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MEASURING THE AIR USE OF THE SERVO-PNEUMATIC DRIVE

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Abstract

This paper is about the measuring of servo-pneumatic drive with a view of air use. It is not easy to find a right measuring method to define the air using of servo-pneumatic system, because the air using is not constant.

Keywords: servo-pneumatic, pneumatic system, measurement.

1. Introduction

The positional problem of pneumatic drive has been studied since the end of the 50's. The classical pneumatic systems could stay in accuracy at the two end positions of the pneumatic cylinder. This disadvantage was eliminated by the appearance of the various servovalves and high-speed controllers. In these days the piston can stop at any position between the two end positions with the help of above-mentioned devices.

The servo-pneumatic drive is much faster than the fine mechanical devices (rack and pinion, screw-ball) in the mechatronic systems, so the application of the servo-pneumatic devices in the surface assembling machine the manufacturing process could be faster.

2. System Description [1]

The essential element of the servo-pneumatic system (see: *Fig.1*) is a rodless double acting cylinder (1), the piston of which is connected to a linear potentiometer (2). The potentiometer registers the position of piston at full length of the stroke. There are two servovalves (3), both of them include a servomotor.

The servomotors get their control signs from the PID controller. There is also a computer, which is needed to the working of the servo-pneumatic system.

We can adjust the desired motion of piston through the computer. On the basis of this the PID controller directs the servomotors to open or close the servovalves.

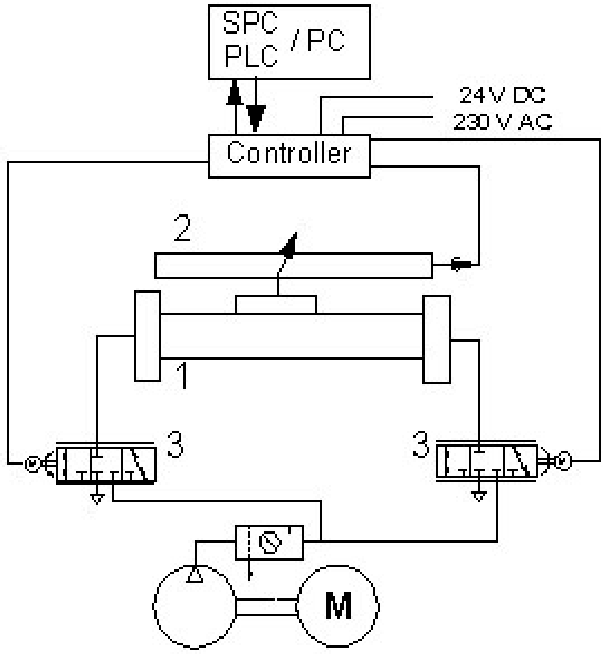

Fig. 1. Hoerbiger Origa servo-pneumatic system

The PID controller makes comparison between data coming from the potentiometer and the desired value; if necessary it directs the appropriate servovalve. We can set the acceleration and velocity of the piston by changing the time-base of the system.

Because of the compression of air the piston of cylinder could be moved, but the PID controller registers the position changing, corrects the difference and restores the piston to the desired position.

The accuracy of the servo-pneumatic system could be set or change with switches on the PID controller. We have possibility to adjust 100 μm for position accuracy. The servo-hydraulic systems are also able to get this accuracy, though it is a not much liked application possibility because of the high pressure and the working medium.

3. Application

We can adjust the maximum acceleration, velocity and the delay of the control for the different load cases. It is possible to set it with the help of the potentiometers in the PID controller. Thus we can bypass the oversweep at the moving of a large mass, but the system dynamics remain good. Since the servo-pneumatic cylinders are used as a part of surface assembling machines, the moved mass either does not change or hardly changes after picking up the useful mass. This system spreads better and better in the drives of manipulators moving little load, because of their easy, fast and flexible programming [2].

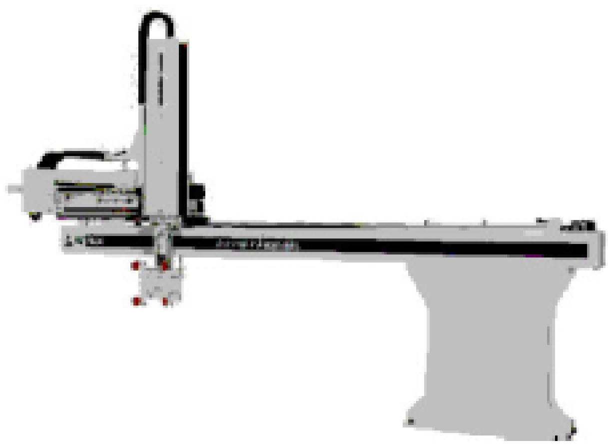

Fig. 2. Manipulator with servo-pneumatic drives

The newest application of servo-pneumatic system is the automation of window cleaning. The huge window surfaces of skyscrapers are very difficult to be cleaned from outside. The pacing-machine with vacuum-gripper/disc was developed and the element of this is the servo-pneumatic cylinder. This machine was spread because of its light mass and dependability.

4. Examination of Servo-pneumatic System

Because the servo-pneumatic systems begin to be widely used, it is necessary to examine this system comprehensively. There are many kinds of viewpoints to examine this system. First of all we are interested in using of energy of this system.

The energy using of the servo-pneumatic system consists of two parts. The first one is the electrical energy using which operates the PC, the PID controller and the servovalves. The other one is the compressed air using.

