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1.2 Improvement of sugar beet storage technology with the development of kagatu ventilation modes

Currently, the method of long-term storage of beets in field boxes on cultivated fields is widespread, which is associated with increased losses of beets up to 11-16%. Beet-harvesting combines during the harvesting of sugar beets form field ridges 2.5-3 m high on the periphery of the field. Storage of root crops in field kagatas has a number of significant disadvantages. With the low provision of agricultural territories with paved roads, the risks of reducing the rate of transportation of root crops from the fields of cultivation to the sugar factory on roads are increased , which leads to a decrease in productivity during the processing season due to a shortage of raw materials - sugar beets.

The preservation of sugar beet pulp depends on the ratio of the mass of stored raw materials to the surface area of the pulp exposed to the environment . In field kagats with a height of 2.5-3 m, the ratio is in the range of 0.35-0.42. This ratio characterizes the degree of influence of environmental factors on the array of root crops, in other words, the inertial properties of the embankment. The environment affects the embankment due to solar radiation, air temperature fluctuations , precipitation and wind. The outer layer of the embankment with a thickness of 0.5-1 m is exposed to the most aggressive influence of the environment . In field kagatas , up to 77% of the volume of the embankment is exposed to the influence of the environment , and when frosts occur, they can freeze completely [19, 20].

Frozen roots of sugar beets lose their technological value, because the processes of rotting and infection with pathogenic fungi and bacteria intensify in them, which lead to an increase in losses of beet pulp .

One of the ways to ensure the preservation of root crops is to increase the size of sugar beet pods to increase the ratio of the mass of stored raw materials to the surface area of the pods exposed to the environment . In kagatas with a height of 5-6.5 m, a width of the base of 28-30 m and a width of the upper platform of 8-10 m, this ratio is equal to 1.05 - 1.35. In such kagatas, from 13 to 31% of the mound of root crops is exposed to the influence of the environment [19]. In kagatas with high inertia, part of the excess heat is removed worse due to weak convection of air masses, so storage in them involves the use of active ventilation systems .

The presence of an active ventilation system makes it possible to regulate and maintain the optimal temperature inside large sugar beet bags , in contrast to field bags stored in cultivation fields [17, 18, 19, 20].

Long-term storage of sugar beets in sacks equipped with an active ventilation system allows to reduce the loss of beet pulp to 3-5% [19, 20].

active ventilation system in kagatas is possible at organized sites - beet points [16, 20]. Centralized storage at beet points allows you to solve the problem of transporting root crops to the plant for processing when off-road.

Storage in warehouses equipped with an active ventilation system takes place under changing weather and climate conditions. Ensuring the safety of root crops in kagata during long-term storage largely depends on the perfection of control algorithms and operating modes of the active ventilation system. The existing control algorithms do not ensure the correct operation of ventilation during the entire storage period, as they require the participation of highly qualified personnel. Widespread implementation of sugar beet bag storage technology with active ventilation is possible when switching from automated to automatic control type.

In the case of centralized storage of sugar beets in boxes at the beet center the task of determining the order of unloading of long-term ventilated storage bags for further processing is relevant . Currently, sugar beet kagatas are shipped in order of formation, that is, the first kagata formed is the first to be processed. This method does not take into account the intensity of processes occurring inside the kagat during storage, which largely depend on the heterogeneity of the quality of the stored sugar beet roots .

it is practically important and urgent to improve the technology of sugar beet storage with the development of kagat ventilation modes . By implementing modern storage technology, plants will be able to avoid processing root crops that have not gained mass in August-September, increase the duration of the processing season with a simultaneous reduction in the loss of beet pulp during storage [16]. Application of the technology of active ventilation of sugar beet stalks at beet stations allows to increase the duration of plant operation by 9-22% and reduce the cost of sugar by 2-4.5%.

There are many different designs and types of active ventilation systems . It is known that in most cases, active ventilation systems are used to cool plant products in closed storage with enclosure structures.

In this work, the tasks of improving the technology of storing sugar beets for more than two months in casks, the surface of which is exposed to environmental influences, are solved by developing the modes of operation of the ventilation system with an automated type of mode control , as well as on the basis of the developed mathematical model of heat and mass exchange processes.

The system of active ventilation of the kagat refers to a complex of engineering systems that provides support and regulation of the microclimate by injecting air into the kagat through ventilation branches. The ventilation branch refers to an engineering system for supplying air from the environment to a piece of kagat through an air distributor with the help of a fan built into the ventilation unit. The ventilation branch includes a fan, duct, outlet, air distributor and other elements designed to supply air to the kagat fragment.

