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ACCURACY INCREASE OF POSITIONING OF PNEUMATIK DRIVES FOR MECHANICAL SYSTEMS

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Summary. The pneumatic drives of mechanical systems that made on the basis of controlled valves - amplifiers, possessing improved static and response characteristics are reviewed, increase accuracy of positioning and improvement of its response characteristics are shown.

Key words: a pneumatic drive, valve - amplifier, control, feedback transfer function.

INTRODUCTION

One of priority problems of increase of technical and economic efficiency of mechanical systems is the maintenance of optimum regimes of their drive operation. In a number of areas of industry the pneumatic drives are widely applied, that is explained by simplicity of their construction, reliability and safety, the low cost and ease of maintenance. Therefore one way of the solution of increase of technical and economic efficiency of such systems is the development and research of new effective devices of monitoring pneumatic drives, that can ensure essential positive effect.

In connection with wide usage of microprocessor engineering special digital controllers permitting to realize a wide set of adjusting functions recently are developed [1]. Applying of digital control unit allows adjusting input control influence in the pneumatic actuating device with the purposes of adjusting its characteristic, that predetermines usage of an intermediate element intended for connection of a micro-computer (or any other automatic control system) with the executive pneumatic gear.

The analysis of construction of modern amplifiers of pneumatic automatic control systems demonstrate, that the tendency of usage of membrane pneumatic valves – amplifiers, that being more saving recently is laying down as contrasted to spool-type and, specially by jet-stream and vortex amplifiers, which one due to small leakages of an working medium, have enough fast response time and high throughput capacity. There is a great number different constructions of membrane amplifiers [1], however development and research of pneumatic drive of adjusting bodies of transporting systems with space-saving, fast-response valves - amplifiers working in analogue and discrete modes, is actual till now.

RESEARCH OBJECT

In a considered pneumatic drive the valve - amplifier (fig.1) with position feedback created on the basis of pneumatic [2] and electromagnetic [3] amplifiers with pressure feedback is used.

The amplifier works next way: when feeding puts in channel 3 passes in the chamber of the amplifier flapper-nozzle.

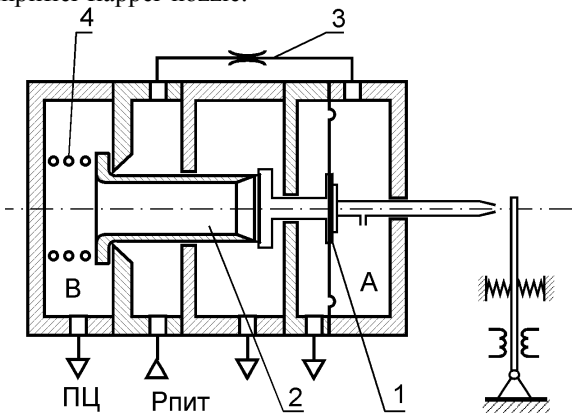

Fig. 1. Valve - amplifier

The valve 2 by spring 4 is pressured to a saddle and there is no pressure in a volume B. While shutter is approaching to the nozzle the pressure in chamber A increases and membrane assembly 1 displaces hollow valve 2, opening an outlet to feeding pressure to the chamber B and, therefore, and one of cavities of a pneumatic cylinder. The pressure in a volume of a pneumatic cylinder will grow until amplifier will standing a new steady position, the valve 2 will land on a saddle and will cut off the feeding pressure chamber from the chamber B.

The pneumatic drive on the basis of such valves - amplifiers is shown on fig.2.

It consists of a pneumatic cylinder 1, two valve - amplifiers 2 and 3, shutter 4, electromechanical converter 5, control unit 6 and feed back sensor 7.

When the nozzle is one of valves works, applying the pressure in one of cavities of a pneumatic cylinder, and the outleting pressure is proportional to a command signal. This drive has "auto braking", as at removal of a command signal (or their simultaneous delivery in both chambers) the valving assembly takes initial position, the outlet to atmosphere is cutoff. There is an equalization of pressure in cavities of a pneumatic cylinder and its braking.