Air using might be traced back to electrical energy using, because the compressed air is made by electrical energy. The energy using of the valves, controller and computer is negligible compared to the energy used for the compressor.

Thus we only examine the compressed air using.

4.1. Measuring of Air Using [3]

There is a rodless double acting cylinder in the servo-pneumatic system. At the classical double acting cylinder one of two sides of the piston is under pressure. But at the servo-pneumatic cylinder both sides of the piston are under pressure during finding and staying in its position.

Changing position one of the sides is exhausting, the compressed air departs to the environment.

This system might be fast, so the position changing occurs many times, this means that the compressed air using will be much.

Measurements were done to determine the quantity of the used compressed air. A manufacturing process was simulated, where three kinds of workpieces were moved to their right position by the servo-pneumatic cylinder. These workpieces are on a common conveyor, so that means three different length ways of moving. These distances are as follows:

1. from 0 to 160 mm (1–2 section)
2. from 0 to 320 mm (1–3 section)
3. from 0 to 480 mm (1–4 section)

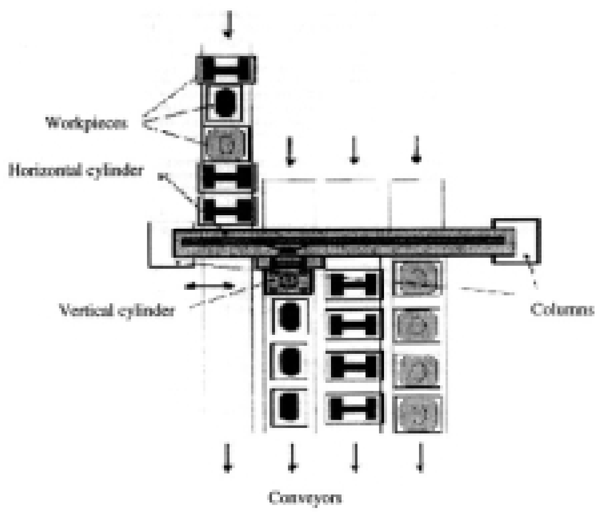

Fig. 3. Simulated manufacturing process

The piston waits three seconds at each position while the another cylinder grips and drops, holds up and lays down the workpiece with the help of the gripper of the pneumatic device.

4.2. Theory of Measurement

The course of measurement is as follows: the pressure of the compressor is measured, the discharging air is calculated. We could write the two states of compressed air of the tank:

$$p_1 V = \frac{m_1}{M} R T_1 \tag{1}$$

and

$$p_2 V = \frac{m_2}{M} R T_2. \tag{2}$$

The changing of temperature might be ignored, if we deflate a little part of air contents of the tank. The temperature changes but it will be restored in a few moments. During this process the pressure does not change considerably. We can take it as an isothermal process. This is:

$$T = T_1 = T_2. \tag{3}$$

Eq. (2) subtracted from *Eq.* (1) and reduced to the discharging air, we get:

$$p_0 V_0 = \frac{m_1 - m_2}{M} R T = (p_1 - p_2) V, \tag{4}$$

from this V_0 is:

$$V_0 = \frac{p_1 - p_2}{p_0} V, \tag{5}$$

where

V_0	:	the volume of used air (m^3)
V	:	the volume of tank (m^3)
p_0	:	atmospherical pressure (1.013 bar)
$p_1 - p_2$	:	the changing of pressure in the tank (bar)

The changable parameters in the measurement unit were as follows:

- working pressure,
- position of the cylinder: vertical or horizontal,
- moved mass.

4.3. Process of Measurement

The measurement was performed between discrete pressure values (from 6 bar to 5 bar), so the periodical sign was needed for the agitation of a piston. In our case this sign is the square-sign. The program counts the number of periods while the pressure in the tank decreases from 6 bar to 5 bar. After this we calculate the value of V_0, then we divide it with the number of periods.

The results of measurements are shown against the different masses, sections, the real value of pressure in the cylinder, as well as the position of the cylinder.

The results support our previous expectations (*Table* 1).

Table 1. Results of measurement

Load (kg)	Air using L (l/period)											
	Cylinder position											
	Horizontal						Vertical					
	Pressure											
	$p = 2.5$ bar			$p = 4$ bar			$p = 2.5$ bar			$p = 4$ bar		
	Positions											
	1.–2.	1.–3.	1.–4.	1.–2.	1.–3.	1.–4.	1.–2.	1.–3.	1.–4.	1.–2.	1.–3.	1.–4.
0	1.23	2.26	2.92	2.38	3.17	3.85	1.52	2.31	2.98	2.54	3.88	4.95
2.8	1.5	2.57	3.38	2.59	3.2	3.89	1.61	2.53	3.11	2.79	4.18	5.73
5.6	1.67	2.76	3.42	2.62	3.22	3.91	1.76	2.83	3.87	2.88	4.34	5.79
8.4	1.72	3.01	3.79	2.65	3.24	3.93	1.89	3.04	4.26	2.98	4.48	5.85
11.2	2.01	3.3	3.97	2.88	3.52	4.31	–	–	–	3.11	4.55	6.15
14	2.04	3.36	4.06	2.91	3.55	4.34	–	–	–	3.27	4.76	6.22

5. Conclusions

Air using depends on the loads. At the different sections the air using is changing.

At smaller pressure the air using is also smaller.

At the vertical position of the cylinder the compressed air using is bigger than at the horizontal position of the cylinder during finding and staying its position.

It is possible that the servo-pneumatic system uses more compressed air than the classical pneumatic system doing the same exercise. We need to perform further measurements to verify this statement.

References

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