A DYNAMIC MODEL OF LITHIUM BROMIDE WATER ABSORPTION REFRIGERATOR

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Abstract: The results of the development of a mathematical model of the dynamics of lithium bromide water absorption refrigerator and its automatic control system. Using a mathematical model for the design and operation of the automatic control system machine allows absorption reasonably specify the settings of the system improve the management of its cooling capacity.

Keywords: absorption chiller, mathematical model, transfer functions, automatic control system

1 INTRODUCTION

Absorption machines are thermally activated and for this reason, large amount of input (shaft) power is not required. In this way, where power is expensive or unavailable, or where there is waste, gas, geothermal or solar heat available, absorption machines provide reliable and quiet cooling (ASHRAE, 1997). A number of refrigerant-absorbent pairs are used, for which the most common ones are water-lithium bromide and ammonia-water. Given the shortage and high cost of electric capacity, growing demand for environmentally friendly refrigerants increasingly used for Lithium Bromide Water Absorption Refrigerator (LBWAR), allowing to reduce capital, operating costs and shorten construction or commissioning of new power systems [1,2].

2 ANALYSIS OF RECENT ACHIEVEMENTS AND PUBLICATIONS

It is known that the purpose of managing the process of absorption is to maintain the material and heat balances absorption system. Changes in cost components of the circulating solution is output values of previous technological devices, and, consequently, the processes of absorption. At present there are models of the dynamics of vehicles LBWAR [3-8], but they do not establish a connection between the majority of managers, disturbances and control parameters, and of little use in the development of control systems with cooling capacity LBWAR.

3 MATHEMATICAL MODEL OF DYNAMICS OF LITHIUM BROMIDE WATER ABSORPTION REFRIGERATOR

In order to improve management efficiency LBWAR developed a mathematical model of the dynamics and automatic control system for an absorption machine. In conducting research LBWAR used with single-stage steam generation of the working substance and combined heat and mass transfer in the absorber (Fig. 1). Generator, a condenser, absorber, evaporator shell and tube are made horizontal. The generator was flooded type evaporator and absorber, and - irrigation. The generator and condenser, and absorber and evaporator combined in pairs in the blocks. The main indicator of changes in heat load is LBWAR chilled water temperature at the outlet of the

evaporator, refrigerant - water absorber - lithium bromide (LiBr). Cooling capacity is controlled by changing LBWAR concentration, directed from the generator to the absorber, and is achieved by changing the steam. The number of circulating in the system LiBr solution, depending on the cooling capacity can be varied in proportion to steam flow. In conducting research used specifications LBWAR steam heated single-stage recovery solution. As a source of energy is used heating water vapor low pressure of 0.2 - 0.7 atm. Ratings and characteristics of LBWAR -600P: cooling power - 685 kW; steam consumption - 1610 kg/ h; consumption of cooling water - 118m³/h; cooling water flow - 176 m³/h; circulation rate of flow of 10 kg/s; heat transfer coefficient for the absorber - 0.9, evaporator - 0.95, condenser - 0.9, generator - 0.85. The main design parameters are also available in Fig. 1.
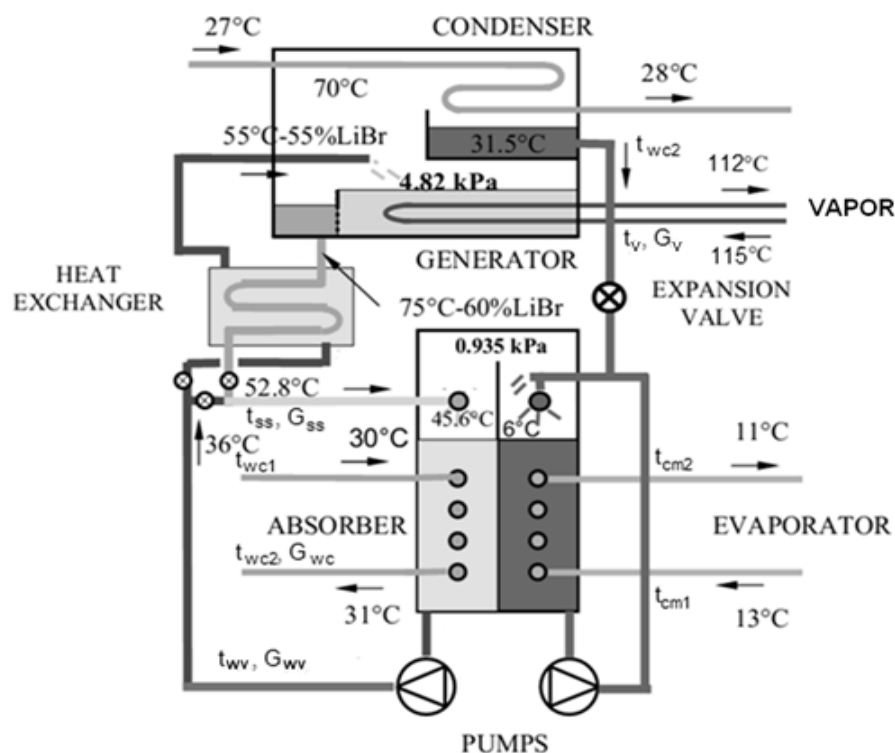

