SYNTHESIS OF FUNCTIONAL MECHATRONIC MODULES IN A SYSTEM OF PACKAGING MACHINES

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The process of creating a packaging machine for a flow-processing system consists of separate stages: the first - a clear definition of technological functions of the equipment and description of the operating conditions of the packaging machine; the second - the search for principles of construction and organization of the structure of the packaging machine for a particular type of food product; the third - the creation of a pilot technical project, evaluation of the main criteria and parameters to ensure all necessary requirements for operation.[1]

The purpose of the proposed method of creating a packaging machine, due to the change in the concept of building technological equipment. Modularity of design is one of the priority directions of packaging machine development. Despite the variety of engineering approaches to the development of new equipment, the creation of a design from separate ready-made functional mechatronic modules (FMM) and functional units (FU) - creates a number of undeniable advantages.

Firstly, it is the possibility to use ready-to-use technical libraries from different engineering companies; secondly, the use of integrated complexes of corporate CAD/CAE/CAPP/CAM programs in the course of project development. This creates the possibility to collectively develop a technical project and quickly make changes in it during the whole life cycle of the packaging machine (PLM system). [2,3]

The implementation of such an approach is only possible with the involvement of function-oriented design technologies in the project. Our methodology is based on the concept of recursive communication between the stages of packaging machine design and technological design, as well as on a logistic approach that ensures continuous project support in a special information environment. [3-6]

The task of our study was to create a methodological basis for the development of the stages of equipment design using a function-oriented approach to ensure the specified properties of the packaging machine.[3]

The result of the design and development process of a packaging machine based on FMM is achieved by replacing the task of summarizing functions and describing operating conditions (terms of reference) - to create a simulation model with accompanying design, technological documentation. The model of transformations for a packaging machine, when operated in a technological line, is presented in Fig. 1.

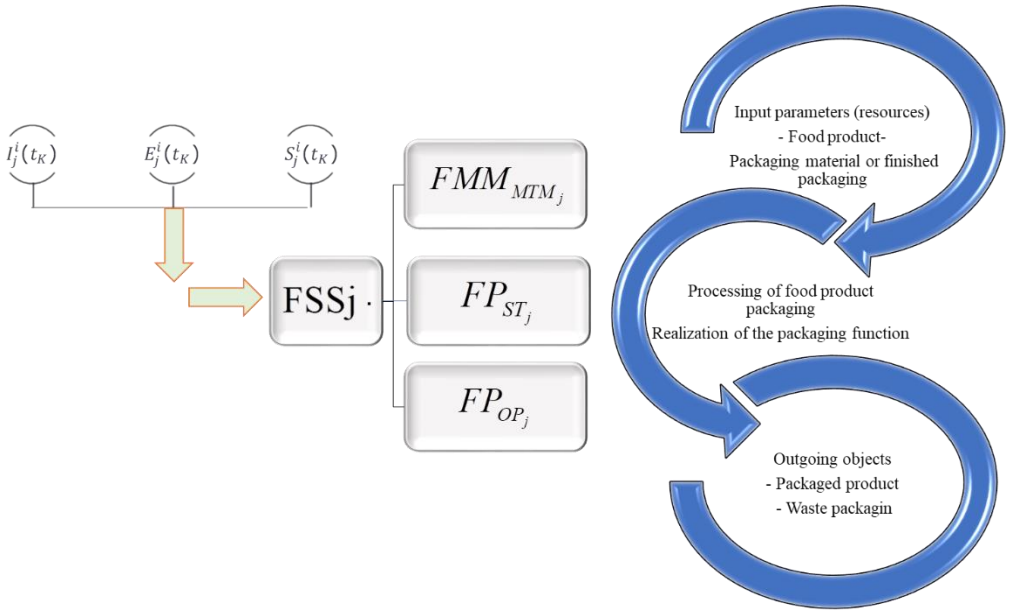

Figure 1. Generalized model of transformations between levels in a packaging machine

