QUANTIFICATION OF A MECHATRONIC PNEUMATIC GRIPPING SYSTEM FOR A MULTI-LINK ROBOT MANIPULATOR

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Abstract. *The basis of the work is the tasks related to the synthesis of working bodies for moving artificial food, and the development of a control program for them based on PLC - namely, pneumatic grippers. An urgent task was also to ensure the movement of products processed by a robot manipulator according to the given law of movement. Based on the study of the dynamic characteristics of the drive and the control system of the power part of the position electro-pneumatic drive. Mathematical and computer modeling methods, methods of solving ordinary differential equations and partial differential equations, correlation analysis method are used. Analytical dependencies were obtained for controlling the drive of a robot-manipulator with a pneumatically controlled gripper to determine the kinematic parameters of the product movement during processing. The dynamic model of the pneumatic gripper and its drive was mathematically tested. The law of motion of the final link of the manipulator, close to the optimal speed, was obtained. On the basis of the research calculations and the analysis of the functional mechatronic modules, the energy efficiency of the proposed control scheme of the power part of the positional pneumatic drive was confirmed. The result of the study of the electropneumatic positional drive is presented in the form of an algorithm and a special program for calculating and comparing the kinematic and dynamic parameters of the drive.The technological time of the operation is adjustable and when using the exhaust cross-section of the working chambers of the pneumatic cylinder - 4 mm, the value of the working pressure up to 7 bar, the movement of the rod - up to 200 mm, it has optimal kinematic characteristics of work for a pneumatic gripper. The discrepancy between the value of the time of the working stroke of the output link of the functional mechatronic module calculated during the mathematical modeling after working out the kinematic cycle of the gripper was up to 3% for various input parameters.*

Key words*: functional, module, pneumatic gripper, electro-pneumatic drive, precision, variable gripper soft pads.*

I. INTRODUCTION

The complex process of optimal control of drives of technological equipment based on manipulator robots for food production has already been studied by many authors [1-4]. Therefore, modeling of the process of movement of artificial products by a gripper based on various mechatronic systems, taking into account the features of the design and real boundary conditions, dynamic processes in the pneumatic gripper - are relevant. After the implementation of existing technical decisions regarding the types of grippers in the technological equipment, robots-manipulators of packaging machines (PM) were chosen.

[5 -10]. In order to choose the law of operation of a pneumatic gripper and subsequent movement of an artificial product, one must first of all consider the possibility of practical implementation of such a law with a pneumatic drive. We considered the possibility of ensuring a smooth change of all technical parameters of the pneumatic gripper. [13] The criterion that characterizes the operations of moving an artificial product can be the law of motion, chosen on the basis of the quantification of the technical characteristics of the pneumatic gripper. [14-20] Therefore, the task of mathematical and physical modeling of the drive of a robot-manipulator is relevant**.**

II. LITURATURE ANALYSIS

The processes of food, chemical, textile, perfumery and many other industries are based on operations of metered supply of liquid products. For example, in work [1-20], the costs of the product, which are established by the technological regulations, are investigated. The authors describe a process control system based only on the contours of the automatic adjustment of one dosing parameter. The issues of development and implementation of aerial mechatronic dosing systems with tracking circuits for two or more technological parameters remain unresolved. Critical analysis of liquid food product dosing systems is based on electropneumatic systems and is complicated by the lack of ready-made industrial executive modules. In particular, in [2] dosing devices for small dose ranges. The analysis of the task of automating technological processes of aerial dosing, in work [3], describes the design of servo-pneumovalves. This description is even more complicated because the control object has an inertial delay and parametric non-stationarity. The results given in [4] can be a solution to overcome the relevant difficulties. In this case, a high-quality organization of dosing processes is possible only when closed systems of automatic regulation are used. Such tasks require the development of universal automatic dosing systems, which are functionally adapted to perform both batch and continuous dosing operations. [5,6] The text of the source [7-11] describes data on the dosing process with an analysis of the reliability parameters of technological elements. Pneumatic valves and product line connection systems are described, but the results are not complete. The dosing principle, described in [12], is time-oriented with the condition of ensuring a constant flow of liquid. Unfortunately, the results of the conducted experimental studies do not describe the energy consumption of the dosing system [13-17]. Therefore, there are reasons to assert the expediency of conducting a study devoted to the construction and testing of liquid product dosing systems based on electropneumatic complexes. And also, according to the method of empirical research, to obtain results for the analysis of the process of forming the dose of the product for the airlift dispenser system and the study of further dosing accuracy.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of research is the processes that take place in cyclic and positional electro-pneumatic drives of the robot manipulator and the associated pneumatic gripper.

The subject of the study is a self-developed design of a robot-manipulator with a gripping device with replaceable pads of contact surfaces.

The purpose of the study is to determine the optimal law of movement of the rod of the electropneumatic positional drive.

The purpose of the research is to expand the functional capabilities of food packaging equipment, it involves finding ways to improve pneumatic gripper drives in functional mechatronic modules of manipulator robots.

