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*Odessa National Academy  
of Food Technologies*



International Competition of Student Scientific Works

**BLACK SEA SCIENCE 2020**

Information Technology, Automation and Robotics

Proceedings

Odessa, ONAFT 2020

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**TABLE OF CONTENTS**

|   |     |
|---|-----|
| AUTOMATED EMERGENCY CALL SYSTEM BASED ON SOUND INCIDENT RECOGNITION<br>Authors: <b>Ruslan Kakatsiy, Valerii Stadnichuk, Kristina Tytarenko</b><br>Supervisor: <b>Sergiy Krivenko</b>  | 9   |
| AN APPLICATION FOR DEMONSTRATING AND COMPARING SORTING AND RETRIEVAL ALGORITHMS<br>Author: <b>Oleksandr Sokolskyi</b><br>Supervisor: <b>Oleksandr Melnykov</b>  | 22  |
| INFORMATION SYSTEM FOR WORKING WITH EDUCATION PROGRAMS AND HIGHER EDUCATION STANDARDS<br>Author: <b>Kateryna Didevych</b><br>Supervisor: <b>Oleksandr Melnykov</b>  | 37  |
| AUTOMATION OF PROCESS CONTROL FOR POSITIONING PISTON ACTUATORS<br>Author: <b>Dmytro Makletsky</b><br>Supervisor: <b>Volodymyr Honhalo</b>   | 52  |
| LATCH AUTOMATIC CONTROL SYSTEM FOR MONITORING THE DOSING OF BULK SUBSTANCES<br>Author: <b>Mykhailo Halitovskyi</b><br>Supervisor: <b>Volodymyr Honhalo</b>  | 57  |
| METHOD OF INCREASING THE HIDDEN CHANNEL BAND CAPACITY FOR INFORMATION PROCESSING TECHNOLOGIES AND TRANSMISSION OF VIDEO INFORMATION RESOURCES<br>Author: <b>Viktoriiia Dymchuk</b><br>Supervisor: <b>Volodymyr Barannyk</b> | 62  |
| DYNAMIC SCHEDULING STRATEGY OF INTELLIGENT RGV<br>Author: <b>Kong Weikang</b>   | 73  |
| USING VR AND AR TECHNOLOGIES IN INCLUSIVE EDUCATION FOR CHILDREN WITH DISABILITIES<br>Author: <b>Mukhamedali Kusainov</b><br>Supervisor: <b>Ekaterina Kim</b>   | 89  |
| DEVELOPMENT OF MOBILE APPARATUS AND MEASURING COMPLEX FOR WASTEWATER COMPOSITION CONTROL<br>Author: <b>Ivan Bohatskyi</b><br>Supervisor: <b>Nonna Shapovalova</b>   | 95  |
| ASSESSMENT OF THE FUZZY STATE OF COMPLEX SYSTEMS<br>Author: <b>Artem Yakovenko</b><br>Supervisor: <b>Olexander Goloskokov</b>   | 108 |
| THE DEVELOPMENT OF THE TOOL FOR REAL-TIME NOTIFYING THE PEOPLE ABOUT LEVEL OF AIR POLUTION IN RECREATION ZONES<br>Authors: <b>Aleksandr Marchuk, Yaroslav Davydov</b><br>Supervisors: <b>Iryna Getman, Ihor Staskevych</b>  | 120 |

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## **AUTOMATION OF PROCESS CONTROL FOR POSITIONING PISTON ACTUATORS**

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**Abstract.** *The paper considers a control model for positioning piston actuators, briefly discusses the issues of existing analogues, the advantages of pneumatic and hydraulic drives. The main goal of the work is autonomous accurate positioning of piston mechanisms and the development of a prototype for a practical experiment, as well as for practical work. Advantages of using pneumatic drives:*

- 1. Long service life.*
- 2. Reliability, warranty.*
- 3. High speed start-up, operation, response to operator signals.*
- 4. Simplicity of design for easy maintenance.*
- 5. Production efficiency (low cost of the work environment along with the absence of taps).*
- 6. Fire safety. This makes pneumatic actuators common in the chemical or mining industry.*

**Keywords:** *piston mechanisms, pneumatic drives, hydraulic drives, efficiency.*

## **Introduction**

PR drives include an engine, control system, gears, braking devices, feedback sensors and communications. Communications are needed to transfer energy to the drives and transmit control signals, as well as to provide feedback.

The choice of drive type depends on the functionality of the PR. The main factors determining the choice of drive type are: purpose and operating conditions, load capacity and the required dynamic characteristics of the structure, as well as the type of control system.