Fig. 1. LBWAR single-stage steam generation of the working substance

The dynamic characteristics of vehicles LBWAR depend on the direction of flow diagrams, and the design of the temperature distribution along the direction of flow, etc. Dynamics of the apparatus described by a nonlinear system of differential equations in partial derivatives. The solution of equations yields the transcendental transfer functions, whose use in the engineering practice of automatic control is difficult. In calculations of processes in the system of regulation appropriate to use a simplified model of the object of regulation, taking into account the recommendations of [9]. To simplify the determination of dynamic characteristics of the devices used LBWAR transformation of partial differential equations into an equivalent linear differential equations using the methods of direct and inverse Laplace transform. Symbols used in formulas are summarized in Table. 1 and 2.

An idea of the physical picture of the transition process, the temperature change is a strong solution and refrigerant vapor after a sudden perturbation of the parameters at the input generator LBWAR. Accepted the

following assumptions: the highest temperature of the solution at the end of its boiling temperature in the generator is equal to the heating source, the state of steam coming from the generator to the condenser is determined by the average concentration and pressure, the boiling solution, and the coefficients of heat transfer (at a steady flow of media), and specific heat are constant both in space coordinates and time.

Table 1. Symbols of the parameters

Designation of the parameter	Name of parameter
c	specific heat capacity
G	mass flow rate
k	thermal conductivity
M	mass
n	exponent (0,184)
t	temperature
W(p)	transfer function through the transfer of control actions and disturbances
α	heat transfer coefficient
F	active area of the heat transfer surface
τ	time

Table 2. Subscripts

Subscript	Symbol
ab	absorber
gn	generator
ev	evaporator
cd	condencer
w	water
v	vapor
wv	water vapor
ss	stronstrong solution
wc	wednesday cooling
cm	cooling medium
ws	weak solution
r	refrigerant
1, 2	parameter input and output

The estimated equations to analyze the characteristics of the generator obtained from the equations of heat balance and heat transfer. Generator circuit is considered lumped parameters. As output parameters taken a strong solution temperature and vapor refrigerant at the outlet of the device. The equations of heat balance and heat transfer to the generator, as well as the Laplace transform allows to describe its dynamic properties of a step change in inlet temperature steam (Δt_v), steam flow (ΔG_v), the temperature of the weak solution (Δt_{ws}) and flow (ΔG_{ws}) for steady state operation the following system of equations

$$\frac{\alpha_{m.gn} \cdot F_{gn} \cdot M_{gn}}{G_{gn.v}} \cdot \frac{d t_{gn.v}}{d\tau} = k_{gn} \cdot F_{gn} \cdot \Delta t_{v.1} - \left(\frac{k_{gn} \cdot F_{gn}}{2} + \right.$$

