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System of automated packaging machines when closing a package with metal clips

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1. Introduction

A problem of avoiding food product losses that appear because of the long distance the products travel from the producer to the end user and to maintain good quality is a social concern, not only the economical one. The problem can be solved and food products protected from the environmental factors, including the influence of harmful substances, by a rational use of polymer and protein substances not allowing the products to lose their beneficial properties and their components, which define the nutrition value of a product [1,2].

For packaging of smoked, boiled, liver sausage-meat of mechanical filling, also butter, curd, diet curd, curd for children, sour-cream, ice-cream mass and similar consistence products, one of the ways is packaging into various size bar-type film packages closing their ends by metal clips [3,4].

2. Choice of the basic package formation scheme

After carrying out the analysis of references, a basic functional scheme of package formation, which is presented in the Fig. 1 was chosen. The sleeve former twists the packaging band from a roll into the sleeve, which is then welded in longitudinal direction and evenly extruded. The sleeve is filled up with a product. Two clips are formed out of aluminium wire and put on the sleeve, removing the product from the clip position before that. The formed bars between the clips are separated.

Automated packaging machines can be designed either in the vertical or horizontal way according the above-presented basic scheme. When the casing is provided by the sleeve, according to the basic scheme a special mechanism for the blank supply in the corrugated blank of corresponding length can be used instead of the sleeve shaper.

3. Automated packaging machine module with slider-crank mechanisms

Without the comprehensive kinematic and dynamical characteristics of these mechanisms it is complicated to design automated packaging machines having optimal parameters. The best way is to use the module design method. Kinematic investigations of different models are performed by the method of vector contours, which was theoretically proved by prof. V.Zinovjev [5, 6].

Designing the automated packaging machines instead of package closing device with slider-crank mechanisms, which were discussed in [7, 8, 9, 10], a double slider-crank mechanism shown in Fig. 1 can be employed. Selecting the distances $x_B = x_E \leq l_2$ according to Fig. 2 rockers *3* and *6* can have a straight shape, not bended as shown in [7]. When $x_B = x_E = l_2$, angles φ_F and φ_D in the stroke of package closing zone will approach 90°, and in the limiting positions ($\varphi_2 = 180^\circ$) they will be equal 90°.

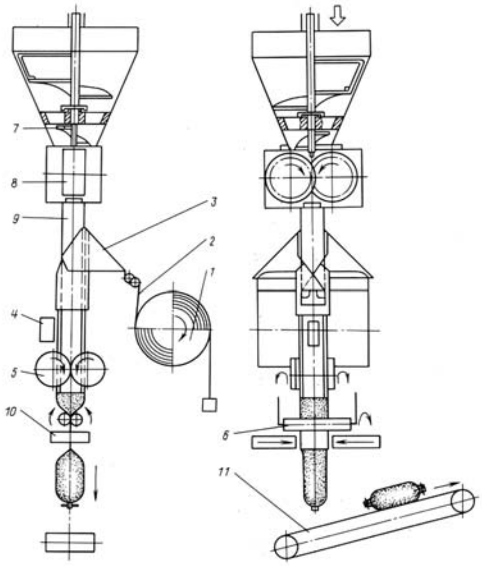


Fig. 1 Basic functional scheme of automated packaging machines for film packaging of the products with the package ends closed by metal clips: *1* - roll of packaging material; *2* - band of film material; *3* - sleever former; *4* - the device for longitudinal seam welding; *5* - the mechanism for sleeve extrusion; *6* - the device for removing product from the clip position; *7* - bunker; *8* - pump-dosing device; *9* - the pipe for product filling; *10* - the mechanism for clip formation and fixing; *11* - transporter

The angles φ_F (φ_D) < 90º, when $\varphi_2 = 180^\circ$, should not be used, because the investigations of package closing module with five-bar mechanism indicated that it decreases the mean velocity coefficient in package closing area.

$$i_{32} = -\frac{\sin\varphi_2}{a\sin\varphi_3} \tag{1}$$

For angular acceleration of link *3* we have

$$i'_{32} = \frac{-\left(\cos\varphi_2 + i_{32}^2 a\cos\varphi_3\right)}{a\sin\varphi_3} \tag{2}$$

In order to determine kinematic characteristics of the points we will use the characteristics of package closing device with five-link mechanism discussed in [7].

