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DESIGN AND TESTING OF HYDRAULIC AND PNEUMATIC CONTROL SYSTEMS

Methodological instructions for laboratory work

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Methodical instructions for performing laboratory and practical work on the subjects “Modern elements of hydropneumatic systems”, “Fundamentals of the theory of pneumatic drives”, “Pneumatic and vacuum equipment of hydropneumatic systems” for full-time and part-time students of the specialty “Applied mechanics” / compiled by: Krutikov G. A., Stryzhak M. G., Nikonov P. Ya. – Kharkiv: NTU “KhPI”. – 2024. – 69 p.

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INTRODUCTION

In the modern technical world, pneumatic control systems play an important role in ensuring effective and precise control of various mechanisms and equipment. They are widely used in industry, automotive engineering, aviation and many other areas.

These methodological guidelines are intended for students of the specialty 131 - Applied Mechanics. They contain a methodology for the stages of design, verification of operability through computer modeling, testing on a laboratory bench and optimization of pneumatic systems in order to ensure their reliability and efficiency.

These guidelines contain not only theoretical aspects of design, but also practical advice on the selection of components, setting appropriate parameters and performing tests. This contributes to the deepening of knowledge in the field of pneumatics and control systems, as well as the acquisition of practical skills necessary for the successful mastering of the specialty.

LABORATORY WORK № 1
IMPLEMENTATION OF ELEMENTARY FUNCTIONS USING STANDARD PNEUMATIC EQUIPMENT

The purpose of work - acquisition of practical skills in creation of pneumatic schemes; acquaintance with the general principles of drawing up and modeling of work of schemes of pneumatic actuators with manual and electric control with use of the program **FluidSim**.

1.1 Memory items

The requirement for the function of memory elements is to record the current operating state of the distributor by applying a short-term (pulse) pneumatic signal. This state must be maintained until another pulse signal cancels it.

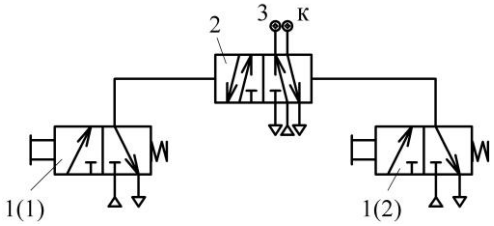

Fig. 1.1. Switching from red to green and memorizing this state by briefly switching on the distributor 1(1), as well as a similar procedure using the distributor 1(2)

The red indicator remembers that the last effect was a pulse from the distributor 1(2), and the green indicator remembers that the last effect was a pulse from the distributor 1(1).

1.1.1 General description of the FluidSim program and principles of drawing up schemes

The FluidSim program was developed by *Festo Didactic* and is designed to design pneumatic actuators with manual, electric and electronic control. It allows you to explore the operation of complex circuits in different modes using animation.

The interface of the FluidSim program (Fig. 1.2) is simple and intuitive to the user, typical for Windows applications.

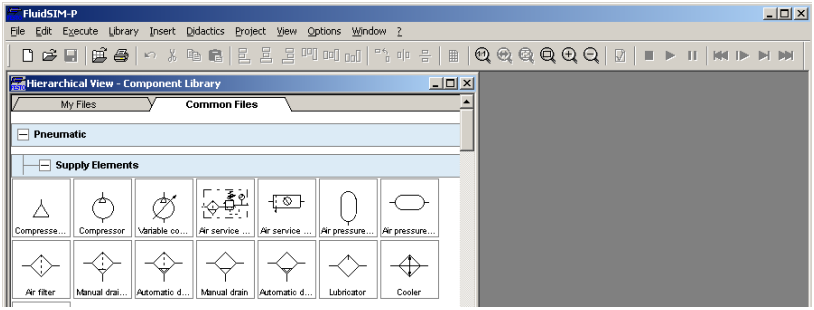

Fig. 1.2. Main menu FluidSim

The work begins with selecting the main menu item of the program File-New. There are two windows on the screen – a library of components (Component Library) and the project window (Fig. 1.2). In order to place one or another element of the library in the project window, it is enough to select it with the left mouse button and, holding it, drag it into the project window.

As the first project we will make the scheme for demonstration of action of elements of memory shown in Fig. 1.1.

The construction of this scheme is carried out in the following sequence:

1. Find the section "Configurable directional valves" in the component library in the "Valves" block and select the appropriate two-position three-line distributor: "3/n way valve" (distributors 1(1) and 1(2) in Fig. 1.1) and move it to white field of the created file. To clarify the design of the distributor and the type of control by double-clicking the left mouse button, go to the window of its properties. In the window that opens, using the same type of menus, located on the left and right, set the control type. On the left – the mechanical button from the section "Manually" ("manual control") (Fig. 1.3), on the right – we put a mark in a square opposite to the inscription "Spring returned" ("spring return to original state"). In the central part of the window we define the positions of the distributor and the

initial position ("Initial position"). At the same time, a button appears on the left of the distributor, and a spring appears on the right (Fig. 1.3). The process of selecting parameters is completed by clicking "OK".

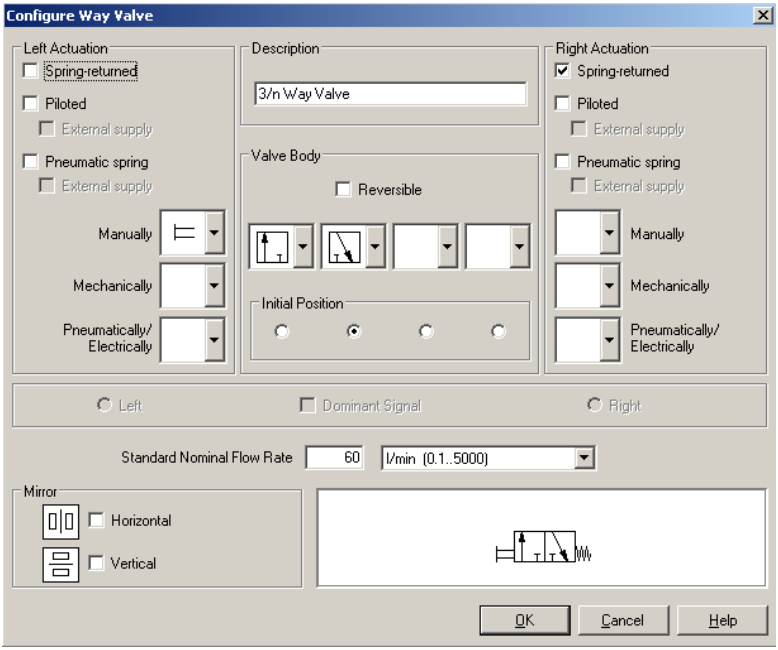

Fig. 1.3. Window for determining the properties of a three-line two-position distributor

2. Since according to Fig. 1.1 2 distributors are required, it is necessary to copy already created. To do this, select the distributor in the rental window, on the "Edit" tab, select the "Copy" command, then on the same "Edit" tab, select the "Paste" command.

3. To add a five-line two-position distributor 2 (Fig. 1.1) to the circuit, select the "3/n way valve" element in the component library in the "Valves" section of the "pneumatically operated" section and drag it to the field of the project window. This distributor (in accordance with Fig. 1.1) must have pneumatic control on both sides. Therefore, in the distributor properties window, uncheck the "returned spring" button in the right part of the

distributor properties panel and select the pneumatic control type ("Pneumatically") (Fig. 1.4).

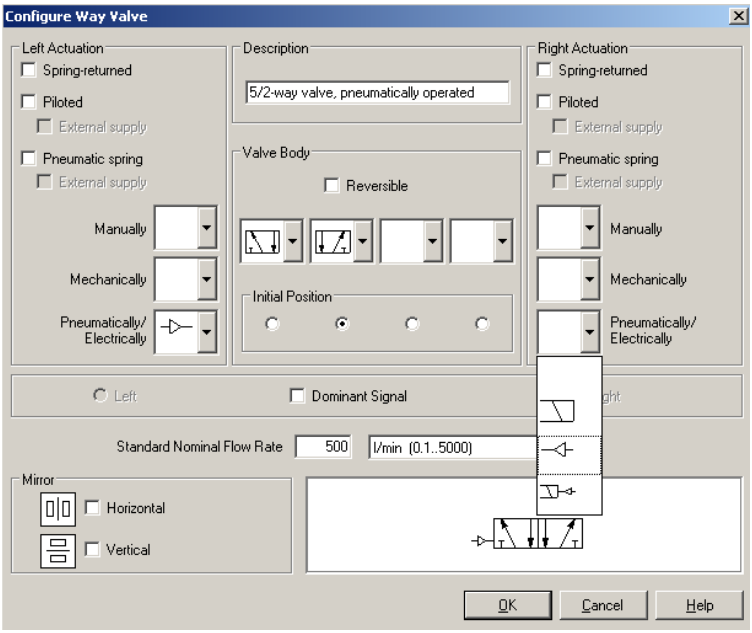

Fig. 1.4. Window for defining the properties of a five-line two-position distributor

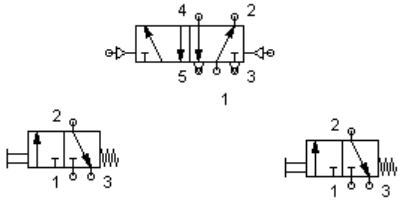

Fig. 1.5. Project window

The result (view of the project window after the actions performed in paragraphs 1-3) is shown in Fig. 1.5.

4. We pass to a stage of a choice of indicators of a signal. In the section "Measuring instruments and sensors" select the light bulb ("Pressure indicator") and move it to the project field. In accordance with the scheme in Fig. 1.1 2 light bulbs are required. We place them next to each other.

5. Combine the elements of the circuit with pneumolines: move the cursor to the 2 output of the distributor 1(1) (numbering here and below in

Fig. 1.1) and click the left mouse button. The cursor turns from an arrow to a target and a green dot lights up inside. While holding down the mouse button, move the cursor to the left control line of the distributor 2 – a green dot appears inside the target. This means that the lines have come into contact. Release the left mouse button – the dot turns red (Fig. 1.6) and a line of communication appears. Similarly, connect 2 the output of the distributor 1(2) with the right control line of the distributor 2 and connect the indicators to 4 and 2 outputs of the distributor 2.

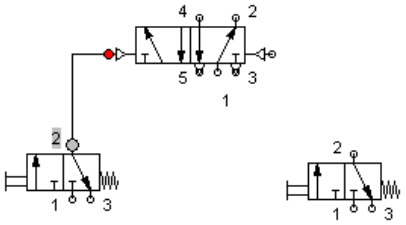

Fig. 1.6. Construction on the scheme of pneumolines

6. Next, you need to supply power to the distributor 1(1), 1(2) and 2. To do this, on the tab "Supply Elements" select the element "Compressed air supply" (Fig. 1.7) and combine with the corresponding muted outputs of distributors 1(1) and 1(2) according to Fig. 1.1. The result is shown in Fig. 1.8.

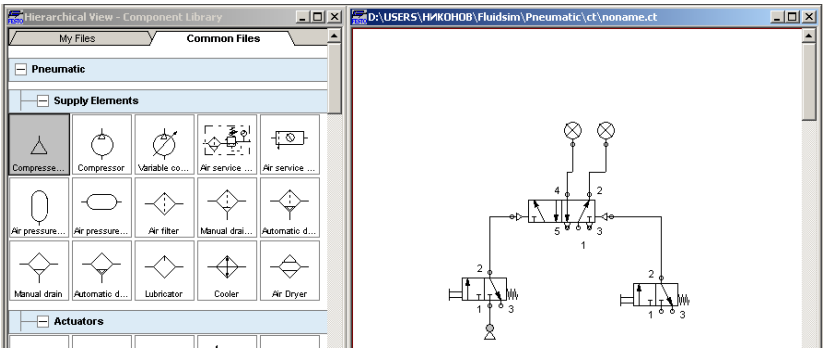

Fig. 1.7. Power supply selection

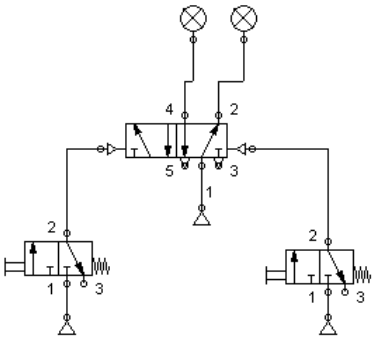

Fig. 1.8. FluidSim model of the circuit with memory elements is assembled

7. We check the efficiency of the scheme in Fig. 1.8: press the Start key (or F9), in the dialog box confirm your action (OK). The scheme turns into an animation (Fig. 1.9). The cursor turns into a "hand".

