THE MODELING AND SIMULATION OF THE PNEUMATIC INSTALLATIONS

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In cadrul acestei lucrări sunt prezentate rezultatele cercetărilor întreprinse în cadrul unui contract de colaborare privind instalațiile de impregnare folosite în industria textilă. Modelele prezentate corespund instalației realizate şi acceptate de către beneficiar. Pentru studiul comportării dinamice s-au folosit diferite programe de simulare.

This paper presents the results of the researches carried out as part of a collaboration contract regarding the impregnation installations used in the textile industry. The presented models correspond to the installation accomplished and accepted by the beneficiary. Various simulation programs were used for the study of dynamic behavior.

Keywords: pneumatic installations, textile industry, simulation

1. Introduction

The 3D textile cord is intended to seal up the connecting elements from industrial installations, such as: pumps, armatures, blenders, filtering systems [1]. The integrated technologic system of producing the 3D textile ecologic sealing cord for industrial uses is made up of the following systems:

System I: impregnating, thermosetting, winding - textile yarn;

System II: braiding, plying – 3D textile cord;

System III: impregnating, thermosetting, formatting, rolling – 3D textile cord.

The modulus of impregnating the textile yarn belonging to System I plays the role of ensuring the adequate soaking of the textile yarns with substances that should improve the mechanical, thermal, antifriction and sealing properties of these.

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Within System II, the modulus of impregnating the 3D textile cord is needed to ensure the adequate soaking of the 3D braided cord with PTFE emulsion in order to improve the assessed properties.

The impregnating of the yarn/cord is done in vats indirectly heated with thermal oil, the displacement of these by a 300 mm stroke being needed.

2. The presenting of the drive pneumatic diagram

The vat drive installation has the basic pneumatic diagram given in fig. 1.

