

Choice of optimum structure of a packing machine for viscous products

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Abstract. Results of synthesis of structure of a packing machine for viscous foodstuff and a choice of an optimum design of the functional module of dispensing are provided. The method of the criteria analysis is used and the complex of the criteria indexes describing process of relocation and dispensing of a product is developed. Results of researches can be used for a choice of optimum structure of the packing equipment

Key words: package, viscous products, dispenser, criterion of optimization, analysis, index

INTRODUCTION

Packing machines (PM) for viscous foodstuff carry to multiposition technological machines of sequential action. Their structure is created on the basis of the modular principle, as method of creation of different technical systems with different characteristics by their configuration of standard modules definitely for creation of the material (transmission of products), energetic (the drive of mobile elements) and information (monitoring and control of operation) communications in between.

Dispensing of viscous foodstuff in a retail container is carried out with use of different types of dispenser and constructive packing machine diagrams therefore as a result of their combination application of broad gamma of designs of machines of this type is possible. And therefore, from all found diversity of the machines intended for package of a specific viscous product it is necessary to reveal optimum option.

It is necessary to mark that optimization of a choice of PM can be executed in two stages:

1. Choice of the PM necessary type from a row of varied PM;
2. Choice of optimum PM from a row similar to it in this type, selected at the first stage. This optimization can be carried out by means of the criteria analysis [3].

MATERIALS AND METHODS

The principle of operation of PM is based on interdependent movement of two material flows - a flow of packages of a product and a flow of tare or a packing material.

If process of packing to provide in the form of a system graph with subsystems 1.1, 1.2, 2.1, 2.2, 3.1, 3.2 that in these researches explicitly we will analyze elements 2.2 and 2.1. (Fig. 1)

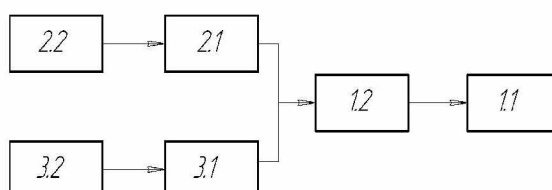


Fig. 1. Process graph of packing of viscous production in soft package, where 1.2, 1.1 - subsystems of preliminary and final manufacture of package; 2.2, 2.1 - subsystems of formation of a dose of a product and packing of its (relocation) in package; 3.2, 3.1 - subsystems of completing of a packing material in the form of a roll and its submission on formation of package [2].

The theory of the criteria analysis and synthesis of processes considers so-called "perturbing factors" process, its shortcomings and errors to which it is possible to refer knock, vibration, shocks, pushes, a pulsation, complexity of the process sometimes realized on difficult space trajectories of centers of masses of objects of processing, violation of appearance of products and many other things. These factors can be classified and provided functionally in the form of special criteria of synthesis and

corresponding to them "criteria indexes" (z, t, c, n, p, v):

1) z - tendency of viscous foodstuff to a turbulence (elements of paths with sharp changes of their direction at any angle are considered):

$$z_0 = \sum z_j, \quad z_0 = 0 \quad \text{if} \quad \sum z_j = 0, \quad (1)$$

where z_0 - optimal numerical value of this criteria index.

2) t - friction of production on walls of the cylinder of the dispenser which is created as a result of production relocation:

$$t_0 = \sum t_j, \quad t_0 = 0 \quad \text{if} \quad \sum t_j = 0. \quad (2)$$

where t_0 - best numerical value of this criteria index. In case of t_0 friction of production in process is absent.

3) c - characterizes a continuity or recurrence of all process of packing (1.1, 1.2, 2.1, 2.2, 3.1, Z.2) that is connected to a machine cycle, and considers t_x no-load time from all time of a cycle of the machine:

$$c = t_x(c^{-1}), \quad c_0 = 0 \quad \text{if} \quad t_x = 0, \quad (3)$$

where c_0 - optimal numerical value of this criteria index. In case of c_0 there is no recurrence of process, i.e. process is the continuous.

4) n - considers number of the technological operations executed by the device of dispensing

$$n = \sum n_j - n_{min}, \quad (4)$$

where n_j - the current value of executed technological operations;

n_{min} - minimum possible number of executed technological operations.

$$n_0 = 0 \quad \text{if} \quad n_j = n_{min}, \quad (5)$$

where n_0 - best numerical value of this criteria index. It is the optimum process including minimum possible number of technological operations, and consequently, reliable and economically expedient.

5) p - pressure of viscous production in the cylinder in case of different options provisions of the piston:

$$p_0 = \sum p_j, \quad p_0 = 0 \quad \text{if} \quad \sum p_j = 0, \quad (6)$$

where p_0 - optimal numerical value of this criteria index. In case of p_0 production pressure in process is absent.