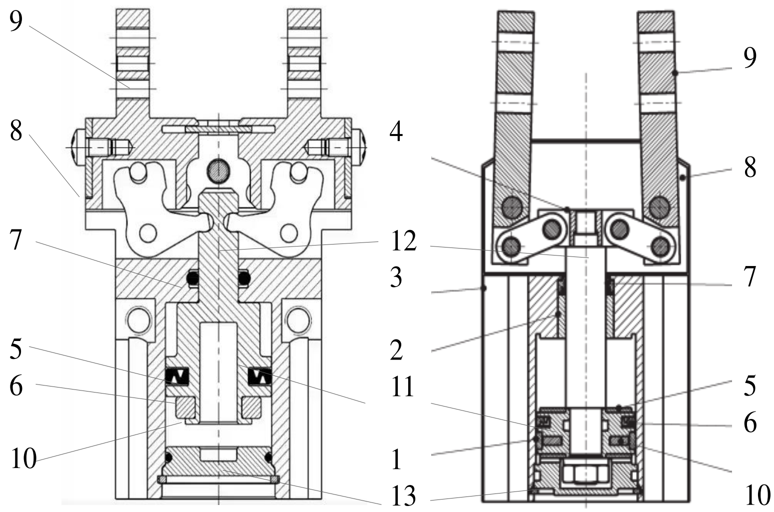
The materials and methods are formed on the basis of the quantification of the results of processing the dynamic characteristics of the drive and the control system together with the power part of the positional electropneumatic drive. Computer modeling and mathematical methods, methods of solving ordinary differential equations, correlation analysis method are used.

In order to obtain the results of the research of gripping pneumatic devices with different contact surfaces, the tasks were formulated:

- modeling of the law of motion of the pneumatic cylinder piston, as the basis of a pneumatic gripper with an initial air pressure drop close to the optimal speed of action. At the same time, two designs of grips and three designs of overlays on the gripping surfaces of the contact are considered.- research on the basis of a self-developed PLC control program (LAD language) and on the basis of experimental modeling of the operation of grippers of various designs, cases of smoothing of the acceleration function at the moment of disconnection of the driving force. The obtained results will make it possible to smoothly change the operating parameters of the manipulator robot: creation of a 3D model of a manipulator robot based on the general structural library of PARTcommunity CAD, taking into account the selection of drive elements for the construction of an experimental stand; a description of the method of selecting the initial stage of movement (by the x coordinate), taking into account the possible decrease in the performance of the executive mechanism; experimental study of the cyclic and positional electro-pneumatic drive for working out the modes of operation of various gripping modules in a packaging machine for artificial products with different surface geometries.

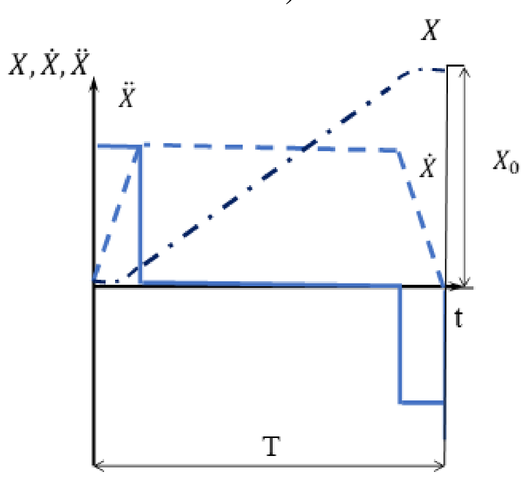
IV. RESULTS

4.1. Experimental stand. The operation of processing artificial products with the help of robot manipulators, in connection with the operation of the gripping elements of the FMM (Fig. 1). The movement of the gripping elements and their control program determine the required performance of the packaging machine or technological equipment. The integrity of the product and the accuracy of positioning of pneumatic grippers depend on the shape, material and law of closing the gripper. Based on the analysis of existing layouts of packaging machines, an electropneumatic positional drive was chosen for the study (Fig. 1a,b). (Fig. 1, c) shows the generalized characteristics of movement, speed and acceleration for the rod connected to the gripping elements using graphs**.**



a)

b)



c)

Fig. 1. The general design of the investigated grippers based on two-way pneumatic cylinders for the robot manipulator: a) a cam gripper system for moving the gripper

elements apart; b) hinged gripper system for opening jaws by 180º; c) general view of soft overlays on gripping elements developed by the authors and printed on a 3D printer (flexible thermoplastic polyurethane thread and PLA with silk thread); d- kinematic characteristics of the output kinematic link (pneumocylinder rod); 1- working piston ring; 2 – sleeve; 3 – body; 4 – guide rod; 5 – damper seal; 6 – piston seal; 7 – rod sealing; 8 – anti-friction plate; 9 – grip finger; 10 – magnet; 11 – piston; 12 – rod; 13 – cover; x,(x,) ̇x ̈ – curves of mixing, speed, acceleration depending on time t; T is the time of the kinematic cycle of the rod; x_0 – movement interval for the full time of movement T;

- The system of the grip shown in the assembly with the pneumatic drive of the robot-manipulator in Fig. 3 works according to the linear - modified [17] law;
- We will limit the overclocking stage to the following conditions: 0<t<0,25T;

$$x = 2x_0\left(\frac{t}{T}\right)^2;\ \dot{x} = 4x_0\frac{t}{T^2};\ \ddot{x} = \frac{4x_0}{T^2}$$

- We will limit the braking stage to the following conditions: 0,75T<t<T;

(1)

$$x = \frac{4x_0t}{T} - x - 2x_0\left(\frac{t}{T}\right)^2;\ \dot{x} = \frac{4x_0}{T}\left(1-\frac{t}{T}\right);\ \ddot{x} = -\frac{4x_0}{T^2}.$$

