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DESIGN OF GRAIN MOISTURE CONTROL DEVICES FOR FLOUR MILLS

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Abstract. *The article reports the results that occur in managing the dehulling process of output, which is the main process of processing grain. The study of the technical thawing processes was carried out the key factors influencing the consistency of the manufactured target product, where the hydrothermal treatment of the grain causes the initial properties of the grain to be altered. And due to the effects of moisture, temperature, as well as thawing decreases, wheat grain vitreousness, the degree of endosperm loosening increases, there is a redistribution of chemicals in the anatomical parts of the grain under the influence of developing biochemical processes. In order to enhance technology production, organization of controls, quantitative accounting of raw materials, goods and monitoring of processes, the implementation of an integrated control system for the management of technical processes is important. To this end, mathematical models of heterogeneous humid systems dielectric permittivity and ways to enhance the reliability and accuracy of dielectric process results of moisture regulation of materials are analyzed. The issues of high-frequency system design and design of moisture control devices based on it are considered for capacitive measuring transducers. It is sufficient to cover the spectrum from infrared to tens of megahertz when designing the dielcometric means of technical control of heterogeneous systems parameters, because it is in this frequency range that the polarization structure factors manifest themselves. The dielectric grain permit model, which takes the material temperature into account, encourages us to estimate the degree and nature of the polarization factor's effect on the total grain moisture measurement error, and can therefore be used to make the required corrections to the result of the measurement. It investigates the criteria for primary measuring transducers.*

Keywords: *Automation, grain, wheat, dehumidification of hydrothermal treatment, vitreousness, moisture, regulation, unit, high frequency process.*

INTRODUCTION Flour is one of the valuable objects of greatest value. In the Republic of Uzbekistan, grain-processing enterprises process more than five million tons of grain annually.

One of the most significant ties in the field of the agro-industrial complex is ensuring the food security of the confectionery industry.

High-quality flour is the target requirement of grain millsTo this end, the technical processes of grain processing enterprises needs to be strengthened, as the grain raw material receives a variety of varieties of finished products as a result.

However, you need quality raw materials, the creation of the correct composition of the grinding batch, the organization of the technical rules of the mills for the production of quality finished products.

The preparation of milling hydrothermal treatment (HTT) of grain is one of the key processes for improving product quality, resulting in improved quality of finished goods, reduced energy consumption, improved sanitary condition of shops and employees' working conditions.

It should be noted that there is still an urgent problem with either the problem of hydrothermal grain treatment.

THE RESEARCH OBJECT AND SUBJECT

Every batch of grain in its composition is also heterogeneous in structure, including physical and mechanical, technical and physical and chemical properties. JSC 'G'ALLA-ALTEG' plants receive batches of wheat grain of different quality.

Given these characteristics, the quality of incoming local grain varieties, as well as study and scientific rationale for improving the technical process, the preparation of grain for milling and the milling process should be carefully studied under the conditions of grain processing enterprises.

One of the problematic issues at JSC "G'ALLA-ALTEG" as well as enterprises of the milling industry of the Republic of Uzbekistan remains the lack of instrumental methods for determining the structural and mechanical properties of grain, which leads to the incomplete use of technological properties of local varieties of grain, which does not allow to set the optimal regimes of preparation and milling of grain.

Knowing the grain's structural and mechanical properties and its deformation mechanism would make it much easier for washing, fractionation, and milling to enhance the operation. A high grain heterogeneity in weight, width and thickness has also been observed, which affects its mechanical properties (Table 1).

Table 1.

Geometric parameters of grain

Wheat	critical speed	length, mm	width, mm	thickness, mm	density, mm	weight of 1000 grains, grams	bulk weight
	8,5-11,5	4,0-8,6	1,6-4,0	1,5-3,8	1,2-1,5	22-42	0,05-0,81

Our studies have shown that during hydrothermal treatment of grain, allows to change its initial properties (physical and chemical, structural and mechanical, biochemical, etc.) in a targeted way. And because of the effects of moisture, temperature, as well as thawing decreases, wheat grain vitreousness increases the degree of endosperm loosening, there is a redistribution of chemical substances in the anatomical parts of the grain under the influence of evolving biochemical processes. As we know from [1], the results of our studies show that with properly selected modes of wheat ash content of high-grade flour is reduced, the yield of flour is increased by 1-2% or more.