For the technology of long-term storage of sugar beet root crops, systems of active ventilation of kagatas, which are used on sites without stationary protective structures, were developed . The ventilation system should ensure uniform supply and distribution of air throughout the entire volume of the kagat. The design of the ventilation system should have flexible regulation of air supply to individual fragments of the kagat. The active ventilation system should be reliable and convenient to operate, and costs should be minimal, taking into account the preparation of equipment at the site of long-term storage of root crops .

Schemes of long-term storage of kagats were also proposed , in which the loading of kagats was carried out using an overhead crane.

Currently, two types of decentralized active ventilation systems with ventilation branches located transversely to the central axis of the kagat are used. In these systems, floor metal ducts with round sections are used. The difference in the schemes lies in the method of injecting air into the air duct: from one or both sides of the kagat. Valezno depending on the method of air injection into the air duct, kagatas are divided into single and paired (Fig. 1). The choice of the fan depends on the intensity of air supply per ton of sugar beet root crops , which is from 30 to 70 m ^{3}/h. depending on the climatic zone. Axial fans of low and medium pressure, whose electric motor power is from 5.5 to 11 kW, have become widespread . Air supply to the kagata is carried out through air outlets holes located on the surface of the duct.

Figure 1. Active ventilation systems: a - air supply from one side for a single kagat; b - air supply from two sides of the paired kagat

Ventilation channels are installed on the storage site during the formation of the kagat and are covered with root crops using a side loader cars. The interaxial distance between the ventilation branches of a single kagat is 6 m, in a paired one - from 4 to 5 m.

The advantage of paired kagates is the best ratio of mass to the surface area of the kagate in contact with the environment . The width of the lower base of the paired kagat varies from 70 to 90 m, the height is from 6 to 7 m, the length is from 160 m . machines of increased productivity from 500 to 750 t/h (superBUM), which is equipped with two tipping platforms for heavy trucks with trailers. SuperBUM is moved in the process of laying kagat with the help of reinforced concrete wheels or crawler tracks, as well as with the help of rail tracks. SuperBUMs lack maneuverability and can move forward and backward. In u in case of technical failure, it cannot be replaced with another superBUM , therefore, the laying of root crops in the kagata stops.

After the formation of a paired kagat during the cooling process , it is necessary to ensure the synchronous operation of two fans connected to one ventilation channel. In the absence of synchronization, the air flow from one fan can spin the impeller of the second one in the opposite direction. Fans with three-phase electric motors with a power of 5.5-11 kW with massive impellers are used in active ventilation systems . In this case, the start of the second fan with the impeller spun in the opposite direction leads to a sharp increase in the starting moment of the resistance of the fan. The risks of premature failure of the electric motor of the fan increase . To eliminate this situation, it is necessary to create a gap between the sections of the ventilation channel in the center of the paired kagat. During the formation of the kagata, the gap is filled with root crops, which perform the function of a valve for air flow, but in this case, the balancing of the air duct may be disturbed. Balancing is a methodical adjustment of air flows from air outlets to achieve uniform cooling of the ventilated fragment of the kagat. Regulation is carried out on industrial samples by changing the location, number and cross-section of holes. The fragment of the kagat refers to its part in which the ventilation branch is located . Areas located closer to the fan should be cooled at the same rate as those further away from it. The ventilation branch is longer (35-45 m) in the paired khagat than in the single khagat (22-25 m).

At the moment, both software algorithms and the work of an operator who changes settings in the system are used for the operation of the active ventilation control system. Algorithms that allow the control system to work without operator participation in automatic mode have a limited scope of application.

They were installed in kagat wireless thermobars according to a certain scheme of binding to numbers fans. On basic station 3 was received signals temperatures from different parts of kagat from thermobar 1, as well as value temperature and humidity surrounding environment from weather station 2. With and stations on the network

Ethernet received signals were transferred to server 4 where they were processed. If fulfillment of the conditions of the algorithm from the server to the base the station the signal to turn on the fan comes from were headed for the closet management ventilation 6, where the start-up of the ventilation was carried out systems. Parameters necessary for complex evaluations work systems were displayed on the automated worker operator's seat 5.

