ISSN 1311-3321 (print)
ISSN 2535-1028 (CD-ROM)
ISSN 2603-4123 (on-line)

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РУСЕНСКИ УНИВЕРСИТЕТ "Ангел Кънчев"

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PROCEEDINGS

Volume 57, book 10.3.
Chemical technologies
&
Biotechnologies and food technologies

НАУЧНИ ТРУДОВЕ

Том 57, серия 10.3.
Химични технологии
&
Биотехнологии и хранителни технологии

Ruse
Русе
2018

Volume 57 of PROCEEDINGS includes the papers presented at the scientific conference RU & SU'18, organized and conducted by University of Ruse "Angel Kanchev" and the Union of Scientists - Razgrad. Series 10.3. contains papers reported in the Chemical technologies & Biotechnologies and Food Technologies section.

Book	**Code**	**Faculty and Section**
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10.1	FRI–LCR-1-CT(R) SAT–LB-2-CT(R)	Chemical Technologies
10.2	FRI–LCR-1-BFT(R) SAT–LB-P-2-BFT(R)	Biotechnologies and Food Technologies
10.3	TUE-SSS-CT(R)	Chemical Technologies
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The papers have been reviewed.

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The issue was included in the international ISSN database, available at https://portal.issn.org/.
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CHEMICAL TECHNOLOGIES
&
BIOTECHNOLOGIES AND FOOD TECHNOLOGIES

Content

TUE-SSS-BFT(R)-05

REALIZATION OF AN OPTIMUM MODE OF FORMATION OF A DOSE OF LIQUID PRODUCTION BY WEIGHT METOD[10]

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Abstract: *In this work was deduced rational function of the dosing for the mechatronic module of weight dosing for liquid products. To provide correct the application of mathematically derived functions, the synthesis of the pneumo drive was performed, for the pre-calculated common types of shut-off valves of various forms of valves (tapered, spherical with a nozzle that does not repeat the shape of the valve, spherical with a nozzle that repeats the form of the valve, cylindrical). Implementation, performed taking into account the accepted parameters of production, packaging, method of execution. The mathematical connection between the coordinate of the valve position and the function of the receipt of products in the container was established, which in turn gave the opportunity to derive the optimal function of movement of the valve of the shut-off valve.*

Keywords: *mechatronic module of weight dosing, shut-off valves, valve, rational dosing, movement function, pneumatic drive.*

INTRODUCTION

The development of means for dosing food products is directly connected with the improvement of technologies for the production of the food industry, which in turn is conected with an increase in the requirements for traditional indicators: productivity, economy (minimum cost), reliability, accuracy (Gavva O., Bespalko A., Volchko A., Kohan O. 2010). Todaty, the methods of dosing and regulating the flow have a lot of structural and design solutions that reflect the specifics of the technological process, the properties of products (Asmolova E., Krasovitskiy A., Loginov A. 2007). Thanks to the active development of computer technology, weighing dosing becomes a promising direction. With this method of dose formation, the accuracy does not depend on its magnitude, but on the dosing process.

EXPOSITION

The structural scheme of the mechatronic weighing device (Graffin A., 1994) was adopted for the object of the study, which was conditionally divided into three blocks, in accordance with their functions: 1. the block of elements of submission of production (regulates receipt of production in container); 2. block of feedback elements (provides current data to the system); 3. block of signal processing elements (receives a signal from the feedback element block and after the processing gives a control signal to the valve drive).

[10] Докладът е представен на студентската научна сесия на филиал Разград, проведена на 15.05.2018г. в секция „Биотехнологии и хранителни технологии" с оригинално заглавие на английски език: Realization of an optimum mode of formation of a dose of liquid production by weight metod