In this case the dynamic factor is calculated as follows

$$\left.\begin{aligned} k_{W32} &= i_{32}\, i'_{32} \\ k_{V32} &= \left(V_F^x\right)_{\varphi_2}\left(a_F^x\right)_{\varphi_2} + \left(V_F^y\right)_{\varphi_2}\left(a_F^y\right)_{\varphi_2} \end{aligned}\right\} \tag{3}$$

For the sake of comparison with the five-link mechanism shown in [7] kinematic characteristics of the slider-crank mechanism are presented in Fig. 3.

We see that the characteristics of the investigated mechanism are close to those obtained for the five-link mechanism of the same dimentions. A conlucion is thus made that both basic schemes are equivalent.

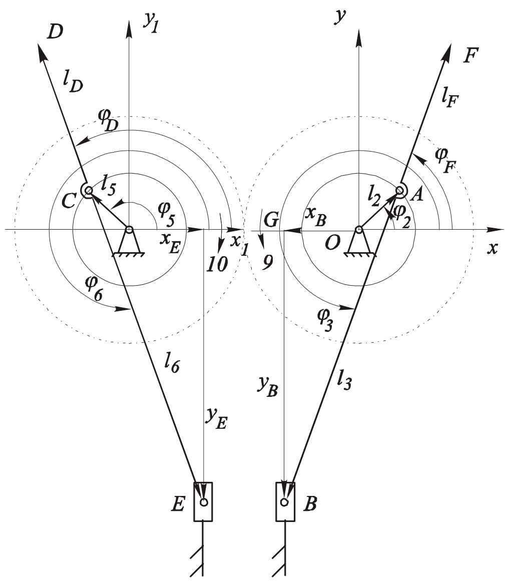


Fig. 2 Kinematic scheme of package closing device with slider-crank mechanism

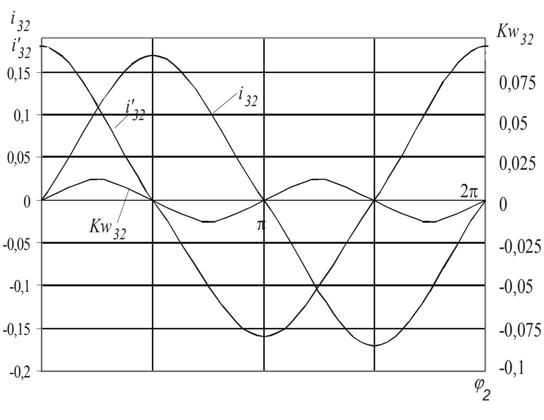


Fig. 3 Kinematic characteristics of link 3 of a slider-crank mechanism when: $l_2 = 1$; $a = \dfrac{l_3}{l_2} = 6.2$; $x_0 = \dfrac{x_B}{l_2}$; $c = \dfrac{l_F}{l_2} = 6.8$

4. Package closing device module with the slider-crank mechanism having curvilinear guides

Package closing device with a slider-crank mechanism having curvilinear guides is shown in Fig. 3. This mechanism has some characteristic properties, which are impossible to achieve in technical sense using simple slider-crank mechanism shown in Fig. 3 or five-bar mechanisms shown in Fig. 5. Straight path of the operation point in certain position of working stroke can be obtained using the mechanism in hand. Multifunctional automated machines can be developed using various sets of the guides.

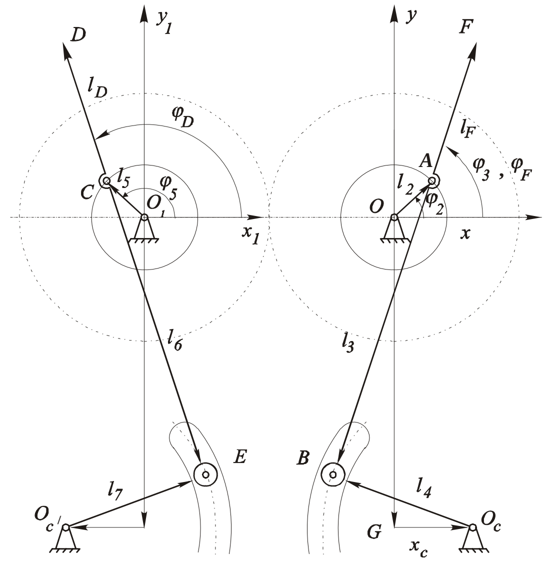


Fig. 4 Vector contours of package closing device with a slider-crank mechanism having curvilinear guides