As you know, there are a number of HT (hydrothermal treatment) methods. So far, however the Republic of Uzbekistan primarily uses one HT form - cold conditioning. In this situation, to alter its structural, mechanical and biochemical properties, the grain is moistened with water and held (thawed) in hoppers for a certain time. The evenness of the batch of grain in terms of vitreousness should be taken into account when choosing conditioning parameters. According to [2], the results of our studies indicate that when the batch of grain is homogeneous in physical and mechanical properties, the best results for hydrothermal treatment are appropriate (Table 2).

Table 2.

Physical and mechanical properties of grain and wheat

length, mm	width, mm	thickness, mm	density, mm	weight of 1000 grains, grams	bulk weight, kg/m^3	hover velocity, m/s^2	supply velocity, m/s^2
4,0-8,6	1,6-4,0	1,4-4,2	1,200-1,500	20-40	700-750	8,5-11,5	3,5-3,86

The first humidification is carried out on the washing machine at a moisture increment of up to 3.5%. The process of the first debinding lasts up to 14 hours. This raises the humidity to 14.5%-14.8% . If the grain's glassiness is above 50 percent, the second thawing would take a period of 12 to 14 hours. If the humidity of the incoming grain is below 12 percent at the washer, the variance of the humidity of the grain in the I dredge system up or down would lead to lower efficiency of processing wheat grain during the second humidification moisture is brought to 15.8-16.5 percent at the humidifier.

It is also known from [3] that in case of high vitreousness of wheat double thawing and moistening is recommended, and conditioning modes are set depending on the type of wheat, vitreousness (one of the main indicators for choosing wheat HT), humidity of initial wheat of local varieties varies from 8% to 12%, etc.

During preparation for variety milling, the duration of basic thawing of wheat grain is recommended from 16 to 28 hours, where the upper values for grain with vitreousness over 60%, the lower values for grain with vitreousness up to 40%.

The main purpose of the HT, is to increase the elasticity of the shells, as well as to weaken the bond between the shells and the endosperm. Using this technological method facilitates the separation of the shells from the grain, with little loss of endosperm, which contributes to an increase in the output of high-grade flour.

Table 3.

Cold conditioning methods for wheat in frozen milling variants

Type of wheat	Glassiness, %	Defrosting duration, hour	Recommended humidity of grain on I pounding system, %
I	less than 40	from 4 to 8	14,5-15,0
	from 40 to 60	from 6 to12	15,0-15,5
	more than 60	from 10 to 16	15,5-16,0
III	less than 40	from 4 to 6	14,0-14,5
	from 40 to 60	from 6 to 10	14,5-15,0
	more than 60	from 8 to 12	15,0-15,5
IV	less than 40	from 6 to 10	15,0-15,5
	from 40 to 60	from 10 to 16	15,5-16,0
	more than 60	from 16 to 24	16,0-16,5

It is recommended that wheat moistening and thawing with an initial moisture content of less than 12.0 percent be conducted sequentially in two phases, the ratio of moisture increase value and the time of thawing should be approximately 3:1.

Take into account the findings of our study, which illustrates the processes and factors influencing the efficacy of hydrothermal treatment, consisting of the following factors: the moistening value, the temperature, the time of thawing, the conditions and the degree of application that constitute the HT regime.

All the dynamic physical and biological changes in the grain are triggered by the moisture element, resulting in enhanced technical properties. The temperature factor contributes to the acceleration of processes, thus altering gluten efficiency. The time of thawing is connected to the rate of movement of moisture in the grain and the different phases occurring in it. Performance is primarily dependent on the technical characteristics of the grain, as the individual characteristics of the grain have a major effect on the selection of suitable hydrothermal treatment modes. Research has shown that grain moistening is inevitably related to the development of microcracks in the endosperm through which it is irreversibly damaged. With varying speed, the phase of crack formation progresses, the presence of the first cracks in the wheat grain endosperm is recorded after 0.5 hours, their formation stops by 8-12 hours. The thinnest microcracks are eventually closed and the original structure is partly restoredThe most intense formation of microcracks in wheat endosperm is observed at 14.0-16.5 percent moistening, not reported at 17.5 percent microcrack formation. At first the acid value of the highest and first grades decreases, hitting a minimum moisture content of 14.5-15.5 percent, and then stays unchanged. The ash content of the total flour in cold conditioning, as a function of time, decreases from one hour to the point of one hour after which the leveling process passes. It should be noted that the content of flour ash decreases most dramatically when thawed from 2.0 to 6.0 hours, and is less evident when thawed for more than 6.0 hours [4].