$$+ G_{ws} \cdot c_{ws}) \cdot \Delta t_{ws} + \frac{k_{gn} \cdot F_{gn} \cdot t_{ws} \cdot c_{ws}}{4 \cdot G_v \cdot c_v} \cdot \Delta G_{ws} - \left(\frac{k_{gn} \cdot F_{gn} \cdot G_{gn.v}}{2 \cdot G_v} + \right.$$

$$+ \frac{k_{gn} \cdot F_{gn}}{2} - G_{gn.v} \cdot c_v) \cdot \Delta t_{gn.v};$$

(1)

$$\frac{\alpha_{m.gn} \cdot F_{gn} \cdot M_{gn}}{G_{ss}} \cdot \frac{d t_{ss}}{d\tau} = k_{gn} \cdot F_{gn} \cdot \Delta t_{v.1} + \left(\frac{k_{gn} \cdot F_{gn}}{2} + \right.$$

$$+ G_{ws} \cdot c_{ws}) \cdot \Delta t_{ws} + \frac{k_{gn} \cdot F_{gn} \cdot t_{ws} \cdot c_{ws}}{4 \cdot G_v \cdot c_v} \cdot \Delta G_{ws} - \left(\frac{k_{gn} \cdot F_{gn} \cdot t_{ss} \cdot c_{ss}}{2 \cdot G_v \cdot c_v} + \right.$$

$$+ \frac{k_{gn} \cdot F_{gn}}{2} - G_{ss} \cdot c_{ss}) \cdot \Delta t_{ss};$$

$$T'_{gn.1} \cdot \frac{d t_{gn.v}}{d\tau} = k_{gn.1} \cdot \left(T_{gn.2} \cdot \frac{d G_v}{d\tau} + \Delta G_v \right) - \Delta t_{gn.v};$$

$$T''_{gn.1} \cdot \frac{d t_{ss}}{d\tau} = k_{gn.2} \cdot \left(T_{gn.2} \cdot \frac{d G_v}{d\tau} + \Delta G_v \right) - \Delta t_{ss}$$

After transformation of (1), reflecting the dynamic properties of the generator via $\Delta t_{gn.1}(p){\rightarrow}\Delta t_{gn.v}(p)$, $\Delta G_v(p){\rightarrow}\Delta t_{gn.v}(p)$, $\Delta t_{ws}(p){\rightarrow}\Delta t_{gn.v}(p)$, $\Delta G_{ss}(p){\rightarrow}\Delta t_{gn.v}(p)$ and $\Delta t_{v.1}(p){\rightarrow}\Delta t_{ss}(p)$, $\Delta G_v(p){\rightarrow}\Delta t_{ss}(p)$, $\Delta t_{wv}(p){\rightarrow}\Delta t_{ss}(p)$, $\Delta G_{wv}(p){\rightarrow}\Delta t_{wv}(p)$, his model has the form

$$\Delta t_{gn.v}(p) = W'_{gn.1}(p) \cdot \Delta t_{v.1}(p) - W'_{v.2}(p) \cdot \Delta t_{ws}(p) +$$

$$+ W'_{gn.3}(p) \cdot \Delta G_{ws}(p) + W'_{gn.4}(p) \cdot \Delta G_v(p);$$

(2)

$$\Delta t_{ss}(p) = W''_{gn.1}(p) \cdot \Delta t_{v.1}(p) + W''_{v.2}(p) \cdot \Delta t_{ws}(p) +$$

$$+ W''_{gn.3}(p) \cdot \Delta G_{ws}(p) + W''_{gn.4}(p) \cdot \Delta G_v(p)$$

The dynamic properties of the condenser for steady-state operation at step changes in inlet temperature of refrigerant vapor ($\Delta t_{r.v}$), its flow rate ($\Delta G_{r.v}$), cooling water temperature ($\Delta t_{wc.1}$) and flow (ΔG_{wc}) are described by