- We will limit the stage of steady motion to the following conditions:0,25T<t<0,75T;

$$x = \dot{x}t;\ \dot{x} = \frac{x_0}{T};\ \ddot{x} = const;$$

(2)

$$\ddot{x} = \frac{6x_0}{T^2}\left(1-\frac{2t}{T}\right).$$

The given descriptions of the laws of motion of the working bodies of technological machines [16] do not provide an opportunity to describe in detail the change in the kinematic characteristics of the working bodies in a layout with an electropneumatic drive. Therefore, taking into account (Fig. 1, d) and works [16, 17], we will formulate the research problems with additional parameters. We take the pressure change processes in the power part of the gripper pneumatic drive as such parameters. The research of the manipulator robot, which was designed and assembled by the authors, was carried out taking into account the inertial processes of the power part of the electro-pneumatic drive. Also, there is a need to supplement information on the operation of executive mechanisms of automatic machines [16], in particular, a packaging machine for packing artificial food products based on manipulators. The properly formed structure of the control system, which also needs to be taken into account in research, allows the work of all components of the robot manipulator to be coordinated (Appendix A, the STEP 7-Micro/WIN control program for the position system).

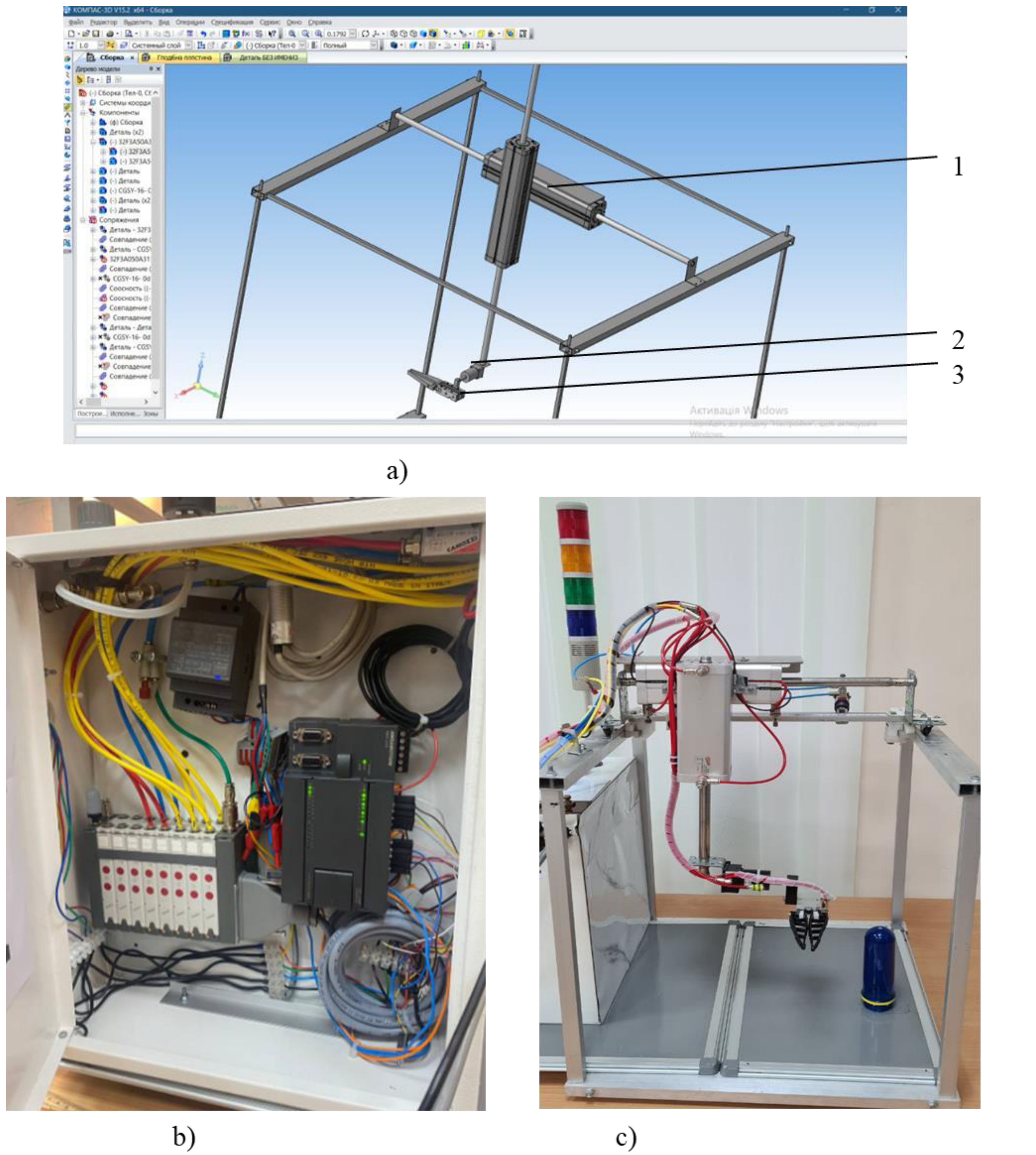


Fig. 2. View of the experimental stand for researching the robot manipulator with a variable pneumatic gripper: a) general view of the 3D experimental stand; b) a general view of the control system of the manipulator module after installation; c) general type of manipulator robot drives: 1 – two-coordinate transport system; 2 – rotary module; 3 – pneumatic gripper with a set of executive elements.

