Proceedings of the 15th International Conference on Manufacturing Systems – ICMaS
Published by Editura Academiei Române, ISSN 1842-3183

"Politehnica" University of Bucharest, Machine and Manufacturing Systems Department
Bucharest, Romania, 26–27 October, 2006

REFABRICATION OF THE PNEUMATIC INSTALLATION OF THE AGGREGATE MACHINE – TOOLS

Anca BUCUREŞTEANU, Mircea DUCA

Abstract: *The paperwork hereby presents the results of the authors' theoretical and experimental research developed when designing and manufacturing a special drilling machine intended for the machining of parts specific to the automotive industry.*

Key words: *refabrication, pneumatic installation, aggregate machine-tools, drilling machine.*

1. INTRODUCTION

Refabrication and reconfiguration of the Machine Tools represent modern solutions widely applied by specialized companies in Europe and USA. Until 1990, Romania had been among the first ten countries producing machine-tools, mainly heavy machine-tools and special machine-tools and aggregates, as well. Many of those machine-tools are now worn out and obsolete. In such cases, refabrication is the most simple and the cheapest way to get modern machines out of them.

In general, refabrication supposes a complete replacement of the electric, hydraulic and pneumatic installations. Many machine-tool aggregates have the feed or auxiliary kinematic chains pneumatically driven. And so has the machine-tool subject of the present paperwork.

2. MODERNIZATION OF THE DRILLING MACHINE BKR2

The topic of the project the authors have run was the modernization of the Drilling Machine BKR – herein shown in Fig. 1 – by redesigning the driving pneumatic diagram.

The pneumatic equipment is located in a panel shown in Fig. 2.

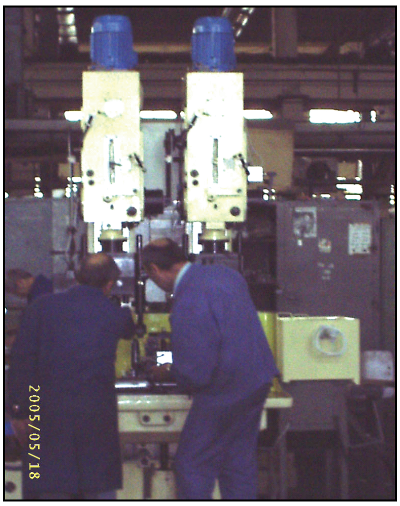

Fig. 1. The drilling machine BKR.

