Innovative Systems for Incremental Positioning in Pneumatics

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Abstract: *The paper presents the structure and functioning of two pneumatic linear incremental positioning systems and the experimental models designed and built in order to determine their performances.*

Keywords: *pneumatics, incremental positioning, positioning accuracy*

1. Introduction

More and more pneumatic applications require the accurate positioning of the actuated load in certain points of the working stroke. The number of stop points is very important when solving this problem. If the number of stop points increases, the accurate positioning is more difficult to obtain. There are efforts to build some special motors, but the results are not widely used.
It is well known that the accurate positioning of the pneumatically actuated load can be done only in two points of the working stroke: the stroke ends or intermediate positions within the stroke, materialized by mechanical stoppers. Without stoppers, it is difficult to control the stopping of the load in any point within the stroke due to air compressibility [1].
If the number of stop points is limited it is possible to design different actuating systems to accomplish the task. A number of such systems are presented in [2].

2. Proposed positioning systems

Two pneumatic linear incremental positioning systems are further presented.
The first pneumatic linear incremental positioning system is based on the principle scheme presented in [3]. In order to build an experimental model, four commercial dosing cylinders where used. Figure 1 shows the functioning scheme of the system.

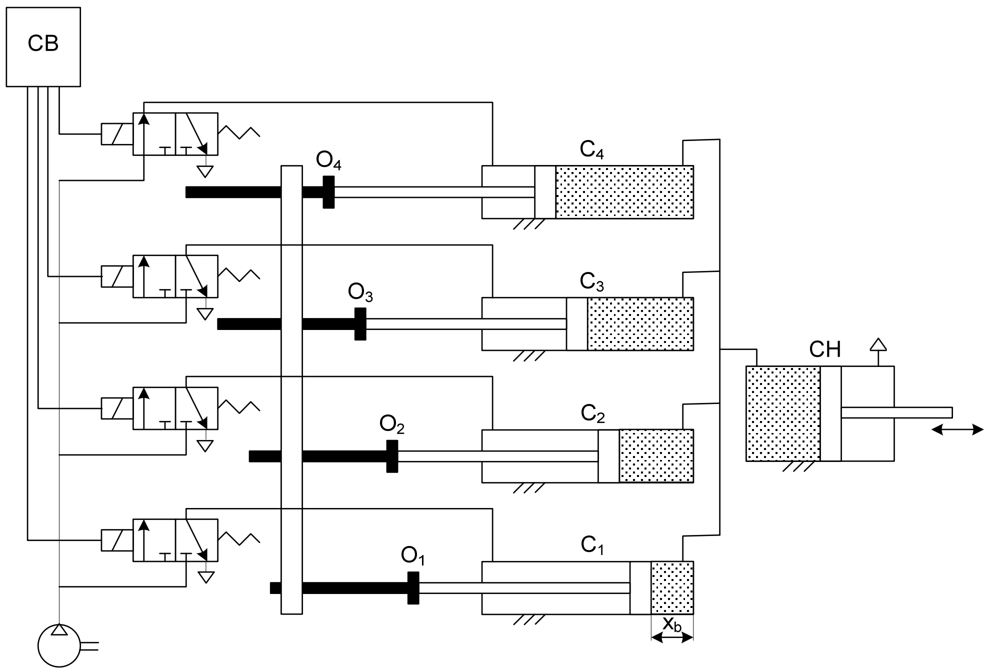

Fig. 1. The functioning scheme of the pneumatic linear incremental positioning system

Based on the scheme in figure 1 and imposing the design parameters, the composing elements of the system (way valves, dosing cylinders, main cylinder, connecting circuits) were dimensioned. The 3D model was designed and the experimental model shown in figure 2 was built.