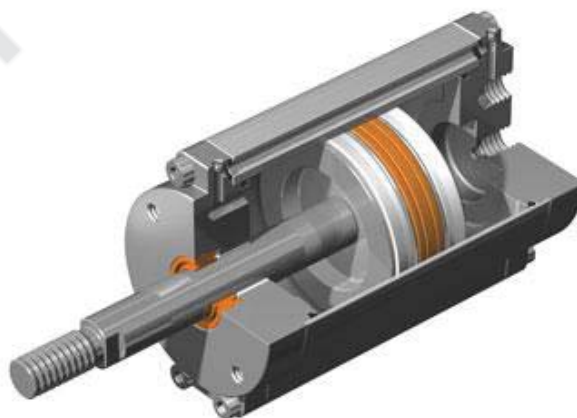
The drive of any kind has the general requirements:

- minimum overall dimensions at high energy performance, providing great importance to the ratio of output power to mass;
- the ability to work in automatic control and regulation, providing optimal laws of acceleration and braking with a minimum of transient processes;
- performance, i.e. implementation of actuator movements with high speeds and low positioning error;
- low mass of drive elements with high efficiency of the entire structure;
- reliability and durability of structural elements;
- ease of installation, repair, maintenance, readjustment and noiseless operation.

Depending on the type of energy used, the drives are divided into hydraulic, pneumatic, electric and combined (for example, electro-hydraulic, hydropneumatic, etc.)

Pneumatic drives are used in 20 ... 30% (according to other estimates in 40-50%) of commercially available PR. They are used for light and medium (with a carrying capacity of up to 20 kg) PR with the number of degrees of mobility 2 ... 3. The positioning error in these drives does not exceed  $\pm 0.1$  mm. The speed of the driven link of the drive with linear movement is up to 1000 mm / s, with an angular - up to 60 rpm. They have a simple design, low cost and quite reliable in operation.

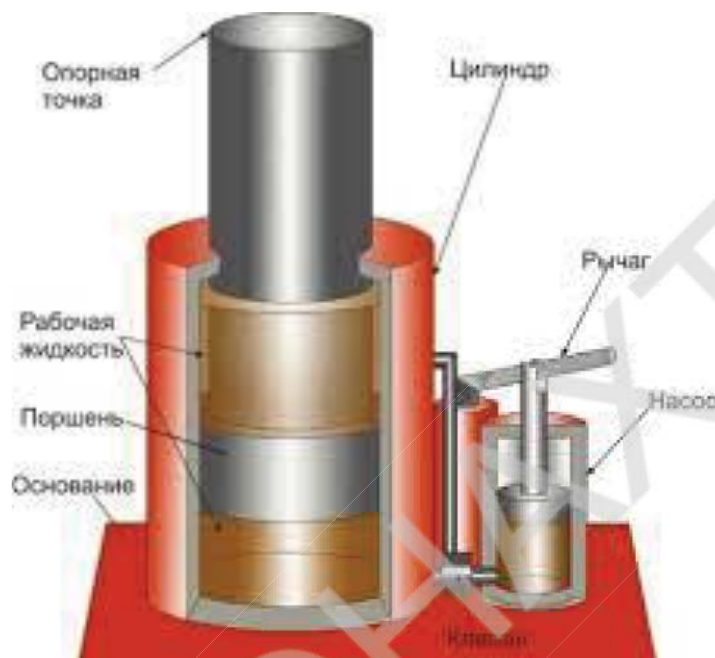
Due to the low adjusting ability, they are not used much in positional and contour modes of operation, and they have cyclic control as the simplest version of positional (two points are set - the beginning and end of the movement).



Hydraulic drives are used in 30% of commercially available medium and heavy PR with the number of degrees of mobility 3 ... 4. The positioning error in these drives does not exceed  $\pm 0.5$  mm with a linear speed of up to 0.8 ... 1200 mm / s. These drives have a complex structure, high cost of manufacture and operation. The hydraulic drive has good adjusting ability, and it is used in PR with positional and contour operation.

Electric drives are used in 40 ... 50% of mass-produced PR with an average load capacity and the number of degrees of mobility 3 ... 6. The positioning accuracy of the electric drive reaches values up to  $\pm 0.05$  mm. They are used both in positional and in contour operation modes.

The advantages of electric drives are higher efficiency, efficiency, ease of assembly and good adjusting properties.



As a rule, synchronous, stepper and DC motors are used in electric drives. Asynchronous motors are used less frequently, which is associated with the complexity of speed control.



### Analytical analysis of the literature

We have considered a large number of publications by various authors exploring this issue.

For positioning piston actuators, the Phoenix axc 1050 controller was selected

### Object, subject and research methods

Pneumatic Actuator Positioning

The positioning of the output link (for example, ultrasound) in the PR with cyclic control is provided at two extreme points and is  $\pm x_{max}$ ;  $\pm \varphi_{max}$  - maximum and minimum piston stroke during linear and angular movement.