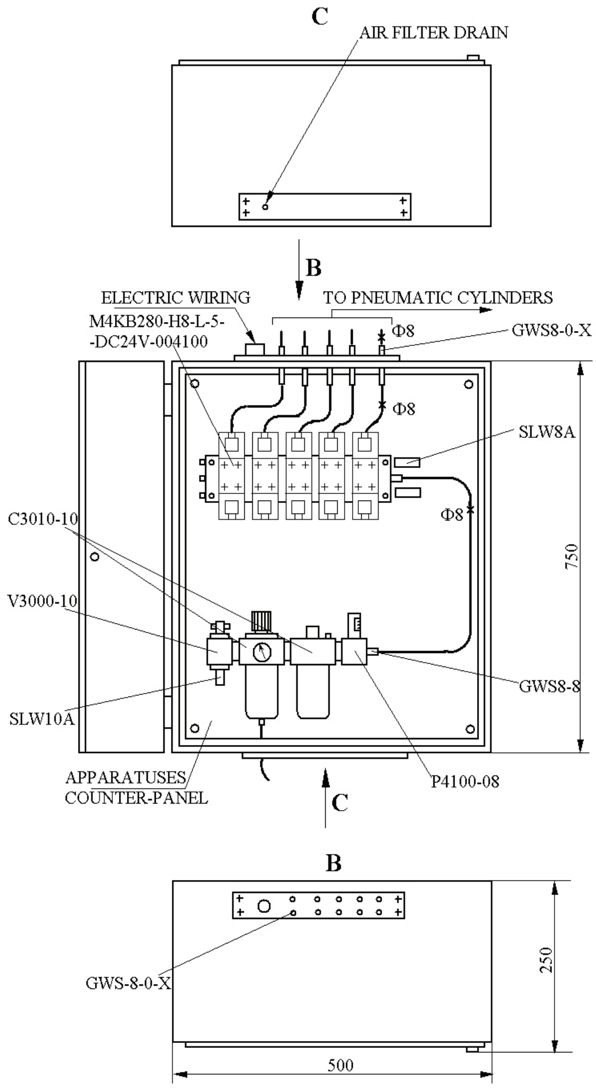

Fig. 2. The pneumatic equipment's panel.

Fig. 3 presents the newly designed and made pneumatic diagram.

The pneumatic installation actuates four (4) cylinders that accomplish the following operation: part clamping, slide feed, coupling–uncoupling of the two working stations. The work-piece clamping cylinder has two positions – loosened and tightened – confirmed by proximity sensors; the speed of the slide feed cylinders