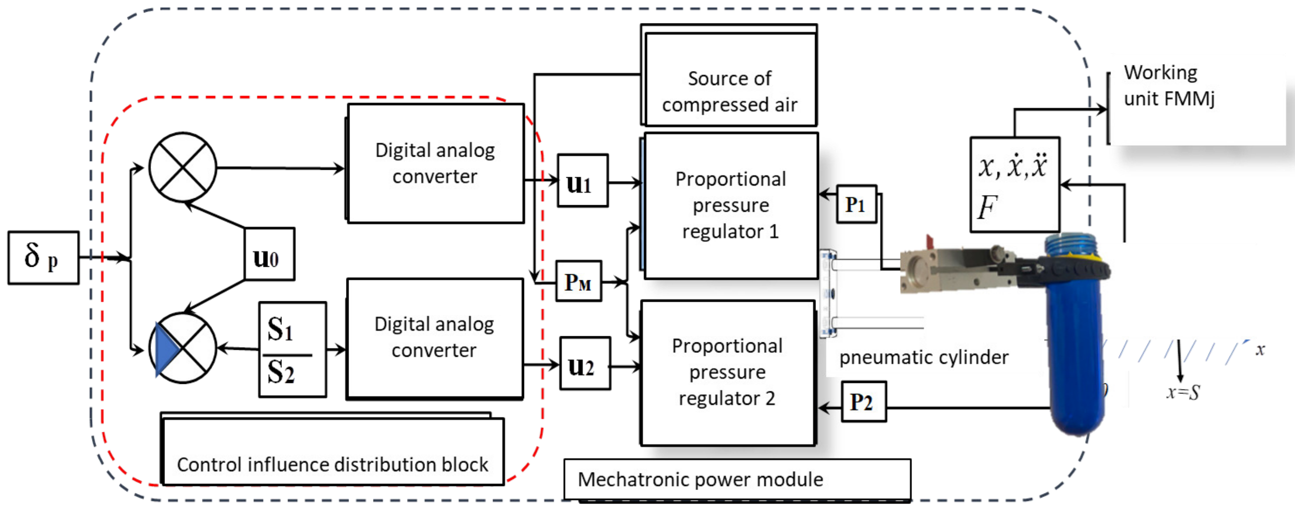


Fig. 3. A generalized diagram of the movement of the cargo during processing with a pneumatic gripper (design in Fig. 1), in a layout with a structural diagram of monitoring the movement of the pneumatic cylinder piston.

4.2. Mathematical model

Thus, the solution of the given problem is reduced to the solution of the optimization problem with initial conditions that are not equal to zero, with subsequent smoothing of the discontinuous function at the moment of turning off the driving force. At the same time, the movement of the piston of the positional pneumatic drive (Fig. 2) consists of four stages:

I stage - initial. The control signal from the electromagnetic relays of the electropneumatic distributor is triggered - and the driving force increases ($Q \le Q(x) \le Q_{max}$). The law of motion of the pneumatic cylinder piston takes on a parabolic form. The movement of the working link begins.

II stage - intense acceleration. It ends when the signal of the control electromagnet (first solenoid) disappears. The driving force is constant ($Q_{max}=const$). Stage condition: Q_{max} - the maximum driving force developed by the pusher does not cause deformation of the artificial product.

III stage - transitional. The electromagnetic relay of the electropneumatic distributor (second solenoid) is activated. The driving force decreases ($Q_{max} \ge Q(x) \ge Q$) due to the resistance of compressed air in the rod chamber of the pneumatic cylinder.

The IV stage is characterized by the reverse movement of the rod, under the action of intensive braking. The stage ends when the control signal from the second solenoid is turned off. The driving force is zero ($Q=0$). At the same time, it is necessary to ensure the separation of the product from the pusher. The boundary conditions in this problem are as follows: $t=0;\ \ddot{x}=0;\ \dot{x}=0;\ x=0;\ \ddot{x}=\ddot{x}_{IV};\ \dot{x}=0;\ x=S.$

where S is the amount of movement of the product from the initial position to the final position; $\ddot{x}_{IV}$ - the amount of acceleration of the product at the stage of intensive braking.

The variable kinematic characteristics of the pneumocylinder rod are set depending on the x parameter. The equation of motion of the piston of a two-way pneumatic actuator will look like this:
mx ̈=p_1 (x)F_1-p_2 (x)F_2-P(x)
(3)
m is the mass of the product; p1, p2 – pressure of piston and rod cavities, F1,2 – piston area of pneumatic cylinder.
We will describe the change in pressure in the form of displacement functions for the piston and rod cavities ofthe pneumocylinder:

$$\frac{dp_1}{dx} = \frac{k}{x_{01} + x}\left[\frac{f_1^э K p_m \sqrt{RT_m}}{F_1}\varphi(\delta_1) \cdot \frac{1}{\dot{x}} - P_1\right]$$

(4)

$$\frac{dp_2}{dx} = \frac{k}{S + x_{02} - x}\left[\frac{f_1^э K p_2^{(3k-1)/2k}\sqrt{RT_m}}{F_2 p_m^{(k-1)/2k}} \cdot \frac{1}{\dot{x}}\varphi\left(\frac{\delta_a}{\delta_2}\right) + P_2\right]$$

