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Block Diagram of Cutting Process of Food Materials

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ABSTRACT: This article presents a block diagram for the cutting process of food materials which is a system with extremely complex physical and mechanical connections. Therefore, to identify patterns of unidirectional changes it is advisable to carry out many identical, but quantitatively different experiments. This is largely due to the one-factor experiment, allowing more deeply to reveal and reasonably analyze the nature of the phenomenon.

KEYWORDS: cutting food materials, structural scheme, input parameters, output metrics, complex characteristics, the object to be processed, hardness, knots, motion of working bodies, perturbing factor.

I.INTRODUCTION

The problems of studying the cutting of food materials must be solved as a problem with a complex structure in which a large number of different phenomena affect the final result not by simply adding them, but as a set of comparable in magnitude, simultaneously acting factors that are in a complex interaction [1].

This problem can be solved on the basis of ideas of the system analysis assuming consideration of properties of object through properties of its parts. The block diagram of cutting is the basis for the next stage of system analysis - modeling of the studied process. For the development of the block diagram it is necessary first of all to allocate input parameters, complex characteristics of the process and output indicators [2].

The input parameters can be divided into factors related to the object of cutting, the design of the cutting machine and its working bodies. The main factors characterizing the processed object are compounding, rheological, tribological and thermophysical parameters combined into a group of technological factors (Fig.1).

Factors related to the cutting machine can be divided into two groups; the technical condition and fixation of the processing object. The first is determined by the rigidity of the nodes, the accuracy of movement and positioning of the working bodies, the second depends on the design of the feed and clamping devices and significantly affects the quality of cutting. The working bodies of cutting machines are two main groups of factors: kinematic, which are determined by the trajectory of the working bodies and the values of cutting speeds and feed, and geometric parameters. The second one is much more numerous and, in turn, can be divided into four subgroups: type of working bodies; the shape of the blade; the characteristics of the macro geometry features of the surface geometry.

Thus, in the block diagram of the input factors contains about 30 parameters, combined into several groups – kinematic, geometric, and technological and others.

Input factors can be controlled and unmanageable. Depending on the level of solving the optimization problem managed and unmanageable in our case may be different factors. For example, when solving a project variant the parameters included in the kinematic and geometric groups are controllable. At the decision of production option those factors which can be varied at conducting technological process i.e. group of technological factors should be carried to those. Currently used cutting and grinding equipment has virtually no possibility to adjust the other factors, so in this version they should be attributed to the unregulated [3-5] the parameters included in the kinematic and geometric groups are controllable. At the decision of production option those factors which can be varied at conducting technological process i.e. group of technological factors should be carried to those. Currently used cutting and grinding equipment has virtually no possibility to adjust the other factors, so in this version they should be attributed to the unregulated [3-5].

The disturbing factors include uncontrolled parameters of the cut material, the error of preparation, sharpening and installation of the cutting tool, the impact of the environment. Due to the presence of these factors in the real process, any of its characteristics cannot be determined exactly and always averaged over a set of random effects.

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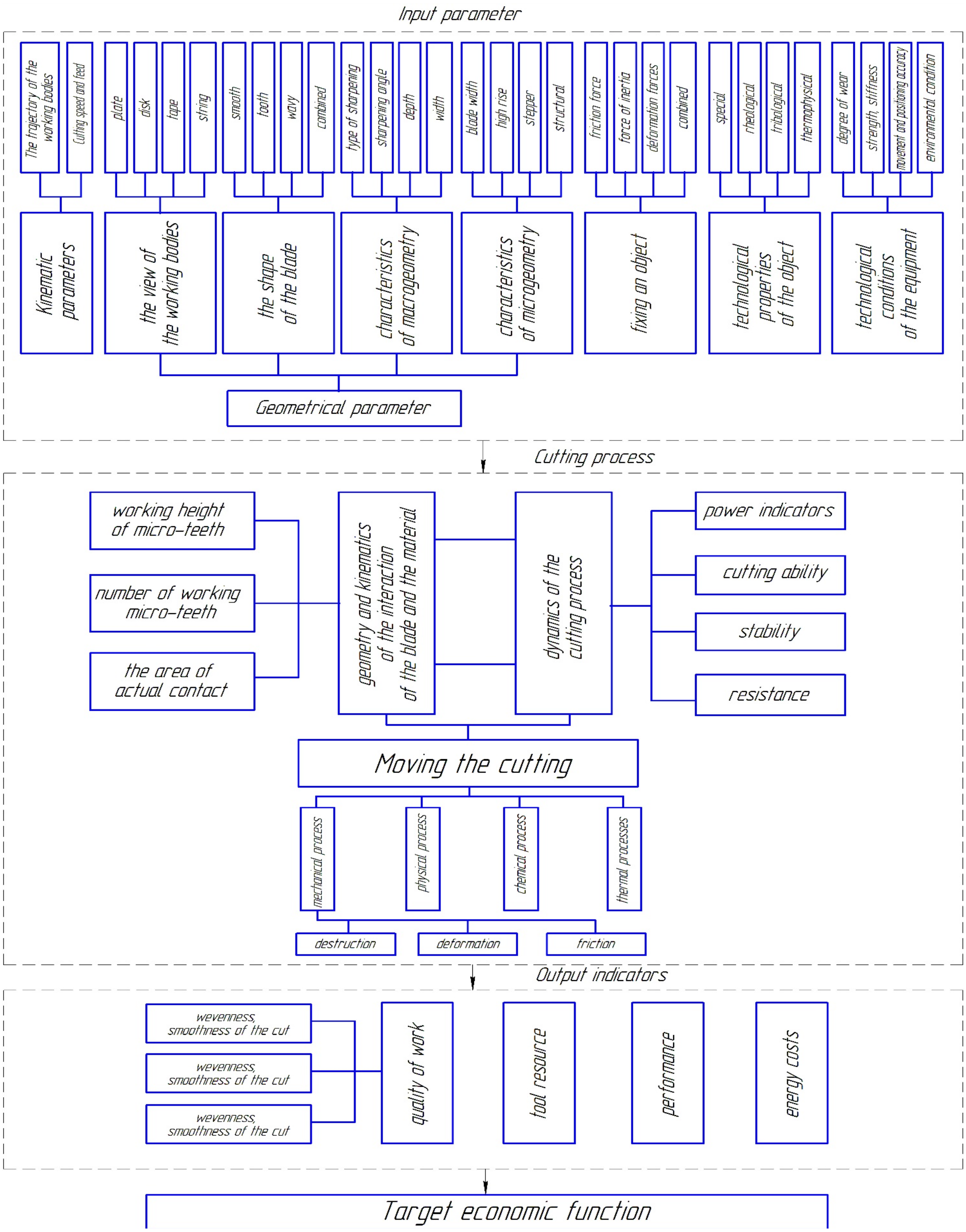

