Project of control system of thermal comfort

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Abstract: Parameters of interiors are very important for comfort, for energy consumption and cost of utilizing of buildings. There are using some different principles and exists big conservatism. New access in the project of system of thermal comfort is solving it newly. It uses new standards and new view using the knowledge of this category. The project solves measurement system, control system and describes the differences between new and conservative accesses. The measurement system deals about new measurement of medium radiation temperature and standard measurement of temperature and moisture of air, flow of air in interiors. The control system is projected by new technique a give the opportunity the optimal comfort with minimum of cost for energy.

Key-Words : thermal comfort, measurement, control, mean radiation temperature, moisture, flow of air, interior

1 Introduction

Comfort environment of men in interiors is not simple problem in the work, relax and home environment. Formatting this environment is solid with connection of solving other kind of comfort: light comfort, noise comfort, quality of air comfort and others.

The current conservative solving has a lot of problems and absence of quality parameters of interior for example for hygienic and physiologic conditions for men. Very important is utilizing measurement and control subsystems for new project solving.

2 Current stage of solving

The first idea to do research the problem by us started up on 1999. The first period of research was during years 2000 up to 2001. There was choice a access according to mathematical models of standards ISO 7730 a ISO 7726. The results of this period are summarized in [5,6,7,8,9]. The main argument is that the voted way is right, that there were confirmed technical, scientist and economical efficiencies. But the main problem was measurement the medium radiant temperature of ambient (next only abbreviation SRT).

The next period was till up to 2004. Its activities were applying to develop of measurement of the SRT. The base outputs were presented in [11]. The thirty period is fallen up to current time. There is project of complex system.

3 Definition of thermal comfort

The strategy of project is built in a model “PMV” . There is defined that thermal energy from body does out according to physical activity, clothing, parameters of ambient: air temperature, air moisture, air flow and surface temperature of interior areas. The problem is showed in fig. 1.

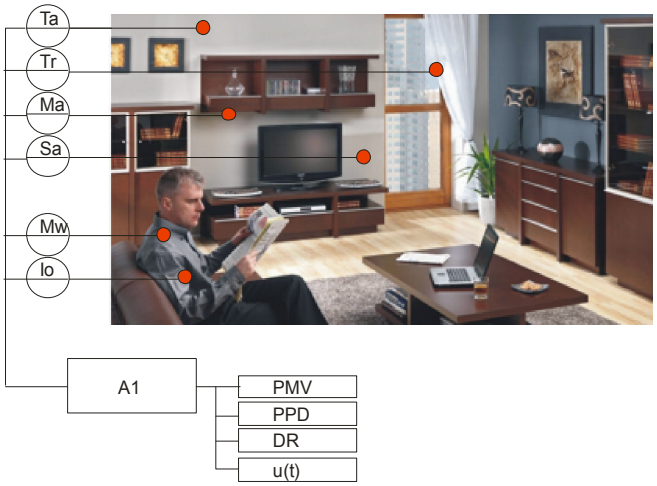

Fig.1 Scheme of thermal comfort in interior(Ta-air temperature, Tr-radiation temperature, Ma- air moisture, Sa-air flow, Mw-physical activity, Io-clotting, A1-control unit, PMV+PPD+DR-parameter of thermal comfort, u(t)-control value)

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The PMV model was defined by [4] and it is a base of the standards [1,2,3]. The formula of the model is:

$$PMV = (0{,}303e^{-0{,}036M} + 0{,}028)\{(M-W) + U_1 + U_2 + U_3\} \quad (1)$$

where is:

$$U_1 = -0{,}00305[5733 - 6{,}99(M-W) - p_a] - 0{,}42[(M-W) - 58{,}15]$$

$$U_2 = -0{,}000017.M(5867 - p_a)$$

$$U_3 = U_{3a} + U_{3b}$$

$$U_{3a} = -0{,}0014M.(34 - t_a) - f_{cl}.h_c.(t_{cl} - t_a)$$

$$U_{3b} = -0{,}0000000396.f_{cl}.\left[(t_{cl} + 273{,}15)^4 - (\overline{t_r} + 273{,}15)^4\right]$$