6) v – traverse speed of production depending on position of the piston:

$$v_0 = \sum v_j \quad v_0 = 0 \quad \text{if} \quad \sum v_j = 0 \quad (7)$$

All found out functionally different "perturbing factors" process - the dimensionless that allowed not only to consider scrupulously them, but also to add.

In these researches coefficients of ponderability of f_j which rangings which was developed prof. Panishev V. G. [1] are defined on special methods also were used. With their help it is received the weighed amounts of numerical values of the criteria indexes, necessary in case of a choice of optimum process of dispensing. Values of coefficients of ponderability are brought together in table 1.

Table 1. Numerical values of coefficients of ponderability of f_j and appropriate indexes

z	t	c	n	p	v
f_z	f_t	f_c	f_n	f_p	f_v
0,11	0,15	0,19	0,03	0,32	0,27

For carrying out the criteria analysis by a researched product foodstuff - the mayonnaise packed into soft package of Doy pack was chosen. Necessary and sufficient for a choice accepted at least three options of process of dispensing of this product:

- by machine with the volume piston dispenser with crane shutoff valves (П1).

- by machine with the volume piston dispenser with valvate shutoff valves (П2);
- by machine with the volume rotor dispenser (П3).

On each process which execute above provided by machines, it was probed process of formation (subsystem 2.2) and relocation in tare (subsystem 2.1) doses of a product, the functional diagrams, appropriate tables and diagrams are constructed, decryption of criteria indexes are carried out.

On a course of process of dispensing criteria indexes j were put down, the table with their numerical values and coefficients of ponderability (table 2-4) is provided. So the order of decryption of criteria indexes of process of education and dose packing by means of the piston dispenser with crane shutoff valves looks like:

Decryption of criteria indexes of process of formation of a dose, subsystem 2.2.

Index «z»:

z_1 - turbulences in case of production submission from the bunker in shutoff valves;

z_2 - product turbulences in shutoff valves.

Index «t»:

t_1 - friction of production on bunker walls;

t_2 - friction of production in case of relocation in shutoff valves;

t_3 - friction in shutoff valves in case of product relocation in dosing a nozzle.

Index «c»:

Π - piece productivity on one flow, accepted from the reference.

Index «n»:

n_1 - operation of submission of a product in the bunker;

n_2 - operation of relocation of a product along the bunker;

n_3 - operation of relocation of a product with turn of shutoff valves;

n_4 - operation of relocation of a product with submission by its piston;

n_5 - operation of relocation of a product on a nozzle.

Index «p»:

p_1 - production pressure in the bunker;

p_2 - production pressure in case of output from shutoff valves in a dosing nozzle.

Index «v»:

v_1 - constant speed of hit of production from the bunker in shutoff valves;

v_2 - constant speed of a flow of production in a dosing nozzle.

Decryption of criteria indexes of process of packing of a dose, subsystem 2.1.

Index «z»:

z_1 - turbulences when deleting production from the cylinder in shutoff valves;

z_2 - turbulences in a dispenser nozzle.

Index «t»:

t_1 - friction of production on walls of the cylinder and the piston;

t_2 - friction of production in case of relocation in shutoff valves;

t_3 - friction in a dispenser nozzle.

Index «c»:

Π - piece productivity on one flow, accepted from the reference.

Index «n»:

n_1 - operation of relocation of a product with turn of shutoff valves;

n_2 - operation of relocation of a product with deleting by its piston;

n_3 - operation of relocation of a product on a nozzle.

Index «p»:

p_1 - production pressure in the dispenser cylinder;

p_2 - production pressure increment in case of submission in shutoff valves;

p_3 - production pressure increment in case of submission in dosing nozzle because of essential reduction of diameter.

Index «v»:

v_1 - constant speed of production;

v_2 – the speed of production decreases because of deleting it from the cylinder in shutoff valves;

v_3 – speed stabilizing in a dosing nozzle.

