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Crushing Place Management System of Grains of a Daily Enterprise based on Determined Models of Optimal Planning of Production

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Abstract - The main drawback of the existing flour-grinding production management system is the discrepancy between the production rate and obtaining information about its indicators, i.e., the receipt of information by the management about the main indicators of the production and economic activity of the enterprise for conducting an operational analysis of its work is significantly behind the production process. Such a delay, time inconsistencies lead to the depreciation of information on the operation of technological plants, does not make it possible to timely determine deviations from operational plans in the process of their implementation, to identify the causes of these deviations, to open internal production reserves, and to take effective measures for their rational use. In order to eliminate these shortcomings, the task was set to develop a hierarchical control system for the technological process of grain crushing based on the developed deterministic models of the production process. If there are deviations from the planned tasks of the intensities of starting the grain into production, the operating modes calculated by the deterministic or operational planning models, then, based on the obtained mismatch value, the models of the operational plans of the production program are adjusted or the batch of starting the modification of the grinding batch of grain for the next control and planning interval is adjusted.

Keywords - Technological process, grain crushing, rhythm of the process, mathematical model of the process, control system.

I. INTRODUCTION

The intensification of industrial production, increasing labor productivity, the economical use of raw materials, stocks, energy resources, the introduction of low-waste technology - all of this, together, defines new tasks and goals in the field of improving management based on the comprehensive automation of all processes: from organizational, economic and technological to implementation production manufacturing process.

The requirements to increase the level of organization of production and ensure coordination of the activities of all divisions of a manufacturing enterprise can be met by integrating all management functions into a single integrated automated control system (IACS).

One of the main tasks of the food and processing industry, in particular, flour mills, is the development of methods and algorithms for managing the main production of grain processing products based on mathematical modeling and optimization in the face of uncertainty in the initial data, as well as stochastic technological processes.

II. BRIEF DESCRIPTION OF THE PRODUCTION PROCESS

Characterization of products, raw materials and semi-finished products of flour milling. Flour is a product of grinding wheat or rye grain. The properties of flour primarily depend on the chemical composition and structure of the grain endosperm - the place of deposition of nutrients. Its bulk is made up of natural polymers — starch and proteins. Their total content in wheat grain is about 85% per dry matter. The structure of the grain endosperm determines the characteristics of the flour produced.

There are three types of wheat: soft, soft glassy and hard. The endosperm tissues of soft wheat grain have a powdery opaque structure consisting of small starch grains enclosed in thin layers of protein substances. From this grain baking flour is produced. The endosperm cells of vitreous, hard wheat species are surrounded by thick amorphous layers of proteins that give them transparency.

Depending on the quality, the flour is divided into wallpaper, higher, first or second grade, as well as grains. Wallpaper flour is produced from non-seeded flour and contains crushed particles of endosperm of grain and the outer shell (bran) in its composition. High-quality flour is made from seeded flour. Each type of flour grade is regulated by the corresponding characteristics of the properties of flour: color, ash content, grinding size and the amount of raw gluten.

Flour mills that produce hundreds per day, and some of them a thousand or more tons of flour, have warehouses and an elevator for grain, warehouses for storing finished products. The production process in them is fully mechanized. For cleaning, grinding grain, sorting products, for their movement, flour mills consume a lot of energy and therefore have their own energy facilities (electric power, steam power or diesel). In the process, the principle of gravity is widely used. Grain or intermediate products raised to the upper floor of the mill by mechanical (elevator) or pneumatic transport, through distribution devices, get onto the machines and then through gravity (gravity) pipelines are sent to the machines located on the floor below. Therefore, flour mills have 5-7 floors with floor-mounted machines [1, 2, 3].

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The current stage of development of industrial flour milling in Uzbekistan is characterized by a transition to the use of advanced technology, the desire to achieve extremely high operational characteristics of both existing and newly designed equipment, and the need to minimize any production losses. All this is possible only if the quality of management of industrial facilities is significantly improved, including through the widespread use of integrated process control systems (IPCS) [4, 5, 6, 7].

The integrated management system of the flour mill, covering the management of all aspects of the activity of this production, unites the individual elements of the system into a single whole, subordinating their functioning to the main goals of the system, the defining principle of building integrated management systems for the flour mill (FM) is a multi-level hierarchical structure. The objective prerequisite for hierarchical management is determined, first of all, by the production factor - the hierarchical organization of the production complexes themselves, and then by information factors related to the complexity of management tasks.

