Automatic System of Regulation of Concentration of Grape Juice

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ABSTRACT

This paper considers an automatic system for regulating the concentration of grape juice. The transition characteristic of the evaporation device was experimentally obtained, the dynamic characteristics of the control object were determined, the quality of regulation was assessed, and the stability of the closed ASR was determined.

Keywords: Concentration, evaporation device, controller, regulation, aperiodic link, dynamic characteristics.

Today, the food industry has become one of the leading sectors of the economy in our country, which has a large production and raw material potential. This industry makes a huge contribution to the economy of the republic and to the development of its export potential.

Bukhara fruits, especially grapes, are in high demand due to their sweetness and high sugar content. The joint venture "Gala-River", created by the private trading and manufacturing enterprise "Continent Invest" in the Bukhara region and LLC "River Invest" of the Republic of Kazakhstan, specializes in the processing of grapes. Joint venture "Gala River" is one of the leading enterprises in the field of industrial production of grapes in the country.

The company mainly performs 3 technological processes:

Preparation of concentrated grape juice; technological process of preparation of sulfas wort ; wine making.

To prepare concentrated grape juice, freshly squeezed grape juice is clarified, filtered and boiled (concentrated) on a vacuum evaporator to obtain 70% grape juice. The use of vacuum evaporators for the processing of fruit and berry juices makes it possible to obtain biologically active products in the form of dehydrated juice. At the enterprise, the technological process is fully automated, but the concentration of grape juice is checked in the laboratory. We propose to measure the concentration using a concentration meter - ohm refractometer K - PATENTS PR -23-A.

The general principle of operation of the automatic concentration control system is to maintain the concentration at the required level juice . The object of regulation is the concentration of grape juice in a vacuum evaporator. The concentration of grape juice is controlled by changing the flow of water vapor supplied to the evaporator.

Microprocessor microcontroller Simatic S7-300 was chosen to keep the concentration of grape juice in the evaporator in the range of 65-75%. The controller changes the flow of water vapor by moving the drive with the help of an electric motor, depending on the sensor signal.

Object of regulation - vacuum evaporator plant:

control parameters - the flow rate of grape juice supplied to the evaporator, the temperature in the evaporator, the flow rate of the supplied water vapor;

adjustable parameter - the concentration of grape juice in the evaporator;

external influences - the amount of liquid (water) in the grape juice, the ambient temperature, the volume of the evaporator and the pressure of the supplied water vapor.

According to the technological regulations, the concentration of grape juice in the evaporator must be maintained within 65-75%.

We use the values of the output quantity to plot the transient process of the regulated object. Considering the concentration of grape juice as a control object, we will determine its transfer characteristic. The analysis of this technological process shows that this object has self-alignment.

Below, in Fig. 1. shows the transient response of the object of regulation - the evaporator, obtained experimentally when applying a step action to the input of the object of regulation.

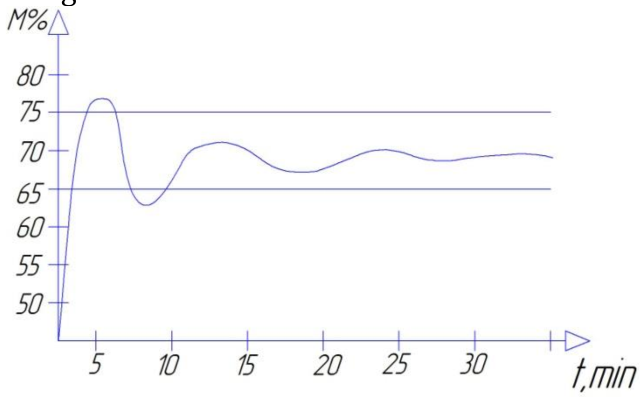

Fig.1. Transient response of the regulated object

According to this graph, it can be determined that the evaporator is a link close to the second-order aperiodic link. The control object can be approximated by a pure delay link and an aperiodic link of the first order, which means that the transfer function of the control object will have the following form:

$$W_{ob}(P) = K_1/(T_{1P} + 1);$$

where K is the amplification factor of the object; T is the time constant.

In order to determine the dynamic characteristics of the control object, we draw a tangent to the curve (*to the inflection point) of* the transient response.

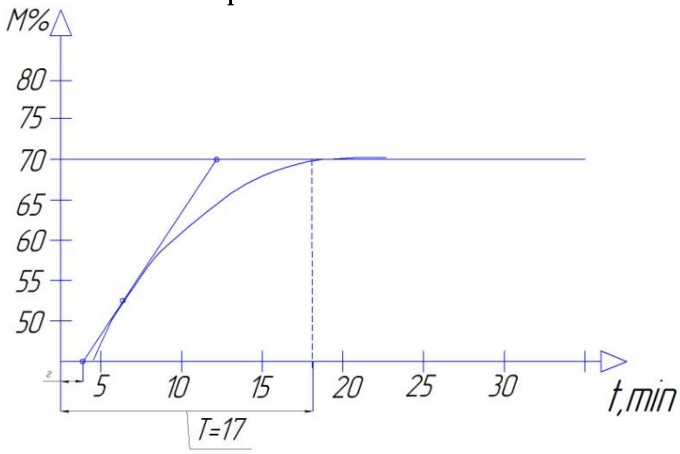

Fig.2. Transitional characteristic of the evaporator.

$$K = \Delta x / \Delta y = 10/5 = 2;$$

$$\Delta y = 75 - 65 = 10;$$

$$\Delta x = 20 - 15 = 5;$$

$$\tau - delay \quad time \quad \tau = 3;$$

$$T - time \quad constant, \quad T = 17;$$

$$W_{ob}(P) = 2/(17p + 1);$$

Choice of regulation law and type of regulator . In order to select the type of regulator you need to know:

- static and dynamic characteristics of the object of regulation;
- quality requirements for the regulatory process;
- the quality of the regulator's indicators;
- the nature of disturbances affecting the regulation process.