$$\frac{\alpha_{m.cd} \cdot F_{cd} \cdot M_{cd}}{G_{r.v}} \cdot \frac{d t_{r.v}}{d\tau} = k_{cd} \cdot F_{cd} \cdot \Delta t_{wc.1} - \left(\frac{k_{cd} \cdot F_{cd} \cdot G_{r.v}}{2 \cdot G_{wc}} + \frac{k_{cd} \cdot F_{cd}}{2} - G_{r.v} \cdot c_w \right) \cdot \Delta t_{r.v} +$$

$$+ (\frac{k_{cd} \cdot F_{cd}}{2} + G_{gn.v} \cdot c_{w.v}) \cdot \Delta t_{gn.v} + \frac{k_{cd} \cdot F_{cd} \cdot t_{gn.v} \cdot c_{w.v}}{2 \cdot G_{wc} \cdot c_w} \cdot \Delta G_{gn.v};$$

(3)

$$T_{cd.1} \cdot \frac{d t_{r.v}}{d\tau} = k_{cd.1} \cdot \left(T_{cd.2} \cdot \frac{d G_{wc}}{d\tau} + \Delta G_{wc} \right) - \Delta t_{r.v}$$

After transformation of equation (3), reflecting the dynamic properties of the condenser through the $\Delta t_{gn.v}(p){\rightarrow}\Delta t_r(p)$, $\Delta G_{gn.v}(p){\rightarrow}\Delta t_{r.v}(p)$, $\Delta t_{wc.1}(p){\rightarrow}\Delta t_{r.v}(p)$ and $\Delta G_{wc}(p){\rightarrow} \Delta t_{r.v}(p)$, the machine model has the form

$$\Delta t_{r.v}(p) = W_{cd.1}(p) \cdot \Delta t_{gn.v}(p) + W_{cd.2}(P) \cdot \Delta t_{wc.1} + W_{cd.3}(p) \cdot \Delta G_{gn.v}(p) - W_{cd.4}(p) \cdot \Delta G_{wc}(p) \qquad (4)$$

The dynamic properties of the evaporator at step changes at the input temperature of cooling water ($\Delta t_{cm.1}$) and flow (ΔG_{cm}), temperature of the refrigerant (Δt_r) and flow (ΔG_r) are described by

$$\frac{\alpha_{m.ev} \cdot F_{ev} \cdot M_{ev}}{G_{cm}} \cdot \frac{dt_{cm.2}}{d\tau} = \left(\frac{k_{ev} \cdot F_{ev}}{2} - G_{cm} \cdot c_w \right) \cdot \Delta t_{cm.1} - \left(\frac{k_{ev} \cdot F_{ev}}{2} - \frac{k_{ev} \cdot F_{ev} \cdot G_{cm} \cdot c_w}{2 \cdot G_{ev} \cdot c_{wv}} - G_{cm} \cdot c_w \right) \cdot \Delta t_{cm.2} +$$

$$+ \left(\frac{k_{ev} \cdot F_{ev} \cdot G_r \cdot c_w}{2 \cdot G_{ev} \cdot c_{wv}} + k_{ev} \cdot F_{ev} \right) \cdot \Delta t_r - \frac{k_{ev} \cdot F_{ev} \cdot t_{cm.1} \cdot c_w}{2 \cdot G_{ev} \cdot c_{wv}} \cdot \Delta G_{cm};$$

$$T_{ev.1} \cdot \frac{dt_{cm.2}}{d\tau} = k_{ev.1} \cdot \left(T_{ev.2} \cdot \frac{dG_r}{d\tau} + \Delta G_r \right) - \Delta t_{ev.2}; \qquad (5)$$

$$\frac{\alpha_{m.ev} \cdot F_{ev} \cdot M_{ev}}{G_{ev}} \cdot \frac{dt_{ev}}{d\tau} = k_{ev} \cdot F_{ev} \cdot \Delta t_{cm.1} - \left(\frac{k_{ev} \cdot F_{ev}}{2} - \frac{k_{ev} \cdot F_{ev} \cdot G_{ev} \cdot c_{wv}}{2 \cdot G_{cm} \cdot c_w} + G_{ev} \cdot c_{wv} \right) \cdot \Delta t_{ev} +$$

