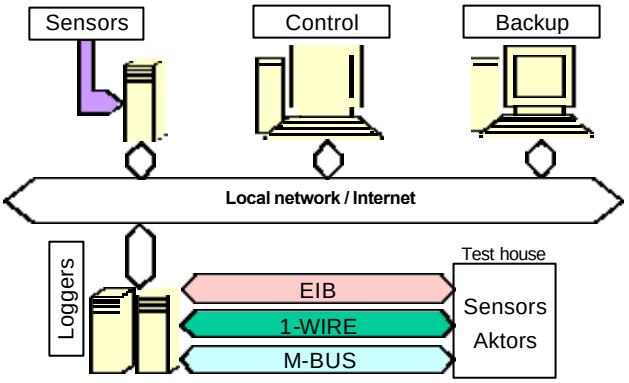

Fig. 5 – System for data acquisition.

Both loggers are based on the Linux operational system. At the same time only one from both loggers acquire the data from sensors, and the second logger observes the first. If the first logger falls out, so the second undertakes its functions.

The sensors, which are connected to the 3 field buses, are scanned by the data logger with defined time intervals. Measuring data is saved in ASCII format on the hard disk and the saved file is transferred via FTP protocol to control computer. Control computer decodes data, write it to the main database and use it for visualization and future processing by the physical room model block. The results from the physical room model block are used by the control block to produce commands for the actors (for instance heater valve). The command file is transferred to the data logger via FTP protocol, which send decoded commands to actors. In the described system can be used more than one control

computer. The main database is saved daily by the backup computer.

Thus, the described data acquisition and processing system contains many different data collection channels and with its redundancy can be a good base for research of optimum measuring dataset for separated room control.

4. SUMMARY AND OUTLOOK

Further heat leakage reduction (outwards of the standard Warmeschutzverordnung in German 2001 [2]) has a lot of problems with the thermal comfort in the room. Additional heat leakage could even be greater than the savings because of users' acts to become better thermal conditions in strong changeable surround (window and door opening etc.) [6], [7].

Improving of technical systems in buildings should be on the way aimed to save heat energy and to protect the comfortable climate in rooms. Separated thermal rooms control in sense of smart heating and ventilation offers good possibility to save energy.

Thus a system for separated rooms' climate automatic control should be a new standard in a low energy building. The thermal comfort must be taken for the realization of new control system as lead value. For this purpose some additional measurements are necessary to be used.

A new concept and realization of data acquisition system has been created and tested in a real house. On its base a lot of different systems configurations for separated rooms' climate automatic control can be realized.

Experiments with this data acquisition system in scientifically configuration (redundancy) showed, that it is reliable. Because such systems are based on the cheep components, it is suitable for using in private house.

5. ACKNOWLEGEMENT

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