# Efficiency of stabilization of technological processes at the mill of food production

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**Abstract.** The article provides the description of the production experiment carried out at a mill for varietal grinding of wheat into baking flour, the technological scheme of which provides for the selection of pasta grits. To obtain a statistical set of data, the experiment was organized for 10 days, during which the values of the studied process parameters were recorded every two hours. The output of pasta grits was chosen as this. These products are subjected to thorough sorption on sieves for separation into independent fractions of products by size and quality, then the grains undergo additional processing (enrichment) on sieve machines and at the last stage - in the grinding process - their final grinding into flour takes place. Such a complex organization of grinding requires serious theoretical and practical training from the technologist to perform the main task - process control at the mill.

## 1 Introduction

The technological process at the mill is a complex open dynamic system [1-3]. This means that it consists of a number of subsystems and elements (technological operations) interconnected by complex relationships. The hierarchical construction of flour technology is important, as a result of which the violation of technology, the deviation of the parameters of the grinding process stages located in the upper part, can no longer be corrected at subsequent, lower stages, subordinate to the previous stages.

Therefore, of paramount importance is the stabilization of the technology parameters at all stages of the grinding process, and above all, at the first, broken process, the main task of which is to maximize the extraction of grain endosperm in the form of intermediate products.

The complex technology of varietal milling of wheat includes several interrelated process steps, each for solving a specific technological problem. At the first stage (tear process), it is necessary to ensure the extraction of grain endosperm in the form of intermediate products - grains of various compositions, these products are thoroughly sorbed on sifters to separate into independent fractions of products by size and quality, then the grains undergo additional processing (enrichment) on sieve machines and at the last stage - in the grinding process - they are finally crushed into flour.

Such a complex organization of grinding requires a technologist to have serious theoretical and practical training in order to perform the main task - to control the technological process at the mill.

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From the point of view of system analysis, flour technology is a complex open dynamic system, and each of the technological stages can be considered as its subsystems, and in case of independent analysis, they can be interpreted as independent systems of the same characteristics [4-8].

Additional complexity in the task of the technologist is introduced by the constant change in the technological properties and quality indicators of grain batches entering the processing.

This requires skillful handling of it, a competent choice of the parameters of the mode of all technological slips and operations in order to ensure high efficiency in the implementation of the technological potential of grain.

All these factors together give rise to a natural variation in grinding results due to changes in process parameters. And therefore, the most important task of the technologist is the stabilization of these parameters, which directly determines the constancy of the grinding results and its consistently high efficiency.

## 2 Research methods

Based on the analysis of schemes for constructing technological processes in accordance with the Rules for conducting technological processes at flour mills? factories, research work on flour-grinding production, technological schemes of mills, we will classify technological schemes of flour-grinding enterprises. We have accepted that the class of the scheme is determined by the presence and degree of development of additional subsystems (meaning the subsystems of the sieve and grinding processes).

The whole variety of technological schemes in the flour milling industry can be divided into four classes: 0,1,2,3. Each class has several types, which include a different number of subsystems, and ways of communicating with each other or with the central subsystem.

To the technological schemes of the zero class, we include schemes of two types: technological schemes for wholemeal milling of wheat and technological schemes for wholemeal milling of rye. It is well known that you do not provide for wallpaper grinding. sorting intermediate products. For this reason, technologically? zero-class schemes contain only the central subsystem and the final subsystem for processing finished products. The central subsystem is present in all schemes of any class, and it cannot be excluded from the technological scheme of grinding, since it plays a fundamental role in the conduct of the entire process.

Technological schemes of the first class include a broken process subsystem (central process subsystem) and a finished product processing subsystem. Depending on the relationship of subsystems in the first class, three types are distinguished. These types include (in accordance with the degree of complexity of the relationship of elements and their number within separate subsystems): technological schemes for single-grade grinding of rye into peeled flour technological schemes of two-grade grinding of rye;? technological schemes of single-grade grinding of rye into pure flour. All these schemes are united according to one common feature: the absence of a sieve and grinding process.

The next, second class, includes technological schemes containing, in addition to the above subsystems, subsystems of grinding and screening processes, but these subsystems have a small extent. The typical schemes of the second class include the technological scheme of single-grade wheat grinding with 85% flour yield and the reduced scheme of two-grade wheat grinding.

