ISSN NO: 2770-4491
Date of Publication:30-04-2023

# Analysis of the Efficiency of the Cold Air-Conditioning System on the Quality Indicators of Grain Products

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**Annotation:** abstract: in this article, to improve the quality of grain during its processing and proper processing, the quality of the grain product is used, and for the process of moistening and steaming flour, the use of cold and hot air conditioning, which improves the quality of flour and saves time.

**Keywords:** grain, hot and cold conditioning, grain processing, humidity.

**Introduction.** Cold conditioning of grain products, i.e. hydrothermal treatment of wheat ears before threshing, is considered the simplest method of moisture-thermal treatment for targeted changes in grain properties and does not require sophisticated equipment. The method of cold conditioning of milling wheat involves the processing of grain in a machine with a pneumatic drive.

Cold conditioning of grain products, known as "grain soaking" in the mills of the world's grain-producing countries, appeared in the early 19th century. During cold conditioning of grain, water acts as a grain strength regulator and affects its individual parts in different ways. In our country, there are many enterprises producing flour products, and they need a cold grain conditioning system. In particular, the example of “ASAKA GRAIN PRODUCTS” JSC can be singled out as an object of study.

The main task facing the workers of the flour milling industry is to increase the production and quality of finished products. The solution of this problem is impossible without the use of an automated control system for the processes of moisturizing and cleaning grain before grinding. For grain spikes, water, within certain limits, is a reagent that reduces the force and helps to reduce the resistance during grinding. Blowing air into ears of grain is an accelerator of all processes. Cold conditioning of grain regulates the movement of moisture in the grain in the right direction, which allows you to change its physical and chemical properties. Saving time increases production productivity, contributes to the high quality of grain products, and in turn increases the efficiency of the enterprise.

Until now, the use of cold grain conditioning has been limited due to several problems. For example, enterprises are not provided with modern technologies, high power consumption, lack of an automatic control system and control of cold air conditioning. Currently, there are two ways to solve the problem [1, 2]: replacement and complete renewal of existing equipment or partial replacement and automation of some stages of the humidification process. The first method requires large economic and material costs, and the second is the most acceptable for most enterprises, allowing you to quickly and flexibly respond to emerging problems.

The article provides for the analysis and development of an adaptive system for monitoring and controlling the process of cold conditioning before grain crushing.

**Material and methods.** Currently, the issue of determining the exact moisture content of grain is very relevant. The problem is that there is no standard for grain moisture, so it must be determined by indirect measurement methods. In laboratory conditions, a drying block installation is used to determine the humidity, the measurement error is 0.1%. However, it is not used to measure humidity in a flow because of the long duration and inconvenience of measurement. To date, a device has not been developed that allows obtaining data from a drying plant with a smaller error.

The time of discharge of wastewater into grain freezing plants was selected experimentally and takes into account the amount of water evaporated during moistening, without taking into account the heterogeneity of grain batches entering processing, i.e., different grain quality. This damage not only negatively affects the

ISSN NO: 2770-4491
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quality of the grain, but also unreasonably delays the process of grain filling on time.
The temperature of the water used for soaking is not taken into account. Wastewater is used for irrigation, the temperature of which can vary between 16.5 - 19 °C, the possibility of using heated water is not taken into account, although in enterprises, especially in winter, the issue of increasing the irrigation process is relevant.
The heterogeneity of the grain structure, that is, the heterogeneity of the grain, causes uneven dynamics of moisture distribution from the shell to the center of the grain. The use of heated water allows you to speed up the process of water redistribution. Some plants need to stand idle when the ambient temperature is below -20°C or use heating of the grain before soaking, for example by drying. The absence of a developed mathematical model of a complex set of changes in the properties of the grain mass in the process of cold conditioning determines the unpredictability of the final moisture content of the grain and the time of scattering when using flexible control modes (for example, water heating).
Because of the analysis of existing technologies and methods for controlling the process of cold conditioning, it can be concluded that in order to improve process control, it is necessary to improve the concept and structure of the management of humidification and cleaning operations and develop the necessary control for this.

