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HEATING SYSTEM CONTROL IN AN INTELLIGENT BUILDING

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Summary. The basic issues relating to electric systems design in intelligent buildings have been discussed in the present paper with a particular emphasis on their elements enabling the intelligent heating control in a building.

Key words: intelligent systems, intelligent buildings, electric systems, HVAC systems.

INTRODUCTION

The modern solutions in building management system (BMS) used in HVAC systems result in an improved occupancy comfort as well as much higher optimisation of heating system operation and minimized costs of an object’s operation. Electric heaters are used more and more commonly in the heating systems. The cooling and continuous temperature control is an extremely tiring and arduous effort. Energy saving is an essential element in the scope of proper building policy and energy consumption should be reduced considering its negative impact on the environment and avoidable financial exenditure. It is possible, by means of active methods, directly responding to varying conditions (e.g. control systems) and passive or fixed methods (e.g. thermal isolation).

These goals can be achieved by means of the modern intelligent systems e.g.. EIB TP, Tebis TX and Xcomfort, enabling a wide scope of automatic temperature control in buildings and energy saving for instance by heating mode shutdown at an open window. The wireless control option is also available in these systems. Their advantages consist in the possibility to control objects from any place (remote control mode), simple and user-friendly operation, easy installation, work reliability and safety. Such heating ensures individual temperatures in various rooms, temperature reduction during night and in the absence of occupants.

The systems installed in the buildings shall be integrated together in order to generate the savings. This objective is called “systems integration” and is achieved by the connection of all individual systems together by means of a superordinated building management system – BMS.

The above-mentioned systems are the open type systems. Their principle advantage is the possibility to supply the devices conforming with the system standard by many manufacturers.

THERMAL BALANCE FOR A ROOM

Thermal balance of a room encompasses the following factors:

– heat energy supplied to the object from surrounding area: solar radiation reaching the room;

– heat energy emitted from the room outwards: associated with transmission through the walls, windows, roof and rooms ventilation;

– heat energy generated in the processes occurring in the object and originating from its occupants and equipment.

The contribution of a/m components in the thermal balance of the building depends on many factors:

– architecture of the building: its size and shape of its body
– building localization,
– number of windows and their layout,
– applied insulating materials
– ventilation intensity
– manner of the object operation.

The equation expressing the heating heat can be determined on the basis of a/m factors:

$$Q_{heat} = Q_{walls} + Q_{windows} - Q_{sun} - Q_{man} - Q_{electr.}, \quad (1)$$

where:

$$Q_{walls} = S_{walls} \cdot k_{walls} \cdot (\upsilon_{in.} - \upsilon_{out.}). \quad (2)$$

$$Q_{windows} = S_{windows} \cdot k_{windows} \cdot (\upsilon_{in.} - \upsilon_{out.}), \quad (3)$$

where:

S_{walls}, $S_{windows}$ – surface area of the walls and windows in the room, correspondingly [m^2],

K_{walls}, $k_{windows}$ – heat transfer coefficients for the walls and windows, correspondingly [W/m^{2}K],

$\upsilon_{in.}$,$\upsilon_{out.}$ – temperature in the room and out of the room, correspondingly [K].

Underfloor heating systems are used as a convenient solution in buildings provided with intelligent systems. The maintenance of heat comfort is ensured at the temperature of underfloor heater of 26^{0}C. In accordance with engineering practices and relevant standards, the temperature of the floor must not be higher than 32^{0}C.

The temperature of the floor surface is determined in accordance with the following procedure:

– To determine the specific thermal power for the heater:

$$q_j = \frac{Q_p}{F_g}, [\mathrm{W}], \quad (4)$$

where: Q_p – heat energy demand for the room, [W],
F_g – surface area of the heater [m^2].

– To determine the temperature of the floor from the nomogram $q_j = f(t_p)$, when t_{room}= const.

If the limit temperature of 32^{0}C is exceeded, different type of the heating should be used.

The heating cables are selected by means of the following methodology:

– To determine the thermal power of the cable:

$$Q_{\text{thermal conduction.}} = 1.1 \cdot Q_p, [\mathrm{W}] \, . \quad (5)$$

The coefficient of 1.1 in the Equation [5] corresponds to the thermal power losses of 10% resulting from the loss of heat from the bottom in the room being heated.

– The selection of heating cable for $Q_{heat\ conduction}$ determined before as well as the surface area of the heater F_g from the nomogram $Q_{heat\ conduction} = f(L)$. The nomogram is also used to determine the length of the cable L and layout b. Furthermore, the length of the cables should be minimized and their specific thermal power should correspond to that of the cables supplied by the manufacturers.

– The determination of the corrective coefficient $K_{r\lambda}$, considering the heat resistance of additional coating of the heating panel. The coefficient is determined on the basis of the type of the material covering the heating panel and its thickness d, after the determination of the thermal resistance of the material covering the heating panel R considering the cables spacing b.

– The calculation of the equivalent specific thermal power for the heater:

$$q_z = q_j \cdot K_{rl}, \tag{6}$$

where: q_j – specific thermal power for the heater, [W/m^2],
$K_{r\lambda}$ – corrective coefficient.

– The determination of the actual working temperature of the cable t_k for the equivalent specific thermal power for the heater q_z, the cables spacing b and assumed temperature in the room t_{room}. If the permissible cable temperature of 70^0C is exceeded, the cable with lower specific thermal power should be selected.