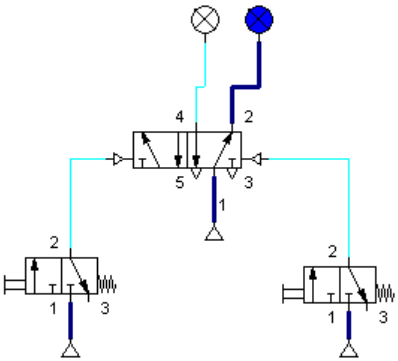

Fig. 1.9. Animated FluidSim model of a circuit with memory elements

The lines that are currently under pressure are highlighted in blue. From fig. 1.9 shows that the right indicator light is currently lit. Bring the cursor- "hand" to the left button (it should turn into a "finger") and press the button. At the same time there is a switch: the spool mixes to the right. The control signal is fed to the distributor 2, which is shifted to the right, connecting the power line with the left indicator lamp (Fig. 1.10). After releasing the control button of the distributor 1 (1), the spring returns it to

its original state. The control signal becomes zero, but the left indicator light continues to illuminate.

If you press the control button on the distributor 1(2) – the power will go to the right control line of the distributor 2. The right indicator light will light up.

After removing the control signal, releasing the distributor button 1(2), the spring returns it to its original state, the control signal becomes zero, but the right indicator light continues to light – this is a demonstration of the memory elements.

To end the demonstration, press the "Stop" (Edit Mode) or F5 button on the control panel.

1.1.2 Implementation of a pneumatic circuit with memory elements on "Festo" elements

After we have made sure that the pneumatic circuit is working by means of modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 1.10.

Fig. 1.10. Pneumatic diagram with memory elements implemented on "Festo" elements

1.2 Implementation of time functions

The time holding function in a tire is based on the fact that to achieve a certain level of pressure in a fixed volume when it receives compressed air through the throttle takes a certain time, depending on the resistance of the throttle and the volume.

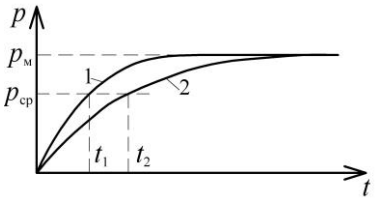

Fig. 1.11. The dependence of the pressure of compressed air entering the closed cavity through the throttle from time to time

The characteristic "pressure-time" for the tank, which is filled through the throttle (Fig. 1.11), shows that the time to reach pressure p_{cep}, required for the operation of the distributor, will be increased by increasing the resistance of the choke or the volume of the tank (curve 2), scilicet $t_2 > t_1$.

Four different time functions are used in pneumatic circuits:

1. In the relay of delay of switching on of a pneumatic signal ON.
2. In the relay of delay of switching on of a pneumatic signal of OFF.
3. Pulse to turn on the pneumatic signal ON.
4. Pulse to turn off the pneumatic signal OFF.

1.2.1 Power-on delay

In fig. 1.12 shows a diagram of the implementation of the delay of the power signal.

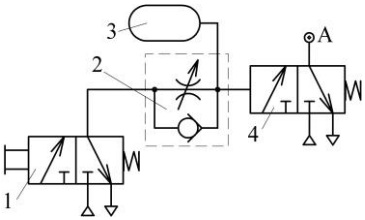

Fig. 1.12. On signal delay scheme

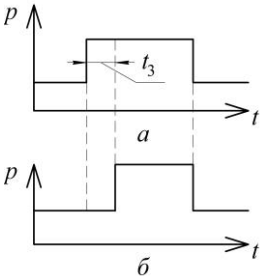

Fig. 1.13. Time functions:
a - switching on-off of the distributor 1;
b - switching on-off of the distributor 4

Signal A at the output of the distributor 4 appears with a delay in time. The value depends on the volume of the tank 3 and the setting of the choke 2 (Fig. 1.13). Switching off signal A is synchronized with switching off signal of distributor 1.

1.2.1.1 Check of operability of the pneumatic scheme of a delay of a switch-on signal in the FluidSim program

The work begins with the creation of a new file (File - New command). Next, from the library of components (block "Valves", section "Valve Groups") you need to select and drag to the working field of the file in accordance with Fig. 1.12 element "Time delay valv, normally closed" (instead of elements 2, 3 and 4); in the section "Configurable directional valves" it is necessary to select and drag in a working field of a file according to fig. 1.12 distributor "3/n way valve" (1 in Fig. 1.12); you also need to add indicator light A ("Pressure indicator" element from the "Measuring instruments and Sensors" section) and the battery ("Supply Elements" section "Compressed air supply" element). Then all the elements must be connected with pneumolines. An approximate view of the assembled scheme is shown in Fig. 1.14.

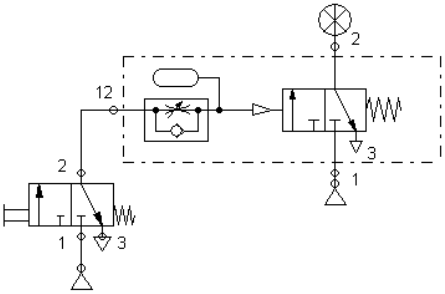

Рис. 1.14. FluidSim-model of the circuit with a delay of the switch-on signal

To check the operation of the circuit, it is necessary to switch it to the animation mode ("Start" button (or F9). It should take some time for the indicator light to fill the tank 3 with compressed air before the indicator light comes on. During the process of filling the tank,

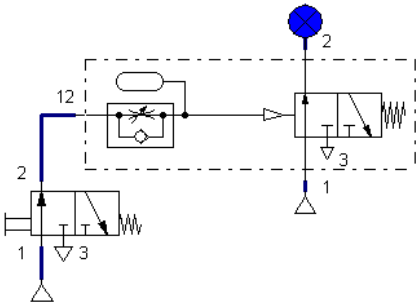

Fig. 1.15. Animated FluidSim-model of the circuit with a delay of the switch-on signal

it is necessary to hold down the control button of the distributor 1 until the indicator light comes on. The result is shown in Fig. 1.15.

1.2.1.2 Implementation of a pneumatic circuit with a delay of the switch-on signal on the "Festo" elements

After we have made sure that the pneumatic circuit is working by means of modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 1.16.

Fig. 1.16. Pneumatic circuit with a delay of the switch-on signal implemented on "Festo" elements

The element "Pressure switch" (Fig. 1.17) is compact and combines individual elements, such as: throttle with non-return valve 2, tank 3 and distributor 4 (numbering in Fig. 1.12).

Fig. 1.17. Pneumatic element "Festo" - "Time relay"

In fig. 1.18 shows the delay of the start signal: pressure gauges serve as signal indicators. It can be seen that there is a signal on the upper manometer (the starting signal is approximately 0.2 MPa), and on the lower manometer, which shows the time delay of the signal on the element "Time Relay", the signal is absent. The control button 1 of the distributor 1 is constantly pressed (Fig. 1.18).

Fig. 1.18. Part of the circuit for implementing the process of delaying the power-on signal on the elements of "Festo"

1.2.2 Shutdown delay

Returning the valve to its original state with the shutdown time is carried out exactly as in the previous case, with the only difference that

instead of limiting the flow of compressed air on the way to the control cavity of the distributor 4 is limited flow at the exit of this cavity (Fig. 1.19).

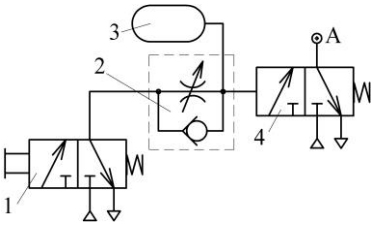

Fig. 1.19. Switch-off signal delay scheme

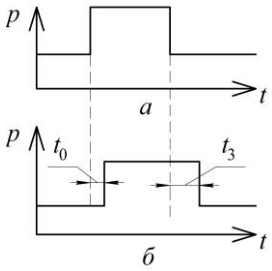

Fig. 1.20. Time functions: a – switching on-off of distributor 1; b – switching on-off of the distributor 4

After operation of the valve 1, the indicator A lights up after a short period of time, because the control signal from the distributor 1 passes smoothly to the control cavity of the distributor 4 while filling the tank 3. After turning off the distributor 1 due to compressed air distributor 4 will occur with a delay (Fig. 1.20), which depends on the setting of the throttle 2.

1.2.2.1 Check of operability of the pneumatic scheme of a delay of a signal of shutdown in the FluidSim program

The work begins with the creation of a new file (command File - New). Next, from the library of components (block "Valves", section "Configurable directional valves") must be selected and dragged to the working field of the file in accordance with Fig. 1.19: two distributors "3/n way valve" (1 and 4 according to Fig. 1.19); adjustable throttle with non-return valve 2 (element "One-way flow control valve" from the section "Shutoff valves and Flow Control Vailves"); capacity 3 (element "Air pressure reservoir" from the section "Supply Elements"); indicator light A (element "Pressure indicator" from the section "Measuring instruments and Sensors") and 2 batteries "Compressed air supply". Then all the elements must be connected with pneumolines (Fig. 1.21).

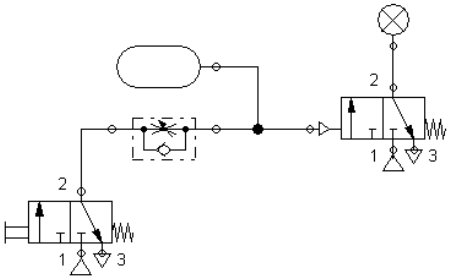

Fig. 1.21. "FluidSim" is a circuit model with a delay signal

To check the operation of the circuit, it is necessary to switch it to the animation mode ("Start" button (or F9). When you press the control button of the distributor 1, air enters through the throttle with a check valve and the tank as a control signal to the distributor 2. At this time, the tank 3 is filled, which causes a slight delay of the control signal to the distributor 4 (Fig. 1.20). The light is off at this time. When the control signal reaches a pressure sufficient to overcome the resistance of the spring of the distributor 4, there is a switch to position 2. The indicator light comes on.

When the distributor button 1 is released (control signal is removed), compressed air flows out of the tank through the throttle and the distributor 1 into the atmosphere. The light bulb continues to burn. When the pressure in the control line of the distributor 4 of the level below the value of the spring adjustment, the distributor 4 is switched to the initial position. The light goes out (the delay time delay can be seen in Fig. 1.20). The simulation result is shown in Fig. 1.22.

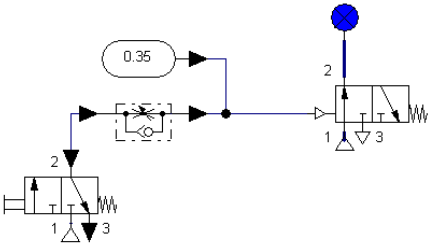

Fig. 1.22. Animated FluidSim-model of the circuit with a delay signal

1.2.3 Pulse on signal

The signal from the distributor 1 comes through the normally open distributor 4 without hindrance and lights the indicator A. But the same signal enters the control cavity of the distributor 4 through the throttle system 2, 3. At the end of a certain time this signal switches the distributor 4 and indicator A turns off (Fig. 1.23).

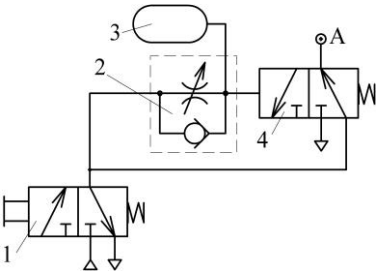

Fig. 1.23. Pulse on signal

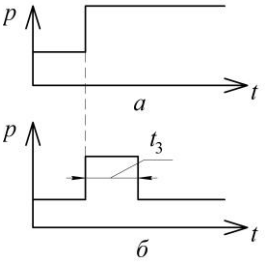

Fig. 1.24. Time functions: a – the signal of the distributor 1; b – the signal of the distributor 4

As a result, a pulse appears at the output of the distributor 4. The time delay determines the pulse duration.

1.2.3.1 Check of operability of the pneumatic scheme with an impulse on inclusion in the FluidSim program

Create a new file (command File – New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 1.23: two distributors "3/n way valve" (block "Valves", section "Configurable directional valves"); adjustable throttle with non-return valve (element "One-way flow control valve" from the section "Shutoff valves and Flow Control Vailves"); capacity (element "Air pressure reservoir" from the section "Supply Elements"); indicator light A (element "Pressure indicator" from the section "Measuring instruments and Sensors") and battery "Compressed air supply". Then all the elements must be connected with pneumolines (Fig. 1.25).

