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APPLICATIONS OF PROPORTIONAL PNEUMATIC EQUIPMENT IN INDUSTRY

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Abstract: *This article is an overview of the possibilities of application of proportional pneumatic equipment. Here below are presented proportional directional control valves, proportional pressure regulators, pneumatic positioning axes and some of their future applications.*

Keywords*: pneumatics, proportional, servo technics, cylinders with embedded displacement transducers, proportional pressure regulators, pneumatic proportional directional control valves, axis controllers*

Proportional drive systems are widely used in industrial applications. Pneumatic servo technics is used in automation applications in industry, at machine tools, paper processing industry, civil engineering, textile industry, mobile machines, instrumentation, semiconductor industry, in robotics, in the electrical engineering industry, in production of medicines, in agriculture etc. The proportional equipment is found in pneumatic applications such as: feed control at welding devices, control of speed and braking in mobile machines, sandblasting and cutting operations, adjustment of voltage in wires, at presses, in grinding, for adaptive suspension control etc. This paper presents information about pneumatic proportional directional control valves and regulators and also several top applications of proportional pneumatic equipment.

The most important proportional appliances are directional control valves and pressure regulators.

The proportional pneumatic equipment with air flow control proportionally to an electrical control parameter is called proportional directional control valves, while devices that adjust air pressure proportionally to an electrical signal (in voltage or current) are called proportional regulators. With their help there can be controlled the rates of movement of mobile subassemblies, clamping forces in actuators of pneumatic robots, and also positioning accuracy of pneumatic axes. Proportional equipment allows change in time or in space of loads involved, of travelling speeds and it can respond to positioning diagrams according to the topics requested by the client.

Pneumatic proportional directional control valves are flow control devices directing the air flow to an outlet or the other in varying amounts, given by the size of aperture of holes, proportional to the voltage or amperage of current applied to the coil of the control electromagnet. Figure 1 shows such a proportional directional control valve of the company FESTO (4). The slide valve can move in the directional control valve body, taking positions based on control voltage or amperage. At an amperage or voltage equal to half the signal of the slide valve it takes the central position, according to fig. 1, and closes the inlet port for pressure. If the signal drops, the inlet port is opened by movement of the slide valve and the air is routed to the outlet port A, which can be a pneumatic cylinder PC. Through the joint B the air behind the piston of cylinder is discharged to the atmosphere. On increased signal, the slide valve of the directional control valve moves in the other direction and the air is routed to the hole B of the directional control valve, to the PC. The pneumatic cylinder PC manufactured by FESTO (5) is provided from factory with the displacement transducer TR from which signals are taken over and conveyed to the automation system. The assembly directional control valve - pneumatic cylinder with embedded displacement transducer along with the controller form a positioning axis. Such axes have very high performance concerning positioning possibilities. Thus, the company FESTO assigns as positioning accuracy for a cylinder type dnci with built-in transducer and proportional directional control valve type MPYE, working with the controller type SPC 200, a resolution of 0.01 mm and repeatability less than +/- 0.5.

To determine the permissible impact mass, M_l, the following formula is used:

$$M_l = 2xE_{per}/v^2 - M_K \quad (5)$$

where:

- M_l is active permissible mass
- E_{per} is permissible impact energy of the cylinder
- V is maximum permissible impact velocity
- M_k is constructional mass of the moving part of the cylinder