By operating tap 1DM, one can effect the connecting and disconnecting of

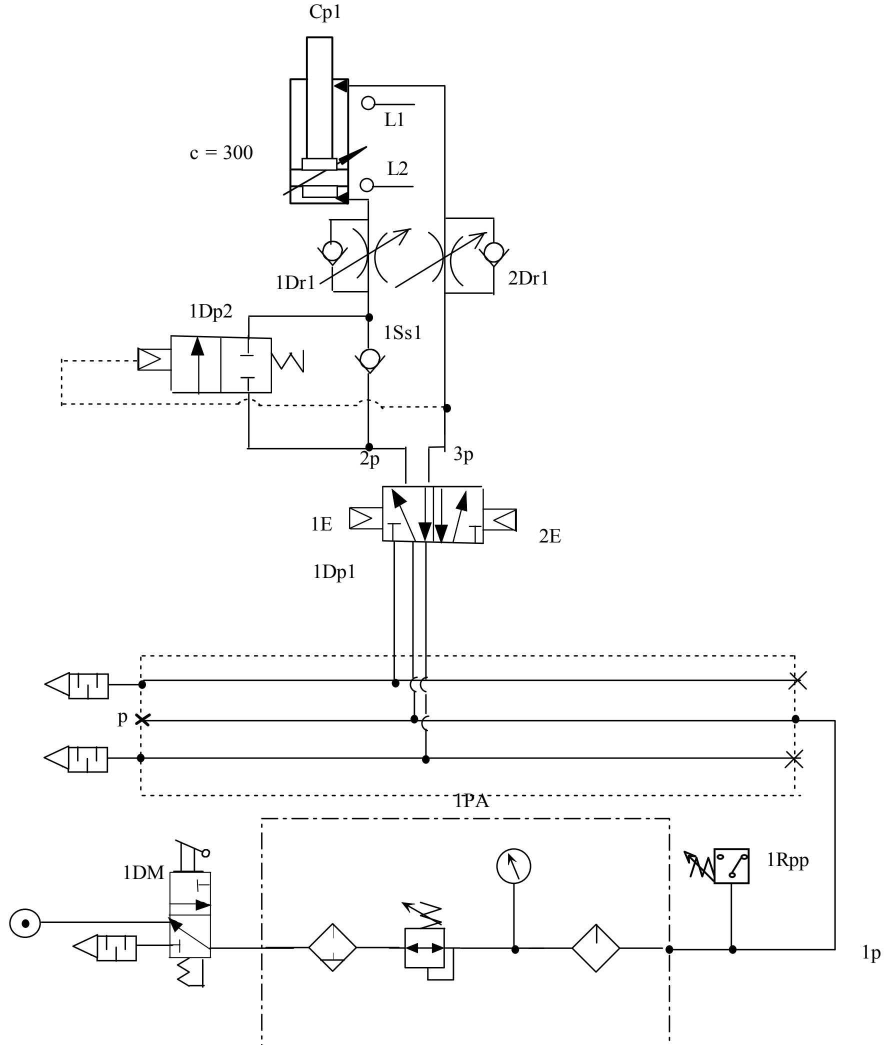

Fig. 1. The basic pneumatic diagram.

the installation to and from the air supply: network or compressor [2]. The air preparing assembly 1PA ensures [3]:

- the air filtering for solid foreign substances;
- the eliminating of water from air;
- the introducing of small oil quantities into the circuit for rubbing diminishing;
- the work pressure adjusting.

The outlet of the preparing assembly coincides with the supply of distributor 1Dp1. This can alternatively send air under pressure to the two active chambers of the linear pneumatic motor Cp1.

The electromagnet 1E is supplied with 24 Vcc tension for lifting the vat. The distributor reaches the position given in figure 1. The air reaches throttle 1Dr1 through distributor and direction valve Ss1, opening the included direction valve. The air under pressure gets into the lower chamber of motor Cp1. The air in the upper chamber is exhausted through throttle 2Sr1 and distributor. Due to the air tripping through throttle 2Dr1, the rising speed is adjustable [4], [5]. The rising goes on until the stroke end is confirmed by arrester L1.

The electromagnet 2E is supplied with 24 Vcc tension for the valve lowering. The distributor reaches the second position. The air gets into the upper chamber of motor Cp1 through the distributor and the direction valve of throttle 2Dr1. The existing pressure drives, according to the given dotted circuit, distributor 1Dp2 keeping it open [6]. The air from the lower chamber is exhausted through throttle 1Dr1 and distributors 1Dp2 and 1Dp1. Owing to the air passing through throttle 1Dr1, the descending speed is adjustable. The descending goes on until the trip end is confirmed by arrester L2.

The linear pneumatic motor 1Cp1 is endowed with brake systems at the stroke ends [7], [8].

Before procuring the needed pneumatic equipment, it was considered that, for verifying the suggested solution, one should resort to simulate the system on the computer.

3. The mathematical simulation of the linear pneumatic motor

The differential equation that is specific to the force balance for motor Cp1 in figure 1 is [2], [9]:

$$M\frac{dv}{dt} + cv + F_f(p) + F_R = pS_1 \tag{1}$$

In the relation (1), it was noted: M [kg] – displaced mass; v [m/s] – instantaneous speed; c [N/(m/s)] – damping coefficient; $F_f(p)$ [N]– sum of friction forces (they depend on p); F_R [N]– resistance force; p [N/m^2] – instantaneous pressure.

For the same moving sense, one can write:

$$Q(p) = S_1 v + ap + \frac{V_M}{E(p)}\frac{dp}{dt} \tag{2}$$

The relation (2) represents the distribution of the discharge under instantaneous pressure p: $Q(p)$ [m^3/s] – supply discharge under pressure p; a [(m^3/s)/(N/m^2)] – discharge loss coefficient; V_M [m^3] – air average volume from the chamber left to the cylinder; $E(p)$ [N/m^2] – the modulus of air elasticity under pressure p.

Equations (1) and (2) are the mathematical model in the dynamic regime of a cylinder without counter pressure on return.

The real behavior of the cylinder also depends on its working mode. Thus, the system is considered as in figure 2 [10], [11].