To test the circuit, it must be switched to animation mode ("Start" button (or F9). When you press the control button of the distributor 1, air

simultaneously flows through the distributor 4 to the indicator light and through the throttle with a non-return valve and the tank as a control signal to the distributor 4 (Fig. 1.25).

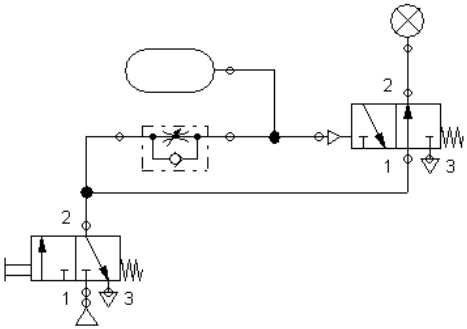

Рис. 1.25. "FluidSim" - a model of the circuit with a pulse signal to turn on

When the spool control pressure 4 reaches a value sufficient to switch the distributor 4 to position 2, the indicator light is turned off (while the signal from the distributor 1 continues to enter the system). When the distributor button 1 is switched off (the control signal is removed), the distributor 1 returns to its original position. At the same time there is a discharge of capacity 3 to atmospheric pressure.

1.2.4 Pulse on the disappearing signal

If you want the pressure pulse to appear after the output signal is removed, the pressure generated by this pulse must be supplied from another source. This method is to ensure the simultaneous switching on of a normally open 3/2 manifold 4 (Fig. 1.26) and the supply of compressed air to the tank 3, using the output control signal. As soon as the action on the distributor 1 stops, the distributor 4 under the action of the spring moves to its normal position. In this case, the supply valve of the distributor 4 is combined with the tank 3. The pressure in the tank will decrease after a certain time (Fig. 1.27). The value is regulated by setting the throttle 2.

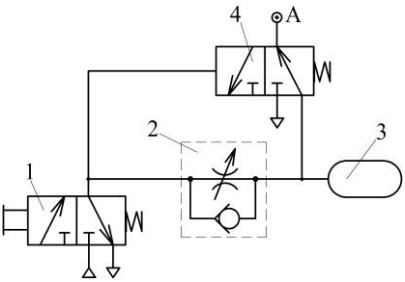

Fig. 1.26. Pulse on the disappearance of the signal

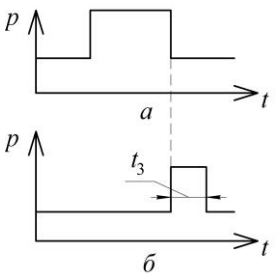

Fig. 1.27. Time functions: a – the signal of the distributor 1; b – the signal of the distributor 4

1.2.4.1 Check of operability of the pneumatic scheme with a pulse on on disappearance of a signal in the FluidSim program

Create a new file (command File – New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 1.26: two "3/n way valve" distributors; adjustable throttle with non-return valve "One-way flow control valve"; "Air pressure reservoir" capacity; "Pressure indicator" indicator light and "Compressed air supply" battery. Then all the elements must be connected with pneumolines (Fig. 1.28).

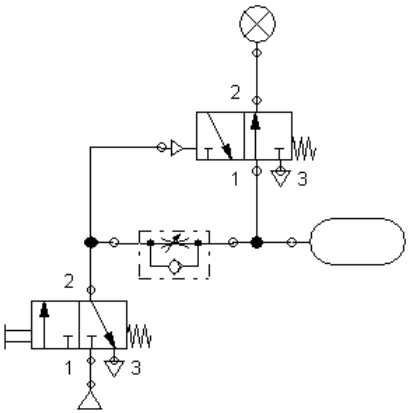

Fig. 1.28. "FluidSim"–circuit model with a pulse signal on activate

To check the operation of the circuit, it is necessary to switch it to the animation mode ("Start" button (or F9). When you press the control button of the distributor 1, the distributor 4 is switched to position 2 and the tank 3 is filled through the throttle with a non-return valve. The indicator light does not light up. When the control signal is removed from the distributor 1 (release of the control button), the distributor 4 returns to its original position.

There is a discharge of the tank 3 through the check valve of the throttle and the distributor 1. There is a pulse signal to the indicator light.

1.3 Operation "OR" (disjunction)

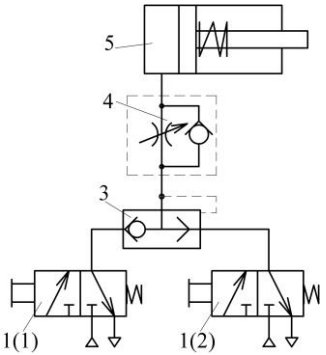

Fig. 1.29. Implementation of the "OR" function

The pneumatic cylinder can be controlled from two sources (fig. 1.29). To implement this function, use the valve "OR" (shuttle valve) (3). The signal to extend the piston can be obtained from the distributor 1 (1) and from the distributor 1 (2) (or both at the same time).

1.3.1 Checking the performance of the pneumatic circuit for the implementation of the function "OR" in the program "FluidSim"

Create a new file (command File - New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 1.29: two distributors "3 / n way valve"; adjustable throttle with non-return valve "One-way flow control valve"; element "OR" "Shuttle valve"; single acting pneumatic cylinder (from the "Actuators" section) and 2 "Compressed air supply" batteries. To bring the file of the pneumatic cylinder added to the field to the form shown in fig. 1.29 double-

click to open the cylinder properties window and uncheck the "Sensing" box in the "Properties" section.

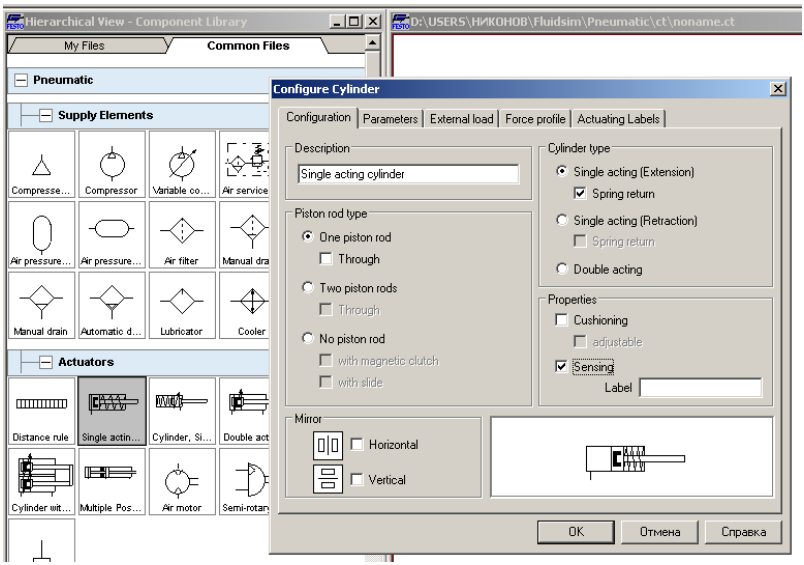

Fig. 1.30. "Single acting cylinder" properties window in FluidSim

Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 1.31).

To check the operability of the circuit, it is necessary to switch it to animation mode ("Start" button (or F9). The "OR" element is triggered when a signal is applied from the distributor 1(1) **or** 1(2) (Fig. 1.31). When the control signal is applied, the shut-off element overlaps either the left or right line of the control signal supplied to the "OR" element.

For example, when you press the control button of the distributor 1(2) (Fig. 1.31), compressed air enters the right control line of the element "OR". In this case, the shut-off device covers the left control channel of the element "OR" and the air through the throttle with a non-return valve enters the single-acting cylinder 5. Adjusting the throttle allows you to adjust the speed of the cylinder rod.

When you release the control button, the distributor 1(2) returns to its original position and the air from the piston cavity of the cylinder 5 through

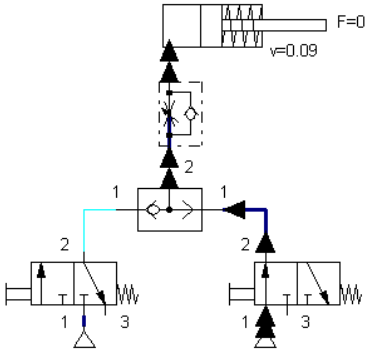

Fig. 1.31. Animation "FluidSim" - the model of the scheme for implementation of the "OR" function

the check valve, the element "OR" and the distributor 1(2) flows into the atmosphere. When the control button 1(1) is pressed, the shut-off element of the "OR" valve moves to the right and closes the right control channel. The process is similar.

1.3.2 Implementation of a pneumatic scheme for the implementation of the function "OR" on the elements of "Festo"

After we have made sure that the pneumatic circuit is working by means of modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 1.32.

Fig. 1.32. Pneumatic scheme for the implementation of the function "OR", implemented on the elements of "Festo"

1.4 Logical multiplication operation "AND" (conjunction)

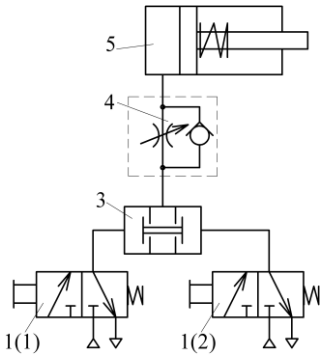

Fig. 1.33. Pneumatic scheme of realization the function "And"

In some cases, the implementation of a particular operation requires the fulfillment of two conditions simultaneously. When signals are received from two distributors 1(1) and 1(2), each of which has its own purpose (Fig. 1.33), the cylinder rod is extended.

Such control is widespread in the forging and pressing industry to ensure technical safety.

1.4.1 Checking the performance of the pneumatic circuit for the implementation of the function "AND" in the program "FluidSim"

Create a new file (command File – New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 1.33: two distributors "3/n way valve" (1(1) and 1(2) according to the scheme in Fig. 1.33); adjustable throttle with non-return valve "One-way flow control valve" (item 4); element "And" "Two pressure valve" (position 3); single acting pneumatic cylinder (item 5) and 2 batteries "Compressed air supply". Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 1.34). To demonstrate the principle of operation of the element "And" it is necessary to choose for one of the distributors a mechanical control button with a latch (Fig. 1.34).

To check the efficiency of the circuit, switch it to animation mode ("Start" button (or F9). Element "And" works at simultaneous giving of control signals from the distributor 1(1) **and** 1(2) (fig. 1.34). In this case, the spool of the element "And" is in equilibrium, which allows air to flow freely into the discharge line.

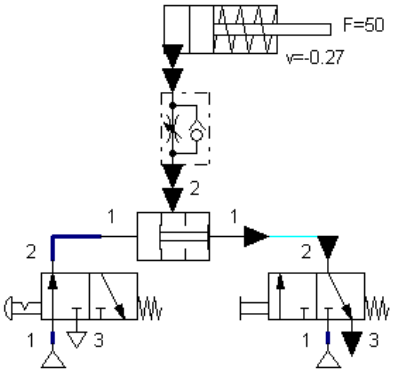

Fig. 1.34. Animation "FluidSim" - the model of the scheme for implementation of function "And"

When the control signal is applied only from the distributor 1(1) or 1(2), the shut-off element moves to the right (left) and blocks the discharge channel, preventing the passage of air.

1.4.2 Implementation of the pneumatic scheme for the implementation of the function "And" on the elements of "Festo"

After we have made sure that the pneumatic circuit is working by means of modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 1.35.

Fig. 1.35. Pneumatic scheme for the implementation of the function "And", implemented on the elements of "Festo"

1.5 The order of priority the laboratory work

1. After acquaintance with methodical instructions and studying of purpose and the principle of action of the used pneumatic devices the student independently collects the scheme in the FluidSim program for the purpose of check of its working capacity.

2. The student independently collects the scheme on the educational stand "Festo" and checks correctness of its work.

3. In the schemes where regulation by experiment is required the maximum possible range of settings is defined.

4. The report on the performance of laboratory work should contain: the purpose of the work, brief theoretical information on the work performed, the statement of the problem, information on the used element base "Festo" and conclusions. Works 1.1 and 1.2 must contain a signal delay graph constructed in coordinates $p(t)$.

LABORATORY WORK № 2
THE PNEUMATIC SCHEMES FOR REVERSE CONTROL OF AIR MOTORS

The purpose of work – acquaintance with ways of reversing of pneumatic motors and acquisition of practical skills in installation of pneumatic schemes of reverse

2.1 Using three-line two-position distributors

Distributors 3/2 are used primarily to control the reverse of single-acting cylinders (Fig. 2.1).

During the working stroke of the piston by means of the 3/2 distributor supply of compressed air in a rodless cavity is provided.