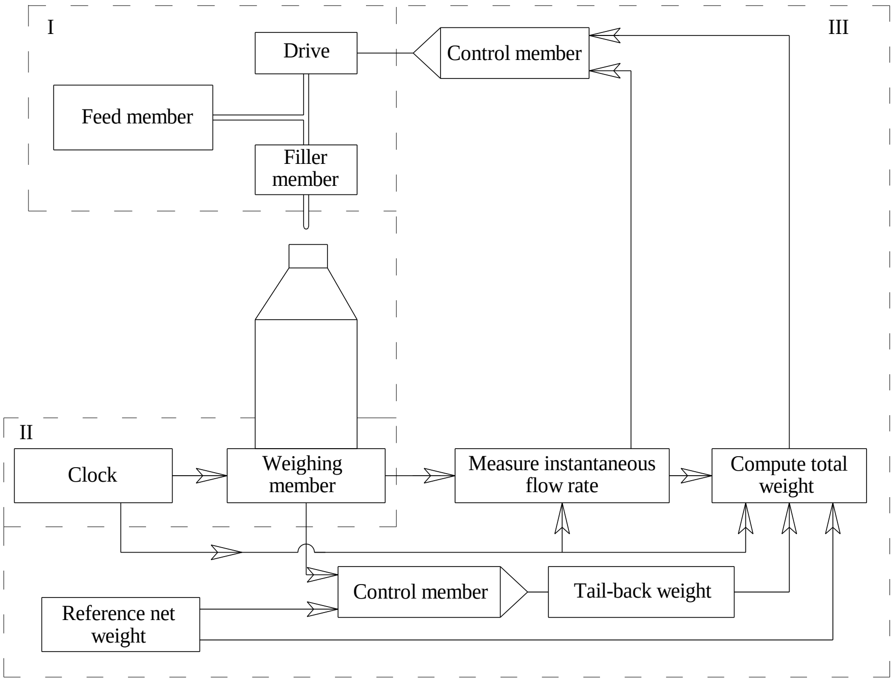


Fig. 1. Structure diagram of a weighing device: 1 - a block of elements for the supply of products; 2 - block of elements of feedback; 3 - block of signal processing elements

In the course of the theoretical definition of a rational filling law, a model of a consumer container in the form of a bottle was adopted (Zaichik R. Trynov V. 2000). It should be noted that the tensometric system perceives static F_c (tare weight) and dynamic forces F_D (from incoming and outgoing products), which affects the readings (1).

$$F_{\Sigma} = F_C + F_D = F_C + m_t \cdot g + F_t \qquad (1)$$

Given the geometric parameter of the package, a system of equations was derived, which describes the dosing process at each individual time. To simplify the task, the container was conventionally divided into two parts, a cylindrical and conical (or rather a cut cone whose upper radius is the neck). Accordingly, solving the subsystem of equations (2.1) with respect to the production level h, all the necessary data were available for determining the dynamic component of the force F by means of equation (2.2). Equation (2.3), taking into account all the values obtained for a given time, describes the value of the dynamic forces that determine the strain gauge system.

$$\begin{cases} \begin{cases} W_1 = \pi \cdot \dfrac{d_1^2}{4} \cdot h; \quad W_2 = 0; \quad 0 < W_1 < W_{1\max} \\ W_2 = a \cdot h^3 - b \cdot h^2 + c \cdot h; \quad W_1 = W_{1\max}; \quad 0 < W_2 < W_{2\max} \end{cases} & (2.1) \\ F_t = \rho \cdot \pi \cdot r^2 \cdot \left(v_0 + \sqrt{2 \cdot g \cdot (H-h)}\right)^2 & (2.2) \\ F_D = W_1 \cdot g \cdot \rho + W_2 \cdot g \cdot \rho + F_t & (2.3) \end{cases}$$

Dosing is carried out in several stages. The transition between them occurs when the nominal value of the total force that acts on the strain gauge system corresponds to the value of the generated dose. In each subsequent stage, the throughput of the valve decreases.