The above-presented considerations are associated with the selection of cable. However, the correct design and completion of the building management system is also extremely important for correct operation of the heating system in the building. The heating system should be provided with proper control solution e.g. with 2 – position control mode preferred in case of underfloor heating to ensure the required control quality for the user. Individual temperature controllers used in the rooms make it possible to improve the occupancy comfort and to reduce the costs of operation. The thermostat should be installed in the area ensuring the correct temperature measurement in the room e.g. its location next to the thermal energy source may result in incorrect functioning and underestimated average temperature in the room.

TEMPERATURE CONTROL METHODS

HVAC system encompasses the heating, ventilation and air – conditioning functions enabling the application of the following:

– Individual control of parameters in individual rooms i.e. the so called local control mode;

– Occupancy time programs for the uses of the rooms being controlled, i.e. the so called time control mode.

The basic subdivision of the temperature control methods consists in the location of the control elements on the object and in the location of the source transmitting the control messages to the heating system.

The purpose of the controller being an essential part of HVCA automatic control, is to determine the manner of the heater valve control on the basis of the temperature measured by and received from the sensor installed in the room and on the basis of the task setting.

Temperature OPEN/ CLOSED control

The heater valves are positioned in two extreme positions in this control mode i.e. OPEN (100%) / CLOSED (0%).

Pulse Width Modulation Control (PWM)

The heater valves are positioned in two positions in this control mode i.e. OPEN (100%) / CLOSED (0%). However, their control algorithm is more complex and consists in the integrated operation of the following elements: controller, binary output and valve.

The task of the controller is to compare the temperature setting with the measured temperature. The control curve is determined on the basis of these data (0%-100%). Then the pulses are formed with the width proportional to the pulse value on the beginning of the pulsing period.

Local control mode – valve with thermostatic head

The local control mode consists in the installation of a mechanical or electronic valve or a valve with thermostatic head on the heater or the energy supply to the heater. The valve is provided with the scale in Celsius degrees or with proper settings to enable the saving of the positions required / temperatures selected by the user. Two valves and “night / day” selector are frequently used solutions.

The valve with thermostatic head is provided with the following operation options:

– ON/ OFF mode; used to shut off the hot water or power supply when the „upper limit temperature” is detected and to restore power supply when the „lower limit temperature” is detected. The temperature fluctuations in the room are equal to 0,5^{o}C.

– Infinitely variable control mode consisting in the reduction of energy supply to the level sufficient to maintain desirable temperature.

– Adjustable heater operation mode consisting in the change of heating elements’ number

– Safety mode; protection against freezing used to prevent the freezing of the room.

Another example of the local control mode is the control system for the heating system provided with dispersed energy sources in form of the radiators and gas heaters integrated with several temperature measurement points. Therefore the local temperature fluctuations can be directly responded by each energy source.

PI control (proportional – integrating) mode

The use of electro – valves with controlled opening degree is required for this control algorithm. It is possible to connect the electro – valves directly to EIB control bus and also to simplify the installation. The valve opening / closing degree is transmitted as a single bit value (0-255). This type of the control is an infinitely variable control mode and ensures the maintenance of pre – set parameters in the most precise manner.

Central control mode

In the central control mode it possible to achieve the temperature change in all or in arbitrarily selected heating points by means of:

- Remote operation mode, used among others in electric heaters.
- Changed heat volume supply to the heating points, used in central heating systems.
- Cyclic switching ON and OFF of the energy supply to the electric heaters.

DEVICES USED IN HVAC SYSTEMS

Nowadays, high standard buildings are more and more often provided with electric bus installations. The European Bus Installation system prevailing in the European market has an advantage enabling the integration of all systems provided in the building, including also HVAC, in an easy manner.

The building heating by means of EIB systems encompasses the local temperature control in the rooms by means of the room temperature controllers. Furthermor, the limitation of heating in case of an open window in a room is possible by means of this automatic control system. The remote control mode and heating devices status displays are possible by means of the application of Internet gate enabling remote access to the electric system. Therefore, the images transmission in real time is possible after the connection with video module. The messages are automatically sent by the Internet gate via E-mail in case of any events and / or alarms.

The connection with the Internet gate can be established in the following manner:
– By means of LAN using the browser and its known IP address or,
– Connection via www.domoport.de (browser).

The safety procedures similar to those being used in the Internet banking are applied when using the remote control mode for an intelligent electric system. All pages are coded (SSL protocol) and 3 – level authorization level is provided.

The Internet gate may be applied in the commercial applications e.g. power supply systems, heating, ventilation, air conditioning as well as in residential buildings e.g. to extend the capabilities of the already existing systems, remote access to the already existing safety systems, remote monitoring of the summer resort houses and remote monitoring of whole – year houses.

CONCLUSIONS

The engineering and legal issues associated with several fields of science and technology are encountered by a designer of the heating systems for intelligent buildings. The basis for the proper design solution is the correct classification of those issues based on their detailed analysis to be used as the criteria of the equipment selection. Owing to the specific and unique features of every object, the implementation of readily available solution without their critical evaluation and functionality checking on the case by case basis would be an extremely risky behaviour on the part of the designer.

Owing to diversity of the classification factors (encompassing the scope between the climatic conditions and specific requirements for the object to be designed) the knowledge possessed by the designer in the scope of heating engineering, except for the selection of intelligent system elements and their programming.

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