Table 2. Numerical values of indexes j and coefficients of ponderability of f_j for the volume piston dispenser with crane shutoff valves

	z	t	c	n	p	v	Σj
s/s 2.2.	2	3	0.37	5	2	2	14.255
s/s 2.1	2	3	0.37	3	3	3	14.255
Σ s/s 2.2 i 2.1	4	6	0.37	8	5	5	28,37
fi	0,11	0,15	0,19	0,03	0,32	0,27	

Table 3. Numerical values of indexes j and coefficients of ponderability of f_j for the volume piston dispenser with valvate shutoff valves

	z	t	c	n	p	v	Σj
s/s 2.2.	3	4	0.18	5	4	2	18.18
s/s 2.1	2	4	0.18	4	3	2	15.18
Σ s/s 2.2 i 2.1	5	8	0.18	9	7	4	33,36
fi	0,11	0,15	0,19	0,03	0,32	0,27	

Table 4. Numerical values of indexes j and coefficients of ponderability of f_j for the volume rotor dispenser

	z	t	c	n	p	v	Σj
s/s 2.2.	3	3	0.25	5	3	2	16,25
s/s 2.1	4	5	0.25	3	3	3	18,25
Σ s/s 2.2 i 2.1	7	98	0.25	8	6	5	34,5
fi	0,11	0,15	0,19	0,03	0,32	0,27	

RESULTS AND DISCUSSION

The analysis of processes at the choice of optimum process of dispensing is made by means of diagrams of summary and differentiated numerical values of criteria indexes of processes. However the final choice of optimum option of process should be realized on the generalized the table, is called as a matrix of decisions (table 5).

In a figure 2 the chart of summary numerical values of criteria indexes of all three selected processes of dispensing and packing is shown. The chart shows that each column is the amount of errors of process, product turbulences in the course of the packing, the indexes expressed by the dimensionless numerical values. It is quite natural that provided that diagrams are executed in one scale, the smallest column and to reflect best of researched processes. (table 5). In cases when a vector of two or several processes match or are very close on values, for detection of best of them use diagrams of differentiated numerical values of indexes (fig. 3). The process having less numerical value at least on one of indexes will be the best.

In the conducted researches П1 and П2 processes, however the best indexes are closest has the process of P1 realized by the piston dispenser with crane shutoff valves. This output matches result of study of the previous chart.

By results of the executed researches the matrix of decisions (tab. 5) is constructed. In the upper part process is characterized by numerical values of separate criteria indexes

and their amount, and in the lower part - the weighed values.

Quickly and visually to receive the characteristic of any of probed processes it is possible by simple summing of numerical values of indexes in top line. The bottom line gives more exact decision for a choice by the amount of work of numerical values of indexes j on f_j coefficients.

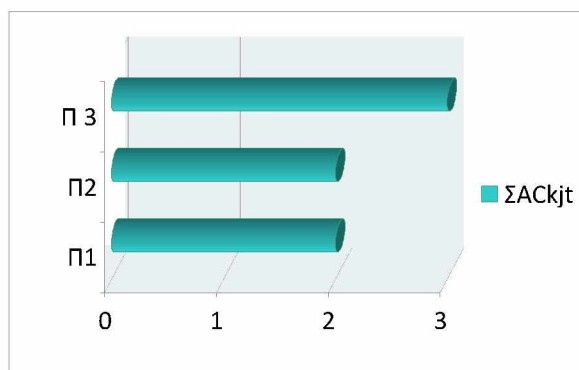


Fig. 2. Chart of summary numerical values of the $\Pi_{1,2,3}$ indexes

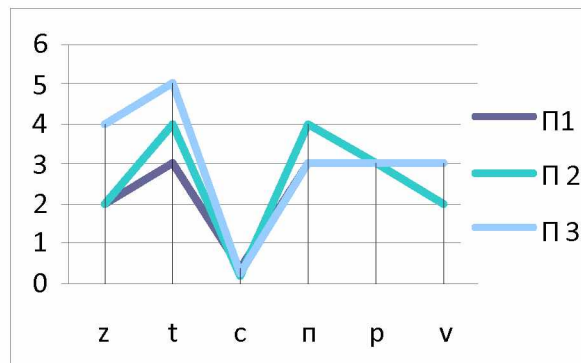


Fig. 3. General diagram of the differentiated numerical values of the $\Pi_{1,2,3}$ indexes

Table 5 Matrix of decisions

Π_j	A_z f_z	A_t f_t	A_c f_c	A_n f_n	A_p f_p	A_v f_v	$\Sigma A_{ij} * f_j$
Π_1	2	3	0.37	5	2	2	14.255
	0.22	0.45	0.7	0,15	0,64	0,54	2,7
Π_2	3	4	0.18	5	4	2	18.18
	0.33	0.6	0.03	0.15	1,28	0,54	2,93
Π_3	3	3	0.25	5	3	2	16,25
	0.33	0,45	0,4	0,15	0,9	0,54	2,8

CONCLUSIONS.

Use of a technique of a choice of optimum structure of PM for viscous foodstuff on the basis of the criteria analysis allows is reasoned to select best of designs of the module of dispensing.

Use of the offered technique will allow evaluating and selecting further more effectively optimum option of PM for viscous foodstuff.

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