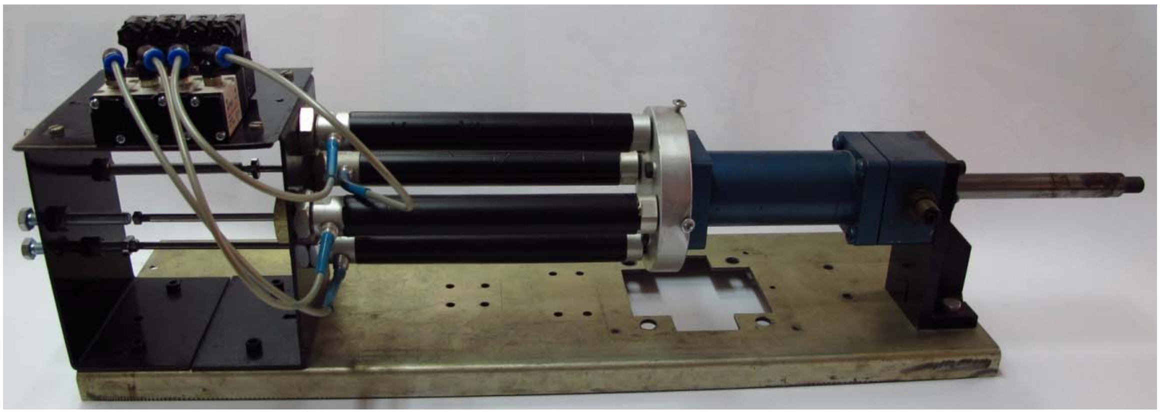

Fig. 2. A view of the experimental model of the pneumatic linear incremental positioning system

The axial positions of the stoppers O_1, O_2, O_3 and O_4 must be properly adjusted in order to limit the active strokes of the cylinders to the values:

$$\begin{cases} x_1 = 2^0 \cdot x_b \\ x_2 = 2^1 \cdot x_b \\ x_3 = 2^2 \cdot x_b \\ x_4 = 2^3 \cdot x_b \end{cases} \tag{1}$$

If the value of the step has to be changed, a new adjustment must be done, respecting the conditions (1).
The control of system can be performed by various methods: a PC with a data acquisition board and an adapting electronic circuit, a programmable automaton or a microcontroller.
The experimental model tested in the Control and Robotics Laboratory of the Mechatronics and Precision Mechanics Department was controlled using a PC and an interface based on dedicated I/O Field Point modules. The working program was developed using the LabView software.
The performed tests showed that the positioning accuracy highly depends on the machining accuracy of the mechanical structure and on the way the volumes V_1, V_2, V_3, V_4, and V and the connecting circuits are filled with oil.
The main advantage of the system is the possibility to adjust the step increment Δ.
The second system is a pneumatic linear incremental positioning system using a pneumatic step by step turning motor [3,4] and a screw and nut mechanism to transform the rotation in translation movement.
The linear step x_p depends on the angular step of the motor φ_p and on the pitch p of the screw:

$$x_p = p \cdot \varphi_p / 360^0 \tag{2}$$

Equation (2) shows that the positioning accuracy is better as the pitch of the screw is smaller.
The average moving speed is lower because the maximum working speed of the motor is limited.
The elements of the system structure - motor, screw and nut mechanism, guiding, coupling - have direct influence upon the positioning accuracy, repeatability and maximum speed.
The main characteristics of the system are:

- linear increment lower than 1 mm;
- high positioning accuracy;
- average moving speed;
- medium or short strokes (lower than 1000 mm);
- high reliability.

Figure 3 shows the experimental model of the system, with the following structure: the pneumatic step by step rotational motor 1, the coupling 2, the mobile slide 3, the screw 4, the guiding 5, the body 6, the control panel 7, the electronic block 8 and the air supply 9.