The main drawback of the existing management system of small enterprises is the discrepancy between the pace of production and the receipt of information on its indicators, i.e., the receipt of information by the management on the main indicators of the production and economic activities of the enterprise for conducting an operational analysis of its work is significantly behind the production process. Such a delay, time inconsistencies lead to the depreciation of information on the operation of technological plants, does not make it possible to timely determine deviations from operational plans in the process of their implementation, to identify the causes of these deviations, to open internal production reserves, and to take effective measures for their rational use. Obviously, all this will lead to a significant decrease in the efficiency and effectiveness of production management.

The elimination of the aforementioned shortcomings in the management of FM is an urgent task, the solution of which can be carried out on the basis of deterministic mathematical models of the production program of the enterprise developed at the upper levels of integrated FM control systems [6, 7].

The compilation of the optimal production program of the enterprise is one of the difficult areas of planned calculations, since here a multivariate extreme problem arises, the solution of which is possible only using a special mathematical apparatus and electronic computer.

The main problem in the formation of the annual plan is that when the internal and external conditions change, the enterprise can achieve optimal (in the sense of a certain criterion) correspondence of the output scheme to the structure of production capacities.

Additional difficulties in planning the production of a flour mill are associated with the need to take into account such random factors as yield and grain harvesting conditions, receiving and storing grain at an elevator. The quantitative characteristics of these factors are not subject to accurate assessment and therefore cannot be explicitly taken into account in planning and management.

The task of calculating the annual plan of the flour mill belongs to the upper level of the hierarchy of the integrated production management system. At this stage of management as a whole for the planning period, the volume of final production and the costs of primary products are determined. Therefore, as a rule, when formalizing the process of volumetric production planning, the technique of reducing many technological operations to one operation is used - to convert the source products to final ones [8, 9].

A slightly different approach has been used in our work. In accordance with it, the continuous multi-stage production process of a flour mill for the purposes of volume planning and control by the aggregation method [10] is reduced to two generalized operations - "CRUSHING" and "GRINDNG".

It is proposed to control (plan) the process according to a two-stage scheme - in accordance with the number of generalized operations. Representation of the production system in the planning period according to a two-stage scheme, taking into account the receipt of intermediate products (dunsts, grains), makes it possible to increase the adequacy of the planning model and, therefore, increase the validity and accuracy of planning [11, 12].

Based on the static two-stage model of the production process of the flour mill built in [12] and the established law of the joint distribution of the releases of the final (intermediate) products for the given parameters of the process and the intensity of the use of discrete technological modes, the problem of volume planning of costs and production is formulated.

The goal of volumetric planning of costs and production is to establish the intensities of discrete technological regimes, in particular grain crushing, and production intensities as a whole (integrally) for the planning period and to evaluate the effectiveness in this interval [11].

The desire in planning the investigated production taking into account the stochasticity of the technological process leads to the need to use the model of in-shop planning. For optimal planning, stochastic programming models can be used allowing to take into account the stochasticity of the control object.. However, the nonlinearity of the constraints that determine the range of feasible solutions of the equivalent deterministic model and the large dimension complicate the search for optimal

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controls. To simplify the control synthesis problem (in accordance with the technique described in), random variables in the model — the output intensities of the intermediate and final product — are replaced by their mathematical expectations, which linearly depend on the intensity vectors of the use of technological modes (the considered model of optimizing the material flows of the flour mill graph of the production process Enterprise is an illustration of a solution method for the average one-stage stochastic programming problem). In this case, the costs and output for each mode linearly depend on the intensities of the modes.

Based on the static two-stage model of the production process of the flour mill built in [12] and the established law of the joint distribution of the releases of the final (intermediate) products for the given parameters of the process and the intensity of the use of discrete technological modes, the problem of volume planning of costs and production is formulated.

The task of managing the production in question is to determine such intensities of the modes of aggregate operations, in which, within the framework of the system of production restrictions, the maximum possible production efficiency is ensured. The latter is assessed using the performance criterion, which reflects the degree of compliance of the obtained solutions with the main management goal. Based on the above materials, a deterministic model of optimal planning of the production program of the flour mill was developed in terms of linear programming [6, 8, 9].

