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Analysis of Schemes of Technological Processes Control Systems using Fluid Flow Meters

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ABSTRACT: The pressure in the fluid flow, especially in the pipes of closed water supply systems, is generated mainly by pumps, and the water flow is usually pulsating. Electromagnetic transducers used to measure such nonstationary and pulsating fluid flow rates must have low inertia and high dynamic accuracy. In such cases, the frequency characteristics of electromagnetic transducers that measure fluid flow are their main parameters. It should be noted that the performance of the converters used to measure the flow rate of pulsating fluids should not depend on the change in the distribution profile of the flow velocities, otherwise additional measurement errors will occur. It is used in measuring non-stationary and pulsating fluid flow rates in controlled and controlled technological processes.

KEY WORDS: Electromagnetic flow sensor, mathematical model, static characteristic, the annular channel, the core, the weight function, eelectromagnetic flow transducer, mathematical model, static characteristic, annular channel, core, weighting function, pipeline, flow rate, magnetic system, sensor, water flow.

I. INTRODUCTION

One of the important tasks is to improve the technical characteristics of automation elements and devices used in them, to expand their functionality, as well as to improve control systems, methods and algorithms to increase the efficiency of control and management systems of existing technological processes in various sectors of the economy.

Fluid flowmeters (FFs) are primarily needed to control production. Without their participation, it is impossible to ensure the optimal mode of technological processes in energy, metallurgy, chemistry, oil, food, agriculture and other sectors of the economy. For example, bringing the performance of hydro-ameliorative facilities (pumping stations, closed irrigation canals, sprinklers, etc.) closer to their optimal modes allows these facilities to use electricity and water resources wisely.

Figure 1.1 shows the technological scheme of automated water distribution used in indoor irrigation systems. The water flow meter is installed directly after the local hydraulic resistances (disc valve, elbow, barrier, etc.) that distort the fluid flow rate profile in the measuring section of the pipe. If the FF output signal depends on the asymmetry of the liquid flow, then the accuracy of adjusting the fluid flow decreases, which leads to a decrease in the efficiency of water use for irrigation.

The analysis of the above technological scheme shows that the FFs used in it have high accuracy, reliability, sensitivity, wide measuring range and linear static characteristics, and the output signal should not depend on changes in water physicochemical properties, pollution and environmental impact.

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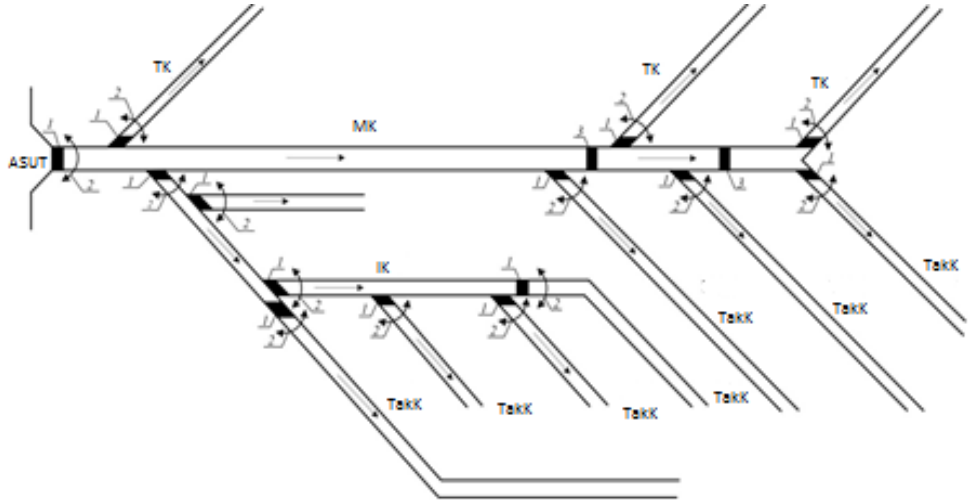

Figure 1.1. Technological scheme of automatic water distribution in closed irrigation systems: 1 - two-position valve; 2 -FF; 3 - water stabilizer; MK, TakK, IK, TK - trunk, distribution, domestic and discharge pipes

II.ENERGY EFFICIENCY

In water supply systems, when adjusting the water consumption supplied by pumping stations, the options of automatic adjustment systems on the rotational frequency of rotors of synchronous motors at the station, water consumption in each pumping unit, total water consumption and lower bef level and their combination can be used. Figure 1.2 shows a functional diagram of the water consumption at the pump station for three of the above options.

In asynchronous motors, the automatic speed control system (dashed lines in Figure 1.2) uses rotational speed gauges, and the other two have water flow gauges. In the "electric drive-pump-pipe" system, the measurement errors in FF and their secondary converters are small, the switching function is linear, the measuring range is wide and the asymmetric flow rate is high (because it is necessary to stabilize water flow in the pump station before and after FF it will not be technologically possible to provide a straight line section).

