About some automated processes in the production of dairy products

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Abstract. When processing milk and producing dairy products, the key factor is the control of the quality indicators of milk and manufactured products using automatic control systems of SAK with the use of microprocessors and microcontrollers. When milk is taken, automated plants allow you to determine the composition and quality of milk, including the content of somatic cells, mass fat content and protein fraction. The milk storage tanks are equipped by the local automatic systems. The technological processes of milk normalization are associated with the adjustment of its parameters. The functional diagram of automatization of the milk normalization process in the flow involves the use of a microprocessor controller. The composition of the automated production area of drinking milk includes information sensors on the status of process parameters, digital instruments for monitoring process parameters. The process of producing liquid starter cultures and bacterial concentrates involves the possibility of changing the productivity of the cultivator. Automatization does not include the supply of milk to the process equipment, the transfer of equipment from one technological operation to another and many others. Further automatization of technological processes in dairy production should be based on the extensive use of robotics and flexible robotic lines.

1. Introduction

In recent years, when solving the problems of automating technological processes of milk processing and milk production, both traditional means (local control systems for certain types of technological equipment) and quality control systems for manufactured products, including automated control systems \cite{1}, have been used. A number of enterprises also use the latest automatic control systems equipped with microprocessors and microcontrollers, control computer systems, etc., which allow for a real transition from partial automation of certain types of technological equipment to the creation of automated production lines, sections and enterprises in general \cite{2}.

Important features of the dairy industry are the complexity of the physical and chemical processes in the manufacture of dairy products, compliance with sanitary and hygienic requirements for the quality of the products. Hence the high requirements for the accuracy of formulation and sterility of technological equipment.
The aim of the study is to identify «problem» places in technological processes in the dairy industry and develop proposals for their elimination. During the research, general methods of scientific knowledge and statistical methods of analysis were used.

2. Research results
Among a wide variety of technological processes in dairy production, processes related to the acceptance, storage and normalization of milk should be highlighted; its heat treatment (pasteurization, sterilization and cooling); with the manufacture of whole milk products, including drinking milk, cream, sour cream, cottage cheese and curd products, pasty products; with the production of canned dairy products (condensed milk, sterilized milk, dried products), butter and cheese; with the washing of technological equipment, pipelines, their sterilization.

In modern dairy enterprises (most often in dairy plants), the shop structure of the enterprise is used (production sites, production departments, workshops). In one of these units, (milk acceptance section) milk is received from various producers (state, cooperative, farmer and private). At the same time, milk is poured into special containers for storage and its subsequent delivery to processing, previously purifying (separating) it from possible mechanical impurities.

For milk reception at dairy plants, local automated installations of the Chirana type are widely used. After the unit is connected to the tank, the milk is mixed and samples are taken for laboratory analysis of the composition and quality of milk (the degree of milk purity, bacterial contamination, somatic cell content, mass fat and protein fraction, acidity, temperature and milk density are evaluated). After making a decision on milk acceptance, the operator turns on the unit and determines the route of movement of milk in a specific container for its storage.

If the temperature of the delivered milk is exceeded above the permissible values, it is cooled in a special cooler with a built-in automatic (local) temperature stabilization system. Milk storage tanks are also equipped with local level control systems. If the milk level in one of the containers reaches the limit value, then, at the signal of the level sensor, a controlled solenoid valve (or a valve with pneumatic actuator) shuts off the milk supply to this tank. At the same time, the second valve of the same kind automatically opens the milk supply pipeline to the next tank [3].

Automation schemes also contain sensors for monitoring the presence of milk in tanks and valves for the release of air displaced by incoming milk. Tanks for storing milk are also equipped with automated control systems for temperature, acidity of milk, its mass (or level).

Controlled valves placed on pipelines for feeding milk to the container and its selection from the tank are used by an independent control system for the circulation washing of the same tank. Tanks for storing milk with a capacity of 50 tons or more are equipped with microprocessor control systems (controllers). Technological processes of milk normalization are associated with the adjustment of its parameters in accordance with predetermined technological indicators (the ratio of fat-dry skim milk residue, the values of the mass fraction of fat and protein) [3].

For example, when using a separator - cream separator, the resulting cream and skim milk are mixed in a certain ratio, and part of the cream and skim milk are taken off as an excess product.

Such a process can be carried out both in static conditions and in the flow movement of the product. The simplest way to normalize milk under static conditions can be performed by mixing a predetermined amount of the starting components, then sent to a container for storing normalized milk [4].

Today there is a modular system with automatic control, centrifugal separation, pasteurization and control of technological parameters and operations, designed for continuous separation of milk into cream and skim milk with simultaneous purification of them from mechanical impurities and with the possibility of obtaining normalized milk and simultaneous pasteurization of skim or normalized milk.

The control system provides automation of start-up and shutdown processes of the production line, product separation, CIP equipment washing, and automatic discharge of sludge from the separator drum during operation and washing, monitoring and regulation of the unit operation parameters. The modular system allows you to supplement the complete set of the installation with homogenizers, deaerators and other equipment. [5].
If it is necessary to normalize milk by protein and fat, cream separators and an ultrafiltration unit are used, separating skim milk into protein concentrate and filtrate, which are then separately mixed (in accordance with predetermined ratios) and normalized milk is obtained with the given values of the mass fraction of fat and protein.

Information about the current values of the monitored indicators is displayed on the digital indicator of the controller. Unfortunately, many auxiliary operations by means of automation have not yet been covered (supply of feed pipelines to technological equipment, transfer of equipment from one technological operation to another, and much more).

The skimming of milk through separators remains today the most effective technology. The Arnd Kulas specialists developed the GEA line of separators for cream separators, which includes separators for the separation of warm and cold milk, whey, buttermilk, cream, cream concentration, and also for clarification.