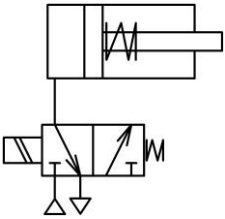

Fig. 2.1. Reverse of the one-sided pneumatic cylinder

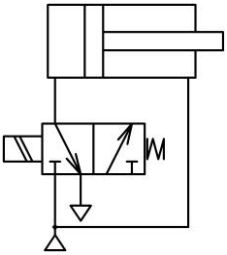

Fig. 2.2. Reverse of the bilateral pneumatic cylinder by means of the 3/2 distributor

Switching by means of the 3/2 distributor of a rodless cavity with the atmosphere provides return of the piston to initial position by force of a spring. The 3/2 distributor can also be used to control a double-acting pneumatic cylinder (Fig. 2.2). The rod cavity of the cylinder is constantly connected to the power supply. When combining the rodless cavity with the atmosphere through the 3/2 distributor, the piston is retracted. When supplying compressed air into the rodless chamber, the piston is extended, developing a force equal to the product of the pressure on the difference between the areas of the piston from the rodless and rod chambers.

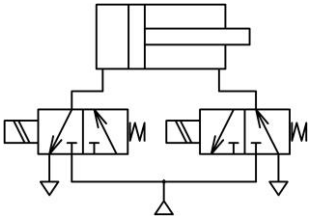

Fig. 2.3. Reverse of the bilateral pneumatic cylinder by two 3/2 distributors

This scheme of control of the reverse of the double-acting cylinder, which reduces energy loss, is called *"differential control scheme"*.

The reverse of the bilateral pneumatic cylinder can be provided by two 3/2 distributors (fig. 2.3). This scheme significantly expands the control of the operating mode, combining at any time one of the working cavities or both cavities simultaneously with the power line or the atmosphere. This allows in some cases to reduce energy consumption, change the force that develops the piston and speed.

2.1.1 Check of operability of the pneumatic scheme for reversal of the unilateral pneumatic cylinder in the "FluidSim" program

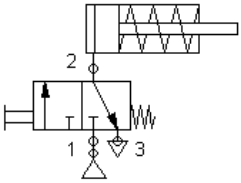

Fig. 2.4. "FluidSim"– model of the scheme of reverse of the one-sided pneumatic cylinder

Create a new file (command File - New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 2.1: distributor "3/n way valve"; single acting pneumatic cylinder and single compressed air supply. Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 2.4).

To check the efficiency of the circuit, switch it to animation mode (Fig. 2.5). In the initial position, the distributor is in position 1, the rod of the single-rod cylinder of unilateral action is retracted and held in this position due to the spring support. When the control signal is applied, the distributor switches to position 2, while the supply from the discharge line is fed through the distributor into the piston chamber of the cylinder and causes the rod to move to the right, overcoming the force of the spring. The rod is in the extended position until the control signal of the distributor is released (button released).

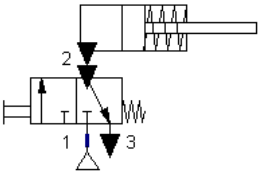

Fig. 2.5. Animation "FluidSim" - model of the scheme of reverse of the unilateral pneumatic cylinder

When the control signal is removed, the distributor returns to 1 position, due to the spring support, the cylinder rod returns to its original position, and air from the piston chamber flows into the atmosphere.

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2.1.1.1 Implementation of the pneumatic scheme of reverse of the one-sided pneumatic cylinder on "Festo" elements

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 2.6.

Fig. 2.6. Pneumatic reverse circuit of a one-way pneumatic cylinder, implemented on "Festo" elements

2.1.2 Check of operability of the pneumatic scheme for reverse of the bilateral pneumatic cylinder by means of the 3/2 distributor in the "FluidSim" program

Create a new file (command File – New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 2.2: distributor " 3/n way valve with pushbutton"; double acting cylinder " Double acting cilinder" and element power supply

"Compressed air supply". Then all the elements added to the working field of the file must be combined with pneumolines (Fig. 2.7).

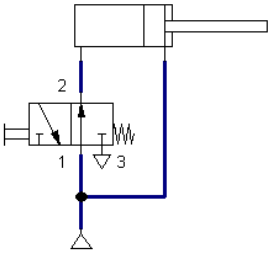

Fig. 2.7. Animation "FluidSim" – model of the scheme of reverse of the bilateral pneumatic cylinder by means of the 3/2 distributor

To check the efficiency of the circuit, switch it to animation mode (Fig. 2.7). In the initial position, the pressure is simultaneously supplied through the distributor in position 1 into the piston and rod cavities. Due to the difference between the planes of the piston and rod cavities, there is a difference in the balance of forces, which leads to the extension of the cylinder rod (in the initial position, the rod is extended). When the control signal is applied (pressing the button), the distributor moves to position 2. The compressed air continues to enter the rod cavity, and the piston cavity is connected through the throttle to the atmosphere, which causes the cylinder piston to move to the left, the rod is retracted.

2.1.2.1 Implementation of the pneumatic scheme of reverse of the one-sided pneumatic cylinder on "Festo" elements

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 2.8.

Fig. 2.8. Pneumatic scheme of reverse of the bilateral pneumatic cylinder by means of the 3/2 distributor realized on "Festo" elements

2.1.3 Check of operability of the pneumatic scheme for reverse of the bilateral pneumatic cylinder by means of two 3/2 distributors in the "FluidSim" program

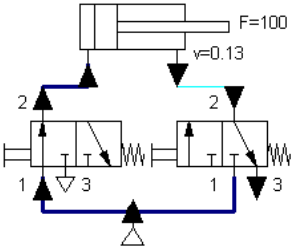

Fig. 2.9. Animation "FluidSim"– model of the scheme of extension of a rod of the bilateral pneumatic cylinder by means of two 3/2 distributors

Create a new file (command File – New). Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 2.3: 2 distributors "3/n way valve with pushbutton"; double acting cylinder "acting acting cylinder" and battery "Compressed air supply". Then all the elements added to the working field of the file must be combined with pneumolines (Fig. 2.9).

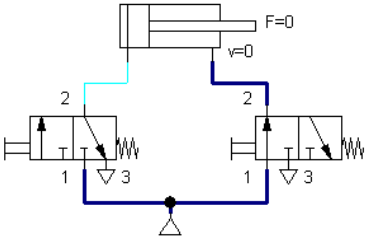

Fig. 2.10. Animation "FluidSim"– model of the scheme of reverse of the bilateral pneumatic cylinder by means of two 3/2 distributors

To check the functionality of the circuit, switch it to animation mode (Start key or F9). In the initial position, the cylinder rod 3 is retracted. When the control button 1(1) is pressed briefly, it moves to position 2. The air from the pressure line enters the piston cavity, which leads to the extension of the cylinder rod (Fig. 2.9).

When the distributor button 1(2) is pressed briefly, it switches to position 2 and compressed air enters the cylinder rod cavity, which moves the piston rod to the left (Fig. 2.10), because the pressure in the piston cavity is equal to atmospheric. The cylinder returns to its original position.

2.1.2.1 Implementation of the pneumatic scheme of reverse of the bilateral pneumatic cylinder by means of two 3/2 distributors on "Festo" elements

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the

"Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 2.11.

Fig. 2.11. Pneumatic scheme of reverse of the bilateral pneumatic cylinder by means of two 3/2 distributors realized on "Festo" elements

2.2 Using four-line and five-line distributors

Reverse control schemes with the help of four-line two-position (4/2) and five-line two-position (5/2) distributors (Figs. 2.12, 2.13) have become the most widespread in the control of two-way pneumatic cylinders. They provide the maximum effort at movement and clamping, after all give the chance to create the maximum pressure difference on the piston. Scheme of fig. 2.13 has advantages over the scheme in Fig. 2.12 with throttle speed control, detailed in laboratory work №3.

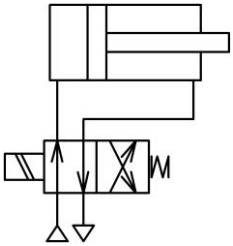

Fig. 2.12. Reverse of the bilateral pneumatic cylinder by means of the 4/2 distributor

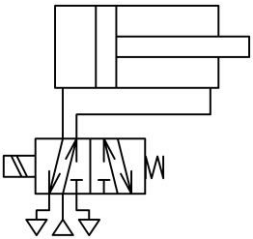

Fig. 2.13. Reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor

2.2.1 Check of operability of the pneumatic scheme for reverse of the bilateral pneumatic cylinder by means of the 4/2 distributor in the "FluidSim" program

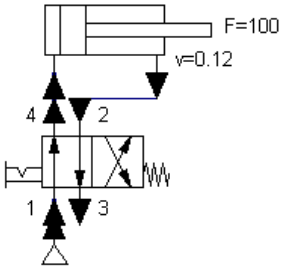

Fig. 2.14. Animation "FluidSim"– model of the scheme of reverse of the bilateral pneumatic cylinder by means of the 4/2 distributor

Create a new file. Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 2.12: distributor "4/n way valve"; double acting cylinder "Double acting cylinder" and battery "Compressed air supply". Then all the elements added to the working field of the file must be combined with pneumolines (Fig. 2.14).

To check the efficiency of the circuit, switch it to animation mode. In the initial position (1 position of the distributor) compressed air enters the rod cavity of the cylinder. The rod is in the retracted position (if the piston was extended – it returns to its original position), the piston cavity is connected to the atmosphere.

When the control button is pressed, the distributor switches to position 2 and compressed air enters the piston cavity of the cylinder, and the rod cavity is connected to the atmosphere, which leads to the extension of the rod of the pneumatic cylinder. When the button is released (control signal is removed), the distributor returns to position 1 and the cylinder rod is retracted.

2.2.2 Check of operability of the pneumatic scheme for reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor in the "FluidSim" program

Create a new file. Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 2.13: distributor "5/n way valve"; double acting cylinder "Double acting cylinder" and battery "Compressed air supply". Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 2.15).

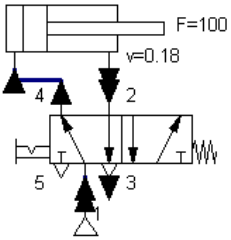

Fig. 2.15. Animation "FluidSim"– model of the scheme of reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor

To check the efficiency of the circuit, switch it to animation mode. In the initial position (1 position of the distributor) compressed air enters the rod cavity of the cylinder. The rod is in the retracted position (if the piston was extended - it returns to its original position), the piston cavity is connected to the atmosphere. Due to the fact that the scheme uses a five-line two-position *distributor, in each position one line* is always connected to the atmosphere, as shown in Fig. 2.13 switching situation, one of the three lines is a backup.

When the control button is pressed, the distributor switches to position 2 and compressed air enters the piston cavity of the cylinder, and the rod cavity is connected to the atmosphere, which leads to the extension of the rod of the pneumatic cylinder. When the button is released (control signal is removed), the distributor returns to position 1 and the cylinder rod is retracted.

2.2.2.1 Implementation of the pneumatic scheme of reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor on "Festo" elements

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the

Fig. 2.16. Pneumatic scheme of reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor realized on "Festo" elements

Fig. 2.17. 5/2 distributor "Festo"

"Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 2.16. In fig. 2.17 shows the 5/2 distributor "Festo".

2.3 Reverse with the use of pressure reducing valves

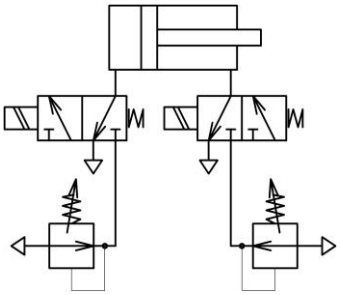

Fig. 2.18. The scheme of reverse of the bilateral pneumatic cylinder by means of reduction valves

Scheme of fig. 2.18 provides connection to the cavities of the cylinder switching objects with adjustable pressure level, which provides regulation of speed and force developed on the rod, while reducing energy loss. It is possible to provide a constant pressure drop on the piston when it moves, which stabilizes the speed and eliminates its oscillations.

2.2.2 Check of operability of the pneumatic scheme for reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor in the "FluidSim" program

Create a new file. Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 2.18: 2 distributors "3/n way valve with pushbutton"; double acting cylinder, two acting valves "Variable pressure redusing valve" and two batteries "Compressed air supply". Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 2.19).