(5)

k – air adiabatic coefficient, x01, x02 – initial and final coordinates of the piston movement, R is the gas constant of air, T_m – air temperature, p_m – pressure of the pneumatic main; φ(δ_1) is the consumption characteristic of the section.
From equation (5), the pressure in the exhaust rod cavity:

$$P_2(x) = \frac{P_1(x)F_1 - m\ddot{x} - P(x)}{F_2} \quad (6)$$

After differentiating the function P_2 (x) with respect to the variable x, we have

$$\dot{P}_2(x) = (\dot{P}_1(x)F_1 - m\dddot{x} - \dot{m}\ddot{x} - \dot{P}(x))/F_2 \quad (7)$$

From equation (4.4), the effective area of the exhaust hole:

$$f_2^э = \frac{\left[P_2 - \frac{dp}{dx}\frac{S + x_{02} - x}{k}\right]\dot{x} F_2 p_m^{(k-1)/2k}}{k p_2^{(3k-1)/2k}\sqrt{RT_m}\varphi\left(\frac{\delta_a}{\delta_2}\right)} \quad (8)$$

Thus, having equations (3-8) that describe the parameters of the movement of the rod taking into account the change in pressure in the pneumatic cylinder, it is possible to proceed to the definition of the equations characterizing the movement of the artificial product on a fixed plane in the complex with the control system (Fig. 3).

Fig. 3 shows a scheme of electropneumatic position drives of a packaging machine. The drives are built by combining into a single module a pneumatic cylinder, reliable and inexpensive serial electro-pneumatic distributors of discrete action, precision sensors of the piston position and a controller that implements a digital relay control algorithm.

To stop the object at various points, feedback from a continuous sensor is used, which measures the current state of the piston relative to the base value. The pneumomechanical subsystem consists of a piston with a rod, a mechanical control object and equivalent pneumatic springs in the cavities of the pneumocylinder. The control influences u 1 and u 2 on two pressure regulation modules, which are implemented in software using the control influence distribution block. To achieve high speed of the drive and obtain the maximum range of force adjustment, it is advisable to ensure a coordinated change in the effects of u 1 and u 2 according to the equation:

$$\begin{cases} \boldsymbol{u_1 = u_0 + \delta_p}\,, \\ \boldsymbol{u_2 = (u_0 + \delta_0) \cdot \frac{s_1}{s_2}}. \end{cases} \quad (9)$$

This equation uses the input influence of the mechatronic FP δ p and the reference value u0, which sets the pressure in the cavities of the pneumocylinder at zero input influence, taking into account the difference in the areas of the piston from the side of the rod cavity S1 and the rodless cavity S2. The presence of an FMM with a positional drive is a distinctive feature of the proposed new structure of the mechatronic FP.

Consider the law of motion of the driven link as part of the mechatronic FP. For this you need: to find the Top time of moving the load in the two-stage mode, which is optimal for the speed of action, in order to determine the required value xIk of the moving of the load at the I stage in the four-stage mode (Fig. 2); consider the movement of the load as a three-stage and determine the time of disconnection of the driving force and the total time of movement. At the same time, the final coordinates for the I and III stages of the three-stage movement mode coincide, respectively, with the final coordinates for the I and IV stages of the four-stage movement mode; determine the equations describing the movement of cargo on II and IV, and then on III stage for a four-stage mode of movement.

Such a sequence of the task is related to the determination of the initial and final coordinates of the cargo movement for each stage and the search for integration constants.

The Top time of cargo movement in the two-stage mode, which is optimal for the speed of action, is determined according to the method [9].

$$T_{on} = \sqrt{\frac{2S}{gf(1 - m_{\text{гр}} gf/Q)}} \quad (10)$$

where S is the amount of load movement (piston stroke); m_gr – weight of cargo; f - coefficient of sliding friction between the supporting surface of the load and the plane of movement. In table 1, for ease of use, the equations for the kinematic parameters of the moving product and the piston are given in the four-stage motion mode (Fig. 2), when T_оп, T, Qmax, τ and x_τ are known. Changing the parameters of the process of moving the product along a stationary plane and the operating parameters of the positional pneumatic drive at Qmax = 20 H; mass of artificial product m_{gr} =0.5 kg; f = 0.3; S = 0.2 m; F1 =$4.9 \cdot 10^{-4}$ m^2; F2 = $3.77 \cdot 10^{-4}$ m^2; $f1_e$ – variable, depending on the diameter of the main pipeline; Pm=$5 \cdot 10^5$ Pa; m=mgr+mp = 0.5+1.5=2 kg, where mp =1.5 is the mass of the moving parts of the pneumatic cylinder; P(s.tr.) = 20 N – dynamic load of the pneumatic cylinder of the gripper.

4.3. Study of the drive system based on electropneumatic control complexes.

For conducting research, a special stand diagram of connections on (Fig. 4) was designed and manufactured, which makes it possible to simulate different modes of operation of the FMM of supplying consumer packaging to the processing area.

Experimental studies made it possible to check the adequacy of the results of the proposed mathematical models to real processes, as well as to determine important parameters, control systems for which there are no methods of determining them in full.

