Natural cold milk cooling system

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Abstract. Ideal «smart» technologies in the dairy industry are low-cost, versatile, reliable and easy to use, focus on solving the problem. Such technologies provide accessible information that can be quickly implemented. One of the areas of application of the technologies under consideration is the technology of cooling milk by natural cold. We propose a device for protecting the structural elements of the pool, which does not require manual labor, and works automatically with high reliability of operation. Before the start of operation of the ice storage facility, when the summer season begins, the surface of the ice storage facility must be insulated, covered with any thermal insulation material. Such a method of protecting the structural elements of the ice storage facility will completely eliminate the destruction.

1. Introduction

The dairy industry is undergoing changes due to ever-increasing technologies and the introduction of technological advances, which have many advantages. However, each new technology causes a number of new difficulties.

Nowadays, dairy farms have far more opportunities to use innovative technologies on farms than ever before. A variation on “smart” dairy farming is the use of technology to measure the behavioral physiological and production performance of individual animals in order to improve farm management. As examples of “smart” technologies on dairy farms, automatic milking machines, plants for primary processing and processing of milk, automatic feeding stations for calves, automatic monitoring to detect signs of hunting, determining the time of the beginning of calving and warning about health problems, etc. The use of these technologies in the dairy cattle breeding system will significantly improve the process of farm management, provide cows with a more comfortable maintenance [5,6].

2. Relevance

Practice shows that it is most expedient to develop the agricultural sector of the industry by reducing the cost of milk production, and the technological prerogative must be maintained by the process of energy and resource saving [1]. Ecological instability and rising prices for hydrocarbon fuels naturally intensify the implementation of projects aimed at introducing alternative energy sources, especially those determined by the specifics of the landscape-climatic conditions of the territorial location of enterprises and production complexes [7-9]. Research conducted on the problem of reducing specific energy consumption, including electricity, for milk production and processing, showed the relevance of a specific area of scientific and technical search and the relevance of engineering solutions in the field of refrigeration and the development of artificial cooling systems.
based on the saving of natural energy resources [10, 11]. The emergence of a new trend in the search for alternative refrigerants required a methodological substantiation and theory of thermophysical analysis for structural heat transfer schemes without the use of freon, the decomposition of which is chlorine and its hydrogen compounds [12, 13]. Resource-climatic analysis confirms the possibility of using natural cold to create technologies for cooling milk with freezing of ice mass [14]. Moreover, design calculations show the promise of creating a natural cold reserve for year-round use in the primary processing of milk. Therefore, the development of energy-efficient methods for introducing technical support that implements ice-freezing cycles in specified temperature regimes with established performance is an important, significant and critical task at present [1, 2, 15-18].

3. Litobzor
A great contribution to solving the problem of using natural cold in our country was made by scientists V.A. Bobkov, I.N. Bosin, V.I. Kvashennikov, B.P. Korshunov, F.G. Maryahin, A.M. Musin, A.I. Uchevatkin, G.V. Anikin, V.A. Shahs and others.

Today, a large number of technical specialists and inventors [3,4] are engaged in the development of designs for the use of natural cold.

4. Main part.
Ideal "smart" technologies in the dairy industry are low-cost, versatile, reliable and easy to use, focus on solving the problem. Such technologies provide accessible information that can be quickly implemented.

One of the areas of application of the technologies under consideration is the technology of cooling milk by natural cold.

The use of natural cold is the use of ice accumulating systems of various designs [1, 2]. Practically in all designs of ice accumulators there is a significant drawback, which consists in the absence of automatic control systems for the intensity of ice freezing during the period of negative temperatures and in the absence of safety devices that protect the ice storage capacity from cold destruction in the process of ice freezing.

Partial elimination of these deficiencies was solved in the works of scientists [3, 4, 5], which are based on reducing the pressure by dropping water onto the frozen ice surface due to bucket and siphon dosing devices installed in the dairy compartment. The same devices are used to record and record the intensity of ice freezing in the ice-accumulating capacity and its quantity. However, the presented constructive solutions do not allow using these systems in conditions of remote summer camps (pastures). To implement this method, it is necessary to have a warm heated room next to the pool, which is connected by pipelines to the pool. Summer camp in winter is not functioning.

In our opinion, it is possible to cool milk up to 4 ... 5 ° C at summer sites of remote summer camps with the natural cold accumulated in the winter in the form of water ice. Such accumulation can be accomplished using the thermosiphon system described in [6, 7].

For this purpose, near the milking platform, it is necessary to build a recessed pool with detonated thermally insulated walls.

The working volume of the basin \( V_b \) is determined on the basis of the average daily milk yield for the entire period of maintenance and the duration of the lager period:

\[
V_b = \frac{m y_{day} N_{day} C(t_{st} - t_{fin}) \eta}{q \rho_p} \tag{1}
\]

where \( m; y_{day}; N_{day} \) - accordingly the number of cows, a goal; daily milk yield, kg / (goal • day); duration of the lager period, days

\( C, t_{st}, t_{fin}, \eta \) - respectively, the heat capacity of milk kJ / (kg • hail), the initial and final temperature of milk is 0 ° C; ice loss rate due to unauthorized heat leakage equal to 1.2 ... 1.3

\( q \rho_p \) - respectively, the specific heat of ice melting, kJ / kg and the density of ice.
At work, thermosyphons do not consume energy, do not require maintenance, they work 24 hours a day, freezing ice from the side surface of the evaporator.

