Microclimate Control System Development

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Abstract. The microclimate is a fundamental factor of a healthy life, and is determined by the temperature, humidity and speed of moving air. These factors determine whether a person feels a thermal comfort. The three factors are to some extent interchangeable with regard to the feeling of comfort and thermoregulation needs. The system for monitoring and controlling microclimate parameters based on OMRON software and hardware was developed and investigated. Control system considers internal and external ambient factors related to the regulation process. Microclimate standards have been studied. The technical standards for the temperature conditions required for comfort are not applicable to all regions owing to the different climatic conditions and clothing traditions. A combinational machine for controlling the microclimate parameters is constructed. This system was designed for climate control of a building and for increasing or lowering the temperature and relative humidity. The program is developed in the language of ladder diagrams.

1. Introduction
The room microclimate for comfortable existence and work of a person or functioning of the equipment indoors is understood as a set of parameters which includes air temperature, relative humidity and speed of the movement of air [1]. The optimal relative humidity for normal human life is considered to be 40-60%, the optimal air temperature is considered to be 22-24°C. To maintain a given level of microclimate and indoor air quality, it is necessary to develop a regulatory system with economical consumption and power for the specified operating conditions.

2. Equipment and devices used in the studies
The theoretical part of the article was developed using the General systems theory and the theory of Finite-state machine. In practical implementation the authors use the microcontroller OMRON [2]. We study monitoring and control of microclimate with the OMRON CX-Programmer version 7.1 and CX-Designer software version 2.1.

3. The results of the study and their discussion
3.1. The main factors that describe the dynamics of microclimate

We analyze the parameters of microclimate as a system that implements the mapping of the family of sets $X_2(t)$ onto the set of elements $X_1$, i.e.

$$X_1RX_2(t).$$

We divide the subset of all elements of $X_2(t)$ into an index greater, or smaller, or equal to $j$:

$$X_j^+(t) = \left[ x_2(t_{j_1}), x_2(t_{j_2}), \ldots, x_2(t_j) \right] \quad X_j^-(t) = \left[ x_2(t_{j_{j_1}}), x_2(t_{j_{j_2}}), \ldots, x_2(t_{j_j}) \right]$$

Then,

$$X_j^iR_i[X_j^+(t), X_j^-(t)]$$

We decompose $R$ into binary relations $R^i$ and $R^0$:

$$X_iR^0[X_j^+(t), C^j] \quad C^iR^i[X_j^-(t)]$$

The set $X_i$ depends on the intermediate term $C$ and does not depend on the elements $X_2(t)$ for which the index is less than or equal to $j$. Elements $C$ describe the state of the system. The state of the object is characterized by a steady $R^i$ or unsteady $R^0$ mode, depending on which the requirements for managing the object change. As available operated parameters to monitor the process of microclimate it is offered to use: a purge air and air conditioning [3]. The ratio of control actions and monitoring parameters is shown in Table 1.

| №  | Operating influences       | Notation | Monitoring Notation | Notation |
|----|----------------------------|----------|---------------------|----------|
| 1  | Fan                       | V        | Dust (mg/m$^3$)    | P        |
| 2  | Fan                       | V        | Moisture (%)        | W        |
| 3  | Air conditioning          | K        | Temperature ($^\circ$C) | T        |

A structural diagram of the control system model presented below (figure 1).

![Figure 1. A block diagram of the system management.](image)

3.2. Research on the relationship between multidimensional control tasks

The relationship between the monitoring parameters is defined by the binary relations $R$ which can be understood as functional relations, preferences, sequences and others reflecting the essence of the relationship (figure 2) [4].
3.3. Analysis of the combinational diagram

In order to develop a combination scheme of operational control, a truth table was constructed, taking into account the influence of the dominant parameters, deviation of the specified values from the norm and control actions (table 2).

Table 2. Truth table.

| Sensors for monitoring of parameters | Equipment management | Emergency Signal (z) |
|-------------------------------------|----------------------|---------------------|
| Temperature (T)                     | Fan (V)              | Air conditioning (K) |
| Moisture (W)                        |                      |                     |
| Dust (D)                            |                      |                     |

| Temperature (T) | Moisture (W) | Dust (D) | Fan (V) | Air conditioning (K) | Emergency Signal (z) |
|-----------------|--------------|----------|---------|----------------------|---------------------|
| 0               | 0            | 0        | 0       | 0                    | 0                   |
| 0               | 0            | 1        | 1       | 0                    | 0                   |
| 0               | 1            | 0        | 1       | 0                    | 0                   |
| 0               | 1            | 1        | 1       | 0                    | 0                   |
| 1               | 0            | 0        | 0       | 1                    | 0                   |
| 1               | 1            | 0        | 1       | 1                    | 0                   |
| 1               | 1            | 1        | 1       | 1                    | 0                   |
| 1               | 1            | 1        | 1       | 1                    | 1                   |
3.4. Synthesis of combinational logic circuits

To obtain logical equations of the equipment operation we have received a minimal disjunctive normal form using Karnaugh map (Table 3–5) [7].

| WP | 00 | 01 | 11 | 10 |
|----|----|----|----|----|
| T  |  0 |  1 |  1 |  1 |

\[ V = WPT \]

| WP | 00 | 01 | 11 | 10 |
|----|----|----|----|----|
| T  |  1 |  0 |  0 |  0 |

\[ z = T \lor V \lor P \]

| WP | 00 | 01 | 11 | 10 |
|----|----|----|----|----|
| T  |  0 |  0 |  0 |  0 |

\[ K = T \]

On the basis of the obtained logical equations Ladder Diagram has been developed using the Omron software and hardware complex (figure 4) [10].

![Simulation of fan activation.](image)

**Figure 4.** Simulation of fan activation.

The operational panel developed by means of program CX-Designer is shown on Figure 5. The system can operate in both automatic and manual modes.
4. Conclusions
In the work the actual problem to develop the automated control system for microclimate is solved, and the following main results are obtained:

1. Relationship of the internal factors affecting the microclimate are identified; now it is possible to develop a matrix of States, taking into account the cross coupling of control loops.

2. Synthesis of the finite automaton performed on the hardware-software complex Omron is carried out.

References
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