SPEED AND POSITION CONTROL USING PNEUMO-HYDRAULIC MOTORS

Constantin Bucșan¹, Mihai Avram², Stelian Toma³
¹,²,³ “Politehnica” University of Bucharest, 313 Spl. Independentei, sector 6, Bucharest
mavram02@yahoo.com

Abstract: The paper presents the functional principles of pneuomo-hydraulic motors and some examples of such motors are given. Two variants of pneuomo-hydraulic motors developed by the authors are also presented.

Keywords: pneuomo-hydraulic motor, displacement transducer.

1. Introduction

Many industrial applications require high positioning accuracy of the actuated load in various points of the stroke. A high positioning accuracy primarily depends on the possibility to control the speed of the actuated load, as an accurate stop requires a low speed in the proximity of the stop point.

It is well known that the pneumatic actuating systems, even though very used, have a limited applicability domain, because of the difficulties in obtaining a rigorous control of the pneumatic power. A rigorous control of the flow and implicit of the actuated load speed it is not possible in pneumatics.

This impediment can be overdrawn by using some hydraulic control systems in the structure of the motor of the actuating system, known as a pneuomo-hydraulic motor. Figure 1 shows the principle scheme of such a motor.

The hydraulic cylinder CH is used for the control of the pneumatic cylinder CP. The feeding system of the hydraulic cylinder is separated from the feeding system of the pneumatic cylinder. The two cylinders can be different or they can be machined in one block, also containing the necessary circuits.

The input ports of the hydraulic cylinder CH are connected together; a small oil tank is connected to this circuit in order to compensate the volume variations caused by the presence of the rod in only one active chamber of the motor and also by the thermal volume variations of the fluid. The only condition for the hydraulic cylinder is to have a stroke at least equal to the stroke of the pneumatic cylinder. If necessary the hydraulic cylinder may have a smaller diameter than the pneumatic cylinder. The hydraulic cylinder functioning is similar to an oil damper functioning, acting as a brake for the pneumatic cylinder. In order to control the speed, two valves are introduced in the hydraulic system, one for each moving direction.

Figures 2 shows two ways of mounting the compensating element EC within the hydraulic circuit.

The elements needed for the control of the speed are also present. The maximum speed is obtained when the distributor D is actuated and the oil travels from one chamber of the hydraulic cylinder to the other through a circuit with a minimum hydraulic resistance. In order to control the speeds \( v_1 \) and \( v_2 \) the flow through the distributor is interrupted; the control of the speed \( v_1 \) is carried out by the distributor DC1 and the control of the speed \( v_2 \) is carried out independently by the distributor DC2.

More complex mechanical systems may be used: the two cylinders have the same stroke and the coupling and uncoupling of their rods is done when needed using some ratchet mechanisms. In order to firmly stop the mobile assembly of the unit, a 2/2
The Romanian Review Precision Mechanics, Optics & Mechatronics, 2012, No. 41

The hydraulic cylinders of a pneumo-hydraulic unit may be coupled in series or in parallel.

2. Examples of pneumo-hydraulic motors

Some pneumo-hydraulic motors made by Specken-drumag are further presented as examples.

Figure 3 shows a motor integrating a hydraulic cylinder which may be controlled in more ways:

- with $v_1$ controlled by the valve $DC_1$ and $v_2$ constant, having the maximum value (Figure 4, a);
- with $v_1$ constant, having the maximum value and $v_2$ controlled by the valve $DC_1$ (Figure 4, b);
- with $v_1$ controlled by the valve $DC_1$ and $v_2$ controlled by the valve $DC_2$ (Figure 4, c);
- with $v_1$ constant, having the maximum value and $v_2$ controlled, with the possibility to stop within the stroke when the distributor $D_1$ is actuated (Figure 4, e);
- with $v_1$ constant, having the maximum value and $v_2$ controlled when the distributor $D_1$ is actuated, with the possibility to choose the maximum speed (Figure 4, f);
- with $v_1$ constant, having the maximum value and $v_2$ controlled when the distributor $D_1$ is actuated, with the possibility to stop within the stroke when the distributors $D_1$ and $D_2$ are not actuated, and with the possibility to stop within the stroke when the distributor $D_2$ is actuated (Figure 4, g).

Figure 2: Two ways of mounting the compensating element EC

Figure 3: a pneumatic motor integrating a hydraulic cylinder
Speed and Position Control using Pneumo-Hydraulic Motors

Figure 4: Some ways to control the hydraulic cylinder

Figure 5 shows a rotary pneumo-hydraulic motor. The piston diameter may be 50, 63, 80 or 100 mm and the maximum rotation angle is 180°.

Figure 5: a rotary pneumo-hydraulic motor

Figure 6 shows the functioning schemes for two variants of such a motor. The alternating translation movement of the linear pneumo-hydraulic motor MPHL is transformed to an alternating rotation movement using a rack-and-pinion mechanism. In the first case (Figure 6,a), the angular speeds $\omega_1$ and $\omega_2$ may be controlled using the valves $DC_1$ and $DC_2$ respectively.

In the second case (Figure 6,b), two one-way valves, pneumatically controlled and relievable $S_1$ and $S_2$ are mounted within the hydraulic circuit.

When the command signals $x_1$ and $x_2$ are not applied, the valves are closed and the hydraulic circuit is blocked, allowing stopping the actuated load in any point within the stroke and maintaining this position. The positioning accuracy in both directions is better than $\pm 2°$, depending on the load, the speed and the size of the motor.

Figure 6: the functioning schemes for two variants of the motor

3. Variants of pneumo-hydraulic motors

Two variants of pneumo-hydraulic motors developed by the authors are further presented.

Figure 7 shows the functional scheme for the first variant. This pneumo-hydraulic motor has the following characteristics:
- the pneumatic motor $CP$ and the hydraulic motor $CH$ are mounted in parallel, they have identical dimensions and their bilateral rods are connected by fasteners at both ends; this way the chambers $C_1$ and $C_2$ of the hydraulic cylinder have equal areas and a compensating element is not needed;
- the position control is achieved by using a hydraulic circuit in which a proportional hydraulic distributor has the ports connected so that it acts as a proportional valve;
- the position of the mobile assembly is measured by a displacement transducer $Tp$.
Figure 7: The functional scheme for the first variant

Figure 8 shows a 3D drawing of the system generated using SolidWorks. The components of the system are mounted on the base plate PB.

Figure 9 shows a view of the built experimental model.

In the case of the second variant (figure 10) [2], two one-way valves, pneumatically controlled and releivable SPC₁ and SPC₂ are mounted within the hydraulic circuit in order to control the speed of the mobile assembly in both directions; such a valve allows the flow of the fluid through the nominal area in one way and in the opposite way the flow is possible only if a command signal occurs; the flowing area is proportional with the command signal and so the flow rate through the hydraulic control circuit is controlled, respectively the speed of the actuated load is controlled.

Figure 11 shows a 3D drawing of the system generated using SolidWorks.

Figure 12 shows a view of the built experimental model.
4. Conclusions

The experimental data confirmed that it is possible to obtain a rigorous control of the flow and implicit of the actuated load speed and also a high accuracy in the case of a pneumatic actuator by using some hydraulic control systems in the structure of the pneumatic motor of the actuating system.

5. Bibliography