Angular velocity and acceleration analogues will be the following

$$\left.\begin{aligned} i_{32} &= -\frac{sin\left(\varphi_2-\varphi_4\right)}{a\,sin\left(\varphi_3-\varphi_4\right)} \\ i_{42} &= \frac{sin\left(\varphi_2-\varphi_3\right)}{a\,sin\left(\varphi_4-\varphi_3\right)} \end{aligned}\right\} \tag{4}$$

$$i'_{32} = -\frac{cos\left(\varphi_2-\varphi_4\right)+i_{32}^2\,a\,cos\left(\varphi_3-\varphi_4\right)-i_{42}^2\,r}{a\,sin\left(\varphi_3-\varphi_4\right)} \tag{5}$$

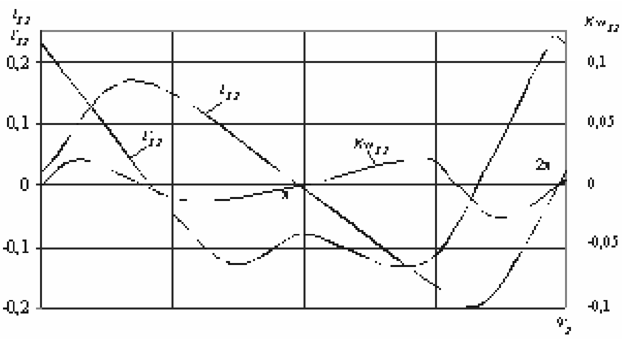


Fig. 5 Kinematic characteristics of the link *3* of the slider-crank mechanism (Fig. 4), when: $l_2 = 1$; $a = \dfrac{l_3}{l_2} = 6.2$; $r = \dfrac{l_4}{l_2} = 2$; $c = \dfrac{l_F}{l_2} = 6.8$

For determining velocities and accelerations in the operation points F and D the equations derived in the [7] can be used.

Kinematic characteristics of the curvilinear guide with constant curvature radius situated on the left part of the mechanism are represented in Fig. 4. We see that a small dynamic factor is achieved in the area of mechanism operation, and this is an advantage of such kind mechanism.

It was determined that:

- straight-line motion of the operation points can be obtained using the discussed basic scheme of automated packaging device. It was also determined that by its functional possibilities this scheme differs from the schemes of analogous purpose with slider-crank anf five-link mechanisms;
- multifunctional automated packaging machines can be designed using various sets of guides. Principal scheme of such automated machine is presented in Fig. 6, d.

5. New design solutions

Fig. 6 represents basic schemes of the developed modules of packaging automated machines.