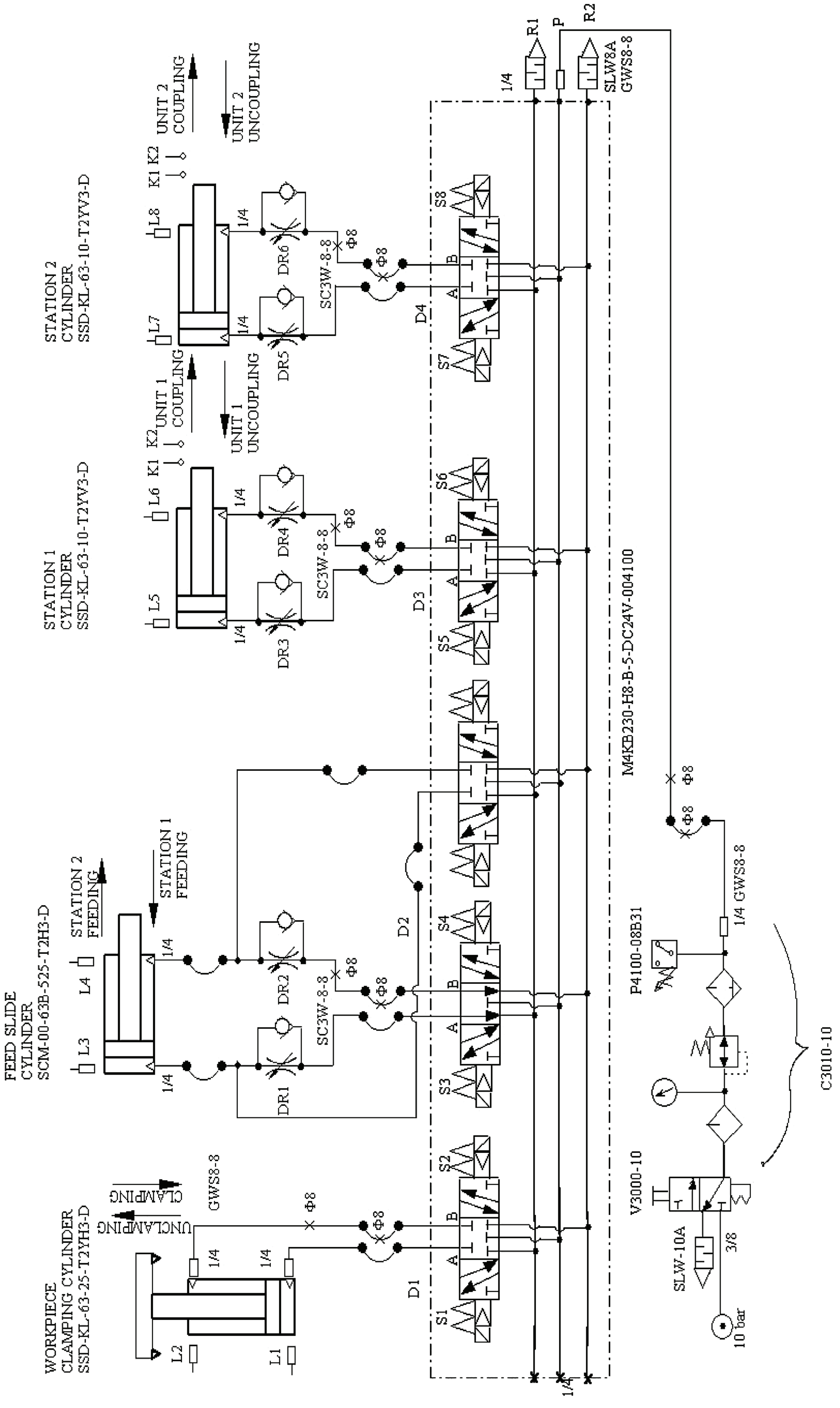

Fig. 3. The new designed pneumatic installation.

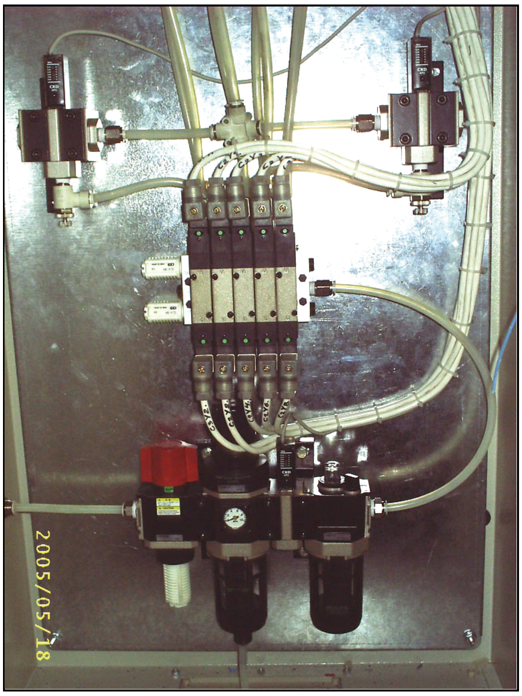

Fig. 4. The equipment on the machine.

and the speed of the cylinders for the working station no. 1 and no. 2 can be adjusted by means of the throttle valves (Dr1÷Dr6) with check valves. The five directional control valves are electro-pneumatically actuated.

Fig. 4 shows the location of the equipment on the machine.

3. DYNAMIC OF THE LINEAR PNEUMATIC MOTORS

3.1. Mathematical models

For the beginning, it is considered the cylinder in Fig. 5. It is supposed that, no matter the direction, the feed is performed with p = constant, Q = constant and the work fluid is incompressible.

Also, the counter-pressure appearing on the return line is being neglected. Given the above mentioned work hypothesis it can be considered that $F_1 = pS_1$ and $F_2 = pS_2$. This method of calculation for the pneumatic cylinders is not correct, it can induce substantial errors. The pneumatic drive has two essential particularities, as against the ideal model proposed:

- the air is a very compressible work medium,
- the friction between the movable elements induces specific forces.

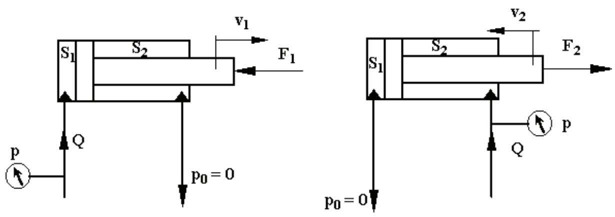

Fig. 5. The considered cylinder.

