METHOD OF AIR PARAMETERS CONTROL WHILE PROCESSING IN AIR-HANDLING UNITS OF HVAC SYSTEMS

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ABSTRACT

Based on theoretical and experimental tests it was determined that the thermodynamic balance condition in the working space of air-handling units (AHUs) of heating, ventilating and air-conditioning systems (HVAC systems) is entirely defined by the humidity potential of the final parameters of air and water: Θ = constant [1]. This makes it possible to put forward a new thermodynamic method for the analysis and calculation of heat and moisture exchange in AHUs of HVAC systems [2,3]. It was established, that condition "Θ = constant of final environmental parameters" is an index of the optimal mode of operation of the AHU, in which high thermodynamic efficiency is achieved in the processes of heat and moisture exchange. The data collected made it possible to work out a new method of air parameters control for processing in AHUs. The features of processes of heat and moisture exchange in AHUs are considered in this paper, and also the results of the proposed method of regulating the moisture content of incoming air.

LIST OF SYMBOLS

- t_1 initial temperature of air (°C)
- d_1 initial absolute humidity of air (g/kg)
- Θ_1 initial humidity potential of air (°B)
- t_2 initial temperature of water (°C)
- Θ_2 initial humidity potential of water (°B)
- B spraying factor (kg/kg)
- G_1 air flow rate (m^3/h)
- G_2 water flow rate (m^3/h)
- p partial pressure (Pa)
- φ relative humidity (%)
- I enthalpy (kJ/kg)

INTRODUCTION

In the operation of AHUs (when initial parameters of environments or modes of operation are being changed), there is a need for regulation of one of the parameters (for example, moisture content of incoming air) for the purpose of maintaining its constant value. To analyze the progress of heat and moisture exchange processes, a model of the working space of the AHU (fig. 1) was used, including distinctive zones (L_I, L_{II}, L_{III}) of air parameters change through the AHU.

The progress of heat and moisture exchange processes is characterised by hygrothermal and hydrodynamic conditions of interaction in the working space of AHUs. Hygrothermal conditions are determined by the combination of initial parameters of the air (t_1, d_1, Θ_1) and water (t_2, Θ_2), and hydrodynamic ones are determined by a ratio of air flows (G_1) and water (G_2), i.e. by value of a spraying factor (B).

The combination of conditions determines the operational mode, including the direction of change of air parameters through the AHU (fig. 2). In fig. 2 the possible directions of air processing (lines A and D) are shown, ensuring achievement of required final values of air parameters (t_1', d_1', Θ_1') in a mode of cooling and drying of air. Thus the final parameters of air and water are on a line Θ = constant. When the process goes along the line A (fig. 2), a calculated regime of air processing takes place through the AHU: cooling and drying.