This equipment is distinguished by high productivity, efficiency, economy, versatility: separators are used to clean milk from unwanted non-dairy impurities, to skim milk and to remove bacteria from milk.

The markets for the separation of cold milk are expanding dynamically. Dairy enterprises, especially in the USA, Mexico, Australia and New Zealand, are increasingly using cold milk separation to skim cream. The process of improving the separator is continuous.

The process of improving the separator is continuous. Among the modern design separators for the separation of warm milk, MSE-500-01-777 of standard design is recommended; for cold separation - MSE-500-48-777, which has a hermetic design.

The first direct-driven cage represents a higher stage in the development of cages and operates without an engine shaft, gearbox, couplings and motor bearings. Due to the fact that fewer components are installed, energy losses, operating costs are reduced, therefore, the availability of the machine is increased. To accommodate a separator with integrated direct drive, an area of about one third less than the area that would be needed to install a machine with a gear drive or a flat belt drive is required.

The company's equipment is characterized by high performance, cost-effectiveness and efficiency. For example, as an alternative, cream separators can be equipped with a proplus system, which increases the discharge intervals of milk separators from 20–30 to 90 minutes. This provides additional practical benefits, a significant increase in the yield of protein from the used volume of milk, due to the constant minimization of losses up to 75%.

GEA has become a pioneer in the design of cottage cheese separators, and today nozzle separators provide many advantages in the process and enable the production of soft cheeses in large volumes. The main units of a standard quark production line are a coagulation tank, a cottage cheese separator, a cottage cheese storage tank, and a cottage cheese mixer.

The process of thermoquark production, in contrast to the standard one, includes various temperature time modes of processing of unboiled and fermented skim milk. The process proceeds at a higher temperature than traditional. Fat normalization occurs at a certain stage of the process (using a dosing pump, cream is continuously fed into the mixer, where they are mixed with low-fat cottage cheese to obtain a homogeneous product) [4].

The main technological operations in the production of drinking milk are associated with the thermal and mechanical processing of milk, its storage and bottling in appropriate containers [4]. Varieties of technological equipment for the heat treatment of milk include plate and tube pasteurization and cooling plants, as well as plate and tube sterilization plants. Plate sterilization units heat milk to a temperature of 135–140 °C, hold and cool to 20°C. The indicated varieties of plants for heat treatment of milk are usually equipped with equipment for its mechanical processing (separators, cleaners, separators - cream separators and homogenizers) [2].

The equipment is equipped with controlled valves for regulating the flow of milk and detergent solutions and containers for neutralizing solutions. The elemental base of the control devices are: sensors of information on the state of the process parameters, the Alert-5 microprocessor controller that performs logic-program control, a microprocessor unit that controls milk normalization, digital process control devices, microprocessor controllers - parameter stabilizers.
An important aspect in dairy production is the automation of the technological process for the production of liquid starter cultures and bacterial concentrates [3].

During continuous cultivation, milk or whey with the addition of bacterial concentrates is fed into the cultivator, in which the multiplication of microorganisms is carried out.

Fermented product at the exit of the cultivator is characterized by a certain concentration of microorganisms, metabolic products and physic-chemical properties (pH of the culture fluid, temperature and more). At the same time, the temperature of the culture fluid serves as a control parameter of the process, and it is possible to stabilize the pH during continuous cultivation by changing the flow rate of fresh or fermented milk. These considerations are the basis for the development of automation schemes [5].

In accordance with the adopted technology, the incoming milk is preheated in a heat exchanger to a predetermined temperature, and only then it is sent to the cultivator, from where the fermented milk is taken by a pump. The stabilization of the pH value of the culture fluid is carried out, as already indicated, by changing the flow rate of milk supplied to the cultivator, and the level of the culture fluid (its volume) is stabilized by changing the flow rate of fermented milk taken from the cultivator.

The literature [4] contains various variants of cultivation automation schemes related to the specifics of the technology used, functional schemes of cultivator automation in the production of bacterial concentrates. However, in the above schemes there are also no means of automation of auxiliary processes, the amount of which is usually 18-25% of all technological operations.

The concentration of microorganisms and the pH value of the culture fluid are taken as the output coordinates of such an automation object.

Dry milk products remain in demand on the market. The continuous operation of the equipment with maximum performance is ensured by the inclusion of additional units of evaporation and product supply systems in the production line before the drying unit.

A continuous line that allows the dryer to work for a long time before washing, drying is carried out for 3 months without stops, which significantly increases the efficiency of the equipment.

One of the determining factors in the production process of dried or concentrated dairy products is bacteriological safety, which is associated with the expansion of the production of products with a large number of ingredients. At the same time, requirements for the content of microorganisms in whole milk powder and skimmed milk powder are increasing [5].

3. Conclusions
The international engineering concern GEA is one of the largest manufacturers of system solutions for food production with a wide range of processing industries.

One of the important points in the production of any dairy products is quality. The quality of technological equipment is a hygienic design that allows you to produce a product without negative changes. This design is ensured by the use of hygienic anti-mixing valves VARIVENT, installed on product lines.

The valve body design provides for equal piping heights at the inlet and outlet, which eliminates stagnant zones in the valve. The spherical body provides excellent throughput and no increase in flow rate and resistance. Tank filling through the ECO-MATRIX automated pipe connection system is based on a unique design solution. A short vertical pipe under the tank in combination with ECO-MATRIX two-seat valves minimizes the number of washing paths and guarantees good cleaning conditions and minimal product loss.

Hygienic performance is safety, as the technological equipment allows you to produce the product without the use of additional (antimicrobial) substances. Technological equipment allows washing without disassembling all surfaces in contact with the product without loss of working time.

GEA, a leader in food technology, is responsive to rapidly changing market demands.
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