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Automation of the process of forced evaporation in the production of urea

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Urea, also known as carbamide, is an organic compound with chemical formula $CO(NH_2)_2$. It is a colorless, odorless solid, highly soluble in water. The need for the production of urea is explained by the constant growth in demand for this product. The main area of application of urea is agriculture, where urea is used as fertilizer.

The relevance of the development of a scheme for the automation of the forced evaporation process is due to the need to reduce the cost of urea production and improve product quality.

A solution containing 68 – 70 % urea at a temperature of 408 – 411 K is fed into the tube space of a shell-and-tube heat exchanger with a heat exchange surface of 80 m^2. Distillation gases flow under a pressure of 1.6 - 1.7 MPa with an initial temperature of 421 – 425 K and a final temperature of 403 – 405 K is used as a heat carrier in the apparatus. The vapor-liquid mixture is separated in a vacuum-separator at a residual pressure of 0.080 - 0.086 MPa. The solution containing 75 – 78 % of urea is fed to a two-stage vacuum evaporation.

The advantages of the described method are the low cost of evaporation. This is achieved through the use of distillation gases as a heat carrier, which do not require additional heating. When developing the automation scheme, the final concentration of urea was taken as a controlled value. The flow rate of the hot coolant was chosen as a control action.

The scheme of automation of the forced evaporation process is shown in Figure 1.

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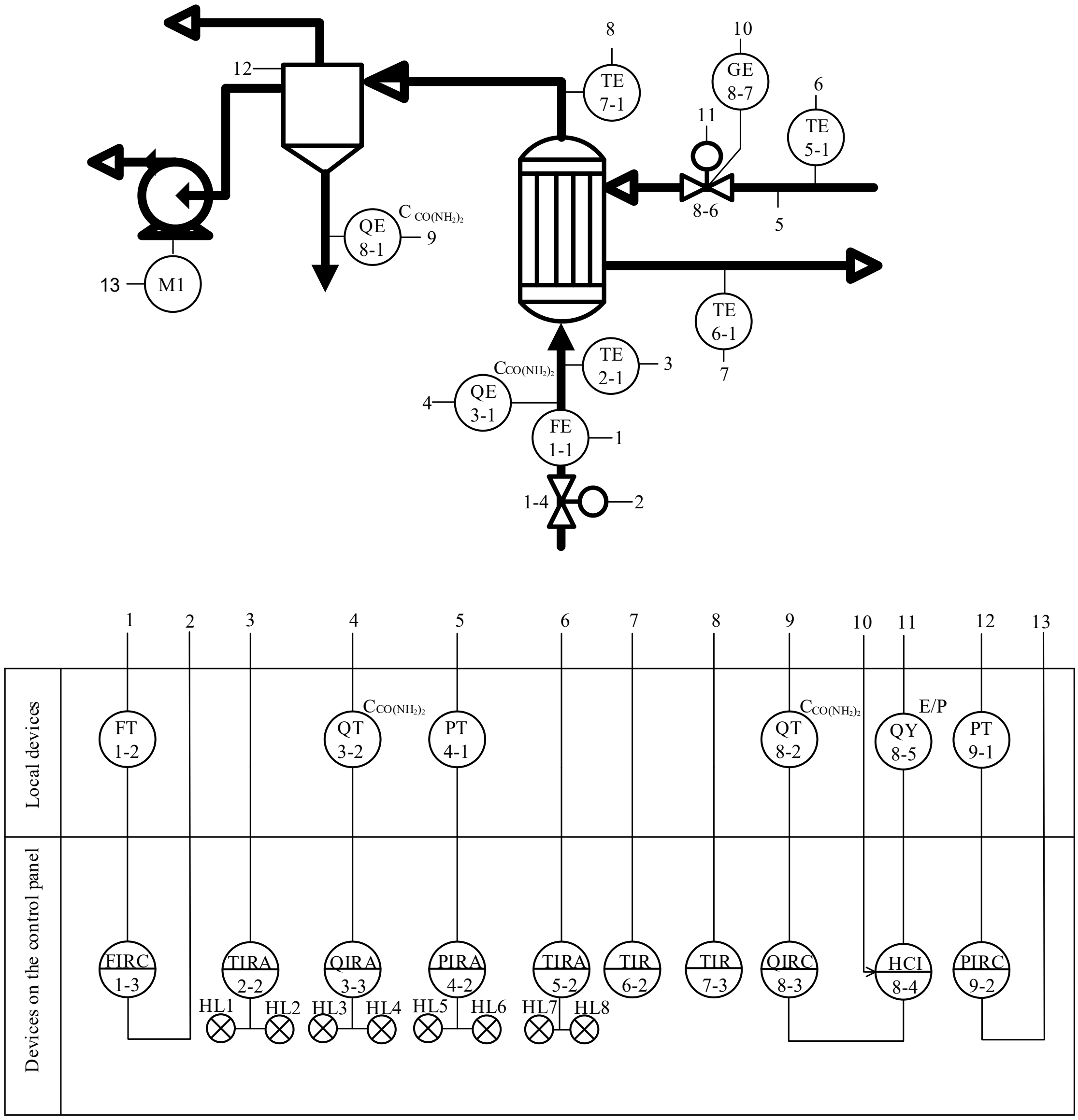

Figure 1. Scheme of automation of the forced evaporation process.

The automation scheme, shown in the figure, contains the following control and regulation circuits:

- Circuit 1 is designed to stabilize the flow rate of the illuminated urea solution at the inlet to the heat exchanger. The signal from the flow meter 1-1, 1-2 goes to the regulator 1-3, which generates a control signal to the actuator.

- Circuit 2 is designed to control and signal the initial temperature of the solution. The signal from the temperature sensor 2-1 goes to the secondary device 2-2, signaling that the parameter is out of the required limits.

- Circuit 3 is designed to control and signal the initial concentration of urea in the solution. The signal from the concentration sensor 3-1 goes to the secondary device 3-2, signaling that the parameter is out of range.

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- Circuit 4 is designed to control and signal the pressure in the hot coolant pipeline. The signal from the pressure sensor 4-1 goes to the secondary device 4-2, indicating that the parameter is out of limits.

- Circuit 5 is designed to control and signal the initial temperature of the hot heat carrier. The signal from the thermometer 5-1 goes to the secondary device 5-2, signaling that the parameter is out of limits.

- Circuit 6 is designed to control the final temperature of gases. The signal from the thermometer 6-1 goes to the secondary device 6-2, which records the parameter value.

- Circuit 7 is designed to control the final temperature of the solution. The signal from the thermometer 7-1 goes to the secondary device 7-2, which records the value of the parameter.

- Circuit 8 is designed to control the final concentration of the solution. The signal from the concentration sensor 8-1, 8-2 goes to the regulator 8-3, which generates a control signal to the actuator 8-6.

- Circuit 9 is designed to regulate the residual pressure in the vacuum separator. The signal from the pressure sensor 9-1 goes to the regulator 9-2 and generates a control signal to the electric motor of the vacuum pump.

The developed circuits will make it possible to fully automate the process of concentrating the urea solution, which will affect the productivity, quality and cost of the process.

Bibliography:

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