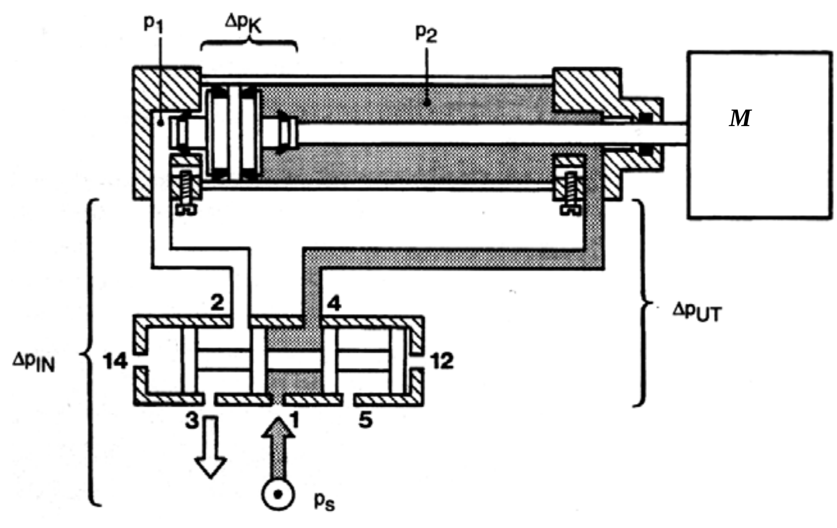

Fig. 2. The considered system.

In the position given in the figure, the piston is kept withdrawn by pressure p_2 (in the connection 1 – 4 from the distributor). Initially, the chamber on the left is under pressure p_1 that is equal to the atmospheric one (on connection 2 – 3). In changing the distributor state (1 – 2 and 4 – 5) pressure p_1 increases and pressure

p_2 decreases. Initially, p_1 increases over the value needed for the load moving at constant speed, after that coming back to an approximately constant value. For this period the equation $\Delta p_k = p_1 - p_2 \approx$ ct. is defined.

At the same time with starting the brake, p_1 and p_2 increase. At the stroke end, p_1 reaches the maximum value, and p_2 becomes equal to the atmospheric pressure.

Figure 3 presents the pressure evolution.

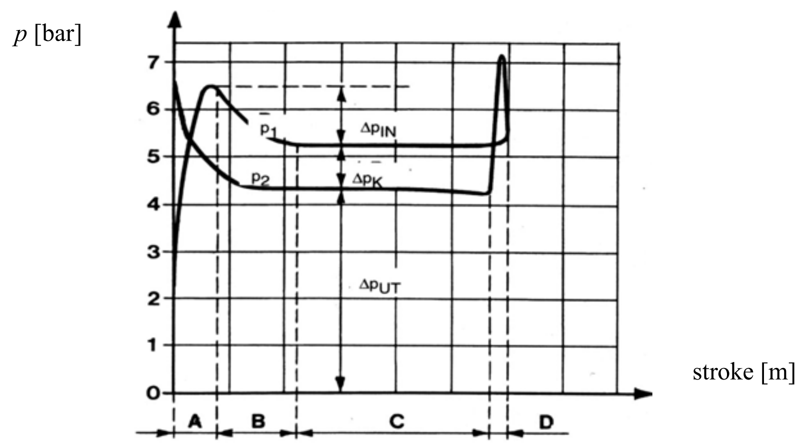

Fig. 3. The pressure evolution.

It was noted:

A – the accelerating zone;

B – the decreasing of pressure p_1 at the value needed for moving with constant speed;

C – the portion of moving with constant speed;

D – brake zone;

Δp_{IN} is the pressure peak and Δp_{UT} is the pressure difference on return.

Depending on the way of component part assembling, load and apparatus type, the final speed v_F behaves during the stroke effecting as in figure 4.

The percentage stroke is considered the abscissa, (c/c_{max}) and speed as the ordinate. The damping of the system can be seen on curves a, b or c. The curve a is for $\xi = 1$, curve b for $0 < \xi < 1$ and curve c for $\xi > 1$, where ξ is the damping coefficient.