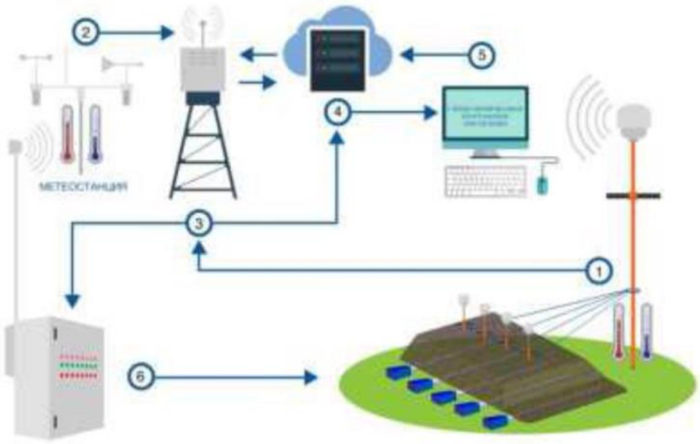

Figure 2. Schematic diagram of interaction elements systems long storage sugar beets: 1- wireless thermobar, 2 local weather station, 3 - basic station, 4 - server, 5 - automated working operator's place, 6 - cabinet management ventilation.

Despite the similarities organizations systems management ventilation were observed essential differences in software supplies for tasks management hardware complex, from what directly depends efficiency work systems active ventilation Insufficient level competences in the matter long ventilated storage in kagatas led to incorrect technical tasks for developers’ software provision. Currently for work systems management of active ventilation are used as software algorithms, as well as the work of the operator, which changes settings in the system. Algorithms which allow work system control without operator participation in automatic mode, have limited scope of application.

The algorithm allows to implement the mode of operation systems ventilation is not taken into account variability temperature ranges surrounding air Application of the algorithm is effective at the initial stage storage kagatas in the period high ambient temperatures air in October. However, since November, observed him incorrect work that leads to the necessity involvement of the operator in the operation of the algorithm by means of adjustment

The algorithm allows you to implement the operation mode of the ventilation system without taking into account the variability of the temperature ranges of the surrounding air. Application of the algorithm is effective at the initial stage of storage of kagatas during the period of high ambient air temperatures in October. However, since November, its incorrect operation has been observed, which leads to the need to involve the operator in the operation of the algorithm by means of adjustments setting values. The operator's work requires a high level of personnel qualification , which hinders the scale of technology at sugar factories. Reducing the dependence of the active ventilation system control algorithms on the operators is possible by improving the software by specifying the active ventilation system operating modes under weather and climate conditions that change during the storage period. The difference between the air temperature in the interroot space of the sugar beet kagat and the ambient air temperature at which the active ventilation system is activated depends on two parameters:

- minimally permissible setpoint value that is defined attitude quantity allocated heat in kW to quantity spent under work time systems active ventilation;
- implementation conditions achievement given settings
- On the uncle's rice 3 presents a graph that characterizes dependence cooling coefficient from differences between air temperatures in the root spacious sugar cane beets and air from the surrounding environment.
- When determining the value of the minimum setting differences between air temperatures in the book sugar beets and air from the surrounding environment necessary consider least favorable the period for ventilation is October.

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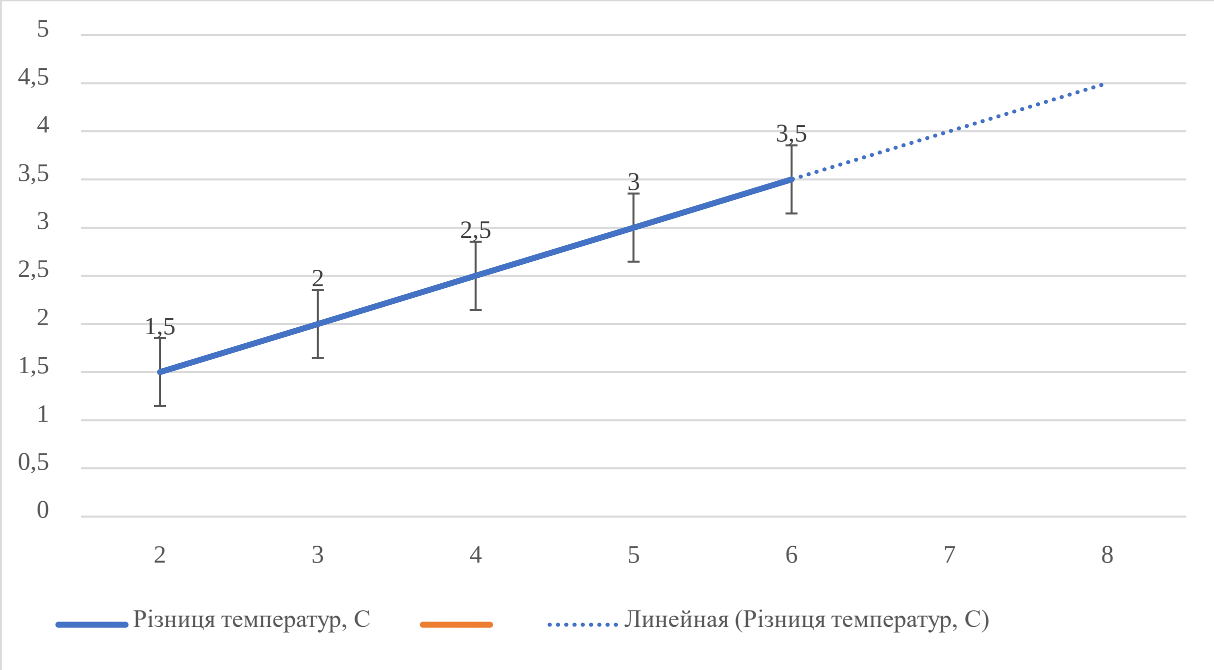