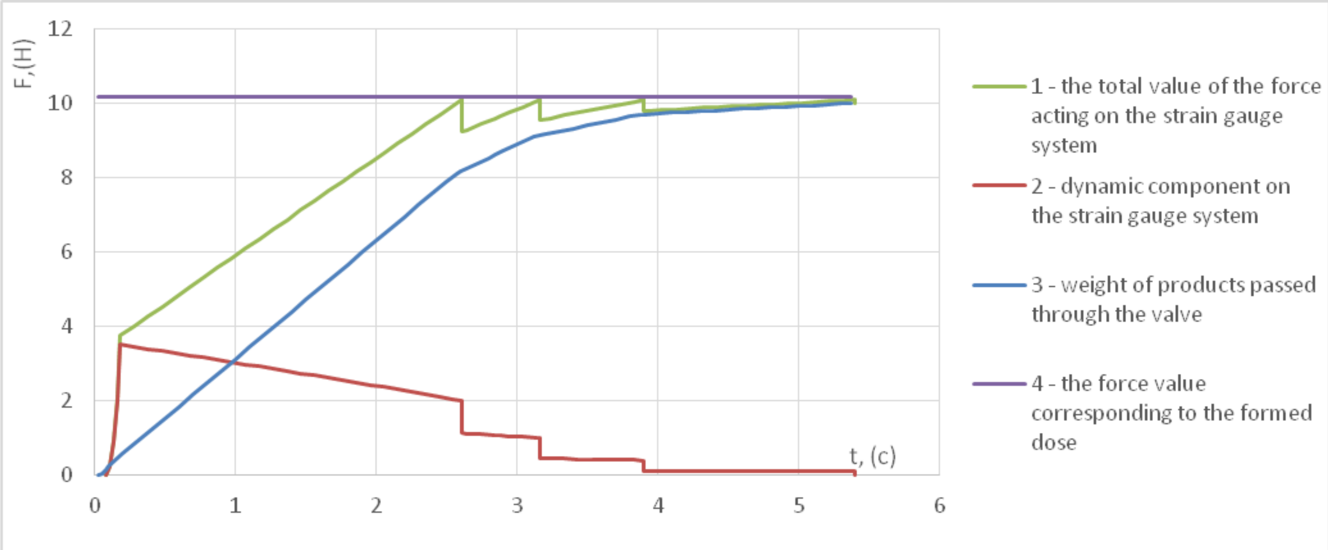


Fig. 2. Change in the weight of the force acting on the strain gauge system: 1 - the total value of the force acting on the strain gauge system.

The data obtained, which describe the packing process, were approximated using the trigonometric function (3).

$$f(t) = a + b \cdot \cos(c \cdot t + d) \qquad (3)$$

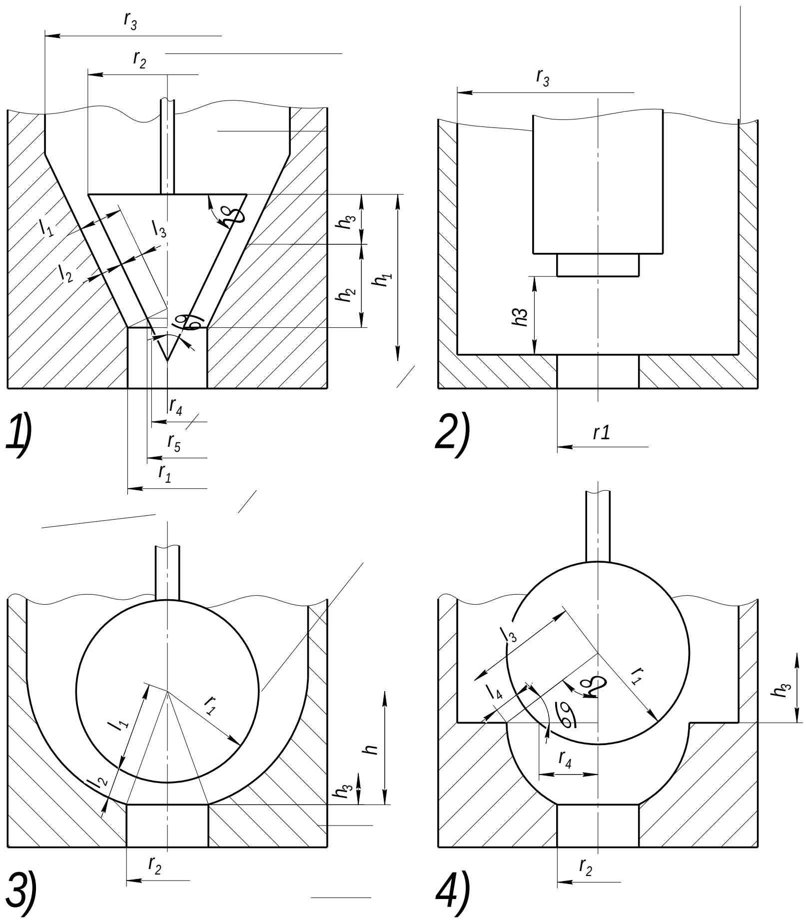


Fig. 3. Calculated models of distributed shapes of valves: 1 - conical; 2-spherical, with a nozzle repeating the shape of the valve; 3 - spherical, with a nozzle that does not repeat the shape of the valve; 4 - cylindrical shape

This dependence does not provide the necessary information for the derivation of the law of motion of the valve, precisely because it describes all the products that are in the container. At one time, the time derivative of a given function determines the instantaneous growth of a liquid, which in the future can be expressed by changing the effective cross-sectional area.

