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THE ROLE OF THE MATHEMATICAL MODEL IN DOUGHMAKING PROCESS OPTIMIZATION

The article analyzes problems of optimizing mathematical theories in design of the primary component of the mixing component of a periodic action dough mixing machine. The following software was used in designing this new mixing component: Maple-8, COSMOSWorks 2007, SolidWorks 2007, and Microsoft Excel.
Keywords: **Optimization problems, mathematical theory, critical domain, design parameters, mixing component.**

GOAL AND OBJECTIVES OF THE ARTICLE

The goals of this article are to determine the type of mathematical theory that should be used in the energy model of dough production, and to analyze the problems in mathematical models used in this research. Based on these goals, we established the following objectives:

- determine the areas of use of computer programs;

- define the mathematical parameters of optimizing the mixing component's effectiveness the processing zone of the machine;

- establish a mathematical model of research and identify the characteristics of researching the power model of dough production;

- suggest ways of mathematical encoding of energy transformations during the dough production process.

OBJECTIVE

This article seeks to determine the efficiency of operation of the mixing machine's mixing unit. There are two questions w are trying to answer: Should emphasis be placed on emphasize the effect on the dough or on increasing the productivity of the dough mixing component? To what extent is it possible to increase its productivity during kneading? It is impossible to provide a precise answer, but researching this opens up many interesting areas of investigation.

[1] The effectiveness, efficiency, and productivity of the mixing component. Using computer software solves the problem of optimization, one of the most important and widespread problems arising in both theoretical and applied research, allowing us to determine optimal parameters and their values, which is often the key issue. Specifically, optimization problems have included:

- technological control of the kneading process, when there is a need to achieve high performance with minimum input;

- designing a periodic action dough mixing machine (which requires selecting a combination of parameters that provide for as high a level of functionality of the mixing component as possible; [2] computation and encoding of an experiment plan that corresponds to the selected criteria.

Mathematically, the optimization problem can be formulated as

$$Y^* = Y^*(X^*) = Y^*(X_1^*, X_2^*, ..., X_n^*) = \underset{X}{extr}\, Y(X), \quad (1)$$

where **Y***, the desired function and the criterion of optimization, is encoding and statistics;

$X_1 = X^*, X_2 = X^*., X_n = X^*$, the controlled factors, factors are the Maple-8, COSMOSWorks 2007, SolidWorks 2007, and Microsoft Excel-2003 programs;

X_T — the extreme point value– is the technological and technical indeces of dough making.

[3] Analysis of the most recent results: Improvement of the periodic action dough mixing machine design and its mixing components is based on understanding the logic of dough making parameters and an optimal design of mixing chambers and components. As a basis for the analysis, we used mathematical modeling theory and the results of statistical analysis of previous experimental and theoretical research.

The mathematical model of research is a mathematical determination containing or representing properties of the item under study, in particular, its structure, quantitative connections and its characteristics. The mathematical models (the quantitative nature of which were experimentally derived) were examined. The methods of experiment planning are aimed at producing statistical models, and, as a result, these methods are often called statistical methods of experiment planning.

The mathematical theory used for designing the dough mixing model is the theory of certainty - the science studying the certainty of large-scale, random phenomena. Such phenomena determine the occurrence or non-occurrence of particular events during experiments. Quantitative measurement of the objective possibility of an event's occurrence under a fixed set of experimental conditions determine the certainty of the event. If we reiterate an experiment **N** times and event **A** happens **n A** times, then the certainty of event **A**'s occurrence is defined as the boundary of the relationship

$$\mathbf{P\{A\}} = \lim_{N\to\infty} \frac{\mathbf{n_A}}{\mathbf{N}} . \qquad (2)$$

[4] i.e., if it is given that f $0 \le \mathbf{R\{A\}} \le 1$, an if **A** – is a certain event, then **R{A}**=1; for the impossible event **R{A}**=0. Inverse conclusions are incorrect.

MAIN PART

In solving problems related to processing the experimental data, the results obtained have been certain. The necessary characteristics of random values were unknown and were determined based upon the parameter values used in the experiment. This statistical description of the mathematical model of dough production, applying the notion of certainty, would be considered a mathematical statistical description. The encoding and mathematical statistics used in researching energy transformation during dough production would be as follows [1, 3].

Statistical evaluation. The calculation was conducted with indexes of a specific amount of work – A sp. For simplification of the process we used the following factors: contact angle, thickness and area of contact surface of the mixing component. Statistical methods are used in selecting the limited volume **N** in order to provide a well-based overall description of the properties; i.e., by creating empirical analogs of the probability characteristics of the random value under investigation, and by evaluating the parameters and characteristics of the aggregate using the appropriate functions.