Figure 3. Dependence cooling coefficient from differences between air temperatures in the interradicular spacious sugar cane beets and tidal air from the surrounding environment

During storage the temperature difference between the sugar cane beets and air from surrounding environment constantly was changing parameter (settings) that characterizes the operation of the system ventilation due to the temperature difference between the kagate and the air from the environment environment, determined by the results of the analysis data. It was established that in October observed for 138 hours the temperature difference between the sugar cane beets and air from surrounding environment more than 2°C, which allows to ensure the operation of the system active ventilation within 112 hours.

Thus, the setting of the temperature difference between the sugar cane beets and air from the environment environment, at which the active system is turned on ventilation is equal to 2°C.

At a setting of 2°C the most intense decrease temperature was observed within 45 minutes work systems active ventilation.

Duration is omitted difference content moisture between air from the environment environment and air in the root system kagatu spaces at the time of inclusion systems active ventilation was equal to 3 g /kg. Duration operation of each of the modes determined on the basis of analysis statistical data of changes temperature surrounding air in the period storage sugar beets for decades. According to the results of the analysis of ambient temperatures air from 2019-2021, which is for operation in the mode support the optimal period is from October 1 to 31, in the mode cooling - from October 1 to December 10, in cyclical - from December 11 to the end storage

Convergence computational and experimental data trace regard as a whole satisfactory; divergence is a little more 6-8%, which is within the margin of error experiment.

When applying given models definition losses masses in the process ventilation of sugar cane beets was it is established that the error is 16%. Related this with the fact that the model does not take into account changes parameters tidal air under time of passage through the lower layers in the paper.

After entering a correction factor divergence between experimental data and math model was 9%. Figure 3.8 shows the graph changes losses beet pulp in a ventilated room kagat sugar beets.

Comparison algorithms sequence unloading for processing took place on 6 sugar beets equipped with an active system ventilation, results presented in the table 1.

Table 1.

Comparison algorithms shipment kagats for processing

	Kagat No. 1	Kagat No. 2	Kagat No. 3	Kagat No. 4	Kagat No. 5	Kagat No. 6
Ventilation time, hours	122	113	126	117	124	106
Loss beet pulp from ventilation,	7,8	8.6	7.7	8.1	8.1	7.4
Total	942.8	953.0	951.0	952.2	985.0	767.5
Periodicity shipment by date formation	1	2	3	4	5	6
Periodicity shipment depending from period work and losses beet pulp	5	2	3	4	1	6

Duration work systems active ventilation was obtained from the results of the analysis event log in software security ECMAS-1.0, and the calculation losses beet pulp in the process aeration calculated based on the results of the developed mathematical models.

When shipping were not taken into account by the date of formation duration ventilation and losses beetroots, which are indirect signs that characterize easygoing root crops.

Of the conducted experimental of research, you can do such conclusions:

- in defined the value of the settings that characterize three regimes work systems active ventilation (maintenance , cooling and cyclic):
- difference temperatures between sugar cane beets and air from the surrounding medium is 2 °C;
- - the maximum permissible difference moisture content between air from the environment environment and air in the root system kagat spaces at the time of inclusion systems active ventilation was 3 g /kg;
- duration period growth temperature in the local cell self-heating 72 hours;
- duration operation of the fan during one period of 5 hours.

experimental results comparison of the data was carried out using the sequence method unloading kagats for processing by the fact of formation with the algorithm that takes into account dependence from duration ventilation and losses masses of kagat in the period storage. In the developed algorithms sequence unloading of the kagats loss masses was determined based on the results of calculations using developed mathematical models. It is established that the developed algorithm gives be able to determine the biggest losses.