$$t_{cl} = t_{cla} + t_{clb}$$

$$t_{cla} = 35{,}7 - 0{,}028(M-W) - I_{cl}.f_{cl}.h_c.(t_{cl} - t_a)$$

$$t_{clb} = -I_{cl}.0{,}0000000396.f_{cl}\left[(t_{cl} + 273{,}15)^4 - (\overline{t_r} + 273{,}15)^4\right]$$

$$h_c = 2{,}38(t_{cl} - t_a)^{0{,}25} \; pro h_c > 12{,}1.\sqrt{v_{ar}} \quad \text{or}$$

$$h_c = 12{,}1.\sqrt{v_{ar}} \; pro ... h_c > 2{,}38(t_{cl} - t_a)^{0{,}25}$$

$$f_{cl} = 1 + 1{,}290.I_{cl} \; ... pro ... I_{cl} \le 0{,}078 m^2 °C/W \quad \text{or}$$

$$f_{cl} = 1{,}05 + 0{,}645.I_{cl} \; ... pro ... I_{cl} > 0{,}078 m^2 °C/W$$

M energy output from body (W/m2), 1 met= 58,15 W/m^2
W using energy of body (W/m^2)
f_{cl} proportion dressed and undressed part of body
I_{cl} thermal resistance of clotting (m^2.K/W), 1 clo=0,155 (m^2.K/W)
t_a air temperature (°C)
$\overline{t_r}$ medium radiation temperature (°C)
v_{ar} air flow (m/s)
p_a partial pressure of water steam (Pa)
h_c thermal convection (W/m^2.K)
t_{cl} temperature of clotting (°C).

The index *PPD* is calculated:

$$PPD = 100 - 95.e^{-U_5}$$

where is $U_5 = 0{,}03353.PMV^4 + 0{,}2179.PMV^2$ (2)

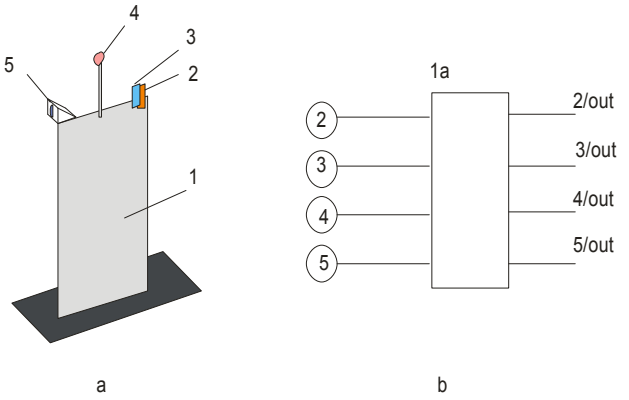
The air flow around of body has index *DR* – draught rating:

$$DR = (34 - t_a)(v - 0{,}05)^{0{,}62}.(0{,}37.v.Tu + 3{,}14) \quad (3)$$

where is:
t_a air temperature
v air flow (m/s)
T_u turbulence (%), rate of standard deviation local flow to average flow.

4 Measuring subsystem

The subsystem is projected for measuring loops of air temperature, medium radiant temperature, air moisture and air flow [7,8,9]. The other two parameters (physical activity as energy output from body and thermal resistance of clotting) constant input. (1)



(5)

Fig.2 Measuring subsystem (a- devices: 1- body, 2- air temperature sensor, 3-air moisture sensor, 4-air flow sensor, 5-radiant temperature sensor; b-scheme of measuring loops: 1a-electronic unit, */out- output signal of sensors)

The measuring loops are using the standard sensor and special arrangement. The sensor of air temperature (position 2 in fig. 2) is a type of NTC thermistor, of air moisture (position 3 in fig. 2) is capacitive sensor, of air flow (position 4 in fig. 2) is NTC thermistor with special arrangement and of radiant temperature (position 5 in fig. 2) is thermopile sensor with special arrangement too.