Verification of statistical hypotheses. Possible values of such statistics, for hypothesis verification purposes, can be divided as follows: hypothesis confirmation domain, and the critical domain. The critical domain

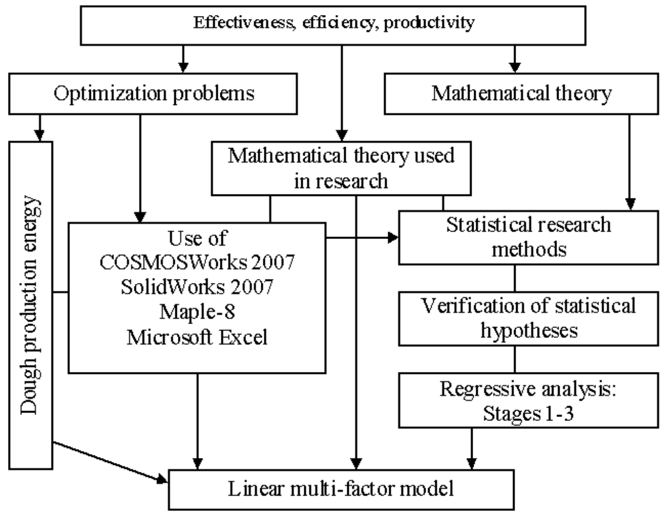

Diagram - Dough making machine mixing component improvement process

consists of statistical values that would lead us to reject the hypothesis, which can be confirmed on the basis of the defined criteria, allowing us to:

- establish the meaning of the observed results. A statement of some of the parameters of the whole corresponds to definite numerical values: If a large number of choices is available and if there is an objective basis, they represent the same general overall whole.

The mixing component dimensions produced in COSMOSWorks 2007 are a result of a calculation of the component's structural strength. The so-called surface model COSMOSWorks 2007, essentially, is a calculation based on the theory of span. It approximates parts by the exclusive use of finite span elements, constructed on the base of a collector, by hybrid grids created within the context of the collector, and by components, which consists of one or more fields. Unlike volumetric finite elements, the nodes of span elements have six degrees of freedom: three degrees of translation and three angles of rotation. The elements represent linear approximation of displacement, and, correspondingly, approximation of continuous strain, or approximation of parabolic and linear displacement, changing along a central distortion. The corresponding parameters are found on a grid, (parameters in a group of parameters, forming a grid). The calculation is conducted with the following approximations:

The spans are thin. During formulation of the final elements we used the Kirhoff-Lyava hypothesis, i.e., the normal to the central surface of the component remains perpendicular and does not become distorted under loading. Normal loads are distributed along the length of the normal. Shearing in the planes perpendicular to the surface is absent; however, there are corresponding tangential loads.

If the he spans are thick. We used the Reisner-Mindlin model. It takes into account a rotation of the normal in relation to the middle surface without distortion. Tangential strain in the planes perpendicular to the middle surface are calculated and it is distributed parabolically. However, in the finite element model they are considered constant. The thickness of the span is 5% larger than its lateral dimension. The range of the spans is the distance between sites of application of force on a particular edge.

The SolidWorks 2007 program is intended to be used directly for geometrical constructions, and for this it has a special computation configuration. It characterizes geometrical elements in the damping state, not in the non-load-bearing parts, but in the working components, which are presented in simplified form. The computation configuration is the model. The exclusion of elements from the model reduces the dimensionality of the problem by several factors. [5].

In developing the model of the dough making machine mixing component profile, Maple-8, the most frequently used software, was used as baseline. It is based on a range of characteristics which describe the changes on the surface of the mixing component of the new dough-mixing machine design. The algorithm of its method is the aggregate of the terms of selection of the initial approximation, the computation ratios, and the computation terminator. A combined method is applied (the method of chords and tangents). It is has the following characteristics: the first, – characteristic **a**, gives the value of the radical within a margin of error the other, **b**, represents the possibility of selecting the computation terminators, and of providing the needed accuracy of the result. The given method is labor intensive, but, using a computer, this is not an issue. A major advantage of the method its ability to provide a high degree of accuracy at the final number of integrations. The computation algorithm using the combined method is aggregate of the following ratios:

terms of selection of the initial approximation

$$X_0 = \begin{cases} a, \text{if } f(a)f''(a) > 0 \text{ or } f(b)f''(b) < 0, \\ b, \text{if } f(a)f''(a) < 0 \text{ or } f(b)f''(b) > 0 \end{cases} \qquad (3)$$

calculation ratios

$$X_n^{(k)} = X_{n-1} - \frac{f(X_{n-1})}{f_1(X_{n-1})}. \qquad (4)$$

Profiles of all intersections are set in a system of coordinates tied to the variable characteristics of the mixing component, which allows for the formation of a mixing component model based on the data obtained. In summary, we created a program which allows us to determine the intersection profile of a new design of the mixing component and a formula characterizing the surface of an intersection of the new design of the mixing component, a polynomial to the eighth order. As a result a theoretical profile of the new design of the mixing component was determined [6, 7].