When using a thermosyphon system, a simple, at first glance, thought comes - to build a pool with thermosyphons before the start of the autumn - winter period and forget about it until the spring of next year. It is expected that all the water in the pool during the winter period will turn into ice, the reserves of which will be enough for the entire summer period.

But, most likely, the walls of the pool will be destroyed, cracks will appear, through which the water will leave, soaking into the surrounding soil, and only one layer of ice 0.25 ... 0.35 mm thick will remain in the pool.

This will happen due to the fact that the density of ice at a temperature of 0 ° C is equal to 916.8 kg / m3; the density of water at the same temperature is 999.8 kg / m3. Consequently, the formation of a volume of ice when water freezes in a closed volume (pipes, radiators, any open vessels, including pools), will cause the creation of enormous pressure of hundreds of mPa.

At negative temperatures of atmospheric air, a crust of ice appears on the surface of the water in the pool. The thickness of the crust increases over time due to the advance of the freezing front down. With an increase in the thickness of the crust, two mutually contradictory phenomena arise.

• on the one hand, the strength properties of the ice layer increase.
• on the other hand, there is an excess pressure in the water, for the reason stated above, which seeks to destroy this layer or wall.

In the future, the development of events will occur in one of two options:

• the strength characteristics of the ice layer will exceed the characteristics of the walls. On the walls there will be irregular numerous cracks. Water through them will be filtered into the surrounding soil and completely leaves the pool.
• the strength characteristics of the walls will be higher than those of the ice layer. Ice will crack. Ice drifts can damage thermosyphon vaporizers with the loss of their tightness. The refrigerant will evaporate and the thermosyphon will not work.

Using the described method of protection of the walls of the pool is not possible. There is only one option - to release water from the under-ice space, with increasing pressure in it, you need to regularly drill a hole in the ice layer. Given the removal of the camp from the main farm and winter off-road, manual drilling of such a hole is not economically feasible.

We propose a device for protecting the structural elements of the pool, which does not require manual labor, and works automatically with high reliability of operation.

Figure 1 shows a diagram of this device.

The device consists of a bell-shaped pressure sensor 13 suspended in the bottom layers of the pool, and a tube 12 connecting a bell-shaped pressure sensor with a pressure switch 10 attached to walkways, a tubular electric heating element (TENA) 11 attached also to the walkways and connected electrically to the pressure switch. The tube 12 has a fitting 14 for connecting the air bus pump to measure and adjust the air pressure.

The operation of the device is as follows (Figure 1).
Figure 1 - Technological scheme of cooling milk with ice water from a pool equipped with thermosiphons.

1 - thermosyphon capacitor; 2 - thermosyphon evaporator; 3 - ice layer; 4 - check valve; 5 - ice water suction pipe; 6 - valve; 7 - return pipe; 8 - plate cooler; 9 - ice water pump; 10 - pressure switch; 11 - tubular electric heater (heater); 12 - metal tube; 13 - bell-shaped pressure sensor.

In a pool filled with water, air pressure is established under the sensor cap 13, depending on the depth of immersion of the sensor. An air tire pump with a pressure gauge is connected to the nipple, the air pressure is corrected by the pump in accordance with the set minimum relay response pressure. Upon the onset of the frosty period, a crust of ice begins to form on the surface of the pool (mark 0-0). Under the crust in accordance with the patterns outlined above, the pressure of water begins to increase. The pressure increases with increasing thickness of the crust.

The water level under the pressure sensor cap rises, compressing the air. Air pressure increases. As soon as the air pressure reaches the installation maximum value for which the proposed device is configured, in the pressure switch 10 there is a contact closure. TEN is supplied with a working voltage of 220 volts. Within a few seconds, ice is melted around the heating element and water, which is under the ice under excess pressure, is thrown onto the ice surface through an annular gap around the heating element, spreading along it in a thin layer.

The water pressure in the under-ice space drops, and as soon as it decreases to the set minimum value, the relay opens the contacts, de-energizes the heater. The annular gap around the heating element is covered with an ice crust. In the subglacial space of the pool, a closed space is again formed with increasing water pressure. Next, the process is cyclically repeated. In the event of a thaw or the installation of constant positive temperatures of atmospheric air, the pressure in the under-ice space stabilizes at the minimum value. TEN in such cases is in a de-energized state.

Before the start of operation of the ice storage facility, when the summer season begins, the surface of the ice storage facility must be insulated, covered with any heat-insulating material.

Such a method of protecting the structural elements of the ice storage facility will completely eliminate the destruction.
5. Conclusion

In the conditions of a modern market economy and the constant increase in the cost of energy, the use of natural cold is becoming more and more efficient and cost-effective. The proposed system will not only reduce the cost of production and primary processing of milk.

The use of thermosiphon systems for freezing ice in a pool built near dairy farms can completely replace the chillers currently used in such enterprises.

6. Discussion.

In modern conditions of agricultural production, it is necessary to substantiate and develop a series of devices for cooling agricultural products with natural cold to negative temperatures based on the use of antifreeze. To identify the reserves for improving the quality functioning of thermosiphon systems when using natural cold in agricultural production.

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