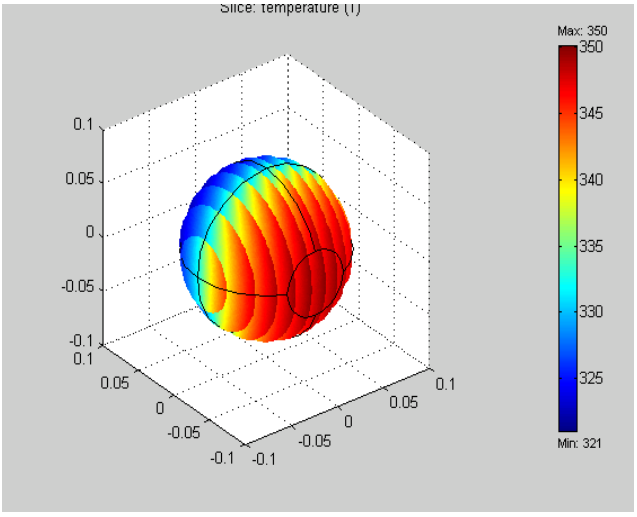


Fig.3 The view on analyzed spherical thermometer in MATLAB-Simulink.

The measuring subsystem doesn´t use a measurement with black spherical thermometer. There was made a study its parameters and feature.

The results of the study were presented in [11]. The result parameters are not optimal. There is a big time constant and a big responsibility to outdoor trouble situation. The studying was making with help of simulating system MATLAB-Simulink. In fig. 3 is showed a situation, where is irradiated one side of the sphere. The surface temperature and temperature of indoor sensor are is very different.

The electronic unit (position 1a in fig. 2) is used to signal condition. It gives the voltage output signal for four parameters.

5 Projecting of evaluation unit

A next part of project is solving of a evaluation unit. The unit isn´t standard it had to be solved. The project scheme is in fig. 4.

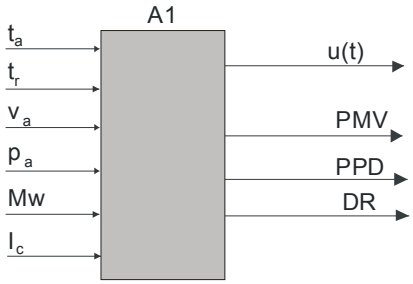


Fig. 4 Block scheme of evaluation unit

The measured parameters of ambient are the first four inputs [10]. The value of Mw (physical activity) and Ic (thermal resistance of clothes) are hand inputs.

The unit is projected in two versions. The first version is a construction using a embedded microcontroller. There is suitable for battery operation. The other version is unit from field of date acquisition units and notebooks. There was made a theoretical model in Matlab-Simulink and Excel. A reason was to test a simulate the evaluation. The Simulink´s scheme is in fig. 5.

The outputs of subsystem are value of PMV, PPD, DR and control signal u(t). The first three output are information, they visualize the parameters of the environment. The output u(t) is continuing signal with signification the loop.

The scheme of evaluation unit into a control loop for interior is in fig. 6.

According to the inputs (2-air temperature, 3-medium radiation temperature, 4-air moisture, 5-air flow and Mw-physical activity, Ic-paramter of cloth) the evaluation unit gives the outputs of information indexes PMV/PPD/DR) and control signal u(t). The signal controls the inputs energy into interior (in summer cooling energy, in winter heating energy) a change the air temperature in the interior so, that the thermal comfort is PMW=0. In a extreme can be Ta=<20°C and in other extreme will be Ta>20°C.