The model of the transformation system in Fig.1 consists of objects (elements, functional mechatronic modules) of a given hierarchical level: technical means (FMM_{MTM_j}), software tools (FP_{ST_j}) and operations personnel (FP_{OP_j}), - are at the same time considered as operators and operands of the system. They create the purposeful action of a material $S_N(t_K)$, energy $E_N(t_K)$ and informational $I_N(t_K)$ types of impact on the object of transformation. $I_j^i(t_K)$ – information action of the i-th type on the j-th object (controlled FMM) at the moment of time t_K; $E_j^i(t_K)$ – the energy action of the i-th type on the j-th object at the time t_K; $S_j^i(t_K)$ – material action of the i-th type on the j-th object at time t_K; FSSj - the j-th functional subsystem of the FMF of the packaging machine. $ФММ_{KTC_j}$ – a group of technical means of the technological process of

packaging, which take part in the implementation of the j-th function; FP_{ST_j} – a group of software tools of the packaging technological process, which take part in the implementation of the j-th function. FP_{OP_j} – a group of packaging process operators who take part in the implementation of the j-th function. To solve the set tasks, we have applied the methodology of flexibility, which consists of the following stages: division of a functional mechatronic module (FMM) into several elements; creation of specification of the nomenclature of elements and links between them; generation of possible structural solutions with different elements and links. The more elements in the structure of the object, the more variants and links between them - the higher the universality of the technical system.[6-7].

Let us consider the technology of obtaining a solution taking into account the criterion of energy efficiency of packaging equipment. As a result of processing the obtained solutions in simulation software complexes CAD/CAE, the results of the criterion analysis were obtained, the example of which is shown in Fig. 2, - the histogram of energy consumption with the analysis of the most energy-intensive FMM in the packaging machine during the performance of technological operations.

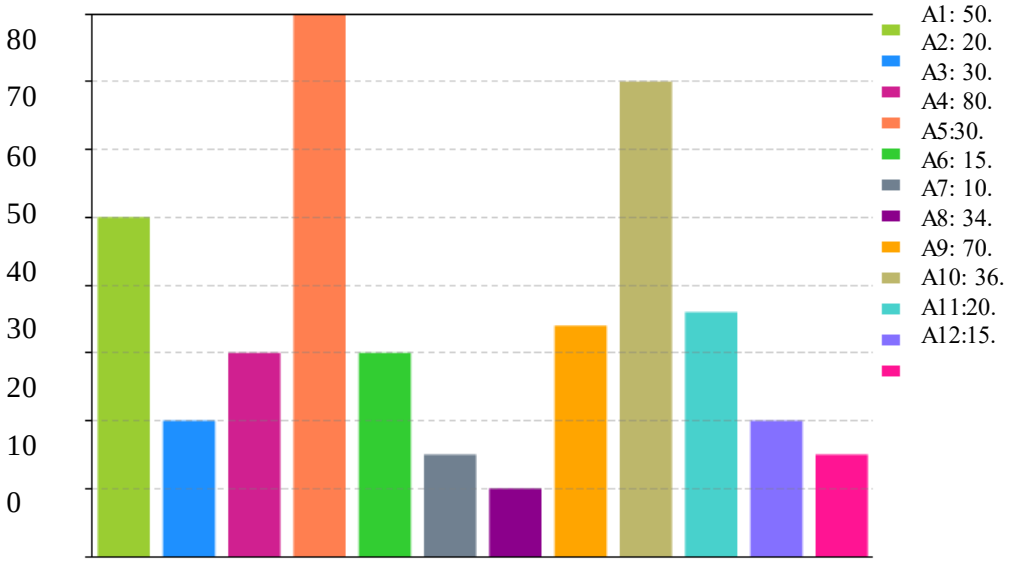

Figure 2. Histogram of the energy efficiency of FMM as a part of the packaging machine (values are given in %): A1-A12 - individual FMMs as a part of the packaging machine

The proposed methodology of integrating functional mechatronic modules into packaging machines, taking into account the object-oriented automatic design, makes it possible to reduce the time for creating a technical solution at the design stage, to obtain concrete results of assessing the efficiency of the created packaging machine, to analyze possible shortcomings in the operation of the finished equipment.

A systematic approach to considering a packaging machine as a design object involves building a conceptual model, i.e., an abstract model that reflects the structure

of the object and the relationships between its elements. When creating such models, two aspects of the packaging machine description are taken into account:

- functional description, which consists of a set of simple functions and a set of relations between them that define the principles of the packaging machine's functioning;

- structural description, which consists of functional models and relations between them that create the packaging machine's layout.

The functional description is more general, because each technical function can be implemented by many design variants of functional modules. At the same time, each function module only implements the function for which it was designed. Thus, the functional description precedes the structural description. To analyze the structure of the packaging machine, it is appropriate to apply the methodology of structural analysis and design (SADT), which involves the construction of three levels of the conceptual model: functional (f-model), functional-structural (fs-model) and structural (s-model).

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