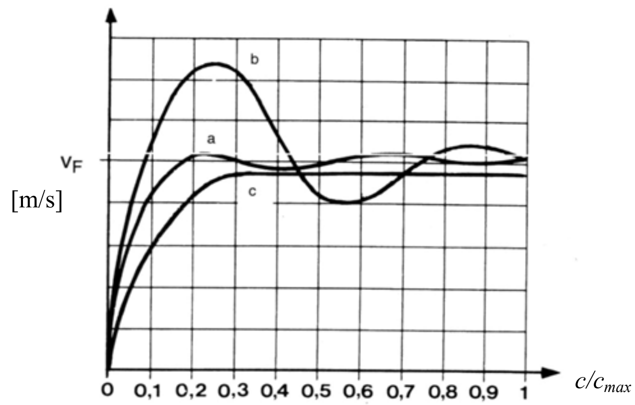

Fig. 4. The final speed v_F.

4. Computer aided simulation. Obtained results

One of the newest systems of designing and testing was used for the pneumatic systems.

The pneumatic diagram has to be redrawn, for obtaining the results, according to a specific "stencil". The pneumatic diagram that is thus drawn, together with the electric diagram, are given in figure 5.

It can be noticed that, the only difference, as compared to the basic diagram, is the fact that, in reality, sense valve 1Ss1 is incorporated into distributor 1Dp2.

After elaborating the diagram, for each apparatus, there are recorded the catalogue characteristics according to requirements [10], [11].

The simulation offers the possibility of motion visualizing on each phase, as well as the establishing of the static and dynamic characteristics.

For ascending distributor 1Dp1 is operated as in figure 6. By means of distributor 1Dp2 and sense valve of throttle 1Dr1 the air, under the pressure adjusted by the controller, reaches the inner face of the cylinder that it starts to push up. The rising speed is adjusted, even during functioning, with throttle 2Dr1.

There exists the possibility of simultaneous studying and visualizing several exists. Figure 7 presents: speed, stroke and pressure.

In the descending phase, the measures of interest develop as in figure 8.

The life safety measures are considered as being very important [2], [6]. That is why, the getting out of order of the installation was simulated. There is the risk that, for whatever reason, the pressure source would no longer supply compressed air. In this case, if the vat is in an upper position, there is the risk that