$$+ (G_r \cdot c_w - \frac{k_{ev} \cdot F_{ev}}{2}) \cdot \Delta t_r + \frac{k_{ev} \cdot F_{ev} \cdot t_r}{2 \cdot G_{cm}} \cdot \Delta G_r;$$

$$T_{ev.1}'' \cdot \frac{dt_{ev}}{d\tau} = k_{ev.1}'' \cdot \left(T_{ev.2}'' \cdot \frac{dG_{cm}}{d\tau} + \Delta G_{cm} \right) - \Delta t_{ev}$$

After transformation of (5), reflecting the dynamic properties of the evaporator through the $\Delta t_r(p) \rightarrow \Delta t_{cm..2}(p)$, $\Delta G_r(p) \rightarrow \Delta t_{cm..2}(p)$, $\Delta t_{cm.1}(p) \rightarrow \Delta t_{cm.2}(p)$ and $\Delta G_{cm}(p) \rightarrow \Delta t_{cm.2}(p)$, $\Delta t_r(p) \rightarrow \Delta t_{ev}(p)$, $\Delta G_r(p) \rightarrow \Delta t_{ev}(p)$, $\Delta t_{cm.1}(p) \rightarrow \Delta t_{ev}(p)$ and $\Delta G_{cm}(p) \rightarrow \Delta t_{ev}(p)$, the machine model has the form

$$\Delta t_{cm.2}(p) = W_{ev.1}(p) \cdot \Delta t_r(p) - W_{ev.2}(p) \cdot \Delta G_{cm}(p) + W_{ev.3}(p) \cdot \Delta t_{cm.1}(p) - W_{ev.4}(p) \cdot \Delta G_r(p); \qquad (6)$$

$$\Delta t_{ev}(p) = W_{ev.1}''(p) \cdot \Delta t_r(p) + W_{ev.2}''(p) \cdot \Delta t_{cm.1}(p) + W_{ev.3}''(p) \cdot \Delta G_r(p) - W_{ev.4}''(p) \cdot \Delta G_{cm}(p)$$

Using the known equations for the statics of the absorber, we define the transfer functions that characterize its dynamic characteristics with step changes at the input temperature of cooling water (Δt_{wc1}) and flow (ΔG_{wc}), the temperature of refrigerant at the evaporator outlet (Δt_{ev}) and flow (ΔG_{ev}), a strong solution temperature (Δt_{ss}) and flow (ΔG_{ss})

$$\frac{\alpha_{m.ab} \cdot F_{ab} \cdot M_{ab}}{G_{ws}} \cdot \frac{dt_{ws}}{d\tau} = k_{ab} \cdot F_{ab} \cdot \Delta t_{wc.1} + \left(\frac{k_{ab} \cdot F_{ab}}{2} - G_{ev} \cdot c_{wv} \right) \cdot \Delta t_{ev} +$$

$$+ \left(\frac{k_{ab} \cdot F_{ab}}{2} - G_{ss} \cdot c_{ss} \right) \cdot \Delta t_{ss} - \left(\frac{k_{ab} \cdot F_{ab} \cdot G_{ws} \cdot c_{ws}}{4 \cdot G_{wc} \cdot c_w} - \frac{k_{ab} \cdot F_{ab}}{2} - G_{ws} \cdot c_{ws} \right) \cdot \Delta t_{ws} - \qquad (7)$$

$$- \frac{k_{ab} \cdot F_{ab} \cdot t_{ss} \cdot c_{ss}}{2 \cdot G_{wc} \cdot c_w} \cdot \Delta G_{ss} + \frac{k_{ab} \cdot F_{ab} \cdot t_{ev} \cdot c_{wv}}{2 \cdot G_{wc} \cdot c_w} \cdot \Delta G_{ev};$$

$$T_{ab.1} \cdot \frac{dt_{ws}}{d\tau} = k_{ab.6} \cdot \left(T_{ab.2} \cdot \frac{dG_{wc}}{d\tau} + \Delta G_{wc} \right) - \Delta t_{ws}$$