The stand for experimental research based on the positional drive of the linear movement of the package (Fig. 2, Fig. 4) includes a mechatronic system, a computer with the SIMATIC STEP 7 V5.3 control program, a Siemens S7-300 controller, PtP data exchange (Point to Point) serial interface RS 485. The mechatronic control system is implemented on the basis of a Camozzi 61 series cylinder (stroke 200 mm with a piston diameter of 32 mm), a pneumatic island with connecting holes G3/8, a linear coordinate measuring device of the Balluff company BTL5 series, an analog differentiator for calculation of piston movement speed. The criterion for setting the control circuit is the minimum duration of movement of the output link of the time pneumatic cylinder to the given positioning point and the minimum duration of the drive adjustment when working out the low-speed modes of supplying consumer packaging to the packaging area. During the experimental study, it was found that in the speed control circuit, with the input signal, to ensure a speed of 1 m/s, oscillatory processes are observed (S=f(t)), in particular, the maximum value of the speed varies from 1.5m/s to 2.2m/s, the acceleration increases to 0.25m/s^2. The resulting oscillations in the pneumatic cylinder system indicate that upon reaching the final stop point of the output link (t=0.1c), programmed by the given law of motion of the consumer package, the piston does not reach a steady speed of movement under conditions of weak damping on the speed contour, the presence of frictional forces, as well as interference interference from the location sensor and analog differentiator.

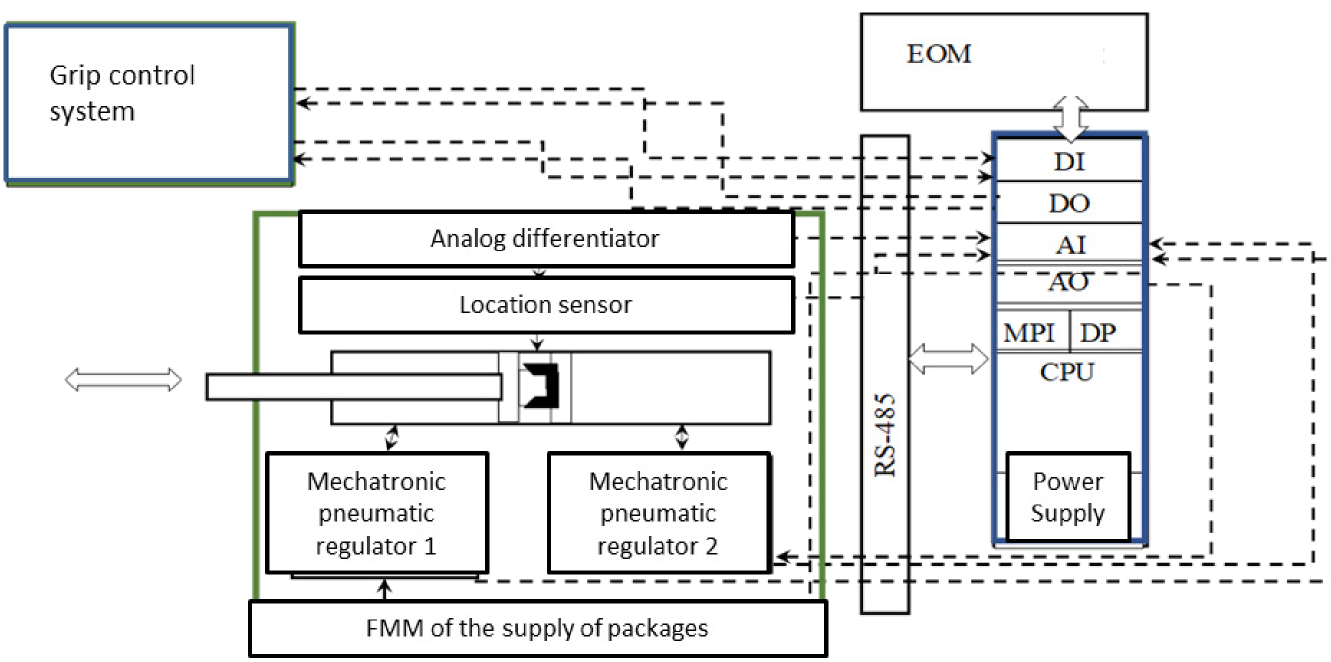


Fig. 4. Structural diagram of the stand for experimental research on the movement and positioning of consumer packaging using a gripper (Addition A,B):

DI – discrete inputs (0-65Hz); DO- discrete outputs; AI - analog inputs (0-10 V, 4-20mA); AO - analog outputs; MPI - information line of data transmission (9.6 Kbt).