Regressive analysis was used because it allows us to obtain experimental data from regressive models of the components under study, which can be expressed $\mathbf{Y = \varphi (X,Z)+e}$. The regressive analysis resolves the fundamental problem of deriving the formula functions which link the value of the initial variable value of the component with the factors **X** and **Z** in the presence of an additive obstacle of a random character e. The system of basis functions $\mathbf{f_1(X), j = 0, d}$, must be selected as a given for conducting experiments and computations. The choice of the system is decided based on information about the nature of the function $\varphi(X)$ and its capability of permitting simple computation. Based on known values **X**, we calculated the values of the base functions $\mathbf{f_1(X)}$. If we speak about correspondence between the working component and the regressive model then, as was noted, it is possible to interpret the result of the expansion of the continuous function $\mathbf{f_1(X)}$ as a series using the base functions system.

Planning of the regressive experiments proceeded as follows. A list of essential variables, of the type at the beginning of the regressive model, can be obtained by means of a qualitative study of the physical characteristics of the phenomenon under consideration. Here the fictitious variable x_0 corresponds to the coefficient β_0 in the regressive model and, as a rule, is always present in such lists.

Stage 1. From the factors $x_0, x_1, \ldots, x_n$ we select **k** where $\mathbf{k = n - p}$. We presume that these are the first **k** factors $x_0, x_1, \ldots, x_n$. For the selected factors we select the spectrum of the plan ПФЭ 2k. The method of constructing the spectrum is known, making it is possible to consider complete the determined program of change of each factor during the experiment.

Stage 2. For the $\mathbf{n - k = p}$ factors, for the change program during the experiment we select columns which correspond to different derivative factors. The relationship between column $x_{k+1}, x_{k+2}, \ldots, x_n$ and column $x_0, x_1, \ldots, x_k$, which is a specific derivative of a combination of factors, we refer to as the generating correlation.

Stage 3. Verification of the usefulness of the plan's spectrum is carried out by creating a matrix of numeral values of the base functions, i.e., all variables from the list of essential variables If there are no fully matching or fully opposite columns in the matrix, then the calculated spectrum of the plan is suitable for the subsequent experiment and the problem of its definition is resolved. As a result of the conducted regressive analysis we obtained a linear multifactor model of specific expenditure of work $\mathbf{A_{sp}}$.

$$\mathbf{y = 75 + 9{,}08X_1 + 724X_2 + 706{,}55X_3.} \qquad (5)$$

We confirmed the proposed premises and obtained an optimal base of experiments that corresponded to theory. This allowed us to conduct as complete a study and as complete a fulfillment of factors as possible in regard to the dough mixing process with minimum expenditure of time and materials. The equation obtained characterizes the experiment.

CONCLUSIONS

Based on the information above and the experimental data, we can conclude the following:

1. We determined the parameters of using the programs Maple-8, COSMOSWorks 2007, SolidWorks 2007, and Microsoft Excel-2003. Our premises were confirmed. As a result, we obtained an optimal base of studies that meet theoretical criteria.

2. We resolved the mathematical problems of optimizing the effectiveness of the mixing component's action on dough. The study allowed us to conduct as complete a study and as complete a fulfillment of factors as possible in regard to producing dough, with minimal expenditure of time and materials.

3. We identified a mathematical model of the research and characteristics of the research of the energy model of dough production. We experimentally analyzed the mathematical models.

4. We identified the methods for experiment planning. The mathematical model that was developed permitted us to explore the processes taking place during dough production.

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ЯНАКОВ В.П.

РОЛЬ МАТЕМАТИЧНОЇ МОДЕЛІ ДОСЛІДЖЕНЬ В ОПТИМІЗАЦІЇ ПРОЦЕСУ ПРИГОТУВАННЯ ТІСТА.

Стаття аналізує проблеми оптимізації математичних теорій при проектуванні основного елементу тістовимішувальної машини періодичної дії - вимішувального органу. Для проектування вимішувального органу нової конструкції застосовувалися програми: Maple-8, COSMOSWorks 2007, SolidWorks 2007, Microsoft Excel.

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РОЛЬ МАТЕМАТИЧЕСКОЙ МОДЕЛИ ИССЛЕДОВАНИЙ В ОПТИМИЗАЦИИ ПРОЦЕССА ПРИГОТОВЛЕНИЯ ТЕСТА.

Статья посвящена анализу оптимизационных проблем математических теорий при проектировании основного элемента тестомесильной машины периодического действия - месильного органа. Для проектирования месильного органа новой конструкции применялись программы: Maple-8, COSMOSWorks 2007, SolidWorks 2007, Microsoft Excel.