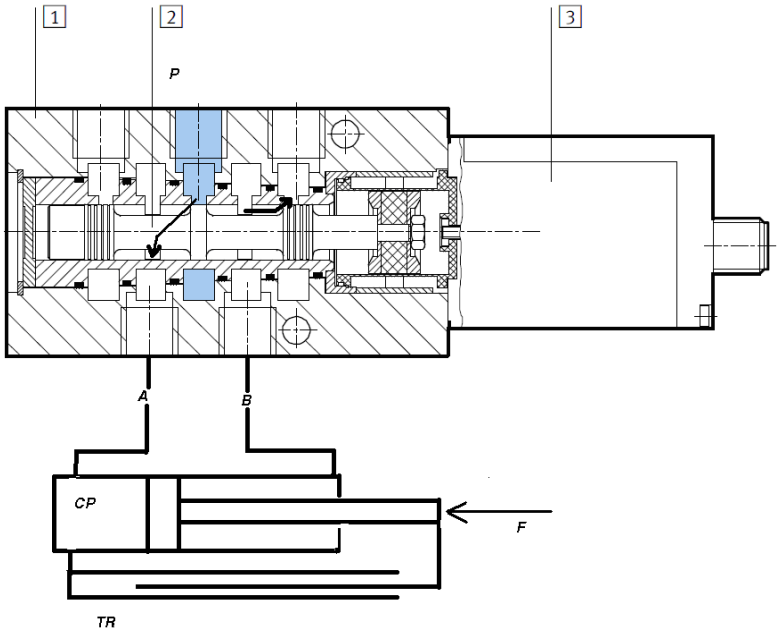

Fig. 1 Directional control valve by FESTO. 1- aluminum body, 2 – aluminum slide valve, 3- electromagnet actuated at amperage 4-20 mA or voltage 0-10 V DC

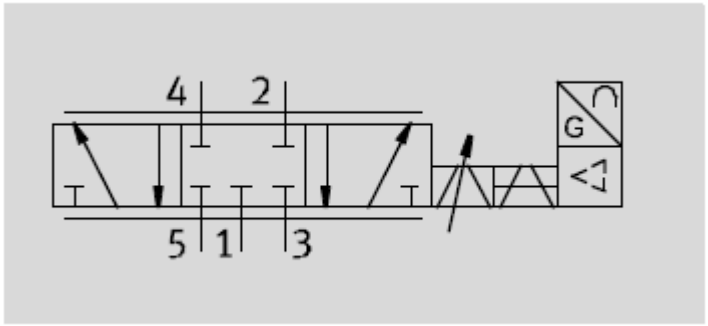

Fig. 2 Schematic diagram of operation of pneumatic directional control valve type MPYE from FESTO.

Through 1 there comes the air at the pressure P and goes to consumers A or B, through the holes 2 or 4, depending on the signal from the automation system. In 5 and 3 there are mounted mufflers made of sintered bronze.
These devices have the working characteristic at pressure of 0 to 10 bar, working voltage maximum 17...30V DC and flow rates 100, 2000 l/min.

Under the action of magnetic field, the slide valve item 2 in Fig. 1 is positioned proportionally to the voltage or electric current towards the body of directional control valve item 1, according to Fig. 3.

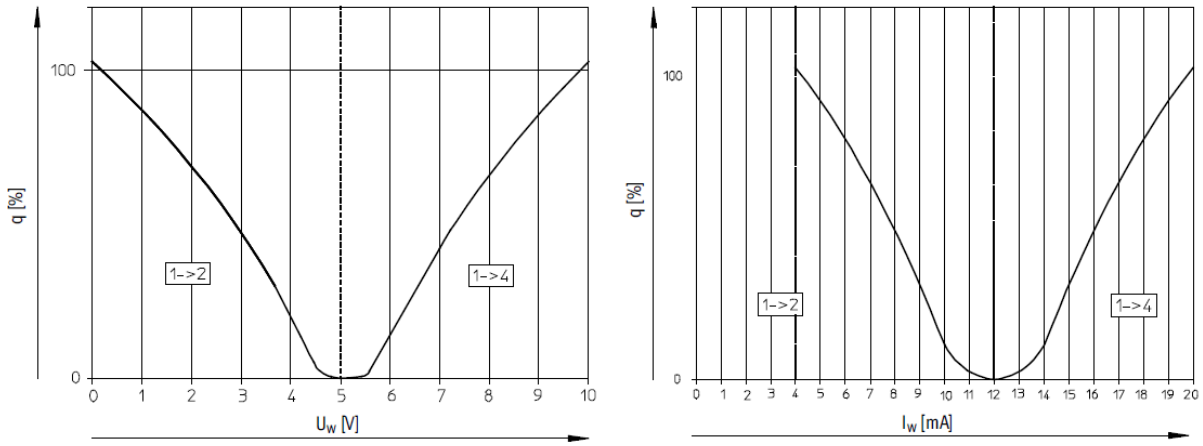

Fig. 3 Flow rate of proportional directional control valve q (%) depending on the control voltage (left) and amperage (right)

The device is presented in the version with actuation in voltage or the one with actuation in amperage.