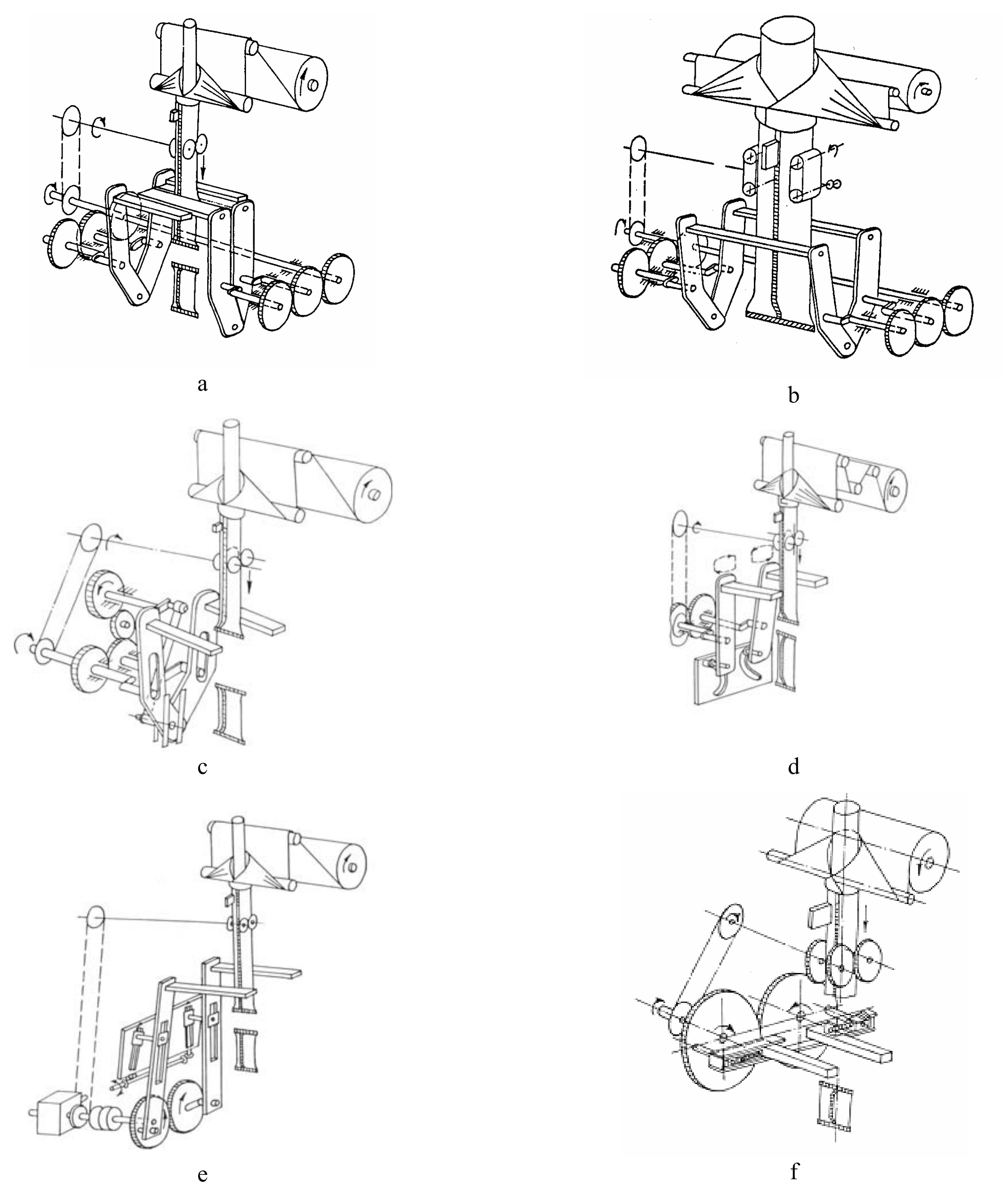
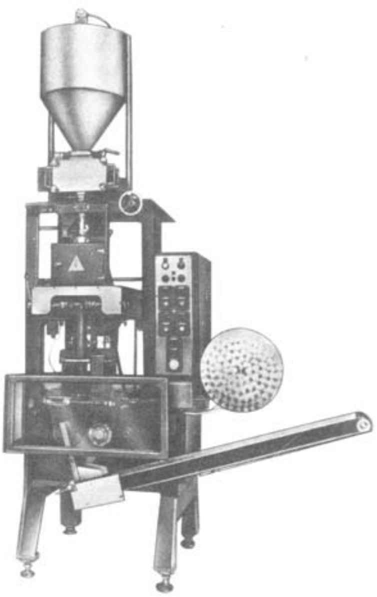


Fig. 6 Basic schemes of automated packaging machines with five-link mechanisms, when: a - two thermal welding mechanism pairs are used for the package end closing; b -the sleeve is welded using long welding elements; c - an additional mechanism for moving the welding elements during welding is employed; d - curvilinear guides are used; e - double slider-crank mechanism is used; f - a simplified scheme of package closing using welding

These are the original design solutions, which are employed as basic modules of automated packaging machines. Various modifications of automated packaging machines for different kinds of products packaging can be designed by changing certain junctions, and taking into account physical-mechanical properties of the product, the package dose, its dimentions, packaging materials etc.

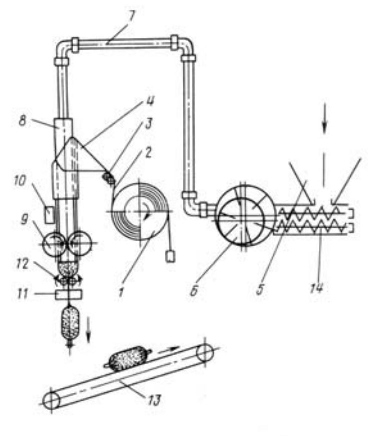
6. Automated packaging machines with five-link lever-type mechanisms for film packaging of food products closing the package ends by metal clips

Accoding the developed principal schemes and performed theoretical investigations a range of automated packaging machines for film packaging of food products closing the package ends by metal clips was designed. The batch production of these mechanisms, which are presented in Fig. 7, was started in the industrial union FASA (Marijampolė, Lithuania). The following machines were developed: an automated packaging machine M1-FUT for povidene film packaging of liver sausages into 250 - 1000 g packages, an automated packaging machine M1-FUR for povidene film packaging of boiled sausages into 500 - 1000 g packages, a modernized automated packaging machine MI–OFD-K for polyethylene film packaging of diet curd into 250 - 500 g packages, and a modernized automated packaging machine M1-FU2T for povidene film packaging of liver sausages into 250 - 500 g packages.