Several common design (Gvozdev O., Ialoha I. 2001) versions of valves were considered (Fig. 3). The theoretical calculations made it possible to obtain the functions of changing the cross-sectional area of the valve, from the vertical coordinate of the position (Fig. 4), which in turn were tied to the found law of increment of production at a single time for conic (4), spherical, with a nozzle not repeating the shape of the valve (5), spherical, with the nozzle repeating the shape of the valve (6) of the cylindrical shape (7).

$$\pi \cdot h \cdot \sin\left(\frac{\alpha}{2}\right) \cdot \left[2 \cdot r_1 - h \cdot \sin\left(\frac{\alpha}{2}\right) \cdot \sin\left(\frac{\pi-\alpha}{2}\right)\right] \cdot \rho \cdot g \cdot v = -3.5925 \cdot \sin(0.3559 \cdot t - 1.6033) \tag{4}$$

$$\pi \cdot r_1 \cdot r_2 \cdot \left(1 - \left(\frac{\sqrt{r_1^2 - \frac{r_2^2}{4}} - h}{\sqrt{r_1^2 - \frac{r_2^2}{4}}}\right)^2\right) \cdot \rho \cdot g \cdot v = -3.5925 \cdot \sin(0.3559 \cdot t - 1.6033) \tag{5}$$

$$\pi \cdot r_1 \cdot \left(\frac{1}{\sin\left(\frac{\pi-\alpha}{2}\right)} - \sin\left(\frac{\pi-\alpha}{2}\right)\right) \cdot \rho \cdot g \cdot v = -3.5925 \cdot \sin(0.3559 \cdot t - 1.6033) \tag{6}$$

$$2 \cdot \pi \cdot r_1 \cdot h \cdot \rho \cdot g \cdot v = -3.5925 \cdot \sin(0.3559 \cdot t - 1.6033) \tag{7}$$

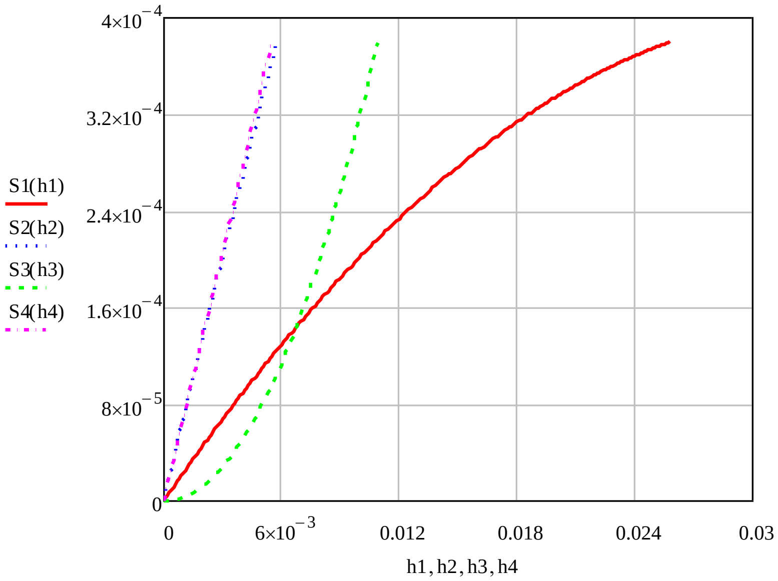
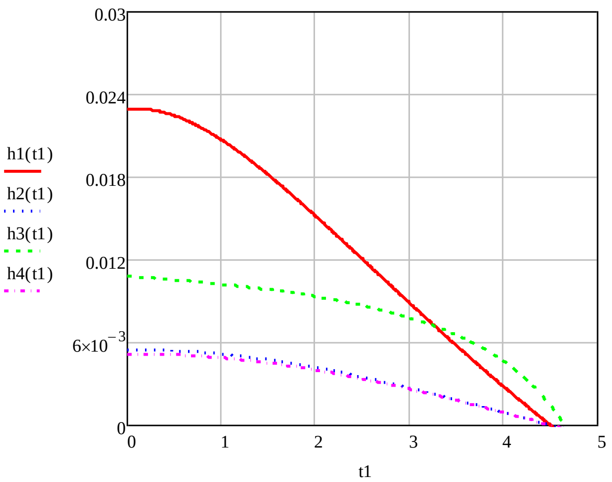
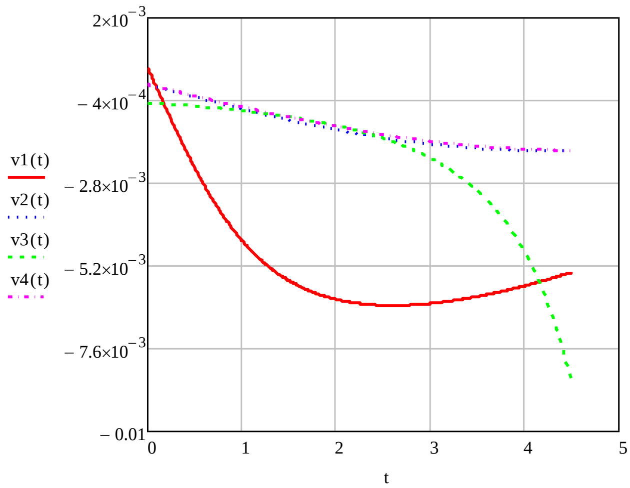