**Research results and their discussion.** Local and integral caking of a grain is determined by both diffusion and capillary permeability, which is associated with the structure of colloidal solutions and the structure of grain parts. The purposeful change of wheat flour and baking properties achieved by conditioning is one of the decisive factors contributing to the improvement of flour production technology.
It can be argued that the technological goal of grain conditioning is not to artificially soften the ears, but to create the greatest strength of the husk and to weaken the bond between the husk and the edge layer of the endosperm as much as possible.
The complex organization of the technological process of grain processing is determined by two main factors [3, 4, 6, 7, 9].
- features of the grain structure of various crops;
- refers to the objective function of a particular process, i.e. to produce flour or grain and what varieties.

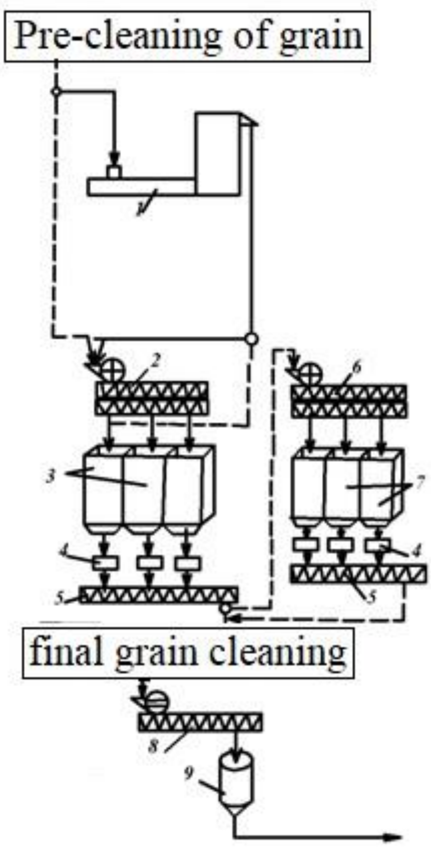


Figure 1. Process flow diagram of a cold air conditioner.

ISSN NO: 2770-4491
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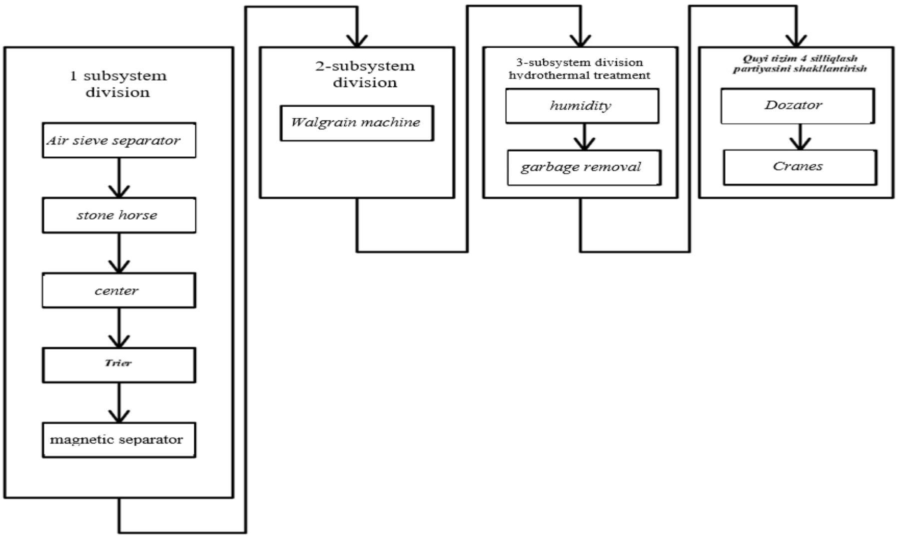
*1-washing machine, 2, 6, 8-humidifiers, 3-first brew hoppers, 4-dispenser, 5-mixer, 7-refill hopper, 9-rest hopper before curtain system.*

In the modern production process at the plant, all technological operations are a single flow, built according to a hierarchical principle.

The preparation of grain for processing includes a number of technological operations that can be considered as independent complex open systems. On fig. 2 shows a block diagram [7] of the system of the preparatory department of the wheat mill. In this scheme, four blocks of technological operations are identified as a subsystem: separation, grain surface treatment, hydrothermal treatment and the formation of crushed charges. All this makes it possible to define the technological process of flour production as a complex dynamic open system with many internal and external links.