In some cases, positioning of the output link at intermediate points is required. In this case, the positioning is carried out using external mechanical stops with damping when approaching each stop (to the point). Calculations and practice show that there can be 6 ... 9 or more such positioning points in pneumatic actuators, due to the high compressibility of the working fluid (air) and the speed of movement.

The number of positioning points can be increased by using the so-called positioners.

The simplest positioning scheme is shown in Fig. 1.

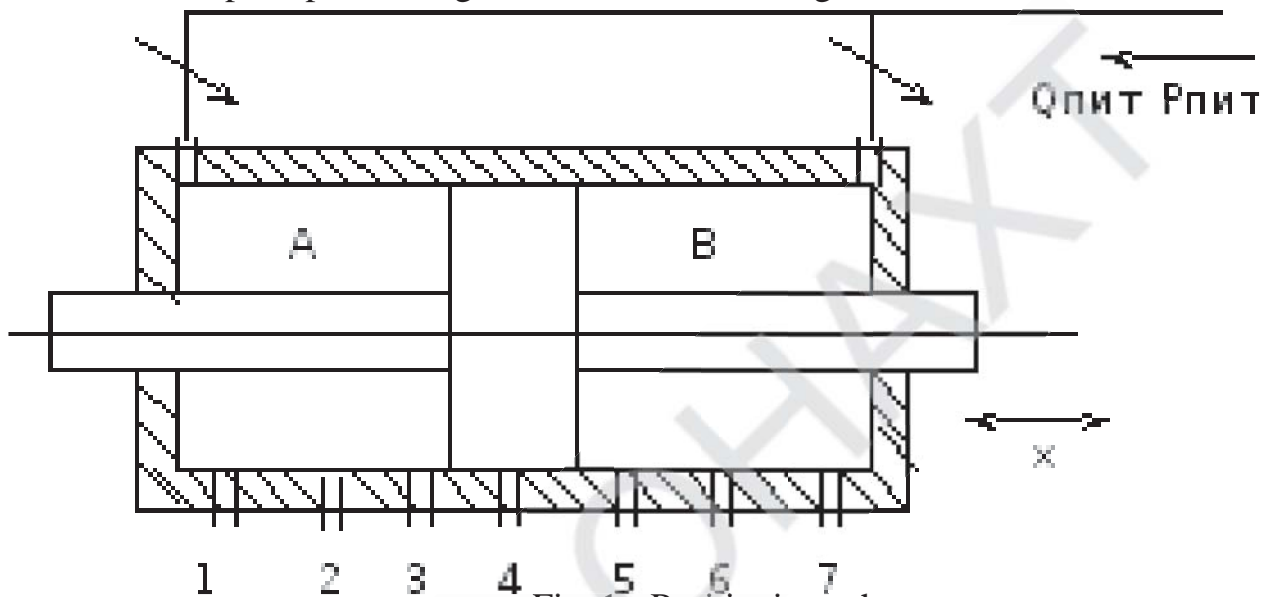


Fig. 1 - Positioning scheme

The air motor is made in the form of a cylinder with a false rod of double-acting. Power is supplied to both cavities simultaneously. With equal pressure in the cavities, the piston is at rest. Highways 1 - 7 serve to release air into the atmosphere. When you open one of the outputs at the command of the control system, the pressure in the corresponding cavity decreases. Under the action of the difference in forces, the piston will move until the outlet is closed and the pressures in cavities A and B are equal. Closing and opening of the outlet can be carried out mechanically or by a pneumatic distributor. The output is mechanically closed by the piston itself.

This method of positioning the output link is used most often.

Another method of positioning is the use of a mechanical brake, which serves to stop the output link. Braking is carried out in two stages, in the first - the speed of the output link decreases by 5–10% of the maximum. Here, using position sensors, braking points are determined at which the further movement of the output link begins to slow down. At the second stage, the output link is stopped at a given point using the brake.