The third class includes the most complex and extended processing systems. In technological schemes of all four types of the third class, all subsystems have a large extent and complex interconnection with each other. Intermediate products are repeatedly returned to the previous subsystems so that they undergo more thorough processing and the maximum amount of flour is obtained. Technological schemes of the third class include: technological scheme of single-grade 72% milling of wheat; technological scheme of three-grade milling of wheat with a yield of 75-78%; technological scheme 75-78% of two-grade milling of wheat; technological scheme of pasta grinding with a yield of 72-75%. The developed classification is shown in.

## 3 Results

Considering the production of flour at one enterprise as one technological system consisting of a number of subsystems, each of which performs one of the listed tasks, it can be represented as a graphical model. Let's introduce the designation of subsystems, starting with the first subsystem of the torn process, since this subsystem is central \ the results of its work affect the final results obtained as a result of the processing of intermediate products on all other subsystems? technological process.

Subsystem B is included in the general scheme of the technological process (for the purpose of enriching grains by grinding them. On the subsystem of the grinding process, aggregates are crushed in order to form more solid coarse products. The presence of this subsystem allows improving the quality of products entering the grinding process subsystem and reducing the load on the working bodies grinding subsystem machines.

System analysis of processes suggests using the calculation of information entropy according to the formula to assess stability [9-14]:

$$\eta = \frac{H_1}{H_0} \quad (1)$$

where $H_1$ and $H_0$ are the values of the entropy of information under the existing modes of the process and with a uniform distribution of the values of its parameters over the entire range of change. The value of H is called negentropy, due to the use of negative probability values in its calculation, in accordance with the formula:

$$H = -p \log p - (l-p)\log(l-p) \quad (2)$$

Where: p - is the probability of a particular event.

The values of H are tabulated and therefore the calculation procedure is simplified.

Using this apparatus, we performed a production experiment at a mill for varietal grinding of wheat into baking flour, the technological scheme of which provides for the selection of pasta grits.

To obtain a statistical set of data necessary for calculating the probability, the experiment was organized for 10 days, during which the values of the studied process parameters were recorded every two hours. The output of pasta grits was chosen as this [15-19].

The milling batch of wheat consisted of 70% winter wheat and 30% spring wheat, and had the following qualities until July: nature 772 g/l, moisture content 12.6%, vitreousness 76%, ash content 1.88%, gluten content 28.1%. At the mill, the yield of pasta grits for a long time was in the range of 18.3% ... 21.6%.

Figure 1 shows the variational curve for the extraction of pasta grits at the initial moment of the experiment, i.e. under existing conditions at the mill.

The results show that the process is characterized by significant instability, there is an unsystematic scatter of data, which is due to seeded disturbances in the grinding mode on the first systems of the torn process, as well as in the sieve process.

Calculated according to formula 1, the value of the stability of the extraction of pasta grits was only 0.055.

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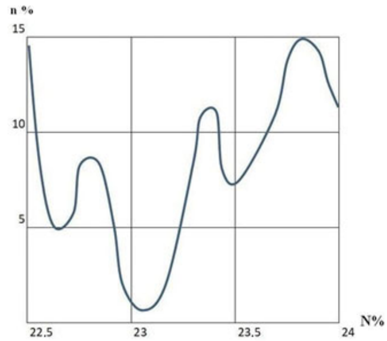


**Fig. 1.** Variation curve at the beginning of the experiment.

In this regard, at first, the modes on the first two systems of the torn process were adjusted and their stability was increased, and then the operating modes of the sieve systems engaged in the enrichment of grains of the 2nd torn system and the sieve, which re-enriches these grains, which represent the final product - pasta grits. As a result, the variation of the results has significantly decreased, which is clearly demonstrated by the graph in Figure 2.