Fig. 4. Change in the cross-sectional space with respect to the coordinate of the height of the valve: 1 – conical (S1); 2-spherical, with a nozzle repeating the shape of the valve (S2); 3 - spherical, with a nozzle that does not repeat the shape of the valve (S3); 4 - cylindrical shape (S4)

Solving these equations with relatively to the vertical position of the valve h, a valve position function was obtained at each instant of the filling process, the first derivative of which characterizes the velocity, and the second velocity of the valve (Fig. 5).



A)



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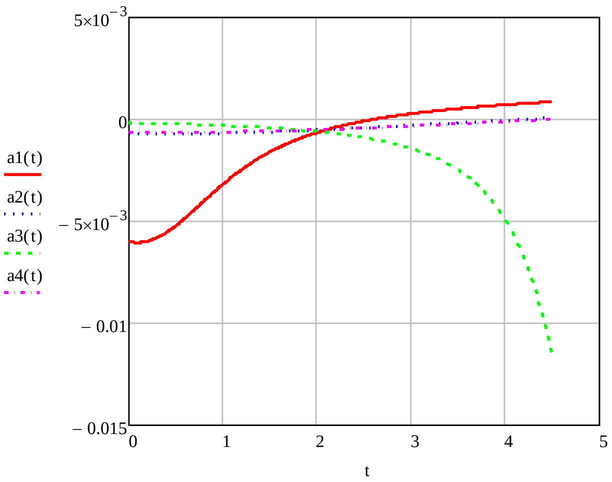

C)

Fig.5. Comparison graphs the coordinates of the vertical position (A), the speed (B) of the acceleration (C) of the conical valves (1), spherical, with the nozzle not replicating the shape of the valve (2), spherical, with the nozzle repeating the shape of the valve (3) .

The obtained dependences are purely theoretical, for their use it is necessary to take into account the operation of the drive in addition. In industry, pneumatic and electric drives are most often used (Borodulin D., Menh A., Shyshpannikov A., Potapov A., 2009).

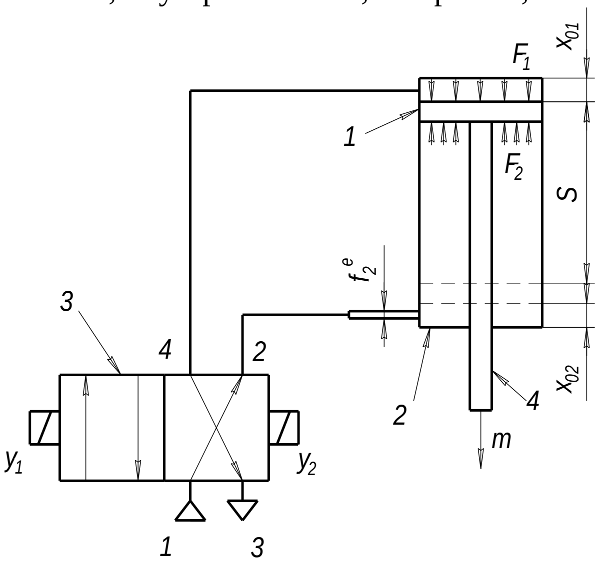

Fig. 6. Diagram of pneumatic drive with initial differential pressure in the cylinder: 1 - piston; 2 - working cylinder; 3 - the distributor; 4 – rod