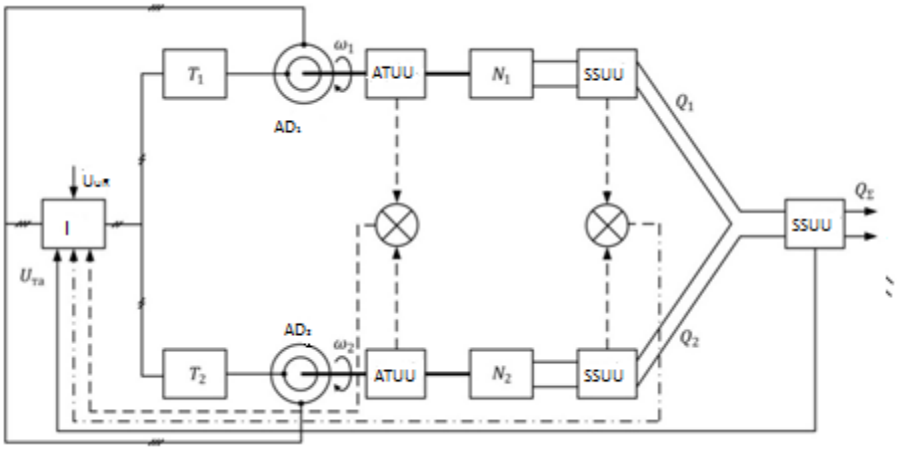

Figure 1.2. Functional scheme of the system of automatic adjustment of operating modes of the pump station: I - inverter; and - rectifiers; and - asynchronous motors; ATUU - rotary speed transducers; and - pumps; FF - water flow meters

In the food industry, FFs are also widely used in the management systems for the reception, storage, normalization of the composition of milk and dairy products and other related technological processes. For example, in

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a control system designed to automatically adjust the set value of the fat content of milk, FFs (usually IR-51 induction FFs) are installed in the pipes where skimmed and normalized milk flows (Figure 1.3). According to the technological process, skim milk passes through the valve K2 and mixes with the milk in the suction line of the pump N1, which drives the milk. The resulting normalized milk is pumped to the pasteurization-cooling device or intermediate tank through the K3 valve. The electrical signals received from the FFs are fed through electropneumatic converters to the pneumatic regulator 4, which regulates the ratio of skimmed and normalized milk. This regulator changes the position of valve 5, which regulates the consumption of skim milk. To control and record the consumption of normalized and skimmed milk, a pneumatic device 3 is installed in the circuit, the indicator of which is connected to the valve 5 position. In addition, the scheme provides a station that remotely controls the status of the assignment device and the regulating valve, and automatically switches the operation of the regulator.

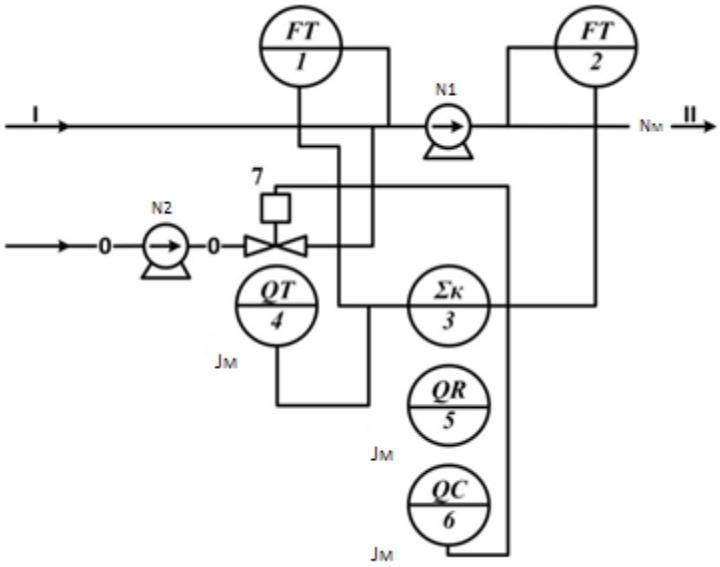

Figure 1.3. The scheme of the technological process of normalization of milk composition

The FF used in this technological process is required to have high measurement accuracy even in different modes of milk flow (symmetrical, asymmetric, etc.), the FF sensitivity is relatively high because the average velocity of milk flow in the pipes is not very high.

As a result of the analysis of the schemes of control and management systems of other technological processes mentioned above and described in the technical literature, it was determined that the following requirements are set for FFs that can be applied in them:

III.RESULTS AND DISCUSSION

1. Must have high measurement accuracy. The given error of the device in measuring the flow rate of the liquid in the desired view of the speed distribution profile in technological processes should not exceed.

2. It should have a high and constant sensitivity in the range of changing the fluid flow to the electrical signal. This feature allows to improve other characteristics of the transducer by reducing the sensitivity, for example, to reduce the power consumption, mass and overall dimensions. In addition, the high sensitivity allows the FF to increase the ratio of the useful signal to the various interference signals that appear in it. As a result, the processing of the output signal using a secondary converter is simplified.

3. The FF measurement range is required to be as wide as possible. Measurement range controls technological processes and it is required that it is not narrower than the adjustable size (fluid flow) range in control systems.

4. FF dynamic measurement accuracy should be high. This requirement is important in measuring the consumption of nonstationary currents in technological processes.

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5. The degree of nonlinearity of the static characteristic of the FF is required to be relatively high. In most control and management systems of technological processes, the value of this characteristic should not exceed. This is because when measuring the pulsating fluid flow rate, a relatively large (2-value error) depending on the pulsation shape occurs when an FF with a nonlinear static characteristic is used.

6. The FF must have a minimum power dissipation (the power it consumes, the power dissipation in the hydraulic resistance in the FF installed section of the pipe, etc.).

7. FF must work reliably in extreme operating conditions and its basic characteristics are stable. It is required that the FF output signal does not depend on the physicochemical properties of the liquid, the various sediments in it, and the ambient temperature.

8. The FF output signal must correspond to a set of unified signals intended for technical means of technological process control and management systems.

FF has a wide range of functions, namely the ability to measure the flow rate of very small and very large quantities and in the opposite direction, without affecting the physical and chemical properties of the liquid, measuring aggressive, viscous, abrasive liquids, sediment (liquefied rocks) and pulsating flow. And be able to rely on imitation.

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