In order to enhance technology performance, organization of controls, quantitative accounting of raw materials, goods and monitoring of processes, the implementation of an integrated control system for the management of technical processes is important.

If there are existing tasks of operational and strict control of raw materials and manufactured goods, precise monitoring of technical regulations, control of the actions of technological workers increased personal accountability of operators for decisions leading to losses, there is probably no alternative to computerized control systems. In particular, the successful functioning of an enterprise under the prevailing market conditions involves the development of an enterprise in order to increase the efficiency of technical processes, the organization of perfect control and production management [5].

ANALYSIS OF THE STATE OF THE PROBLEM. Its moisture content, from distribution to full processing, is one of the regulated parameters of the grain. As is understood, heterogeneous complex mixtures of organic (e.g., grains) and inorganic substances are capillary-porous colloidal materials. A formed inner surface is characterized by organic materials, so they can bind a significant amount of water (up to 50 percent or more). The irregular distribution of moisture in them, which can not be overlooked in the design and operation of moisture measurement instruments, is another important feature of materials of plant origin.

Both grain components include capillaries and pores with a wide range of sizes that are continuous. For grain, therefore, capillary bonding is the primary type of bonding at medium humidity, based on the size of the molecular mechanism of movement of moisture in capillaries. If the capillary radius of the water molecule is much greater than the free path length (λ) in the case of transport in macro capillaries, the mass flux density is calculated by the Poiseuille formula of [6]:

$$n = \frac{r^2}{8\mu}\frac{dP}{dX} = \frac{r^2}{8v}\left(\frac{P_1 - P_2}{L}\right) \qquad (1)$$

For microcapillaries (r '0,1μ), the molecular mode will be used to assess transport. The density of mass flux can be calculated in this case by the formula:

$$n = \frac{1}{\pi r^2}\frac{dM}{d\tau} = \frac{8}{3}\sqrt{\frac{\mu}{2\pi kT}} \cdot r\frac{P_1 - P_2}{L} \qquad (2)$$

where $\frac{dM}{d\tau}$ - the velocity of steam flow.

There are major variations between sorption isotherms obtained by different authors due to the complexity and variability of the capillary porous characteristics of grain and the impact of the history of sorption processes. Liquid can be in the form of free water, capillary bound (physical-mechanical bonding), adsorption bound (physical-chemical bonding) and chemically bound, depending on the form of binding energy and material type. Agro-industrial materials have a complex structure and organic and mineral weed impurities are usually found in almost all forms of agricultural products [7]. The physical characteristics of the components of these materials (F_{ki}) differ considerably and depend on a variety of factors, including their humidity (W_{ki}), temperature (T_{ki}), macro and microstructure characteristics (S_{ki}), maturity level (Z_{ki}), storage and processing conditions (X_{ki}).

$$F_{ki} = f(W_{ki}), T_{ki}, S_{ki}, Z_{ki}, X_{ki} \quad (3)$$

The physical attributes of the material (F_M) are obviously based on the characteristics of its components (F_{ki}), their quantitative ratio (M_{ij}), their mutual arrangement (R_{ij}), the number (N) and the volume (P) of the inclusion of air between them.

$$F_m = Q(F_{ki}, M_{ij}, R_{ij}, N, P) \quad (4)$$

The ratio of the total mass of water in the controlled volume to the dry mass of that volume (M) [8] is defined as material moisture (W).

$$W = \frac{M_B}{M} = \frac{\sum_1^n W_{ki} \cdot M_{ki}}{\sum_1^n M_{ki}} \quad (5)$$

where M_{ki}– mass, i-component;

n– number of material components.