The main element of such drive is the two-stage valve - amplifier with a gain up to 500, which is determined by the ratio of the effective areas of membranes in the chamber of control and hollow valve. The amplifier has a linear static characteristic (on pressure and flow). Due to small weight of mobile parts and practically absence of leakages this valve-amplifier has heightened dynamic characteristics. The experimental researches have shown, that for the valve-amplifier with diameter nominal passage of 4 mm, feeding pressure 0,6 MPa, response time is 0,01c, frequency rate 20 Hz.

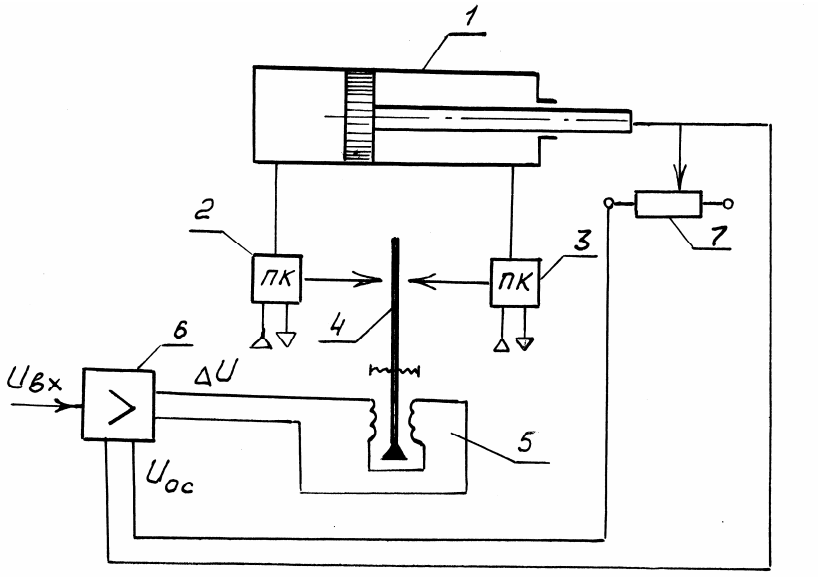

Fig. 2.The pneumatic drive with valves - amplifiers

RESULTS of RESEARCH

For definition of influence of geometrical and energy parameters, and also for numerical research of dynamics of the valve - amplifier the mathematical model based on generally accepted equations was designed. As the result of realization of numerical experiments the approximating model of the valve - amplifier as a transfer function of the second order is developed

$$p,h(t) = \frac{K}{T^2 p^2 + 2T\xi p + 1} \cdot e^{-\tau p}, \tag{1}$$

permitting in rather simple way and with a small error to calculate transient processes, to establish the range of design factor of valves satisfying the conflicting requirements on response, stability and linearity of a static characteristic.

In this expression: p- delivery pressure,
h- replacement of the valve,
K –gain,
T- constant of time,
τ - delay time.

Obtained at a numerical modeling of the valve with nominal passage diameter of 4 mm the cutoff frequency made 24 Hz, that satisfactorily corresponds to the value, obtained from a natural experiment, of 20 Hz [4].

Except two-stage valves in pneumatic drives of adjusting bodies the amplifiers with pneumatic control [1] can be used. A pneumatic control system both analog-digital and digital-to-analog electronic - pneumo and pneumo-electronic converters in this case is indispensable. Any electric moving sensor can be used as feedback sensor. The valves with electromagnetic control [2] are most usable in pneumatic follower actuator. The valves of such a type can be applied as in follower actuator with control from a micro-computer, position pneumatic drives with pulse-amplitude, pulse frequency and pulse-duration modulation, and in relay pneumatic drives (i.e. and drives with digital control).

The proposed pneumatic actuator of the control system of an air flow is offered by turn of blades of the vane on the basis of valves - amplifiers with padding feedbacks on different disturbing effects and new amplifying-conversing device working by a principle of compensation of forces, operational in their members, with improved static and response curves are applied in this work.