For actuation in voltage 0-10 VDC or amperage 4-20 mA at a voltage of 5 VDC (12mA) the slide valve gets in the central position and the flow rate is 0. When the signal drops below 5 V DC or 12 mA the air is routed proportionally to the signal size towards an outlet port, while when the signal rises above this value, the air is routed to the other outlet port. At the extremities - minimum or maximum voltage or amperage – the appliance allows minimum or maximum airflow rates on those outlet ports.

From its construction it can be noticed that the slide valve is kept in equilibrium by forces proportional to the control current. This equilibrium can be easily affected by external forces derived from accelerations or shocks. It is thus necessary to make precautions such as to mount the axis of the directional control valve perpendicularly to the direction of movement of the body in motion. For proper functioning there is used ungreased air and filters of 5 μ.

The company FESTO also delivers the MPZ module that can generate 6 +1 analog voltage signals through which automation can be made in order to obtain levels of preset speeds.

In the field of pneumatic servo technique applications the company FESTO introduces the bionic hand, Fig. 4, demonstrating the level at which one can get in this area. In this application there are solved issues related to drive, positioning and the level of application force.

Fig. 4 The bionic hand

Another application presented by the company FESTO is a smart sorting system that mimics the wavy surface of water. Thus, on a flat surface there are located intelligent pneumatic cylinders that can be actuated individually. The cylinders operate on a membrane on which objects are placed; these objects can be routed in various directions and thus sorted.

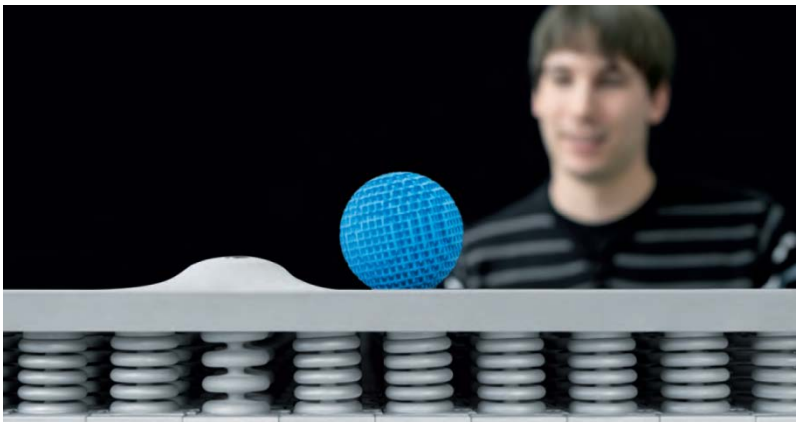

Fig. 5 The way the pneumatic cylinder operates on the conveyor membrane

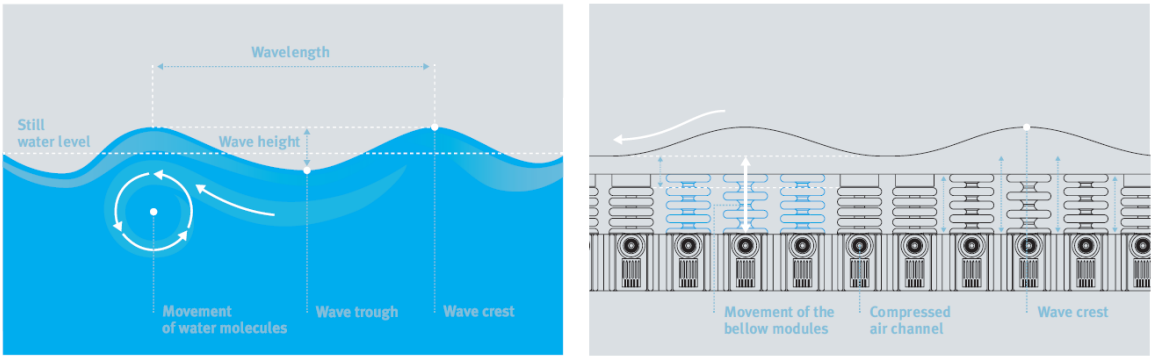

Fig. 6 Pneumatic conveyor for sorting which mimics waving of liquid surfaces

At INOE 2000-IHP there has been developed by a research team under The INNOVATION Programme a proportional pneumatic pressure regulator with membrane, as shown in Fig. 7.