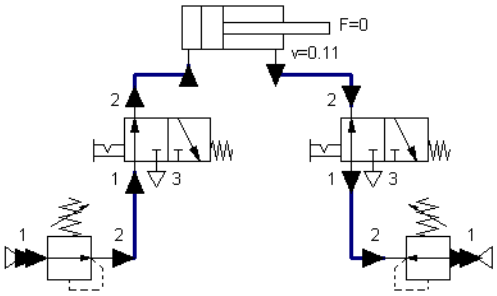

Fig. 2.19. Animation "FluidSim"–model of the scheme of reverse of the bilateral pneumatic cylinder by means of the 5/2 distributor

To check the efficiency of the circuit, switch it to animation mode. In the initial position, the compressed air through the pressure reducing valve 1(2), set to a certain pressure level, and the pressure setting level of the valve 1(1) is higher than the valve 1(2), is supplied to the muffled distributor line 2(2) in position 1. Similarly, compressed air is supplied to the muffled line of the distributor 2(1), the cylinder rod is in the retracted (initial) position.When pressing the control button of the distributor 2(2), it switches to position 2 and compressed air enters the rod cavity of the cylinder, which causes it to return to its original position (retracting the rod if it has been extended) When the control button is pressed, the distributor 2(1) moves to position 1, with compressed air entering the piston cavity. the set pressure level is equal to the pressure of the pressure reducing valve 1(2), the piston rod is extended at a constant speed.

When the control button 2(1) is released, the piston cavity of the cylinder is combined with the atmosphere and the piston rod is retracted (returns to its original position).

When the pressure setting of valves 1(1) and 1(2) changes, the pressure difference on the piston (the ratio of pressures in the piston and rod cavities) changes, which leads to a change in the constant value of the speed of the cylinder rod.

LABORATORY WORK № 3

PNEUMATIC SCHEMES OF PNEUMATIC MOTOR SPEED CONTROL

The purpose of work - acquaintance with ways of regulation of speed of a working body of the pneumatic engine and acquisition of practical skills in installation of pneumatic schemes

Circuits using constant adjustable inductors (local resistors) are the most widespread.

Throttle control circuits are traditionally divided into circuits with throttle mounting in the supply line and in the exhaust line.

3.1 Speed adjustment of the one-sided pneumatic cylinder with spring return

In fig. 3.1 the scheme of regulation of speed of advancement of a rod of the one-sided cylinder by the throttle with the return valve established in the power supply line is resulted.

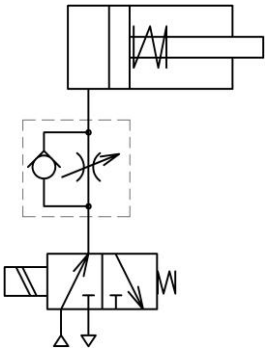

Fig. 3.1. Speed control of the rod with a throttle in the pressure line

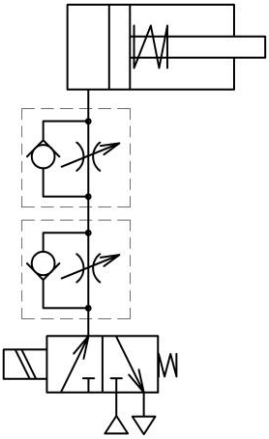

Fig. 3.2. Speed control of retraction and retraction of the piston of a one-way cylinder

3.1.1 Checking the operation of the circuit for speed control of a one-way pneumatic cylinder with spring return in the program "FluidSim" and implementation on the elements of "Festo"

Create a new file. Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 3.1: distributor "3/n way valve with pushbutton"; single acting pneumatic cylinder, single-way flow control control valve and compressed air supply. Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 3.3).

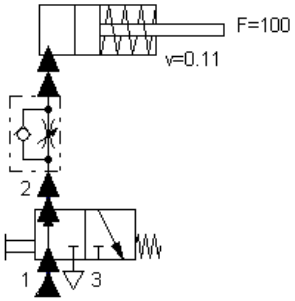

Fig. 3.3. The animation "FluidSim" - model of the scheme for speed control of the unilateral pneumatic cylinder with spring return

To check the efficiency of the circuit, switch it to animation mode. In the initial position, the distributor is in position 1. The piston cavity is connected to the atmosphere. The piston rod of the cylinder is retracted (under the action of spring force). When the control signal is given, the distributor moves to position 2. Compressed air enters the piston cavity through the throttle, which leads to the extension of the cylinder rod. The extension speed is regulated by adjusting the throttle.

When the control signal is removed (button is switched off), the distributor returns to position 1 under the action of spring force. The piston cavity of the cylinder is connected to the atmosphere through the non-return valve - the cylinder spring retracts the rod. Thus by means of a throttle it is possible to regulate speed of extension of a rod of the cylinder.

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 3.4.

Fig. 3.4. Pneumatic scheme for speed control of a one-way pneumatic cylinder with spring return, implemented on "Festo" elements

3.1.2 Checking the operation of the circuit for adjusting the speed of retraction and retraction of the piston of a one-way cylinder in the program "FluidSim" and implementation on the elements of "Festo"

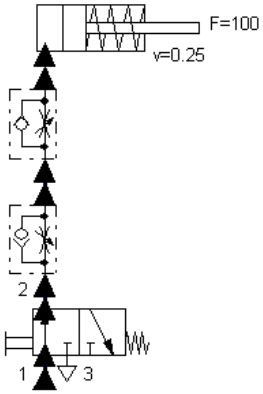

Fig. 3.5. The animation "FluidSim" - model of the scheme for adjustment of speed of extension and retraction of the piston of the unilateral cylinder

Create a new file. Next, from the component library you need to select and drag to the working field of the file in accordance with Fig. 3.2: distributor "3/n way valve with pushbutton"; single acting pneumatic cylinder, two adjustable throttles with non-return valve "One-way flow control valve" and "Compressed air supply" battery. Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 3.5).

To check the efficiency of the circuit, switch it to animation mode. In the initial position, the distributor is in position 1. The piston cavity is connected to the atmosphere. The piston rod of the cylinder is retracted (under the action of spring force). When the control signal is given, the distributor moves to position 2. Compressed air through the non-return

valve of the throttle 1 enters the throttle 2, the non-return valve of which is closed and, as a consequence, the entire air flow passes through the throttle 2, the adjustment of which regulates the speed of the cylinder rod.

When the control signal is removed (button is turned off), the distributor returns to position 1 under the action of spring force. Compressed air from the piston cavity of the cylinder through the check valve enters the throttle 1, the check valve of which is closed and further, through the throttle 2 flows into the atmosphere. By adjusting the throttle 1 regulates the retraction speed of the cylinder rod.

Thus, in the scheme in Fig. 3.2 it is possible to adjust the speed of the piston both when extending and retracting.

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 3.6.

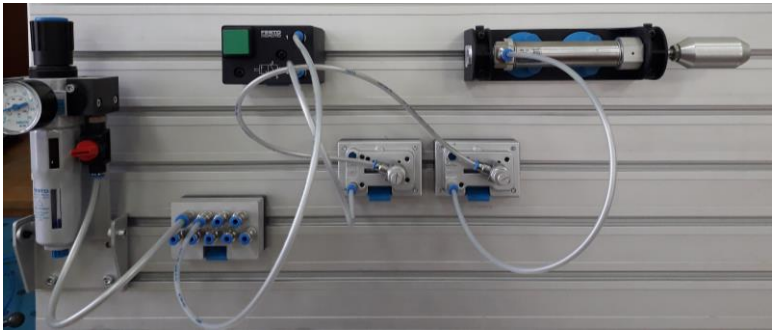

Fig. 3.6. Pneumatic circuit for adjusting the speed of retraction and retraction of the piston of a one-way cylinder, implemented on the elements of "Festo"

3.2 Speed control of the bilateral pneumatic cylinder

The speed of the double-acting cylinder in forward and reverse when using a 4/2 air distributor is regulated by throttles with non-return valves installed in the lines between the cylinder and the distributor (Fig. 3.7).

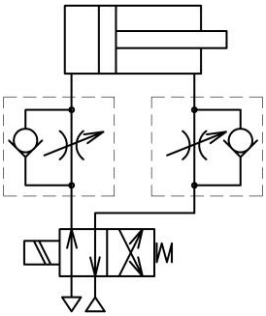

Fig. 3.7. Speed control of the bilateral pneumatic cylinder on the basis of 4/2 pneumatic distributor

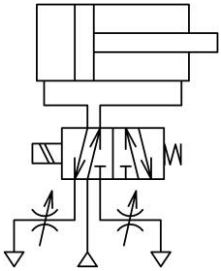

Fig. 3.8. Speed control of the bilateral pneumatic cylinder on the basis of 5/2 pneumatic distributor

In the presence of 5/2 of the pneumatic distributor this task is simplified, after all requires use of exhaust throttles which are screwed in the form of the plug directly into exhaust openings of the pneumatic distributor (Fig. 3.8). This eliminates the need for additional mounting fittings and check valves. However, with a large length of pneumolines between the distributor and the cylinder, this method of speed control may be ineffective due to the large volumes of air in the pipes between the cylinder and the throttle.

3.2.1 Checking the operation of the circuit for speed control of a two-way pneumatic cylinder based on 4/2 air distributor in the program "FluidSim" and implementation on the elements of "Festo"

Create a new file and add to it from the component library according to Fig. 3.7: distributor "4/n way valve"; double acting cylinder, two adjustable throttles with non-return valve "One-way flow control valve" and battery "Compressed air supply". Then all the elements added to the working field of the file must be combined with pneumolines (Fig. 3.9).

To check the efficiency of the circuit, switch it to animation mode. In the initial position, the distributor is in position 1. The piston cavity is connected to the atmosphere through the non-return valve, and compressed air is fed into the rod through the throttle. When the control signal is given, the distributor moves to position 2. Compressed air enters the piston cavity

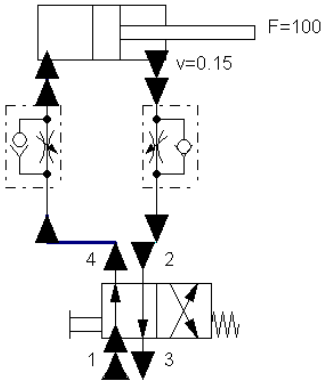

Fig. 3.9. Thr animated "FluidSim" - model of the scheme for speed control of the bilateral pneumatic cylinder on the basis of the 4/2 pneumatic distributor

through the throttle, which leads to the extension of the cylinder rod and the expulsion of air from the rod cavity through the check valve. The extension speed is regulated by adjusting the throttle.

When the control signal is removed (button is switched off), the distributor returns to position 1. The piston cavity of the cylinder is connected to the atmosphere through the non-return valve, and the rod is retracted through the throttle with the power supply. Thus by means of a throttle adjustment of speed of extension and retraction of a rod of the cylinder is possible.

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. Due to the fact that the set of standard elements does not have a 4/2 distributor, we replace it with two 3/2 distributors. An approximate view of the assembled scheme is shown in Fig. 3.10.

Fig. 3.10. Pneumatic circuit for speed control of a bilateral pneumatic cylinder based on 4/2 pneumatic distributor, implemented on "Festo" elements

3.2.2 Checking the operation of the circuit for speed control of a two-way pneumatic cylinder based on 5/2 air distributor in the program "FluidSim" and implementation on the elements of "Festo"

Create a new file and add to it from the component library according to Fig. 3.8: distributor "5/n way valve"; double acting cylinder "acting acting cylinder" and battery "Compressed air supply". Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 3.11).

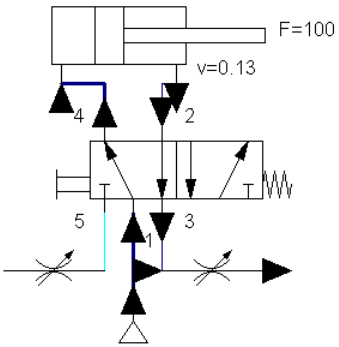

Fig. 3.11. The animation "FluidSim" - model of the scheme for speed control of the bilateral pneumatic cylinder on the basis of the 5/2 pneumatic distributor

To check the efficiency of the circuit, switch it to animation mode. In the initial position (1 position of the distributor) compressed air enters the rod cavity of the cylinder. The rod is in the retracted position, the piston cavity through the air distributor and the throttle is connected to the atmosphere. When the control button is pressed, the distributor switches to position 2 and the compressed air enters the piston cavity of the cylinder through 5/2 the distributor, and the rod cavity through the distributor and the adjustable throttle combines with the atmosphere, which leads to the extension of the pneumatic cylinder rod.

By changing the diameter of the through hole of the throttle 1 (2), you can adjust the pressure of the support in the rod cavity, and hence the speed of extension of the rod. When you release the button (remove the control signal), the distributor returns to position 1, and compressed air through 5/2 distributor enters the rod cavity of the cylinder, and the piston cavity through the distributor and adjustable throttle 1 (1) is combined with the atmosphere, which leads to retraction . By changing the diameter of the through hole of the throttle 1 (1), you can adjust the speed of retraction of the rod.