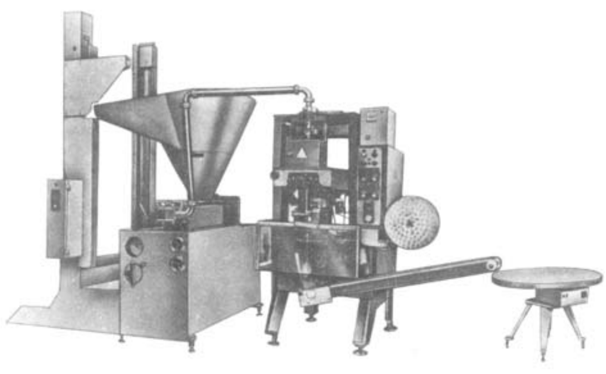


Automated packaging machine MI-FUT

Automated packaging machines MI-OFD-K and MI-FU2T



Functional scheme of an automated packaging machine MI-FUR



Automated packaging machine MI-FUR

Fig. 7 Automated packaging machines with five-link lever-type mechanisms for film packaging of food products closing the package by metal clips. The machines are produced in batches in the industrial union FASA

7. Conclusions

1. Theoretical background for the design of automated packaging machines closing modules with flat lever-type mechanisms was developed, new principal solutions with the methods for their calculation and optimization, and new structures were worked out. New automated packaging machines and their systems for product packaging into film packages closing the package ends with metal clips were designed and applied in industry.

2. The results of theoretical and experimental investigations, which were obtained, enabled to extend the database and to perform modular design of automated packaging machines which is new in terms of quality.

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METALINĖMIS SĄVARŽOMIS PAKUOTES UŽDARANČIŲ PAKAVIMO AUTOMATŲ SISTEMA

R e z i u m ė

Straipsnyje pateikti pakavimo automatų produktams fasuoti į plėveles, užspaudžiant pakuočių galus metalinėmis sąvaržomis, teoriniai pagrindai. Pateiktos sukurtos naujos pakavimo technologijos, pakavimo automatų principinės schemos, šių automatų kinematinių ir dinaminių charakteristikų skaičiavimo metodika, sukurta ir įdiegta pramonėje pakavimo automatų sistema produktams fasuoti į plėveles, užspaudžiant pakuočių galus metalinėmis sąvaržomis. Pateiktos priklausomybės ir grafikai leidžia optimizuoti konstrukcijas ir praplėsti tokių pakavimo automatų automatizuotojo modulinio projektavimo duomenų banką.

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SYSTEM OF AUTOMATED PACKAGING MACHINES WHEN CLOSING A PACKAGE WITH METAL CLIPS

S u m m a r y

Theoretical basics of package closing modules for automated packaging machine are worked out. The developed technology, methodics and new principal solutions with the methods for their calculation and optimization, and new structures are presented. Kinematic and dynamical characteristics of these mechanisms, new automated packaging machines and their systems for product packaging into film packages closing the package ends with metal clips were designed and applied in industry. The given mathematical and graphical relations make it possible to optimize the construction and extend the data bank for automated modules of packing machines designing.

Л. Паулаускас

СИСТЕМА УПАКОВОЧНЫХ АВТОМАТОВ ЗАКРЫТИЯ УПАКОВОК МЕТАЛЛИЧЕСКИМИ СКРЕПКАМИ

Р е з ю м е

В статье представлены теоретические основы упаковочных автоматов для упаковки продуктов в пленку закрывая концы упаковок металлическими скрепками. Представлены принципиальные схемы новой технологии упаковочных автоматов, методика расчета характеристик кинематики и динамики автоматов, а также система машин автоматов для упаковки продуктов закрывая концы упаковок металлическими скрепками, созданных и внедренных в промышленность. Представлены зависимости и графики позволяют оптимизировать конструкции и расширить банк данных модульного автоматизированного проектирования упаковочных автоматов.

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