Modeling and optimization of the operation of the hydrothermal treatment subsystem can be carried out by considering it as a flexible technological system [8], which can be attributed to a system with a renewable structure of technological connections and operating modes.




On fig. 2 - shows the block diagram of the preparatory workshop of the mill workshop.

The scheme of grain operation as a complex open thermodynamic system [35, 34] is shown in Fig. 3:

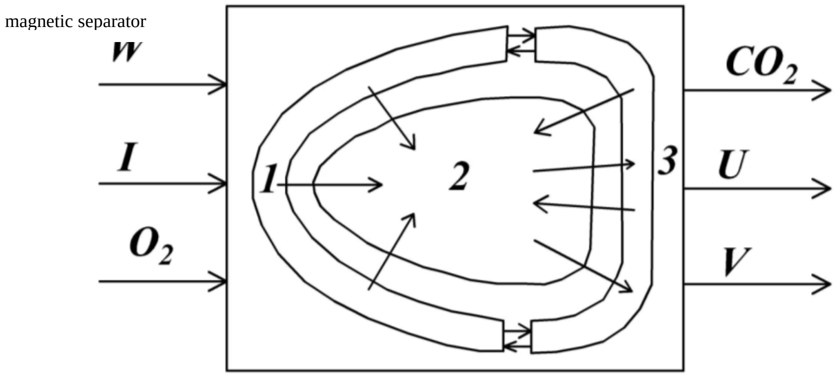



Figure 3. The scheme is presented as a layered opening system.

Here, various symbols define the material, energy and information flows of grain exchange with the environment: *1-shell, 2-endosperm, 3-germ, W-ambient humidity, t-ambient temperature,* $O_2$*-oxygen, V-volume.*

The control of grain properties during the preparation process is aimed at bringing the grain to a state that ensures high efficiency of the processes in the grinding department of the mill or in the cleaning department of the grain plant. The task of controlling the technological properties of grain in the preparatory department of a mill or groats can be formulated as follows [35, 27]: stabilization of the technological properties of grain at an acceptable (or close to optimal) level.

To solve this problem, use:

ISSN NO: 2770-4491
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- formation of batches for processing;
- hydrothermal processing of grain.

Separate stages of the technological process interact with each other, so a change in the parameters of one of them is reflected in the parameters of others. In this regard, it is necessary not only to stabilize the determining parameters at individual stages, but also to synchronize management actions at all stages. This is determined by the complexity of the technological process, its consistency.

In experiments on grain wetting with radioactive tritium water, a three-stage mechanism of grain wetting was confirmed [7]. On fig. 6 is a graph of the distribution of moisture over the cross section of a wheat grain during cold conditioning. The area of the aleurone layer is shaded in the figure. It can be seen that a sharp uneven distribution of moisture in the grain is observed even after 1 hour from the moment of moisture. With further development of the process, water gradually diffuses into the endosperm, but even after 16 hours, uneven distribution of moisture is still noticeable. The final distribution of moisture in the equilibrium ratio between proteins and carbohydrates occurs within 48 hours or more, depending on the individual characteristics of the grain, the mechanical stress that occurs in the second stage of the process is almost completely relaxed.