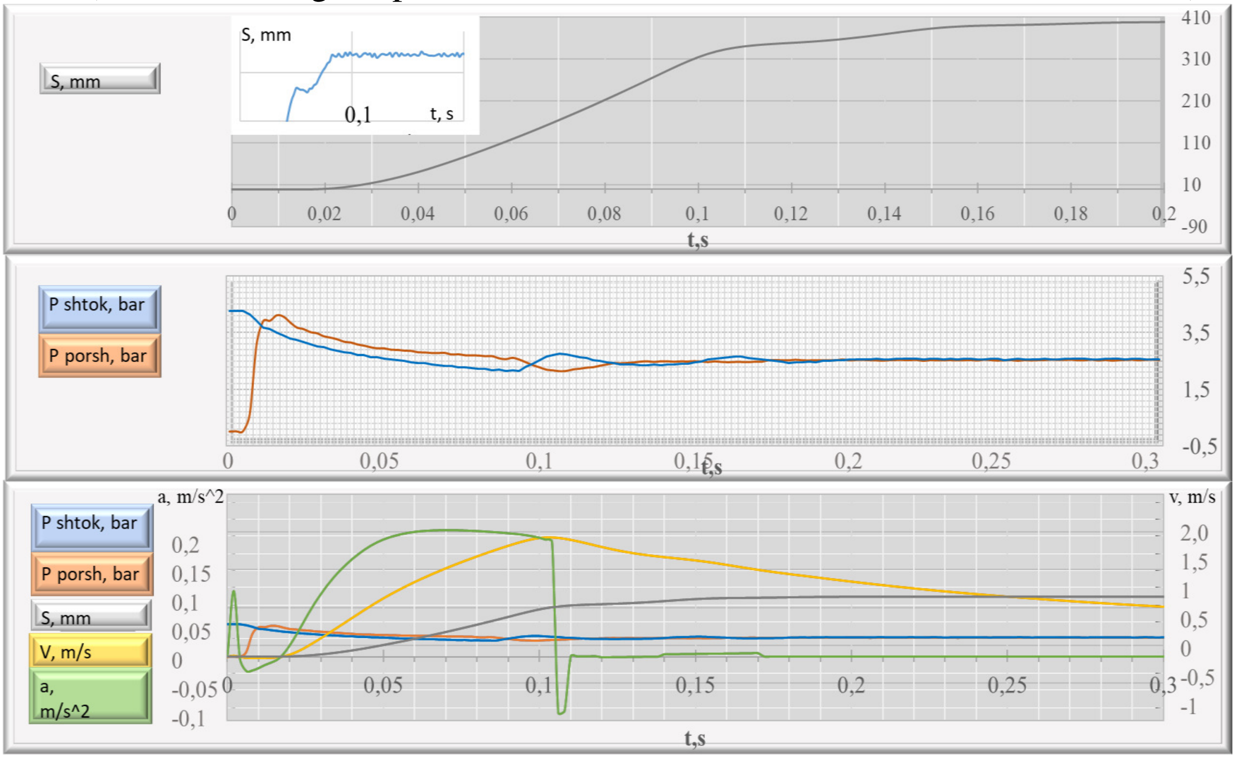


Fig. 5. Generalized kinematic characteristics of the output link of the manipulator during processing of consumer packaging when implementing the law of motion of the piston, which is close to the optimal speed of action: diameter of the pipeline 0.008m, f_1^e=5.027·10^{-5}м^2, x is the coordinate of the movement of the piston 0,2m; pneumatic cylinder piston diameter 0.032m; rod 0.016m; working pressure - 0.5 MPa

As a result of mathematical modeling, data were obtained that allow predicting the interaction of the grip of the manipulator robot with objects of various physical and mechanical characteristics and provide kinematic characteristics of the work process.

V. CONCLUSIONS

The motion for the pivoting link of the experimental manipulator robot - pneumatic gripper is implemented and mathematically described. The authors proposed and developed an experimental stand for the study of pneumatic grippers with various forms of contact soft elements. The conditions of the initial air pressure drop in the control drive system of the manipulator robot are taken into account. A mathematical description of the law of motion of the rod optimal in terms of speed of action for the construction of the pneumatic gripper hydraulic drive was obtained. The manipulator robot control program was developed and tested. In the obtained results, it is clearly observed that when the exhaust section of the working cylinder of the positional pneumatic drive is narrowed, the value of the inertial component at the 4th stage (braking) increases. In addition, taking into account the complexity of the working environment - compressed air, it is necessary to enter additional parameters: coefficients of viscous friction of the working kinematic piston-rod pair, resistance coefficients in the exhaust cross-section during the implementation of the fourth stage of movement. A control system has been developed for an experimental layout with a different set of elements of the output kinematic link. The movement of objects of various geometries by a gripping mechanism with an electro-pneumatic positional pneumatic drive, taking into account the control system, was studied.

The obtained results allow:

- set the working body (pneumatic gripper) to the law of translational motion, close to the optimal speed of action, while not exceeding the maximum allowable dynamic influences for a moving load;
- move the artificial product from the initial position to the final position in the minimum possible time for the pneumatic drive;
- conduct an analysis of the existing designs of executive mechanisms with a pneumatic drive.