After the transformations (7), reflecting the dynamics of the evaporator through the $\Delta t_{wc.1}(p) \rightarrow \Delta t_{ws}(p)$, $\Delta G_{wc}(p) \rightarrow \Delta t_{ws}(p)$, $\Delta t_{ev}(p) \rightarrow \Delta t_{ws}(p)$, $\Delta G_{ev}(p) \rightarrow \Delta t_{ws}(p)$, $\Delta t_{ss}(p) \rightarrow \Delta t_{ws}(p)$, $\Delta G_{ss}(p) \rightarrow \Delta t_{ws}(p)$, the machine model has the form

$$\Delta t_{ws}(p) = W_{ab.1}(p) \cdot \Delta t_{wc.1}(p) + W_{ab.2}(p) \cdot \Delta t_{ev}(p) + W_{ab.3}(p) \cdot \Delta t_{ss}(p) - W_{ab.4}(p) \cdot \Delta G_{ss}(p) + \tag{8}$$
$$+ W_{ab.5}(p) \cdot \Delta G_{ev}(p) - W_{ab.6}(p) \cdot \Delta G_{wc}(p)$$

For equations (2,4,6,8) calculated transfer functions are defined $W'_{gn.1}(p)...W'_{gn..4}(p)$, $W''_{gn.1}(p)...W''_{gn..4}(p)$, $W_{cd.1}(p)...W_{cd..4}(p)$, $W'_{ev.1}(p)...W'_{ev..4}(p)$, $W''_{ev.1}(p)...W''_{ev..4}(p)$, $W_{ab.1}(p)...W_{ab.6}(p)$ is included in them the time constants $T'_{gn.1}$, $T''_{gn.1}$, $T_{gn.2}$, $T_{cd.1}$, $T_{cd.2}$, $T_{ev.1}$, $T_{ev.2}$, $T''_{ev.1}$, $T''_{ev.2}$, $T_{ab.1}$, $T_{ab.2}$ and transmission coefficients. From the results of calculations that the time constants and transmission coefficients of the transfer functions are not fixed numerical values determined by the

variable costs of transportable media G_v, G_{wv}, G_{ss}, $G_{gn.v}$ and appropriate control actions.

The transfer functions in (2, 4, 6, 8) are typical for first-order inertial link, however, this system can be regarded as consisting of parts of infinitely high order. The true behavior of the system characterizes the intermediate state between the inertial system and the continuum. With this approach to devices LBWAR as the objects of regulation is appropriate of the following generalized form of the transfer functions of the equation model (2, 4, 6, 8)

$$W(p) = \frac{k}{T_1 \cdot p + 1} \cdot e^{-T_2 \cdot p}$$

The resulting dynamic equation sets (2, 4, 6, 8) are the mathematical model LBWAR. Such an idea is acceptable for use in solving problems of stability and stabilization of the

parameters for output devices. Holistic model, derived on the basis of models of devices LBWAR (2, 4, 6, 8) has the form

$$\Delta t_{cm.2}(p) = W_1(p) \cdot \Delta t_{s.1}(p) - W_2(p) \cdot \Delta t_{wc.1}(p) + W_3(p) \cdot \Delta t_{cm.1}(p) + W_4(p) \cdot \Delta t_r(p) +$$
$$+ W_5(p) \cdot \Delta t_{ss}(p) + W_6(p) \cdot \Delta G_v(p) - W_7(p) \cdot \Delta G_{wc}(p) - W_8(p) \cdot \Delta G_{cm}(p) + W_9(p) \cdot \Delta G_r(p) +$$
$$+ W_{10}(p) \cdot \Delta G_{wv}(p) - W_{11}(p) \cdot \Delta G_{ss}(p) + W_{12}(p) \cdot \Delta G_{gn.v}(p) + W_{13}(p) \cdot \Delta G_{ev}(p)$$