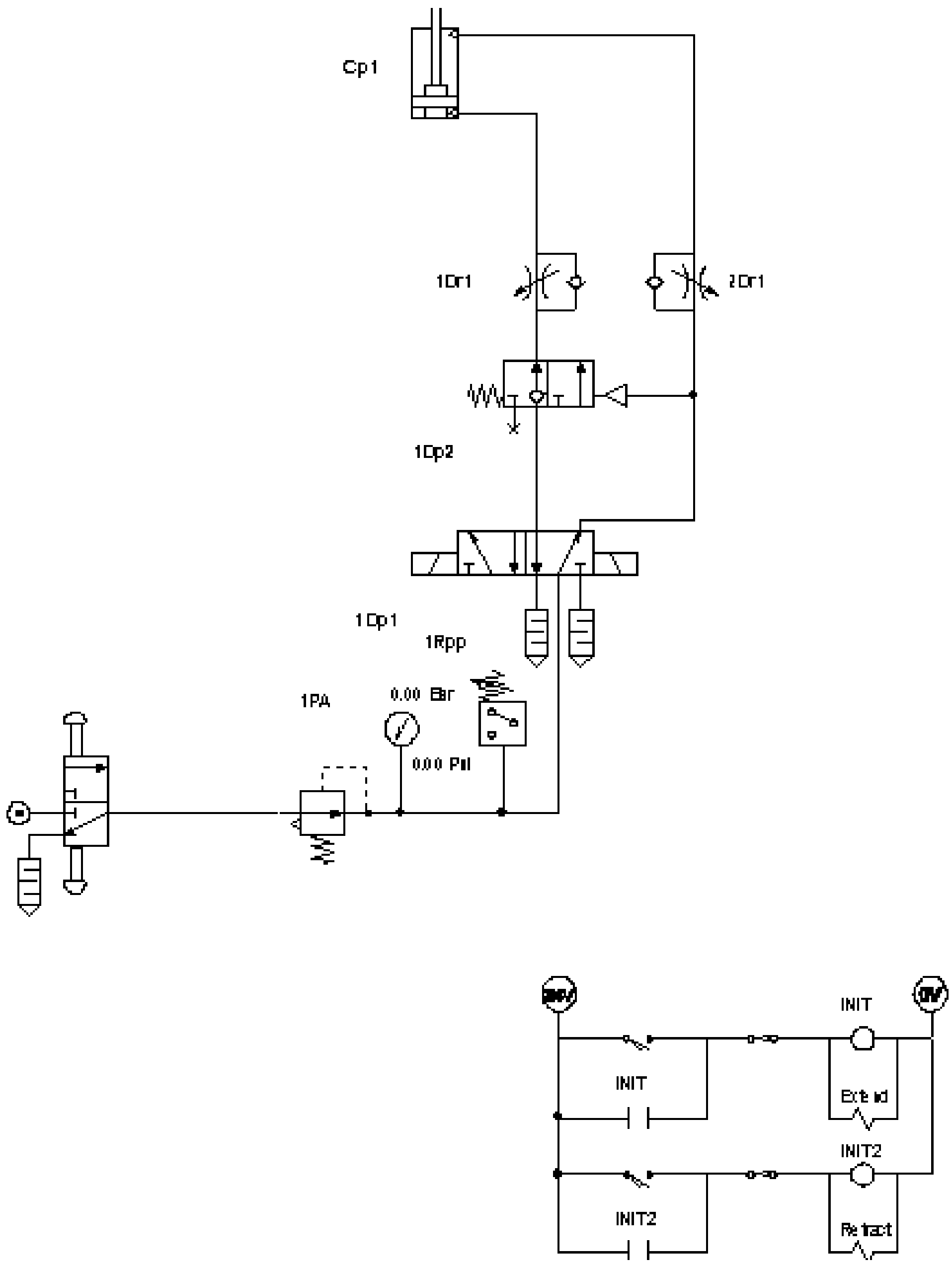

Fig. 5. The pneumatic with
the electric diagram.

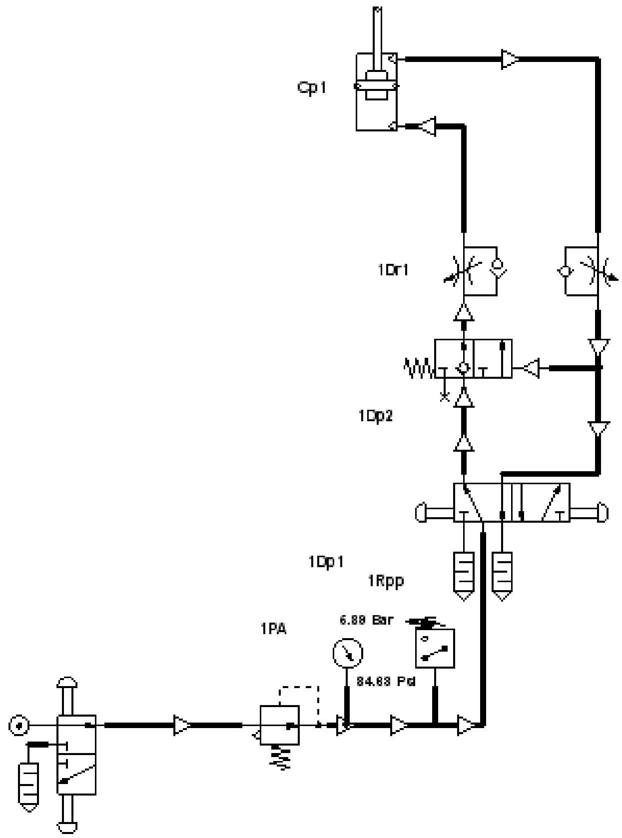

Fig. 6. The ascending phase.