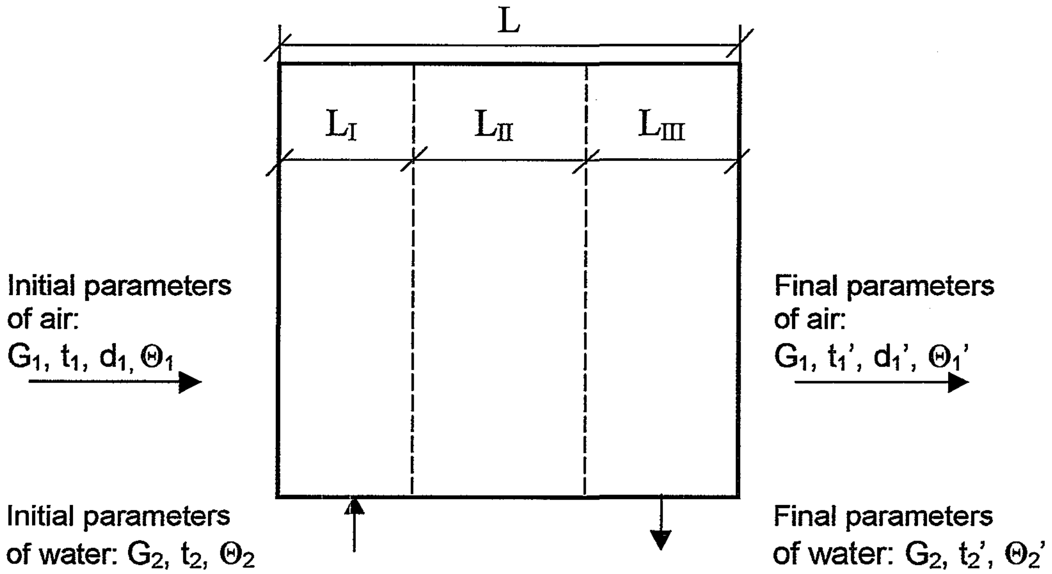

Figure. 1. Model of air-handling unit of HVAC systems

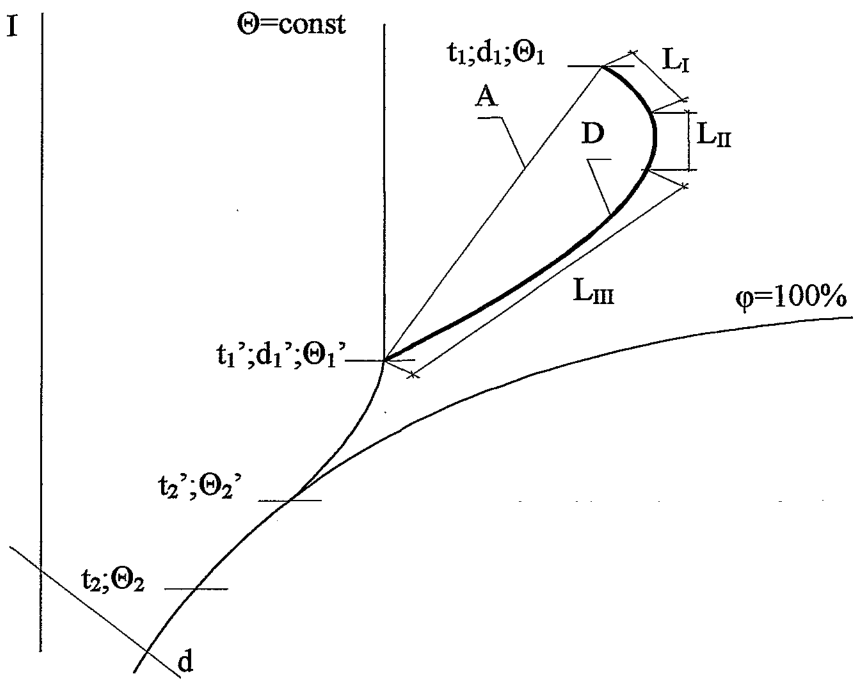

Figure 2. Changing parameters of air and water in air-handling unit at the I-d-Θ diagram

In real conditions the processes take place along the curve D (fig. 2), where one can see that the calculated regime of processing of air takes place only in the third zone (L_{III}). Thus in the first zone (L_I) the process is close to I = constant, and in the second zone (L_{II}) it is close to d = constant. Thus the direction of the processes determines the efficiency of work of the AHU.

METHOD AND RESULTS

Taking into account features of the processes of heat and moisture exchange in AHUs in fig.3 curves (A, B and C) represent the changing air parameters in an AHU. These curves are presented for the purpose of realizing regulation of moisture content (d_1) of air at the AHU outlet. The change of air parameters in curve A takes place at some value of spraying factor $B_1=G_2/G_1$ and constant values of initial parameters of air (t_1, d1, Θ_1) and water (t_2, Θ_2).