After we have made sure that the pneumatic circuit is working by modeling in the "FluidSim" program, we assemble it on the elements of the "Festo" pneumatic stand and check its operability. An approximate view of the assembled scheme is shown in Fig. 3.12.

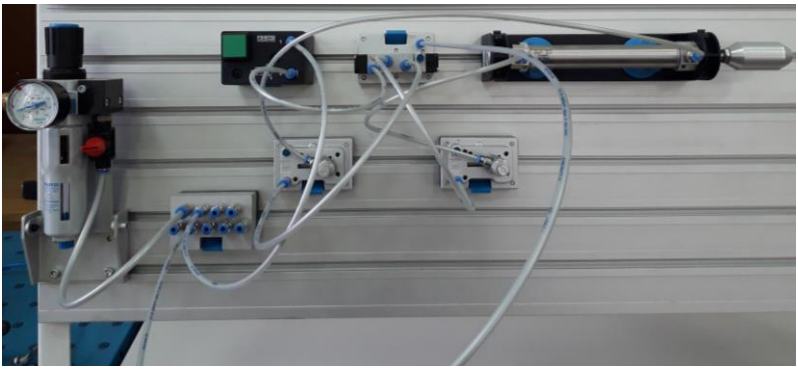

Fig. 3.12. Pneumatic circuit for speed control of a bilateral pneumatic cylinder based on 5/2 of the pneumatic distributor, implemented on "Festo" elements

LABORATORY WORK № 4
CONTROL SCHEMES FOR PNEUMATIC MOTORS WITH CYCLE CONTROL BY END POSITION, PRESSURE AND TIME

The **purpose of work** – acquaintance with methods of control of a cycle and practical realization of control schemes on the basis of the standard pneumatic equipment

4.1 Cycle control by the position of the output link of the air motor

It is used for transport pneumatic actuators, when it is possible to install limit switches in the area of movement of the working body of the actuator.

In fig. 4.1 shows the scheme of automatic cycle control $3\,4\,\overline{3}\,\overline{4}$. The system has 4 limit switches 1(1), 1(2), 1(3) and 1(4) and a separate 3/2 switch 5 for system start-up.

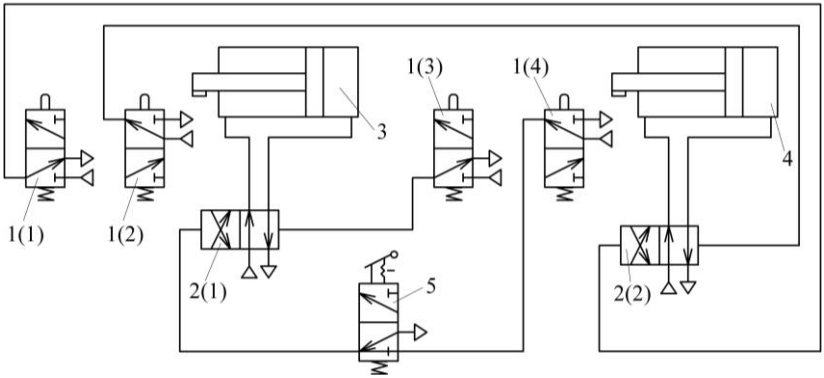

Fig. 4.1. Scheme of automatic cycle control $3\,4\,\overline{3}\,\overline{4}$ with cycle control by means of limit switches

When the toggle switch 5 is switched on, the main distributor 2(1) is switched and the cylinder rod 3 is extended by pressing the end switch 1(1) at the end of the stroke, which sends a signal to switch the distributor 2(2). As a result, the rod of the cylinder 4 is extended and turns on at the end of the stroke of the limit switch 1(3), which passes the signal to switch the

distributor 2(1). The cylinder rod 3 is retracted by pressing the switch 1(2) at the end of the stroke. The latter sends a signal to switch the distributor 2(2), which leads to the return to the original state of the cylinder 4. If the toggle switch 5 is still pressed - the cycle repeats.

4.1.1 Validation of the circuit for cycle control by the position of the output link in the program "FluidSim" and implementation on the elements of "Festo"

Create a new file and add to it from the component library according to Fig. 4.1: five "3/n way valve" distributors; two distributors "4/n way valve"; two double acting cylinders and "Compressed air supply" batteries. Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 4.2).

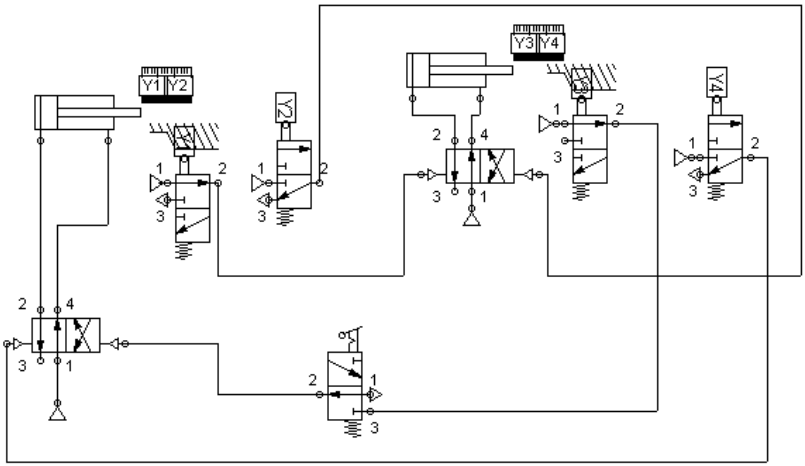

Fig. 4.2. The "FluidSim" – model of the scheme for control of a cycle on position of an initial link

To check the efficiency of the circuit, switch it to animation mode. In the initial position, the distributors 2(1) and 2(2) are in position 1 (Fig. 4.3). Compressed air is supplied to the rod cavity of the cylinders 3 and 4, the rods of which are in the retracted position. The limit switches 1(2) [Y1] and 1(4) [Y3] are pressed. The distributors 1(2) and 1(4) are in position 2.

Power is supplied to the control line of the distributor 2 (2) and holds it in position 1 (cylinder rod 4 is retracted and holds the limit switch Y3 in the pressed state (position 2) The supply pressure through the limit switch Y3 is supplied to the toggle switch 5.

When you press the toggle switch 5, it moves to position 2, while the compressed air enters the control line of the distributor 2(1) and switches it to position 2.

Compressed air enters the piston cavity of the cylinder 3, which leads to the extension of the cylinder rod. The limit switch 1(2) goes to position 1, while the control signal on the distributor 2(2) is zero (Fig. 4.3).

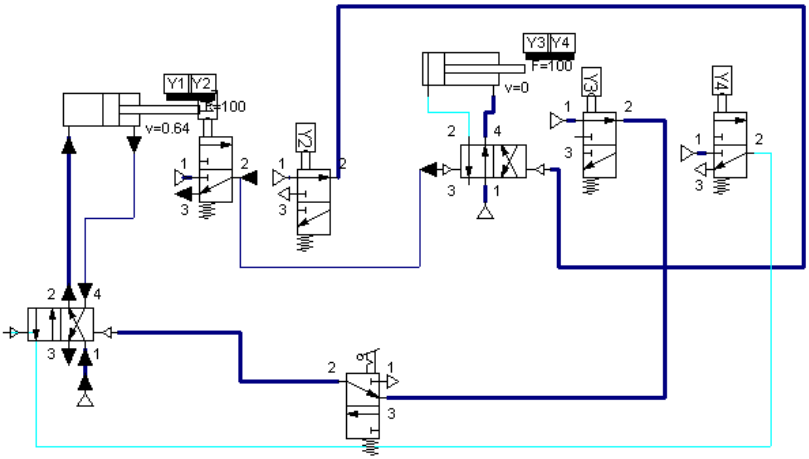

Fig. 4.3. The animated "FluidSim" - model of the circuit for controlling the cycle of the position of the output link (extension of the cylinder rod 3, the cylinder rod 4 in the initial position)

When the rod of the cylinder 3 reaches the limit switch Y2, it moves to position 2. Compressed air enters the right control line of the distributor 2(2) and switches it to position 2 (Fig. 4.4). Compressed air through the distributor 2(2) enters the piston cavity of the cylinder 4, the rod is extended. In this case, the limit switch Y3 goes to position 1, the control signal in the right line of the distributor 2(1) becomes equal to zero.

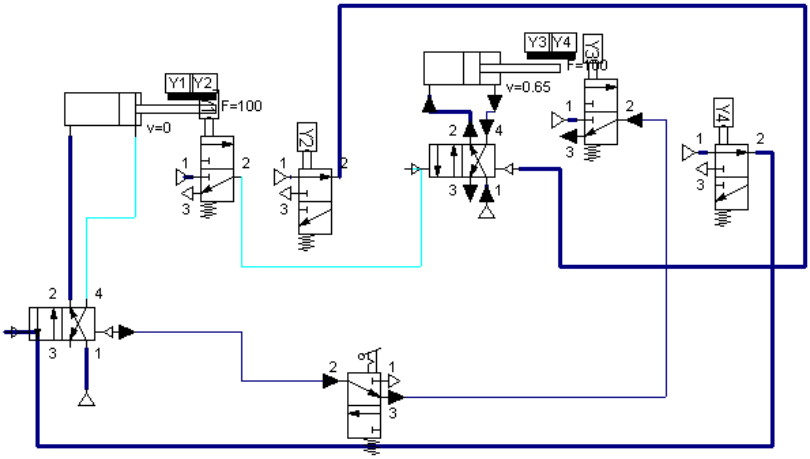

Fig. 4.4. The animation "FluidSim" – model a circuit for controlling the cycle of the position of the output link (cylinder rod 3 in the extreme right position, cylinder rod 4 is extended)

When the cylinder rod 4 reaches the limit switch Y4 air enters the left control line of the distributor 2(1) and moves it to position 1, which leads to the retraction of the cylinder rod 3. When you press the limit switch Y1 (in the retracted position) the control signal switches the distributor 2(2) in position 1, the rod of the cylinder 4 is retracted and returned to its original position. As long as the toggle switch 5 remains pressed, the cycle repeats. When you turn off the toggle switch 5, the cylinders 3 and 4 return to the original (starting) position.

4.2 Control with pressure control

In cases where it is necessary to control the cycle by the force that develops the piston (clamping pneumatic actuators) use control schemes with control of the pressure cycle (Fig. 4.5). In this scheme, sequential type valves are used to perform sequential operation of the cylinders, which respond to the pressure difference in both cavities of the cylinder, which avoids the erroneous command when the pressure in the working cavity of the cylinder increases when the piston moves.

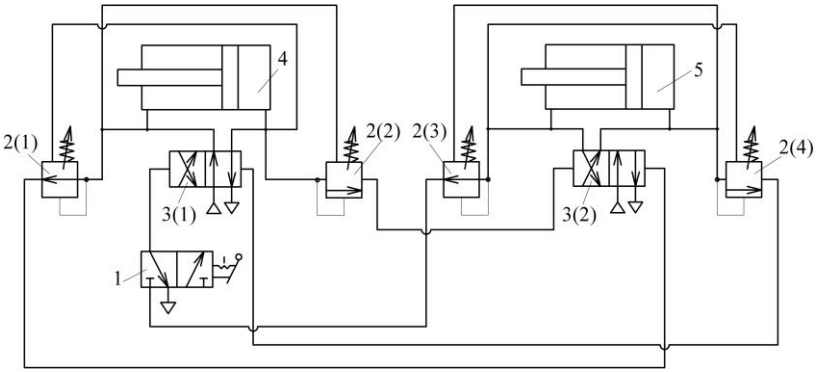

Fig. 4.5. Scheme of automatic control of technological process with pressure control (cycle of work of cylinders $4\,5\,\bar{4}\,\bar{5}$)

When the toggle switch 1 is turned on, the signal from the valve of the sequence 2(3) switches the distributor 3(1) and bends the piston cavity with 4 with the power line. The rod extends. The pressure in the piston cavity increases and when the value to which the valve of the sequence 2(2) is set, causes its operation, and hence the command to switch the distributor 3(2). The rod of the cylinder 5 is extended. The pressure in the piston cavity of the cylinder 5 increases and switches the valve of the sequence 2(4). The control signal from this valve switches the distributor 3(1) to the initial position - the cylinder rod 4 returns to the initial position. The pressure in the rod cavity of the cylinder 4 reaches the required value, the valve 2(1) is triggered and sends a control signal to return the piston of the cylinder 5 to its original position. At the end of the stroke, the pressure in the rod cavity of the cylinder 5 turns on the valve 2(3) and, if the toggle switch 1 is turned on, the cycle repeats.