The dynamics of regulation depends on the relationship τ/T. Efficiency of compensation of stepped perturbation by the regulator can be accurately characterized by the value of the dynamic coefficient of regulation R_d, and speed - by the value of the regulation time.

For the control object $\tau/T = 3/17 = 0{,}17$; $K = 2 < 10$, therefore, to maintain the main output coordinate at a given value without a static error, the control law must include an integral component . In PI controllers, the control element moves in proportion to the deviation, the integral and the speed of the deviation of the controlled variable. $W(P) = K_P(T_P + 1/T_P)$;

In PI regulators, the transient process runs with 20% regulation:

$K_p = 0.7T_o / K_o\tau = 0.7*17/2*3 = 17.85$;

$T_4 = \tau + 0.3T_o = 3 + 0.3 * 17 = 8.1$;

W (P)=17.85(8.1 P +(1/8.1 P));

To assess the quality of regulation, we construct the dynamic and frequency characteristics of the system, by which we determine the main quality indicators.

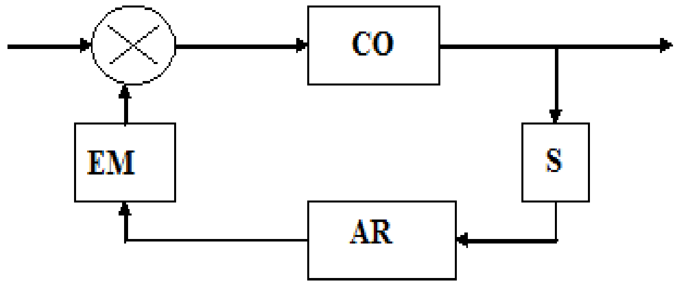

Fig.3. ACS design scheme

1. Vacuum evaporator is a control (regulation) object , its output parameter is the concentration of grape juice, the input signal is a change in water vapor flow, the transfer function of the control object: $W_{ob}(P) = 2/(17p + 1)$;
2. According to the dynamic properties , the concentrator is an aperiodic link of the 1st order, the input signal is the concentration of grape juice, the output signal is a unified electrical signal: $W_d(P) = K_2 / T_2P + 1$;
3. Controller transfer function: W (P)=17.85(8.1 P +(1/8.1 P))
4. Transfer function of the actuator a , which changes the steam flow :

$W_{im}(P) = K_4 / T_4P$;

The general mathematical model of the ACS consists of the transfer functions of the elements of this system. In the diagram, the sensor, regulator, actuators are connected in series

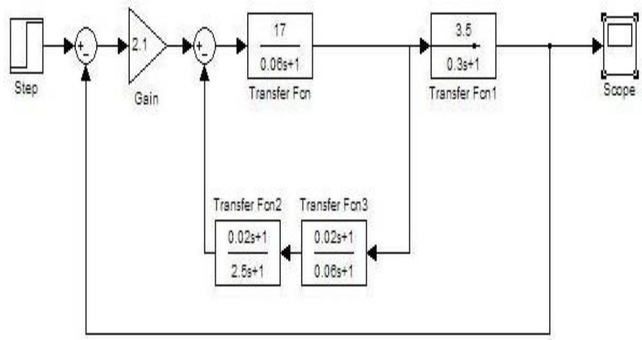

Fig.4. Block diagram of ATS concentration

And the automatic control system must satisfy the requirement of stability, that is, return to the equilibrium state after the removal of the perturbation that disturbed its equilibrium. To do this, we use the Nyquist criterion.

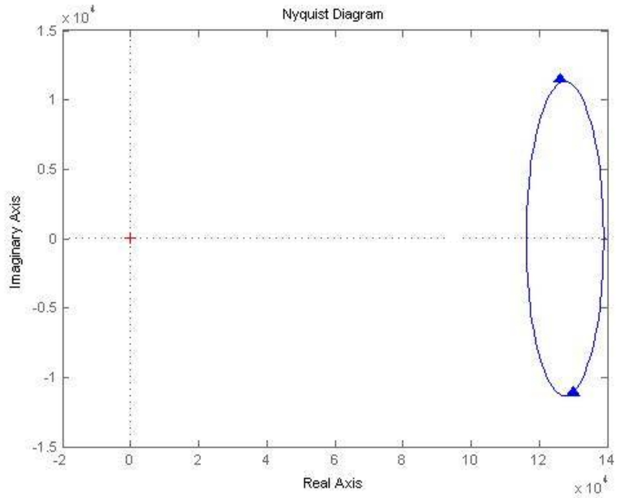

Fig.5. Amplitude-phase frequency response

Since the hodograph of the complex frequency response of an open system does not cover the point with coordinates (-1, i 0) , with the control system, which is stable in the open state, will be stable in the closed state .

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