Fig. 1. Block diagram of cutting.

In the block diagram of the moving cutting there are two main operators: the geometry and kinematics of contact and the dynamics of cut, the interaction of which generates strength, cutting ability, technological rigidity (resistance) and durability of the tool.

Output parameters determining the cutting efficiency can be productivity, quality indicators, energy costs, tool life. When cutting, it is desirable to reduce energy consumption, increase productivity, processing quality and tool life. However, all these goals are simultaneously unattainable in principle. Multi-criteria problems can only have a compromise solution. Therefore, the selection of optimality criteria should be limited to the most important indicators, and the rest should be transferred to the category of restrictions [6].

Cutting of food materials, as experience shows, is limited by quality indicators, that is, compliance with the evenness of the cut and shape, the state of the structure, the amount of waste and scrap. Taking into account the high cost of food raw materials and certain difficulties of processing returnable waste, cutting quality indicators are crucial to minimize the target economic function. However, attempts to objectively determine these indicators in the study of cutting processes are hampered by the relatively low strength and hardness of food materials and heterogeneity of their structure. This makes the known methods of surface quality control – contact and optical-inapplicable [7,8].

Analysis of the literature data shows that there is a rather close correlation between the qualitative characteristics of the cutting process and the efforts. This is noted for all types of food materials [9,10]. Thus, the value of cutting forces can be used as a criterion for optimization. Moreover, it is possible to trace an unambiguous relationship between this criterion and the marked output indicators. Reduction of cutting forces reduces energy costs, increases technological rigidity and tool life.

Analytical dependences for cutting are often very cumbersome and are obtained, as a rule, under certain assumptions. Finding the minimum of such a function can be a difficult task. Therefore, using the principle of decomposition [11], it is advisable to introduce particular criteria or so-called aggregated characteristics consisting in a functional connection with a certain group of input factors. The choice of these characteristics depends on the understanding of the studied processes.

Selected in the structural scheme of mechanical processes - destruction, deformation and friction – play a leading role in the cutting of food materials. Taking this into account, as particular criteria for each selected process can be used aggregated characteristics such as cutting capacity, pre-compression, coefficient of friction. Each of these characteristics is associated with a certain group of input factors and allows to optimize the corresponding process.

The cutting ability is associated with geometric and kinematic factors and determines the conditions for the formation of a new surface when the material is destroyed by the blade.

Pre-compression characterizes the process of deformation of the material during cutting and mainly depends on a group of technological factors. For effective cutting it is necessary that the destruction was born as early as possible, and the plastic deformation preceding it was extremely small. This is important for obtaining low cutting energy and maintaining the shape of the cut pieces. This shows the feasibility of minimizing this aggregate characteristics.

The coefficient of friction is a complex characteristic of the third mechanical process – friction. To improve the cutting efficiency, it is necessary to strive to increase the friction coefficient on the blade (triboactivation) and reduce this aggregate characteristic on the facets and sides of the knife (tribo-passivation).

The structure of the scheme shows that the process of cutting food materials is a system with extremely complex physical and mechanical bonds. Therefore, to identify patterns of unidirectional changes it is advisable to carry out many identical, but quantitatively different experiments. This is largely due to the one-factor experiment, allowing more deeply to reveal and reasonably analyze the nature of the phenomenon.

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