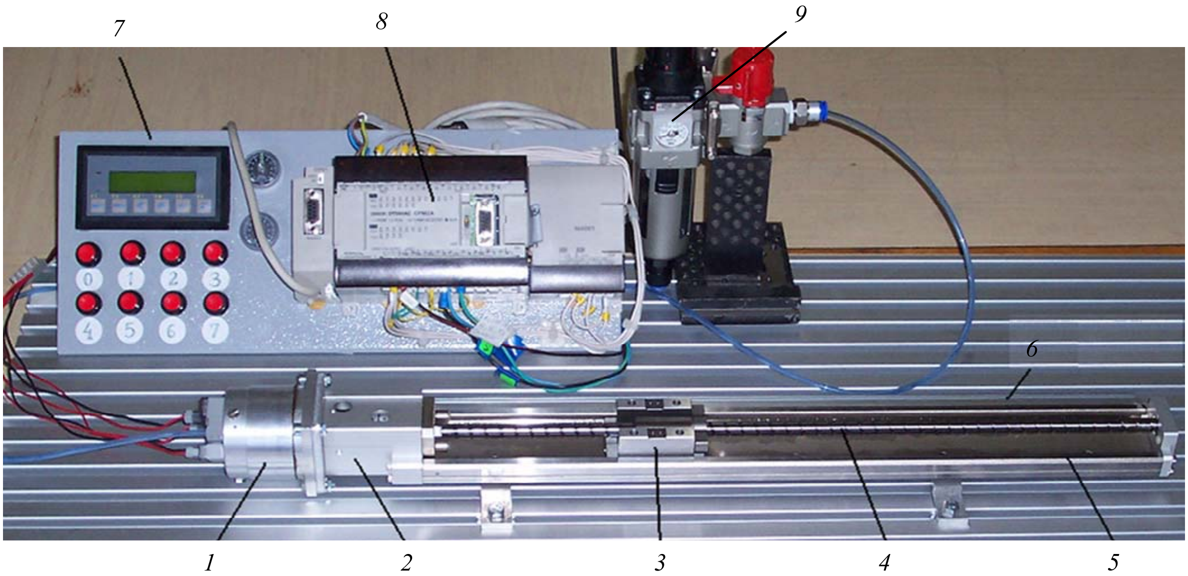

Fig. 3. A view of the experimental model of the pneumatic linear incremental positioning system using a pneumatic step by step rotational motor

The following steps were necessary in order to build the experimental model:

- designing and machining of the pneumatic step by step turning motor;
- choosing the mechanical components (screw and nut, guidings etc.) and also the pneumatic and electric components;
- building the mechanic subassembly;
- making the electric and pneumatic connections.

Figure 4 shows a longitudinal section through the pneumatic step by step turning motor. The motor has the following characteristics:

- it is a three phased motor, with six pistons/pegs 4 diametrically opposed, that are simultaneously supplied through some circuits machined in the lid 8, in order to double the couple of the motor; the axial and unilateral placement of the pistons/pegs was chosen in order to minimize the size of the motor;

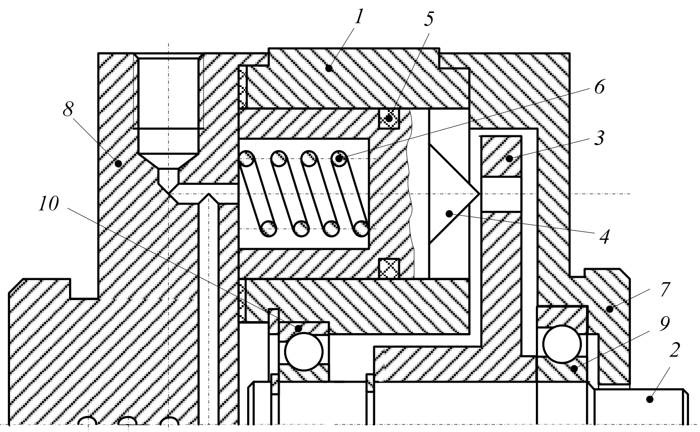

Fig. 4. A longitudinal section through the pneumatic step by step rotational motor

- 16 holes are machined on the frontal surface of the disc 3; they are calibrated and equidistant, resulting an angular step of 7.5^{o};

- the rotor, consisting of the disc 3 and the shaft 2, can rotate against the stator due to the ball bearings 9 and 10;
- the stator consists of the lids 7 and 8 and the intermediate body 1.

The motor has a compact structure, with the three way valves mounted directly on the distribution plate; this way the working frequency was increased by reducing the length of the signal lines and the dead volumes.
The screw and nut mechanism is of the type LTF6 produced by SMC.
A programmable controller type CPM2A-30 produced by OMRON was used to control the system.

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