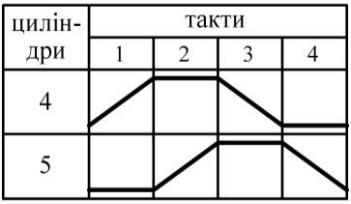

Fig. 4.6. Cyclogram of operation of the pneumatic drive

The cyclogram of operation of the pneumatic system is shown in fig. 4.6.

4.2.1 Checking the operation of the circuit for pressure cycle control in the program "FluidSim"

Create a new file and add to it from the component library according to fig. 4.5: one "3/n way valve" distributor; two distributors "4/n way valve"; two double acting cylinders, four adjustable pressure reducing valves and Compressed air supply batteries. Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 4.7). To check the efficiency of the circuit, switch it to animation mode (Fig. 4.8).

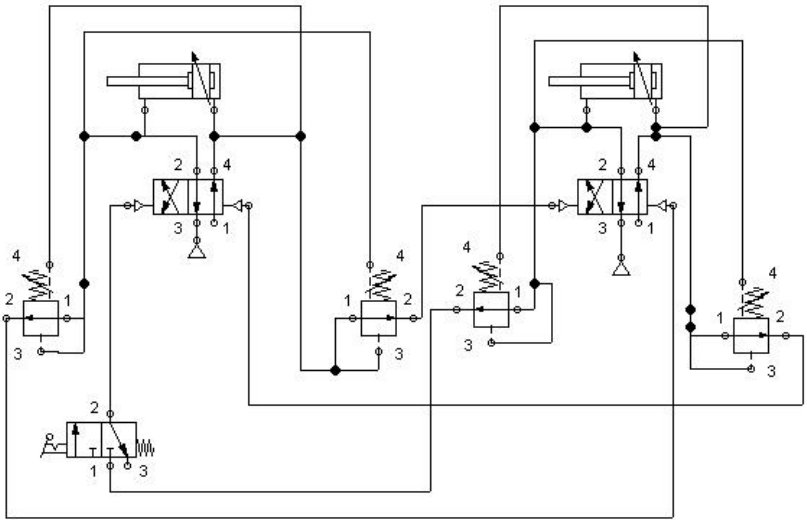

Fig. 4.7 – The "FluidSim" – model of the scheme of automatic control of technological process with pressure control (cycle of work of cylinders $4\,5\,\overline{4}\,\overline{5}$)

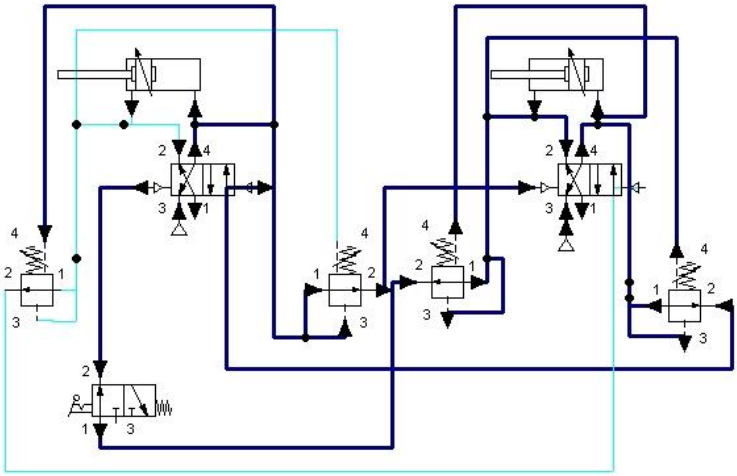

Fig. 4.7 – The aimation "FluidSim" – model of the scheme of automatic control of technological process with pressure control (cycle of work of cylinders $4\,5\,\bar{4}\,\bar{5}$)

4.3 Cycle control based on time control

If the transport pneumatic actuator cannot be controlled by position sensors or limit switches installed in the moving rod area, a time control system is used.

In this case, the most universal means of control can be a generator of rectangular pulses with adjustable pulse duration (Fig. 4.9).

The generator consists of two shutter speed valves 2(1) and 2(2), normally open 3/2 distributor 6 and pneumatic toggle switch 1. When you turn on toggle switch 1, compressed air through the normally open distributor 6 is supplied to control the shutter speed valve 2(1). After a certain period of time, which depends on the conductivity α_1 of the adjustable throttle valve of sequence 2(1), the valve is triggered and at its outlet appears compressed air with the main pressure. This signal begins to enter the control channel of the valve sequence 2(2) and after a certain period of time, which is determined by the setting of the adjustable throttle valve is switched (α_2). The signal from the valve 2(2) is fed to the control

3/2 of the distributor 6, which is activated by switching the control channel of the time delay valve 2(1) with the atmosphere. Moreover, the removal of air from this channel is fast through the check valve. The valve 2(1) is activated by a spring and the atmospheric pressure is set at the valve outlet.

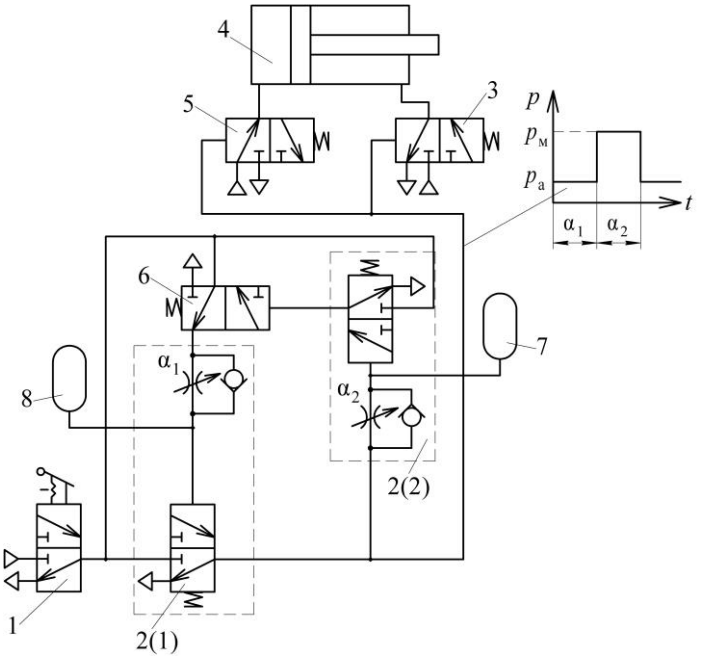

Fig. 4.9. Time cycle control scheme using a rectangular pulse generator

Thus, the duration of the zero pulse p_a depends on the conductivity of the throttle α_1 valve 2(1), and the duration of the pulse with the main pressure $p_м$ depends on the conductivity of the throttle α_2 valve 2(2).

The output channel of the pulse generator is connected to the control cavities of the normally closed 3/2 distributor 5 and the normally open 3/2 distributor 6, which control the pneumatic cylinder 4.

To significantly increase the duration of the pulses, it is possible to connect the tank 7 (as shown for valve 2(2).

4.3.1 Checking the operation of the circuit for time cycle control in the program "FluidSim"

Create a new file and add to it from the component library according to fig. 4.9: five "3/n way valve" distributors; two distributors "4/n way valve"; two double acting cylinders and "Compressed air supply" batteries. Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 4.10).

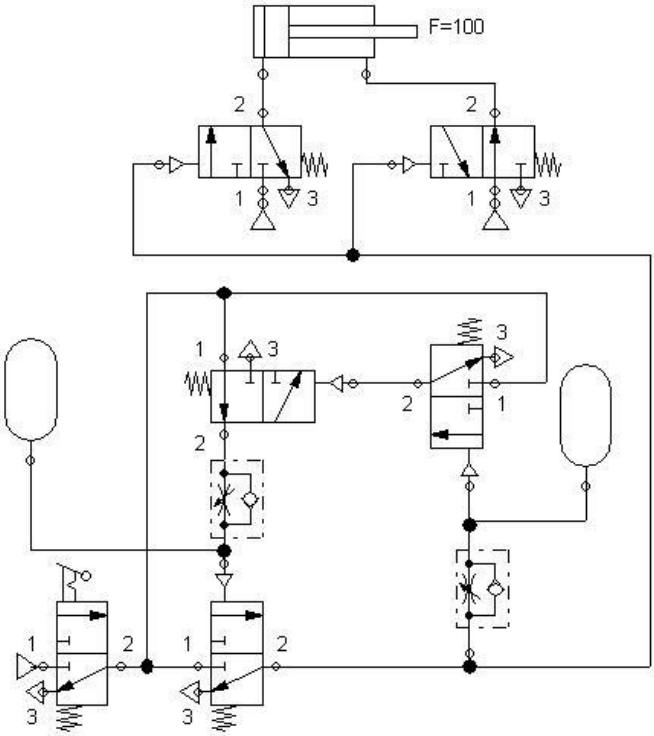

Fig. 4.10. "FluidSim"–model circuit for time cycle control

To check the efficiency of the circuit, switch it to animation mode (Fig. 4.11).

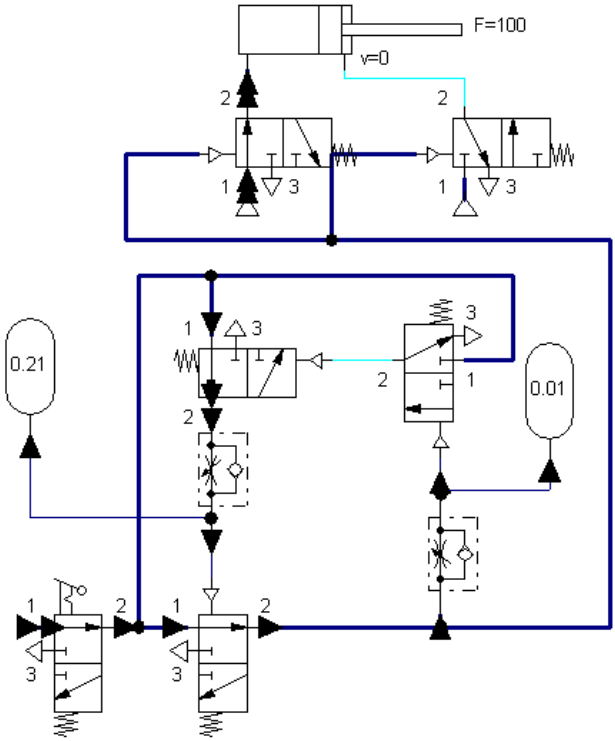

Fig. 4.11. Animated "FluidSim"-model is a circuit for time cycle control

LABORATORY WORK № 5
USE OF PULSE CONTROL OF PNEUMO DISTRIBUTORS WITH MEMORY IN AUTOMATION OF TECHNOLOGICAL PROCESSES

The purpose of work - acquisition of practical skills at the decision of problems of management of technological processes by standard means of pneumatic automation

5.1 Automatic return of the cylinder by converting the output to a pulse signal

Scheme of fig. 5.1 contains a 5/2 distributor 3, which has a memory property, and a 3/2 distributor 4 with a time delay that implements a pulse signal. The piston of the cylinder after reaching the end of the stroke returns to its original position, regardless of whether the signal is removed from the distributor 1, which caused the system to start. This is because the constant signal from the distributor 1 has been converted by the distributor 4 into a pulse signal, and the distributor 3 has memorized this signal. The reverse switching of the distributor 3 will occur when the limit switch 2 is triggered.

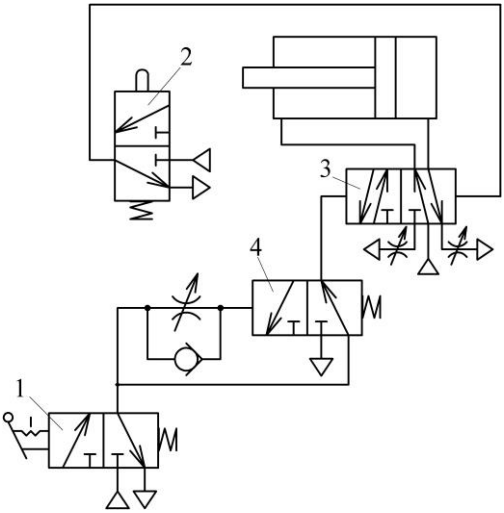

Fig. 5.1. The pulse control circuit

5.1.1 Checking the operation of the pulse control circuit in the program "FluidSim"

Create a new file and add to it from the component library according to fig. 5.1: three "3/n way valve" distributors; one distributor "5/n way valve"; double acting cylinder "Double acting cilinder"; adjustable throttle with non-return valve "One-way flow control valve"; two adjustable throttles "Throttle valve" and batteries "Compressed air supply". Next, all the elements added to the working field of the file must be combined with pneumolines (Fig. 5.2).