The differential equation specific to the balance of forces for the motor in Fig. 5a is:

The calculation of the real developed force, at a certain moment, is quite difficult, taking into consideration the dynamic phenomena.

$$M\frac{\mathrm{d}v}{\mathrm{d}t} + cv + F_f(p) + F_R = pS_1, \qquad (1)$$

where: M – moved mass; v – instant velocity; c – damping coefficient; $F_f(p)$ – sum of the friction forces (these depend on p); F_R – resistant force; p – instant pressure.

For the same direction of motion it can be written:

$$Q(p) = S_1 v + ap + \frac{V_M}{E(p)}\frac{\mathrm{d}p}{\mathrm{d}t}. \qquad (2)$$

The equation (2) represents the spread of the flow for an instant pressure p: $Q(p)$ – feed flow at pressure p; a – flow loss coefficient; V_M – air average volume inside the left-hand chamber of the cylinder; $E(p)$ – air coefficient of elasticity at pressure p.

The equations (1) and (2) represent the mathematical model in dynamic duty for a cylinder without counter-pressure on the return line. The solution of the system for establishing the force and velocity (or the force and consumed flow) raises difficulties due to the necessity of knowing the induced coefficients. In order to simplify these calculations and to support those ones designing and manufacturing pneumatic installations the companies manufacturing such equipment have developed simplified methods. The real behavior of the cylinder depends as well on its driving way. Thus, it is considered the system in Fig. 6.

In the position within the figure the piston is kept withdrawn by the pressure p_2 (on the connection 1 - 4 in the directional control valve). Initially, the pressure p_1 in the left-hand chamber is equal with the atmospheric pressure (on the connection 2 – 3). When changing the condition of the directional control valve (1 – 2 and 4 – 5), the pressure p_1 increases, while the pressure p_2 decreases.

Initially, p_1 increases over the value required for moving the load with constant velocity, and then it returns to a value approximately constant. For this period $\Delta p_k = p_1 - p_2 \approx$ ct. is defined.

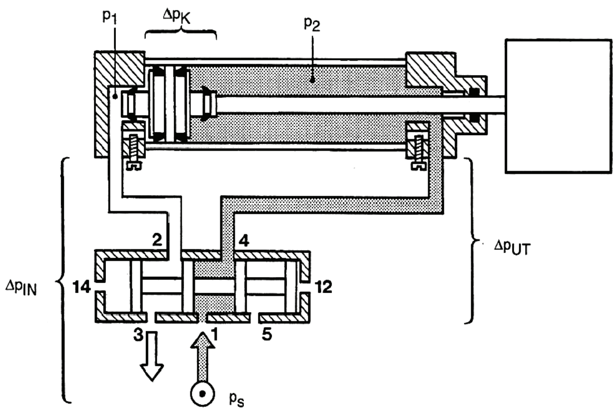

Fig. 6. The real cylinder.

Once the braking has started, p_1 and p_2 increase. At the end of the travel p_1 reaches the maximum value, while p_2 becomes equal to the atmospheric pressure.

Fig. 7 shows the evolution of the pressures.

The notation in Fig. 7 has the following meaning: A – acceleration area; B – decrease of p_1 to the value required for the movement with constant velocity; C – segment of constant-velocity movement; *D* – friction area; Δp_{IN} – peak of pressure p_1; Δp_{UT} – pressure difference on return line.

Fig. 8 presents the evolution of the final velocity v_F during the travel and in relation with the assembling mode of the components, the load and the type of the pneumatic components.

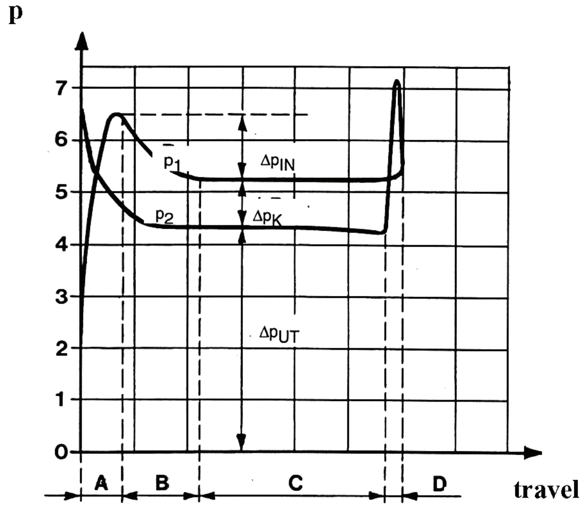

Fig. 7. The evolution of the pressures.