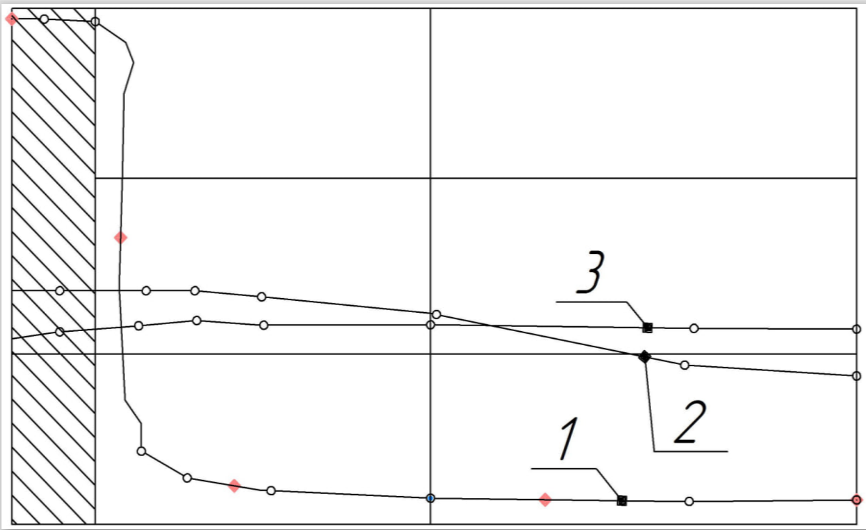


Figure 4. Diffusion of water across the cross section of wheat during cold conditioning with diffusion duration:1-1 hour, 2-16 hour, 3-48 hour.

When the grain temperature rises to 50-60°C, the moisture distribution stops after 2 hours.

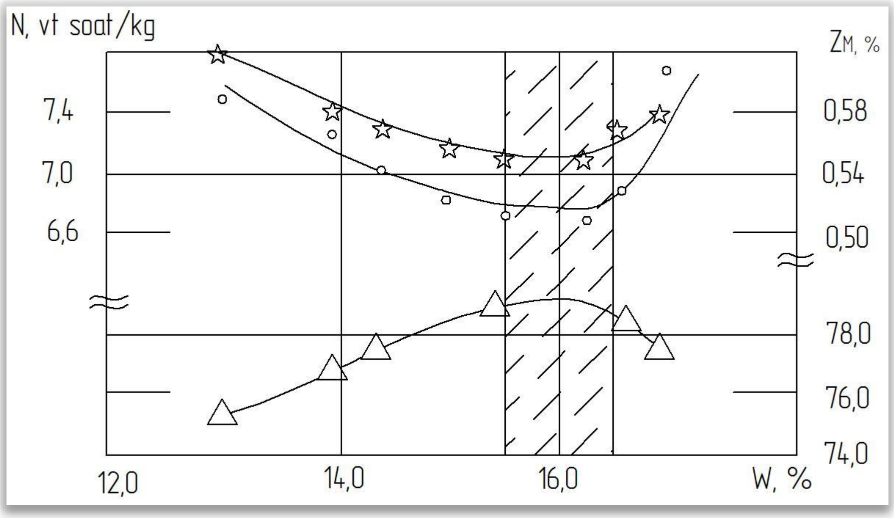


Figure 5. Optimal moisture zone for vitreous grains.

The main factor in changing the properties of grain during cold conditioning is the change in humidity. Moisture-saturated proteins swell, grain enzymes are activated, because of which changes in its structure and properties are observed, and humidity increases significantly.

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The works [7, 10-14] show the processes of penetration of cooling moisture into the central layers of the grain, the change in grain size and the associated strengthening of grain structures, regardless of the initial state (humidity) of the components of the initial mixture., ends simultaneously.

**Conclusion.** When grains are transferred from an arbitrary initial hydrothermal state to a given final state, the correlation between the dynamics of the formation of moisture fields in the grain and the hydrothermal properties of the intergranular space in the grain box is confirmed, which makes it possible to predict the time.
The proposed concept of cold conditioning process control makes it possible to create a control system that operates under conditions of uncertainty in the initial properties of the processed raw materials and ensures the minimum duration of the process of transferring the product from a variety of possible initial states to a certain final one state.
A grain moisture measurement sensor during processing has been developed, which has the advantages of periodic correction of the current calibration characteristics, continuous operation under vibration conditions, discrete continuous grain moisture measurement mode, ease of maintenance and ease of inspection.
The developed transducers make it possible to quickly and reliably control the dynamics of moisture redistribution by grain size.
With the help of digital measuring instruments and secondary converters, a universal decentralized control system for cold air conditioning before grain grinding is proposed, which provides control, storage and remote data transmission, reduces the error of direct measurement and increases the accuracy of indirect control of process parameters.
An algorithm for optimizing the operation of the cold conditioning unit has been developed and software implemented, with the help of which the optimal modes of processing crushed grain batches are determined depending on seasonality, initial technological characteristics and the volume of crushed batches, as well as both the geometric dimensions and the number of silos.

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ISSN NO: 2770-4491
Date of Publication:30-04-2023

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