where
$$W_1(p) = W_{ev.1}(p) \cdot W_{cd1}(p) \cdot W'_{gn.1}(p);$$
$$W_2(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.1}(p) - W_{ev.1}(p) \cdot W_{cd.1}(p);$$
$$W_3(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.2}(p) \cdot W'_{ev.2}(p) - W_{ev.3}(p);$$
$$W_4(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.2}(p) \cdot W'_{ev.1}(p);$$
$$W_5(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.3}(p);$$
$$W_6(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.4}(p);$$
$$W_7(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.6}(p) - W_{ev.1}(p) \cdot W_{cd.4}(p);$$
$$W_8(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.2}(p) \cdot W'_{ev.4}(p) + W_{ev.2}(p);$$
$$W_9(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.2}(p) \cdot W'_{ev.3}(p) - W_{ev.4}(p);$$
$$W_{10}(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.3}(p);$$
$$W_{11}(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.4}(p);$$
$$W_{12}(p) = W_{ev.2}(p) \cdot W_{cd.3}(p);$$
$$W_{13}(p) = W_{ev.1}(p) \cdot W_{cd.1}(p) \cdot W'_{gn.2}(p) \cdot W_{ab.5}(p)$$

In accordance with a mathematical model of the dynamics of LBWAR developed the functional diagram (Fig. 2) automatic control

system (ACS). ACS is designed to maintain the required temperatures of cooling water outlet LBWAR.
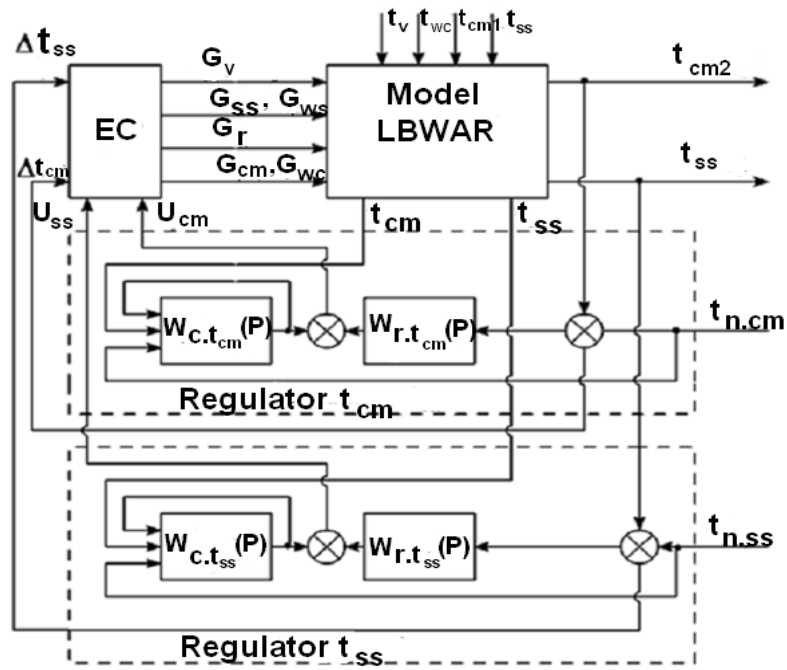
Fig. 2. Functional diagram of the control device LBWAR

Depending on the current values of the deviations of the temperature of cooling water temperature and a strong solution and LBWAR (t_{cm}, t_{ss}) from their normalized values ($t_{n.cm}$, $t_{n.ss}$), the ACS (Fig. 2) formed the control actions U_{cm} and U_{ss} attached to an electronic commutator (EC). The deviations of current values of the temperature of cooling water temperature and a strong solution of their normalized values Δt_{cm} and Δt_{ss} used to select the EC needed control channels ACS. This ensures that changes transportable media G_v, G_{ws}, G_{ss}, G_r, G_{cm}, G_{wc}. The parameters regulating and correcting parts of ACS ($W_{r.t}(p)$, $W_{c.t}$ (p)) are determined using a dynamic model parameters LBWAR. Parameters of the resulting model is also needed when setting up ACS and its implementation in a particular circuit design.