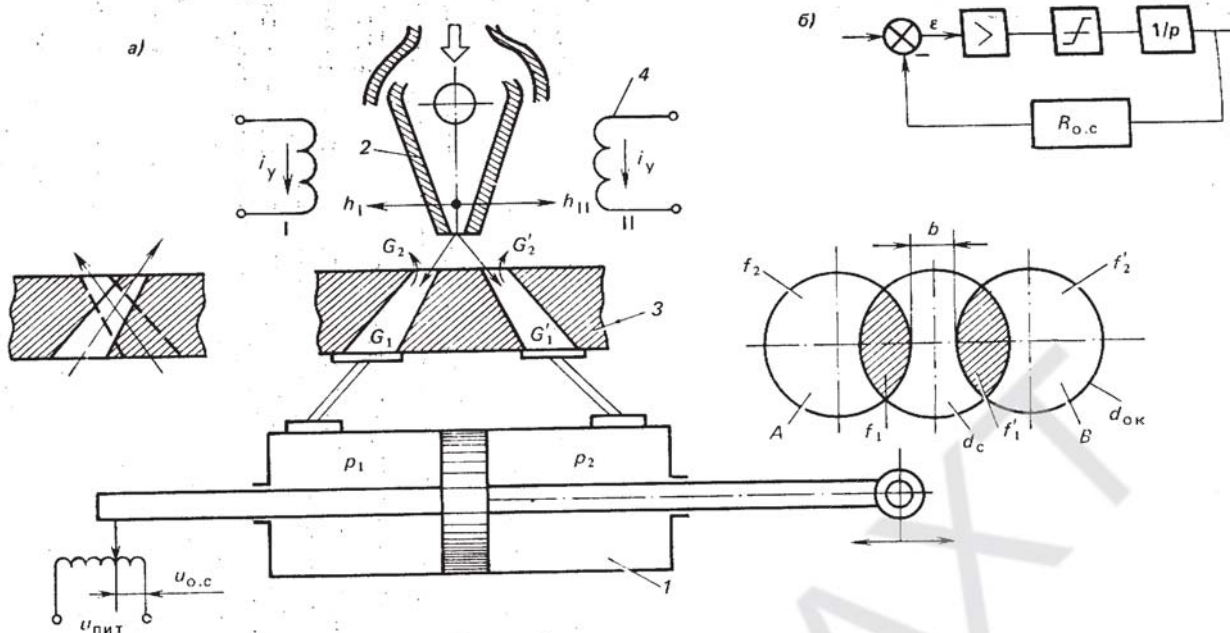
Positional control in PR pneumatic drives is used for a wide range of load capacities from 0.1 to 20 kg. and speeds from 500 to 1000 mm / s.

Pneumatic servo drive

The use of a follow-up pneumatic actuator would make it possible to solve the problem of using the PR contour control. As a result of this, the problem of accurate as well as intermediate positioning of the PR output link would also be solved. However, the

use of a servo drive in PR pneumatic devices is rarely used in practice, which is associated with a number of circumstances, primarily with the properties of the working fluid (air).

A schematic diagram of a pneumatic servo drive is shown in Fig.2



1 - cylinder; 2 - inkjet mechanism; 3 - receiver nozzles; 4 - control winding.

The distributor of compressed air is a jet mechanism 2, when it is deflected to the right and left, a proportional change in the air flow into the left or right cavity of the cylinder 1 through the nozzles of the receiver 3. The armature of the electromagnetic transducer (EPM) is located on the axis of the jet (not shown). When diluting the control currents  $i_y$  in the control windings, a balance occurs of the forces acting on the armature, which, together with the jet, is in the middle position. If there is a difference in the control currents  $i_y$ , the balance of forces is violated, the armature and the jet rotate by an angle  $\alpha$ , which is proportional to the difference of the currents. The cylinder rod position sensor is a feedback potentiometer.

In the figure, fig. 2 is a structural diagram of a drive that performs closed-loop control. The comparison element compares the control signal with the feedback signal and generates an error signal  $\epsilon$ , which is fed to the controller, consisting of the amplifier  $>$  and a nonlinear element with a saturation zone  $f$  and an integrating device  $1/p$ .

$f$  - limits the signal in magnitude,  $1/p$  - increases the accuracy of operation.

Tracking pneumatic drives belong to throttle control systems, as to change the flow rate to the drive due to changes in the performance of the compressor forcing air, unpromisingly because of the compressibility of the air.

The principle of operation of the jet distributor is based on double energy conversion. First, in the jet tube, the potential energy of compressed air is converted into the kinetic energy of the air stream, then, in the nozzles of the receiver, the kinetic energy of the stream is converted into potential energy of the compressed air entering the working cavities of the cylinder. The pressure loss in this case is up to 10%.

To implement the layout for reproducing the experimental stand, the Phoenix axc



1050 controller was used

### **Conclusions**

The paper considers the task of automating the control of the positioning process of piston actuators that implements the task of moving an object to the required position. Study of system performance compared to other drives.

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## **LATCH AUTOMATIC CONTROL SYSTEM FOR MONITORING THE DOSING OF BULK SUBSTANCES**

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**Abstract.** *The paper considers a theoretical mechanical model of a tank for dosing bulk solids using valves on pneumatic cylinders and a PLC (programmable logic controller) that controls pneumatic-electric valves, briefly discusses the issues of existing analogues, the advantages of pneumatic-electric valves over pneumatic. The main goal of the work is the automatic control of valves using PLCs to ensure a given dosage rate. Using a PLC simplifies the control of valves due to pre-recorded scenarios for a given amount of dosed substance, as a result of which the chance of pouring it into the carriage is reduced.*

**Keywords:** *PLC (programmable logic controller), pneumatic cylinder, gate valve, pneumatic distributor, shipment carriage.*