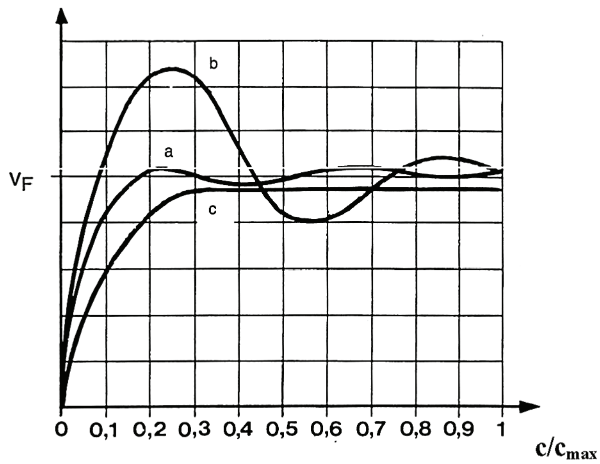

Fig. 8. The evolution of the final velocity.

The percentage travel (c/c_{max}) is the *x*-coordinate, while the velocity is the *y*-coordinate. The amortization of the system can be followed on a, b and c curves.

4. CONCLUSION

When modernizing or refabricating aggregate machine-tools it is recommended to fully replace the pneumatic equipment. The pneumatic drives and controls have incontestable advantages: reduced size, reduced noise, leakage-free operation, and they are suitable for automation.

At present, the manufacturers of pneumatic equipment provide catalogues and diagrams that are very useful for the designers when projecting compact, noise-free and reduced response time drive and control systems.

The static and, if possible, the dynamic calculation of the consumers is recommended.

The pneumatic system designed and made by the authors has been operating without interruption for over one year in a factory producing cars.

REFERENCES

[1] Bucureşteanu, A. (2003). *Acţionări hidraulice şi pneumatice*, Editura Printech, ISBN 973-652-819-9, Bucharest.

[2] Bucureşteanu, A. (2004). *Air Motors*, Proceedings of the International Conference on Manufacturing Systems ICMaS, Editura Academiei Române, pp. 155–159, ISBN 973-27-1102-7, 7–8 October, Bucharest, Romania.

[3] Bucureşteanu, A. (2004). *Air Springs*, Proceedings of the International Conference on Manufacturing Systems ICMaS, Editura Academiei Române, pp. 159–163, ISBN 973-27-1102-7, 7–8 October, Bucharest, Romania.

[4] Barber, A. (1997). *Pneumatic Handbook*, Elsevier Science Ltd, ISBN 185617 249 X, Oxford, U.K.

[5] Prodan, D., Dusan, C., Bucuresteanu, A. (2004). *Acţionări pneumatice. Elemente şi sisteme*, Editura Printech, ISBN 973-718-020-8, Bucharest.

[6] *** *The Pneumatic Catalogue* SMC.

[7] *** *Pneumatic Components for Industrial Automation,* ASCO JOUCOMATIC, PNE. GB. R11a-383 6400.

[8] *** *Technische Informationen – Know-how in Pneumatik,* REXROTH.

[9] *** *Catalogue* HUBER AUTOMATION – *A chaque forme sa griffe.*

Authors:

Dr. Eng. Anca BUCUREŞTEANU, Lecturer, "Politehnica" University of Bucharest, Faculty for Engineering and Management of Technological Systems, Machine and Manufacturing Systems Department, E-mail: ancab66@yahoo.com

Eng. Mircea DUCA, General Manager, Ducas Technic S.R.L., E-mail: ducami@pcnet.ro