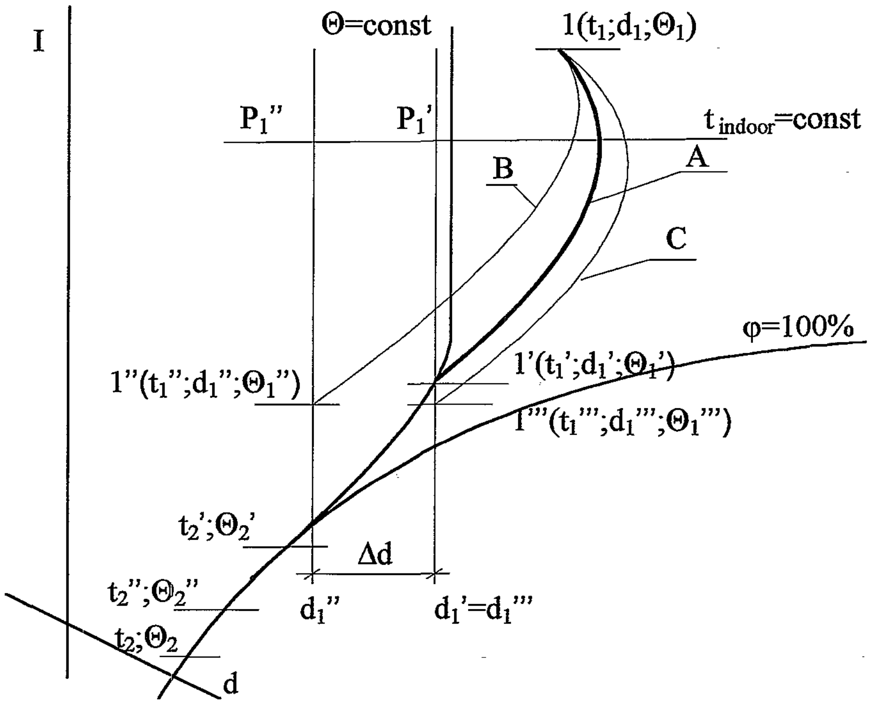

Figure 3. Method of air parameters control on I-d-Θ diagram.

When increasing a spraying factor to the value B_2 ($B_2>B_1$) under the same initial parameters of air and water a direction of process on curve B (fig.3) will take place but final air parameters will be moved to the point 1″ and will have values t_1'', d1″, Θ_1''. The deviation of moisture content of inlet air from the calculated value d1 to lower values: $\Delta d = d_1'' - d_1'$ will happen.

But if at the same time as increasing spraying factor to B_2 one increases the initial temperature of water to t_2'' ($t_2''> t_2$), then the air processing will go along curve C (fig.3) to parameters t_1''', d1‴, Θ_1''' that will ensure an achievement of the required value of inlet air moisture content $d_1'''= d_1'$. Thus, as a result of proportional increase of initial temperature of water and increase of a spraying factor the constancy of final moisture content of incoming air is ensured and precision of air parameters in a working space is increased. The regulation of parameters of incoming air if its moisture content deviates to larger values is made in the same way.

To confirm the theoretical conclusions and to validate the proposed method of regulation, a series of experiments was conducted in an injection spray chamber. The results of one of the series are presented in Table 1.

Table 1. Results of tests of the spraying chamber

Test	Air parameters, °C				Parameters of water, °C		B, kg/kg	moisture content of final air parameters, d (g/kg)
	initial		final		initial	final		
	t_1	t_m'	t_1'	t_{m1}''	t_2	t_2'		
1	26.1	19.5	15.1	14.0	6.9	11.0	1	9.5
2	26.0	19.4	12.8	12.3	6.8	10.5	1.49	8.7
3	26.1	19.4	14.0	13.5	8.9	11.8	1.5	9.5

The analysis of the experimental results demonstrates that, with an increase of the spraying factor to 1.49 kg/kg (test 2) at constant initial air parameters, the moisture content of final air parameters decreases down to 8.7 g/kg. To support the required value of moisture content (d1=9.5 g/kg) the initial temperature of water was increased to 8.9°C (Table 1, test 3). Thus, the possibility of air moisture content regulation at the outlet of the spray chamber is achieved with a proportional change of initial parameters of water and spraying factor.

DISCUSSION

In this paper a method of air parameters control (moisture content in particular) is presented, taking into account thermodynamic features of the processes of heat and moisture exchange in AHUs. This method is designed on the basis of humidity potential theory and taking into consideration thermodynamic legitimacies, the progress of heat and moisture exchange processes in AHUs.

The presented method allows regulation of air parameters controlling the processes of heat and moisture exchange, providing optimal conditions of interaction. The factor of optimal conditions preservation in the working space of an AHU is the preservation of the condition Θ = constant of air and water parameters at the outlet of an AHU.

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