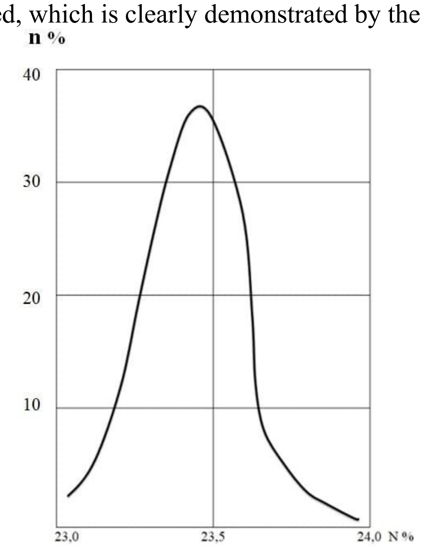


**Fig. 2.** Variation curve at the end of the experiment.

After adjusting the grinding modes on torn systems, the stability of extracting pasta grains increased to 0.209, and then, after adjusting the operation of the sieve systems, to 0.236 and, finally, to 0.315. At the same time, the total extraction of semolina remained at the same level (on average 23.5%), but as a result of the increase in the stability of the system, it became possible to carry out measures to increase its selection [15-17]. Subsystem A includes the primary processing of grain in order to obtain the maximum amount of grains and the minimum amount of flour. At this stage, the grain is, as it were, torn apart. At the same time, they strive to get as many large bran particles as possible and remove them from the process of further processing. Depends on the quality of the obtained intermediate products. further maintenance of the technological process. The torn process subsystem is present in the technological schemes of all types of grinding and, accordingly, is the leading system. According to the functional purpose of the stage of the subsystem of the torn process, most experts divide it into two stages - groat-forming and grinding [20-23].

In the final part of our experiment, as a result of the impacts on the process, it was possible to increase the yield of pasta grits of standard quality to 27.3% i.e. noticeably improve grinding efficiency.

The result of our production experiment reflects well the calculation of the complex efficiency criterion, according to the formula:

$$D = \frac{Z_0}{Z_1} \tag{3}$$

where $Z_0$ and $Z_1$ - are the ash content of grain and finished products, in this case, pasta grits. Before the start of the experiment, D = 82.5%, and after the phased improvement of the process, these values were 82.8%, 83.4% and 84.6%. But after increasing the yield of semolina, as noted above, the value of the criterion increased to 96.4%.

## 4 Conclusion

Thus, the involvement of system analysis methods in the study of mill technology makes it possible to substantively identify the factors of process efficiency and directly improve the technology, increase the technological and economic efficiency of the enterprise.

Production technological processes at mills of high-quality grinding have one characteristic task - stabilization of grain moisture within the required limits. The quality of products suffers largely due to the fact that the lines for moistening the grain are inoperative and the production personnel are forced to introduce water according to an estimate of the thickness of the jet "by eye" ("half a finger", "finger", etc.).

There are many reasons for this, for example, broken flasks of glass rotameters, clogging of inlet filters for water purification, the inconvenience of constant manual adjustment of the water supply, etc. values of the initial grain moisture and grain moisture on the 1st torn system), which is 2-3% of the total weight. Moisturizing and dampening of wheat with an initial moisture content of less than 12% is recommended to be carried out sequentially in two stages, while the ratio of the moisture increment in the first and second stages should be approximately 3: 1, which makes the use of outdated moisture systems even more inefficient.

Unlike traditional layout solutions based on controllers scattered over the floors of the mill, our company has taken the path of modular system design, highlighting the mandatory groups of devices: grain moisture measurement devices in a continuous flow, grain feed control devices in a continuous flow, feed control panel water, a panel of secondary instruments, a cabinet for devices for matching with an object (SHSO), a microprocessor technological station.

The operation of the humidification scheme was based on the principle of positioning the grain moisture meter in a continuous mode, which ensured the condition for the minimum transport delay that exists between the grain moisture measurement point and the water inlet point. This condition is dictated by the fact that the enterprises for the processing of bakery products, due to the presence of flammable dust, belong to the category of fire and explosion hazardous industries. In addition, the grain is actively blown with air and dried during the production process.

Fundamental in the complex of implementation problems is the issue of embedding the newly developed humidification system into the existing technological equipment of the mill, including the electrical circuit. At the same time, of course, the requirements of the Gosgortekhnadzor for explosion and fire safety and the implementation of basic technological interlocks and protections must be observed.

This problem was solved by the appropriate development of an automation scheme, which included not only the equipment of the automatic humidification plant, but also part of the mill equipment. The introduction of technological interlocks solved mainly the problems of protecting equipment from blockages, shocks, stopping the water supply in the absence of a grain flow, and correctly measuring grain moisture in the flow. To solve these problems, free contacts of factory electrical automation and sensors installed earlier at the facility were widely used.

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