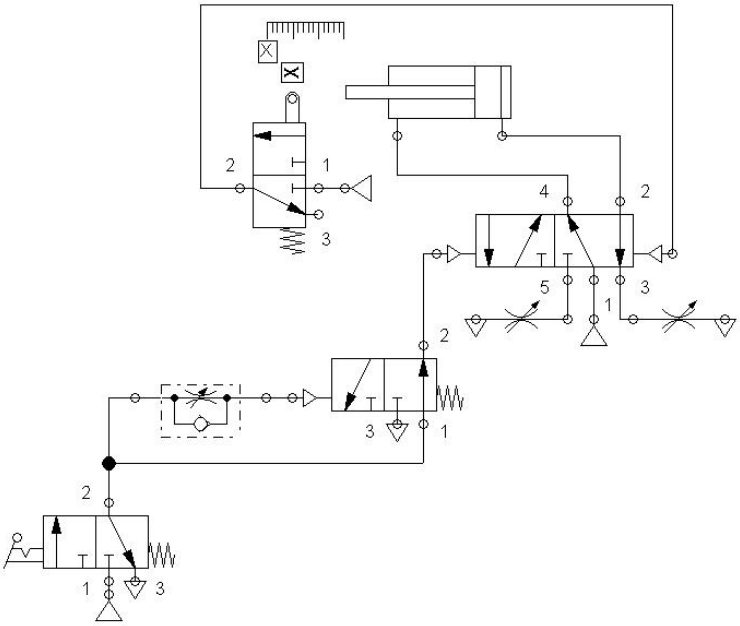

Fig. 5.2. The "FluidSim" – model of the pulse control circuit

To check the efficiency of the circuit, switch it to animation mode (Fig. 5.3).

In the initial position, the inlet 1 of the distributor 3 (Fig. 5.1, 5.2) is supplied with supply pressure, while compressed air enters the rod cavity of the cylinder, the rod is retracted.

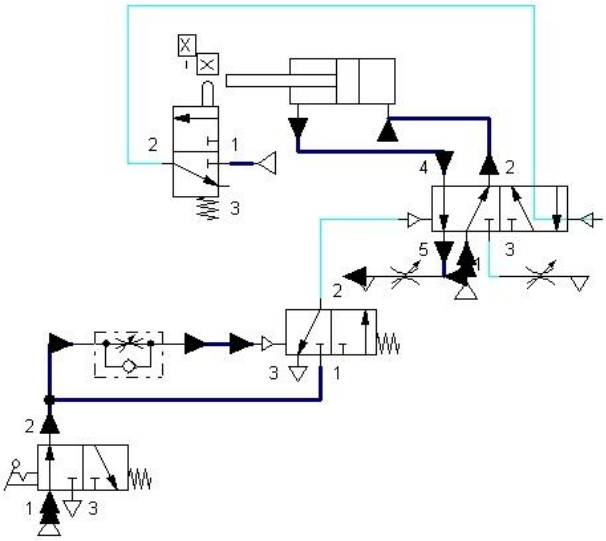

Fig. 5.3. The animated "FluidSim" – model of the pulse control circuit

The distributor 4 under the action of the control spring occupies the extreme left position, the input 1 is connected to the control signal of the distributor 3. When pressing the manual control lever of the distributor 1 short-term pressure pulse, passing through the distributor 4, switches the distributor 3 the throttle with the check valve arrives as a control signal on the distributor 4 and at achievement of size of pressure of control the distributor 4 returns to initial position. In this case, the control signal on the distributor 3 becomes equal to zero. But due to the fact that the distributor 3 operates in the "memory" mode, power is supplied to the piston cavity and the extension of the rod continues.

Reaching the end position x (Fig. 5.3), the rod presses the limit switch 2 and the control signal enters the line 2 of the distributor 3 and switches it - the supply pressure begins to enter the rod cavity of the cylinder, returning it to its original position. The rod is retracted, and the distributor 2 returns to its original position under the action of the force of the control spring.

The control signal of the input 2 of the distributor 3 is zero, but due to the fact that the distributor 3 acts as a "memory element", the piston of the cylinder remains in the retracted position.

The presence of two adjustable throttles in the circuit allows you to control the speed of extension and retraction of the cylinder rod.

5.2 Semi-automatic machining scheme

A short-stroke single-acting cylinder A is used to clamp the part (Fig. 5.4). To ensure safety, the valve of sequence 1 is used, the signal of which indicates that the pressure in the cylinder has reached the specified value and the part is clamped securely. The value of the operating pressure of the valve sequence 1 is determined by the degree of compression of the adjustable spring. The signal from the sequence valve is a signal to start machining (extension of cylinder B). The piston of cylinder B must return to its original state after processing at the signal from the limit switch 5. But until the rod of cylinder B has returned to its original state, the part must be clamped, ie the signal from the valve sequence 1 is. Therefore, it is possible to receive two mutually exclusive signals to control the distributor 6.

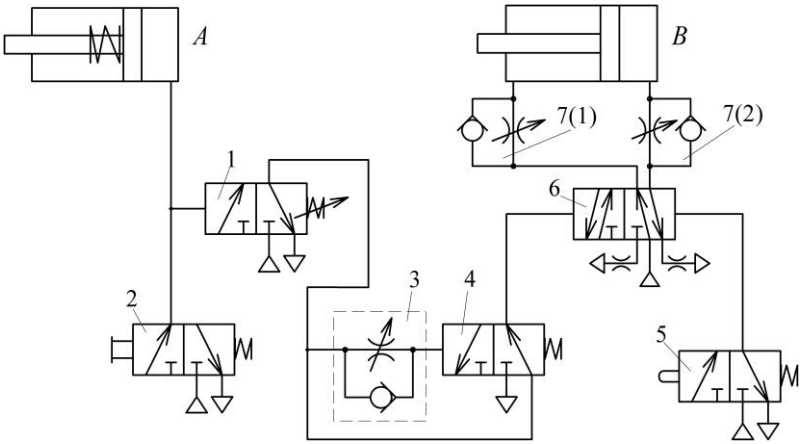

Fig. 5.4. The scheme for clamping and machining of parts, single cycle

However, the conversion of the signal from the sequence valve into a pulse signal due to devices 3 and 4, as well as due to the presence of memory in the distributor 6 eliminates the competition of two mutually exclusive control signals.

5.1.1 Checking the operation of the pulse control circuit in the program "FluidSim"

To check the efficiency of the scheme in Fig. 5.4 collect it in the program "FluidSim" and switch to animation mode (Fig. 5.5).

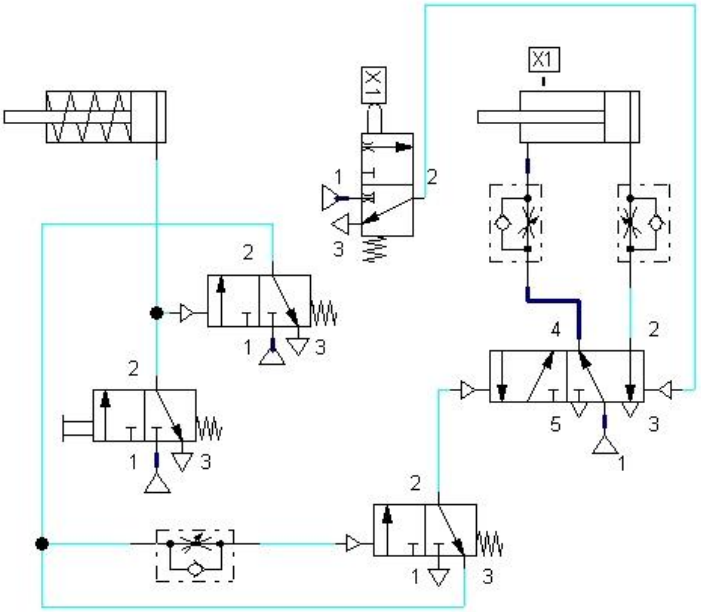

Fig. 5.5. The animation "FluidSim" – model of the scheme for clamping and processing of details, unit cycle (starting position)

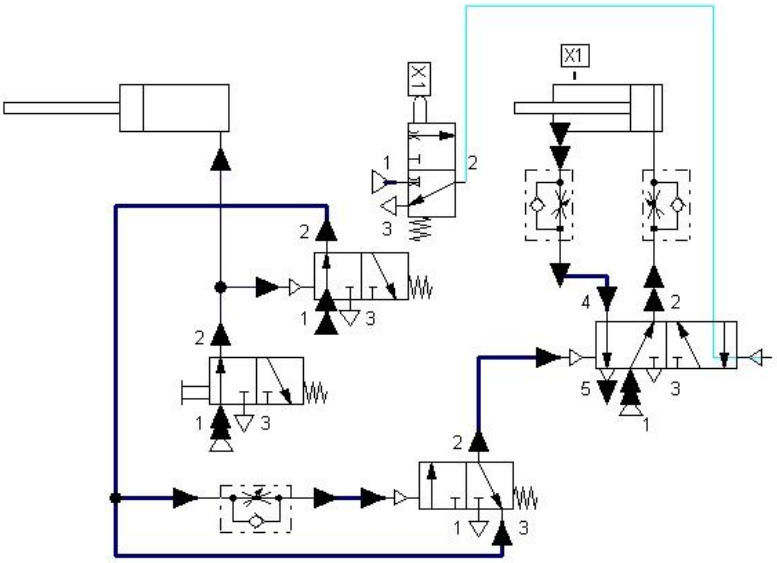

Fig. 5.6. The animation "FluidSim" – scheme of the scheme for clamping and processing of details, unit cycle (performance of technological operation)

5.3 Automatic machining scheme

Scheme of fig. 5.2 operates in semi-automatic mode, if the operator constantly presses the button of manual control of the distributor 2. At the same time the detail at the end of a half-cycle and remains clamped.

In scheme 5.3, the signal of the pneumatic button "start" is stored when it is pressed briefly by means of the distributor 1.

The reverse switching of the distributor 1 and the removal of the piston of the cylinder A to the initial state (expansion of the loop) occurs when the limit switch 8 (1), which fixes the moment of return of the piston of the cylinder B to its original position (retraction into the cylinder).

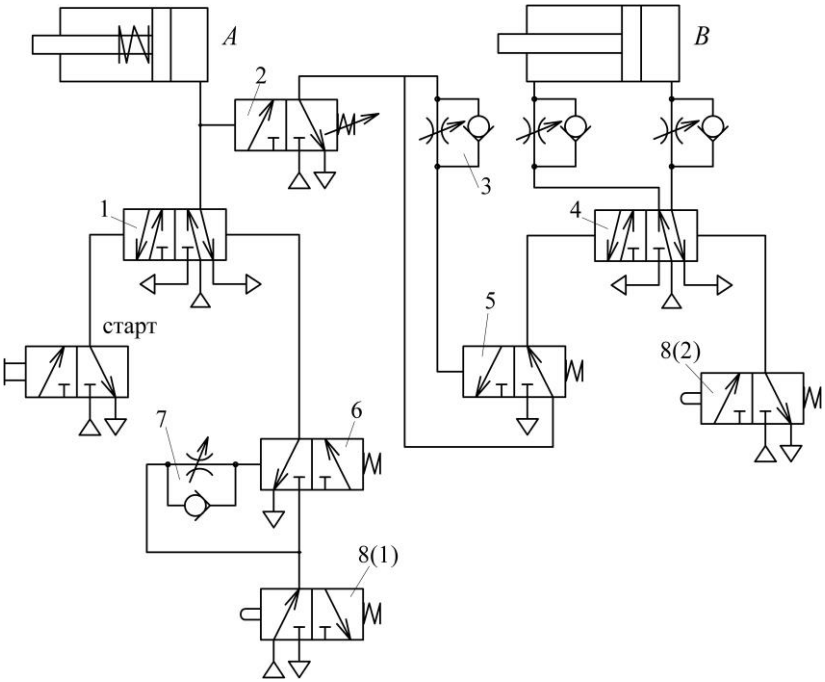

Fig. 5.3. The scheme of automatic control of the mode of clamping and processing of a detail

This signal is also converted by a 3/2 distributor 6 and a time delay device 7 into a pulse signal. Thus, the use of pulse control and memory function in 5/2 distributors eliminates the competition of mutually exclusive control signals.