Fig. 7 Proportional pneumatic pressure regulator with membrane

A section through this regulator is shown in Fig.8. The device adjusts the air pressure in a circuit depending on the size of an electrical signal.

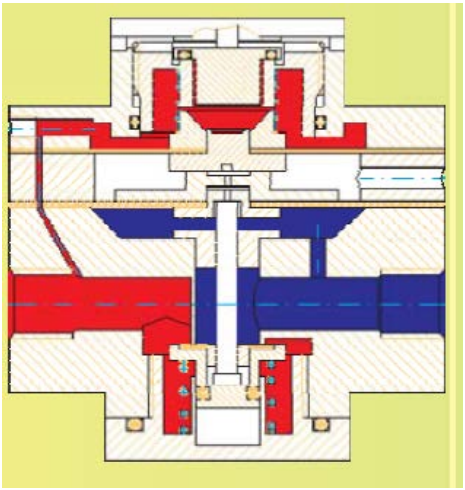

Fig. 8 Section through proportional pneumatic pressure regulator with membrane

Using proportional devices, there has been developed a dental chair and a small table for the equipment, with height adjustment, seatback tilt adjustment and lifting of the table along with the chair. Fig 9.

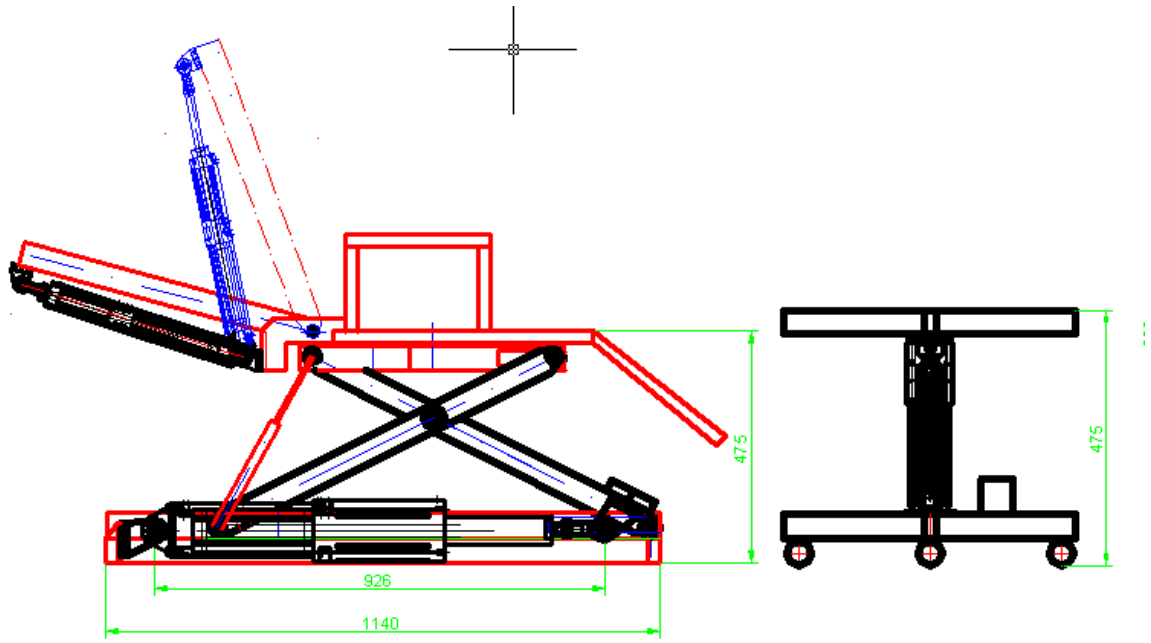

Fig. 9 Dental chair and small table operated by proportional equipment

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