Functional diagram of the ACS LBWAR (Fig. 2) is technically just implemented in any programmable control devices, the price of which is now minimal.

4 DEVELOPMENT AND STUDY MODELS IN MATLAB

The system of equations (2, 4, 6, 8) is used to develop a model LBWAR to investigate the dynamic properties of the program MATLAB 6.5 - Simulink for transient loads. In Fig. 3 shows the result of modeling a system that reflects the dynamic properties of LBWAR, namely the temperature change of cooling water when applied to the inputs of the model disturbances and control actions of stepwise character.

5 CONCLUSIONS

From the obtained results. A mathematical model of the dynamics of LBWAR is a combination of aperiodic links with the transport of the first order lag with varying parameters. A mathematical model and the results of studies of the dynamics of LBWAR reflect the real nature of parameter changes on its outputs. Using the model for the design and operation of the automatic control system will reasonably ask LBWAR system settings, as well as improve the management of its cooling capacity of air conditioning systems.

Results of the study of mathematical models of the dynamics LBWAR reflect the real nature of parameter changes on its outputs.
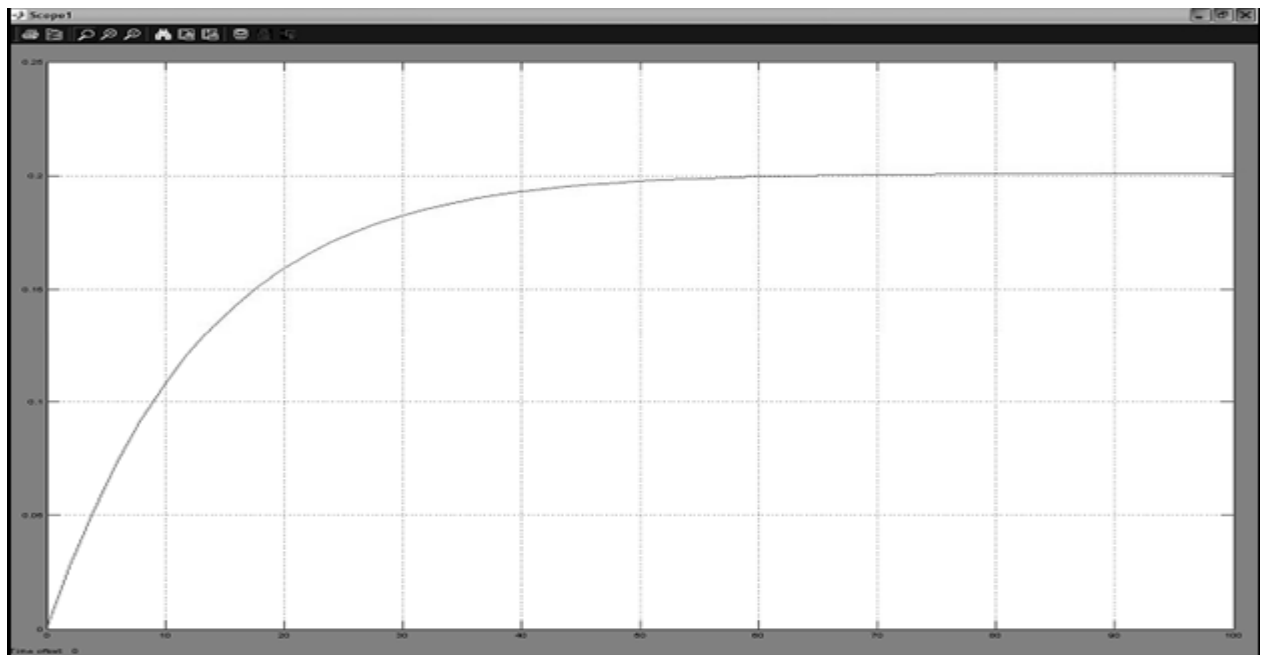
Fig. 3. The simulation results in MATLAB LBWAR

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