At the level of controlling the technological complex of the grain crushing section, the following technical settings can be distinguished: stabilization of the launch intensity of the grinding batch of grain of a certain modification; load distribution between parallel and sequentially operating units; coordination of work in parallel and in series connected installations; distribution of material flows between units and plants interconnected by a given specific structure of production.

The main objective of the developed flexible control system for the main production of FM based on volumetric deterministic models is to manage the material (intensity of starting the initial product of the grinding batch of grain) flows in production in order to coordinate the loads of the aggregates of the technological complex for grain processing, as well as to determine and implement optimal modes of technological processes that satisfy the technical and economic indicators of the volumetric, operational plan of the flour mill in the integrated management system.

The main input parameter of the technological complex primary processing of grain (PPG) is the intensity of the launch of the grinding batch of grain in the cleaning and humidification workshop (CHW), as well as the intensity of the launch of the modification of grain dunsts in the grinding workshop. They determine the productivity of technological processes, the fluctuations of which affect all technological units and, ultimately, are reflected in the output.

Fluctuations in the flow rate of the grinding batch of grain in front of the (CHW) grinding mills are due to changes in humidity and grain size distribution of the grain, the transition to a new batch of modifications of the grinding batch of grain, etc. The listed disturbing parameters have a different nature of the effect. The launched batch of the grinding batch of grain usually remains unchanged for a rather long (compared to days) time. With the accurate operation of volumetric grain storage (silos), as well as observing the maintenance personnel of the correct alternation of filling the grain bins, they achieve the necessary duration of the technological complex PPG. The main disturbing effect is the weediness and moisture of the grain, because, on the one hand, it cannot be stabilized with the necessary degree of accuracy, and on the other, it changes more often than other disturbances. In order to stabilize the supply of the grinding batch of grain before the (CHW), as well as the products of the process of crushing the grain before grinding, a flexible integrated control system for the technological section of the plant is proposed PPG (Figure 1).

According to the proposed control scheme, the feed rate of the grinding batch of grain for production is calculated by the value of the starting modification of the grinding batch of grain, the value of which is consistent with the results of solving the problem of optimal planning of the production process of the subsystem of technical and economic planning (TEP), as well as the tasks of scheduling production in the operational management subsystem production (OMSP).

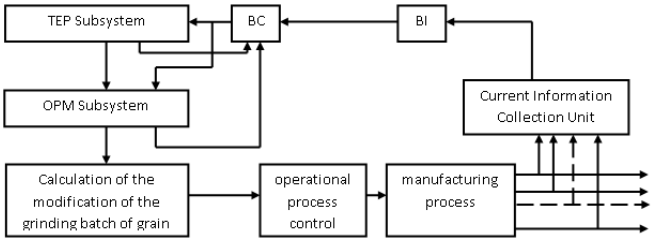

Fig. 1. Integrated management system technological process grain crushing based on deterministic models of the production process

At the operational production management (OPM) level, the production program of the enterprise is ensured. Based on the forecasting of the supply of raw materials to the FM, the shipment of finished products, as well as the state of technological equipment, according to the operational management models, operational plans, batches of starting modifications of the grinding batch of grain for certain operational periods of time (10 - 20 days.) are calculated. Current information on the

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implementation of operational plans and the production program enters the integration (BI) and comparison (BC) blocks, where the deviation of the output and technical and economic indicators from the corresponding indicators of the optimal operational plans and production program is detected.

If these deviations exceed the permissible value of the mismatch, then the models of the operational plans of the production program are adjusted or the batch of starting the modification of the grinding batch of grain for the next control and planning interval is performed.

III. PRACTICAL VALUE

The proposed control system for the technological process of grain crushing based on deterministic models of the production process allows us to synthesize highly efficient automated control systems for technological processes of the production of flour products and ensure the required quality of the final product. The justified engineering methodology for applying the integrated package “LINPROG MATLAB” to the implementation of similar mathematical models of technological processes for grain processing and the developed software interface for the implementation of the deterministic model can significantly simplify the procedures and techniques of simulation and system analysis of the results of industrial experiments in a wide variation in the characteristics of the feedstock (including grain modification) and parameters of technological modes. The proposed control system in the conditions of multi-level automated and automatic control of the main production of the flour mill allows, ultimately, to increase the level and quality of management decisions.

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