Despite the fact that the drives are increasingly installing microcontrollers, which independently make corrections, the pneumatic equipment requires additional calculation. To realize the obtained dependences, a pneumatic drive was synthesized (Herz E., 1985) (Fig.6.). Since the law of motion provides for a rapid opening and gradual decrease in capacity, throttling is carried out only on the rod cavity of the pneumatic cylinder. The specific effective area of throttling for each form of the valves considered (Fig. 7).

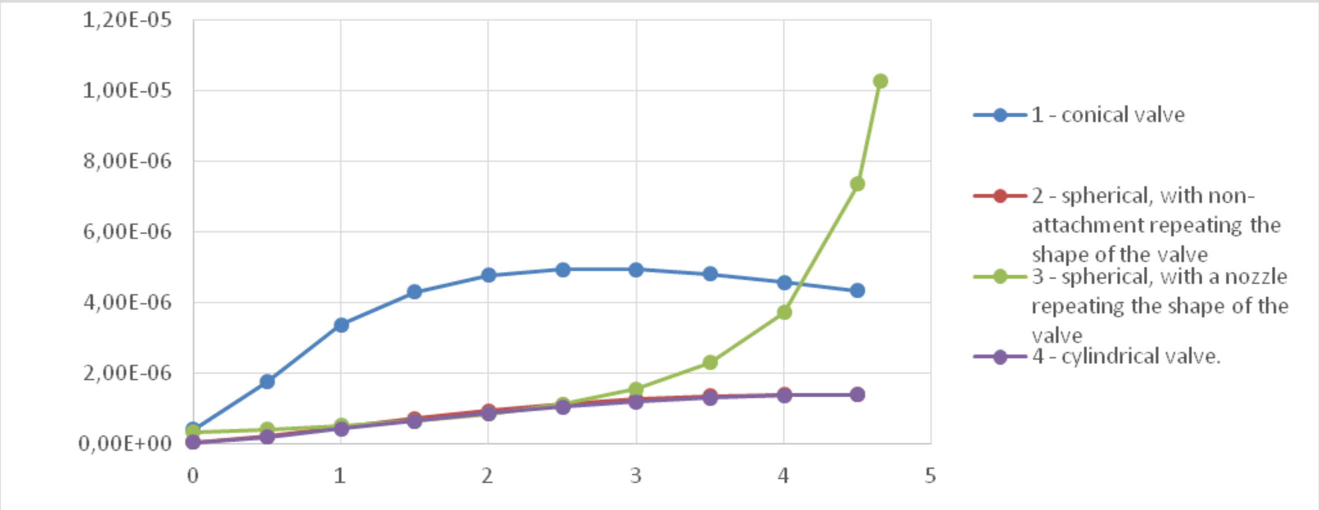

Fig. 7. Changing the cross-sectional area of the throttlein the dosing process, using different types of valves

CONCLUSION

The scheme of realization of the weighted method of dosing liquid products, with feedback, makes it possible to study the process of filling the container, as a result of which a rational filling law was obtained. The analysis and calculations of common valve shapes made it possible to obtain rational laws of valve motion and to perform a pneumatic drive synthesis in order to ensure the fulfillment of the previously derived law of motion.

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PROCEEDINGS
Volume 57, Series 10.3.

Chemical technologies
&
Biotechnologies and food technologies

Under the general editing of:
Assoc. Prof. Tsvetan Dimitrov

Editor of Volume 57:
Prof. Diana Antonova, PhD

Bulgarian Nationality
First Edition

Printing format: A5
Number of copies: on-line

ISSN 1311-3321 (print)
ISSN 2535-1028 (CD-ROM)
ISSN 2603-4123 (on-line)

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