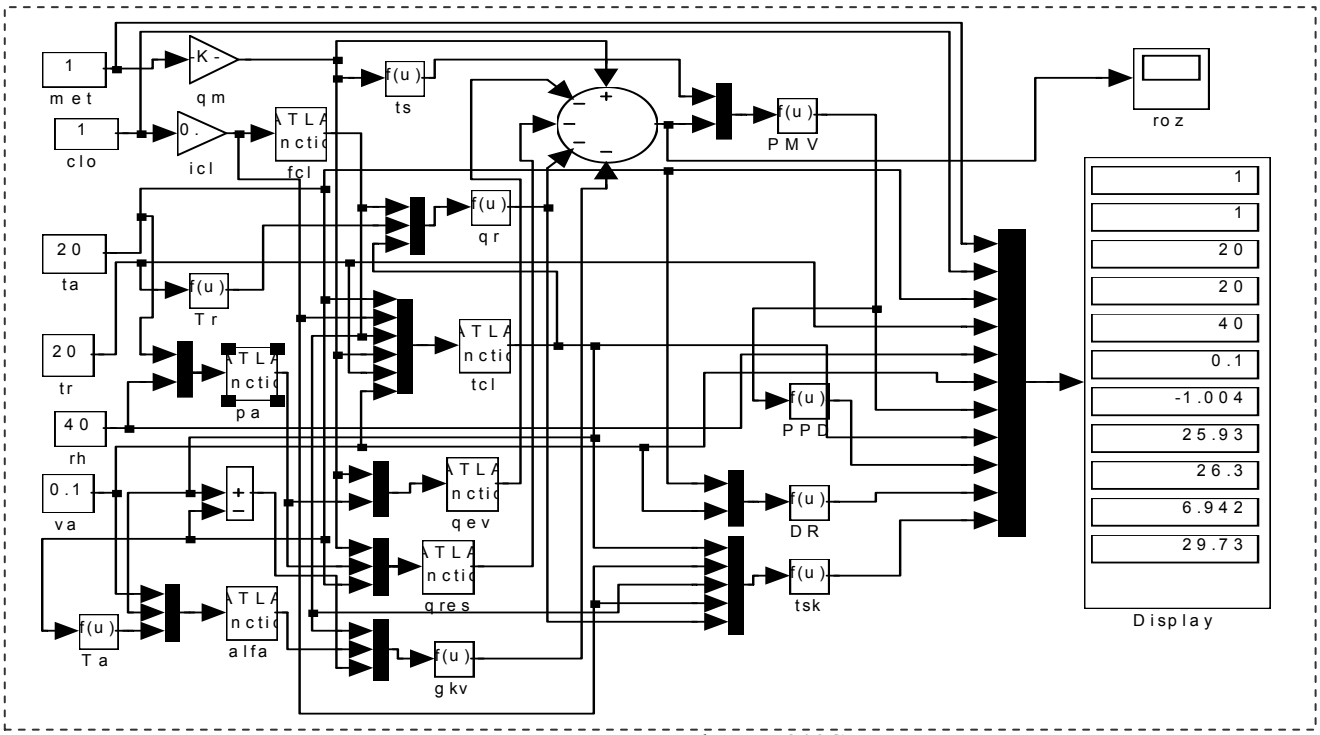


Fig.5 Model of evaluation in the MATLAB-Simulink.

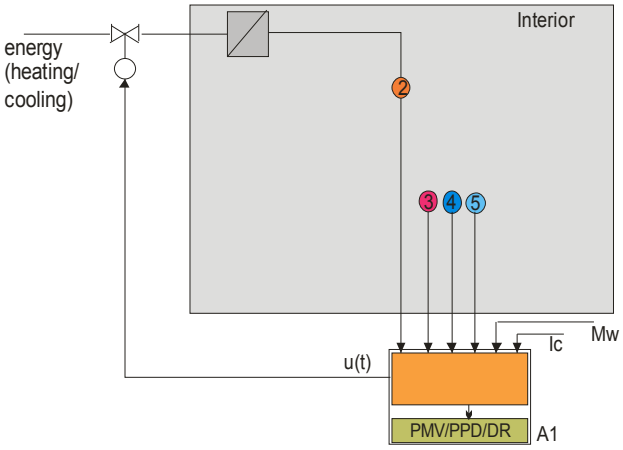


Fig.6 Scheme of control loop with evaluation unit

7 Conclusion

The project follows the results reached from research work until 2009. There is used the solving of new measuring equipment, the block measurement for four parameters of interior. There is projected the evaluation unit with information and control functions.

The results of research confirm the right solving and guaranteed the success of projects. According to the projecting there is a possibility to offer the modern solving of thermal comfort in the interiors by standard ISO .

8 Acknowledgement

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