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Addition A

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Author: Yemelianov Dmytro, Shevchenko Serhii/ MAIN (OB1)
Block: MAIN
Author:
Created: 05/11/2022 10:24:45 am
Last Modified: 01/29/2023 10:42:17 pm
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LDW>= AIW0, +32000
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ALD
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= M0.0
Network 2
LDN I0.0
CALL SBR_0
CALL SBR_2
Author: Yemelianov Dmytro, Shevchenko Serhii
COMMENTS
SBR_2 SBR2 SUBROUTINE COMMENTS
Network 3
LD I0.0
CALL SBR_1
Author: Yemelianov Dmytro, Shevchenko Serhii
SBR_1 SBR1 SUBROUTINE COMMENTS
Network 4
LD I0.3
LD Q0.3
CTD C30, +3
Network 5
LD C30
= Q0.3
1 / 5
Author: Yemelianov Dmytro, Shevchenko Serhii / SBR_0
(SBR0)
Block: SBR_0
Author:
Created: 05/11/2022 10:24:45 am
Last Modified: 01/29/2023 10:42:17 pm
Symbol Var Type Data Type Comment
IN
IN_OUT
OUT
TEMP
SUBROUTINE COMMENTS
Network 1
LD M0.0
S Q0.0, 1
R Q0.1, 1
Network 2
LDN M0.0
R Q0.0, 1
S Q0.1, 1
2 / 5
Author: Yemelianov Dmytro, Shevchenko Serhii SBR_1
(SBR1)
Block: SBR_1
Author:
Created: 05/11/2022 10:28:26 am
Last Modified: 01/29/2023 10:42:17 pm
Symbol Var Type Data Type Comment
IN
IN_OUT
OUT
TEMPSUBROUTINE COMMENTS
Network 1 Network Title
Network Comment
LDW<= AIW0, +1000
OW>= AIW0, +32000
LD I0.1
EU
OLD
CALL SBR_0
R Q0.2, 1
CALL SBR_1
Symbol Address Comment
SBR_0 SBR0 SUBROUTINE COMMENTS
SBR_1 SBR1 SUBROUTINE COMMENTS
Network 2
LDW>= AIW0, +6000
AW<= AIW0, +6100
LDW>= AIW0, +12000
AW<= AIW0, +12100
OLD
LDW>= AIW0, +18000
AW<= AIW0, +18100
OLD
LDW>= AIW0, +24000
AW<= AIW0, +24100
OLD
EU
R Q0.0, 2
S Q0.2, 1
3 / 5
Author: Yemelianov Dmytro, Shevchenko Serhii / SBR_2
(SBR2)
Block: SBR_2
Author:
Created: 05/11/2022 09:16:04 am
Last Modified: 01/29/2023 10:42:17 pm
Symbol Var Type Data Type Comment
IN
IN_OUT
OUT
TEMP
SUBROUTINE COMMENTS
Network 1
LD M0.0
AW>= AIW0, +10000
AW<= AIW0, +20000
= Q0.2
Network 2 Network Title
Network Comment
4 / 5
Author: Yemelianov Dmytro, Shevchenko Serhii / INT_0 (INT0)
Block: INT_0
Author:
Created: 05/11/2022 10:24:45 am
Last Modified: 01/29/2023 10:42:17 pm
Symbol Var Type Data Type Comment
TEMP
TEMP
TEMP
TEMP
INTERRUPT ROUTINE COMMENTS
Network 1 Network Title
Network Comment
5 / 5
```

Addition B

END) / MAIN (OB1

```
Block:          MAIN
Author:
Created:        12/08/2022 05:13:15 pm
Last Modified:  01/31/2023 11:15:07 am

Symbol          Var Type   Data Type   Comment
                TEMP
                TEMP
                TEMP
                TEMP

PROGRAM COMMENTS
Network 1    Network Title
Network Comment
LD   I0.0
S    Q0.0, 1
TON  T54, 180

Network 2
LD   Q0.0
TON  T37, 10
TON  T38, 30

Network 3
LD   T37
R    Q0.0, 1

Network 4
LD   T38
S    Q0.2, 1
TON  T39, 20

Network 5
LD   T39
R    Q0.2, 1
S    Q1.0, 1

Network 6
LD   Q1.0
TON  T40, 30
TON  T41, 10

Network 7
LD   T40
R    Q1.0, 1

Network 8
LD   T41
S    Q0.4, 1
TON  T42, 20

Network 9
LD   T42
R    Q0.4, 1
TON  T43, 10

Network 10
LD   T43
S    Q1.1, 1
TON  T44, 65

Network 11
LD   Q1.1
TON  T55, 20
TON  T45, 55
TON  T46, 15

Network 12
LD   T55
S    Q0.6, 1

Network 13
LD   T46
S    Q0.5, 1
TON  T47, 15

Network 14
LD   T47
S    Q0.3, 1
TON  T48, 20

Network 15
LD   T48
R    Q0.3, 1
TON  T49, 15
TON  T51, 25

Network 16

Network 16
LD   T49
S    Q1.0, 1

Network 17
LD   T51
R    Q1.0, 1

Network 18
LD   T44
R    Q1.1, 1

Network 21
LD   T45
R    Q0.6, 1
TON  T52, 20

Network 22
LD   T52
S    Q0.7, 1
TON  T53, 10

Network 23
LD   T53
S    Q1.1, 1

Network 24
LD   T54
S    Q0.1, 1
TON  T60, 20

Network 25
LD   T60
R    Q0.1, 1

Block:          SBR_0
Author:
Created:        12/08/2022 05:13:15 pm
Last Modified:  01/31/2023 11:15:07 am

Symbol          Var Type   Data Type   Comment
                IN
                IN_OUT
                OUT
                TEMP

SUBROUTINE COMMENTS
Network 1    Network Title
Network Comment

Block:          INT_0
Author:
Created:        12/08/2022 05:13:15 pm
Last Modified:  01/31/2023 11:15:07 am

Symbol          Var Type   Data Type   Comment
                TEMP
                TEMP
                TEMP
                TEMP

INTERRUPT ROUTINE COMMENTS
Network 1    Network Title
Network Comment
```