The main elements of such a system is the pneumatic positioner (valve - amplifier) working together with an actuator and having negative feedbacks on replacement and, for example, temperature (fig.3)

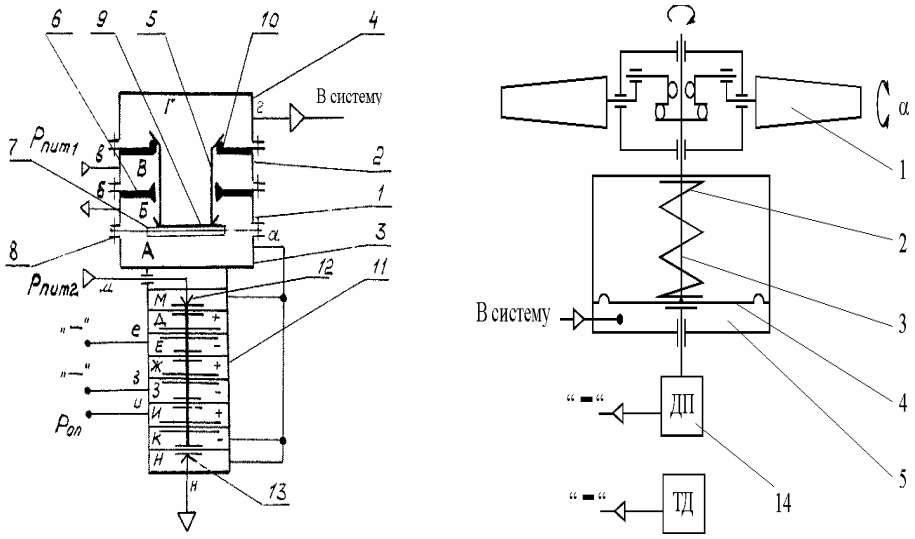

Fig. 3. The membrane rotation gear of blades of the vane and positioner with negative feedbacks onto movement and temperature.

As position sensors the standard devices with a pneumatic output signal of standard range of pressure 0,02 … 0,1 MPa can be used. Feeding pressure of a control unit - 0,14 MPa, positioner - 0,2 … 0,8 MPa, outlet pressure (in a system) - 0,2 … 0,8 MPa. A reference signal is the outlet pressure (control pressure) from the PI-regulator of the control system of temperature - 0,02 … 0,1 MPa.

The control system of the flow of cooling air works next way: when the signal of temperature of heat carrier from the sensor goes in the negative chamber of control element, the equilibrium of membrane assembly is upset also output signal goes in the

chamber A of positioner. The hollow valve 5 rises and feeding pressure from the chamber Г passes in the chamber Г and outlet in the membrane chamber. The diaphragm of the drive rises, overcoming an effort of a spring and through the mechanical device turns blades of the vane, increasing or reducing the flow of cooling air. It will take place until the temperature will not reach the best value determining by a reference signal. The system works similarly at a repositioning of an adjusting body.

The matching of relations of transient processes in systems of drives with production proportional both pi-regulators and tendered system with positioners with padding feedbacks both improved static and dynamic characteristics, has allowed to draw a conclusion, that the quality of transient processes and the dynamic error of regulation decreases,

CONCLUSION

Applying of tendered positioners with padding negative feedbacks on movement, pressure, temperature, power etc., possessing a number of advantages as contrasted to used earlier, namely: by absence of a static error of regulation; by a fast response time, regulator performance; by absence of self-oscillations in a broad band of change of parameters, that is favorable has an effect for durability of drives and results in reduction a dynamic error of regulation on 20 %, transient period on 50%, and increase of accuracy of positioning.

Outgoing from above-stated, it is possible to draw a conclusion, that the reviewed drives on the basis of controlled valves - amplifiers due to high static and response characteristics are perspective for applying in pneumatic drives of mechanical systems.

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ПОВЫШЕНИЕ ТОЧНОСТИ ПОЗИЦИОНИРОВАНИЯ ПНЕВМАТИЧЕСКИХ ПРИВОДОВ МЕХАНИЧЕСКИХ СИСТЕМ

Осенин Ю.И., Ремень В.

Аннотация. Рассмотрены пневматические приводы механических систем, выполненные на базе управляемых клапанов-усилителей, обладающих улучшенными статическими и динамическими характеристиками, что обеспечивает повышение точности позиционирования и экономичности привода.

Ключевые слова: пневматический привод, клапан-усилитель, управление, динамические характеристики.