RESULTS OF THE RESEARCH. The next step is to select an instrumental support system and design for measuring grain moisture. Technique applied to the measurement methods are better for materials like grain.

Two forms of concentrated media are considered according to the principle of heterogeneous polarization. In comparison with the distances to the nearest elements of the system [9], weakly concentrated media are those where the sizes of inhomogeneities are minimal. These inclusions are found in highly condensed media and have a direct effect on the properties of the entire material [10].

The existence of a certain common phase, the matrix, in which the unconnected particles that make up the second phase are contained, is defined by matrix systems. Dielectric permittivity is a complex function of the partial dielectric permittivity and volume concentrations of the components of the dispersed medium ε_1, v_1 и and the dispersed phase, invariant to index replacement in static disperse systems.

$$\varepsilon = f(\varepsilon_1, \varepsilon_2, v_1, v_2) = f(\varepsilon_2, \varepsilon_1, v_2, v_1). \quad (6)$$

The dependency between the dielectric permittivity of the material under control and its humidityis the basis for high-frequency humidity control devices [11]. The solution to this problem needs in-depth theoretical and experimental study to develop fundamental questions on the theory and practice of express moisture measurement in technical systems, to develop scientifically justified principles for the construction and implementation of engineering calculation methods, to choose the optimum operating frequency for the design of transducer measurements. The primary moisture transducers are the key elements which provide information relating to the basic characteristics of the object under study and which largely determine the consistency and reliability of the route of measurement [12].

RESEARCH METHODS. The establishment of analytical dependencies between the physical and electrical characteristics of high-frequency grains, taking into account the heterogeneity of structure, wellness, bulk mass, distribution of grain size and electrolytic composition, i.e. frequency-moisture characteristics, is the key requirement for the good performance of the problem raised [13-14]. Special attention should be paid to studying the effect of contact electrical conductivity between particles, taking into account the roughness, the height of microroughness, the number of contact points, etc. A methodology for finding the separation parameters of informative (useful) and uninformative (disturbances, noise) signals, as well as frequency optimization for frequency separation of parameters, also needs to be developed. It is important to improve the design of measurement transducers and measurement circuits for moisture meter systems, taking into account the data obtained. There are some changes to each of the above measurement methods, but their main objective is to enhance measurement precision.

The criteria for selecting a measurement method based on which to construct moisture meters should be the precision that can be given by the selected method. Such a criterion can hardly be formalized in the form of a mathematical expression, but it is clear that the precision of measurement remains the main component therein [15-16]. The absence on the market today of many of the above-mentioned moisture control devices demonstrates once again the objective, practice-proven lack of any of the methods' obvious advantages [17].

The following little-studied problems need to be solved in the experimental analysis of the dielectric properties of these materials, grains, in a high-frequency field [18]:

- primary high frequency transducer measurement; for this reason, the dependence of the dielectric properties of the products under study on the moisture content of the most important influencing factors must be investigated experimentally.
- building an electrical model of the primary transducer on the basis of the experimental data collected, with an ideal approximation of the actual characteristics of the materials under analysis.
- Implementation of the data collected by designing and testing under laboratory and industrial conditions, high-frequency moisture control systems for grain and grain products.

CONCLUSIONS We can state the following on the basis of the study performed and according to [19-20];

1. The study shows that the development of universal analytical models of dielectric properties of heterogeneous systems in general, and of scattered moisture-containing bodies in particular in known works, has not been given sufficient attention. The lack of consideration of the effect of the kinds and types of moisture bonding on the electrophysical properties of the material is one of the key reasons for the satisfactoriness of the known mixture formulas when applied to wet material.
2. It is sufficient to cover the spectrum from infrared to tens of megahertz when designing the dialectometric means of technical control of heterogeneous device parameters, because it is in this frequency range that the polarization structure factors manifest themselves.
3. The dielectric grain permit model, which takes account of the material temperature, helps us to estimate the degree and nature of the factor's effect on the total grain moisture measurement error and can therefore be used to apply the required corrections to the result of the measurement.

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