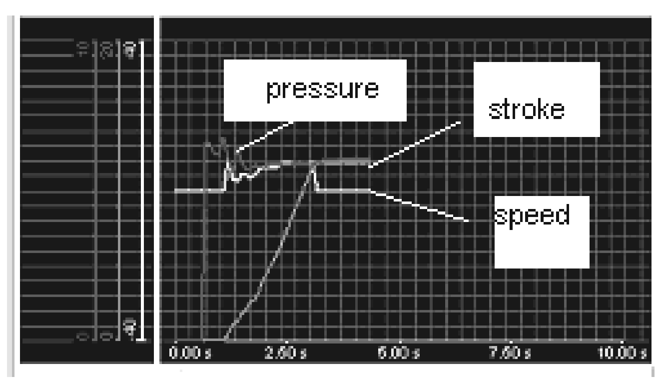

Fig. 7. Speed, stroke and pressure for the ascending phase.

it could fall under the action of its own weight. For this situation, there was foreseen the pneumatically actuated distributor 1Dp2. Figure 9 shows the results of simulating this situation.

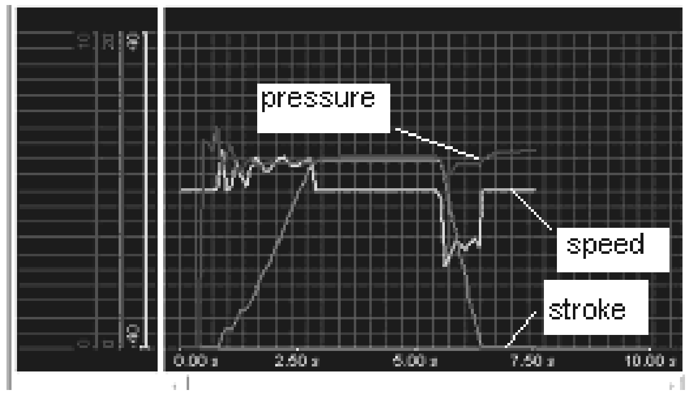

Fig. 8. Speed, stroke and pressure for the descending phase.

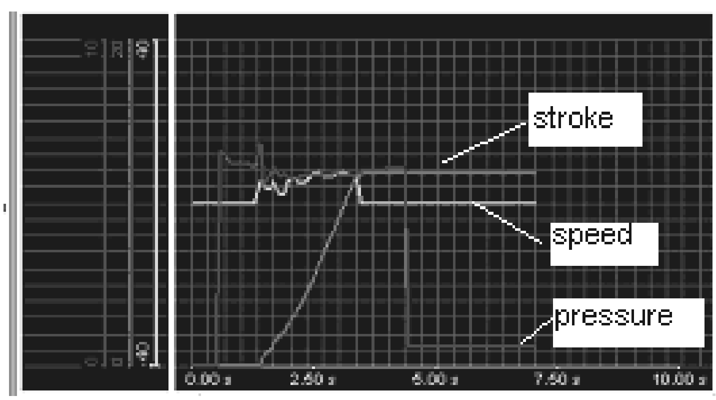

Fig. 9. Speed, stroke and pressure for the getting out of order situation.

One can see that the speed is null, the stroke does not change its value and pressure decreases to zero. Therefore the safety system functions and ensures the vat blocking in the upper position, by mechanical elements.

For all the above simulations, it was considered that the throttles were adjusted to a value of 50% of the maximum one [2], [12]. The throttles are completely opened for verifying the maximum speeds in ascending, as well as descending, respectively.

5. Conclusions

The modeling and simulating of pneumatic installations are modern methods, which are used for dimensioning or verifying the employed components. The mathematical models, in a dynamic mode, represent, or don't represent, systems of linear differential equations. After establishing the type of entry measures, there are had in view the exits that represent interest in the case of the studied system. In the case of impregnation vats, the measures of interest are: stroke, speed and pressure. The simulating of the system behavior allows the achieving of certain corrections ever since the designing phase, a fact that reduces the expenses and time taken by the testing and homologating phases.

The pneumatic installation for actuating the impregnating vats was experimentally accomplished, tested and homologated as part of the research contract effected within partnership by the University "Politehnica" of Bucharest and the Research – Development National Institute for Textile and Leather.

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