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

RETROFITTING THE HYDRAULIC INSTALLATION FROM VERTICAL LATHES

Dan PRODAN, Emilia BĂLAN, Nicolae PREDINCEA

Abstract: *In this paper a type of retrofitting of the hydraulic installation from a heavy vertical lathe is presented. This way the lathe can be transformed in a CNC machine tool with good performance data: increasing working productivity by increasing the feed speed and the position speed of the movable assemblies. The speed of the quick positioning of the ram increases from 2.500 mm/min to 10.000 mm/min. The theoretical researches consist in mathematical modelling of the balancing installation of a movable assembly and in the optimization of this structure. The designed hydraulic installation is adjusted to a vertical lathe type SC 27 CNC, built in Romania.*

Key words: *retrofitting, vertical lathe, hydraulic installation, balancing installation, optimization.*

1. INTRODUCTION

Vertical lathes are used for internal and external cylindrical turning, facing, taper and plane turning. They are characterized by a rigid frame and high cutting speed. The CNC vertical lathes can be used for more other kind of manufacturing, such as: milling, internal and external threading, contouring milling, oval surfaces turning etc.

In Romania was designed after license an important number of these types of machine tools with the diameter of the faceplate between 1 000–4 000 mm and 6 000–16 000 mm.

A lot of CNC machine tools are necessary now. For this reason the rebuilding and retrofitting of the old machine tools is an important field of activity.

In this paper a vertical lathe type SC 27 CNC, which has its original mechanical structure is presented.

It represents the easiest version of rebuilding and retrofitting a vertical lathe. The frame, the unmovable and movable cross rails aren't modified. The two slides are moving on the guides of the movable cross rail. On the slides there are the working rams. The left ram uses a turning cutter-holder and the right ram uses a turret head.

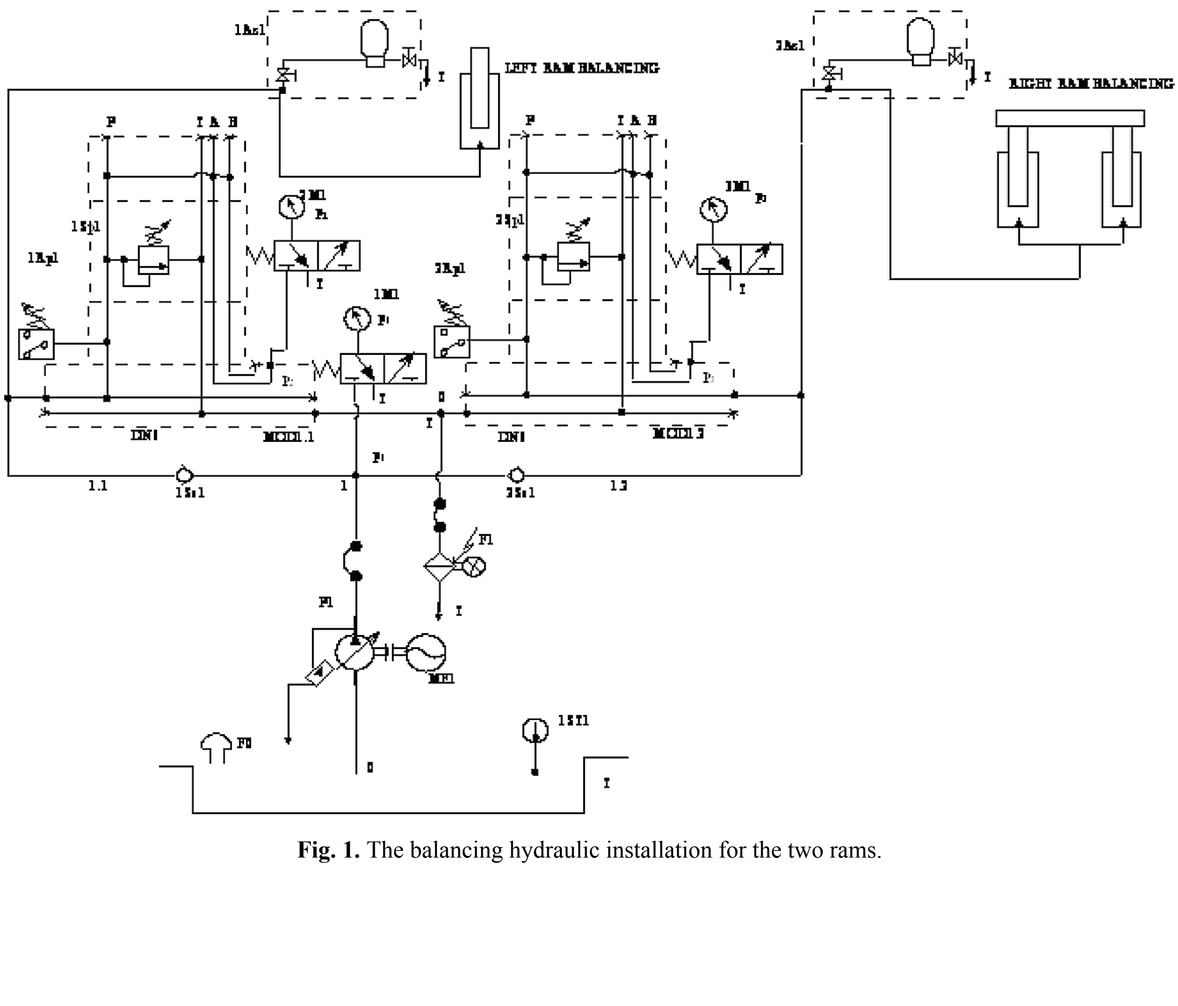

Fig. 1. The balancing hydraulic installation for the two rams.

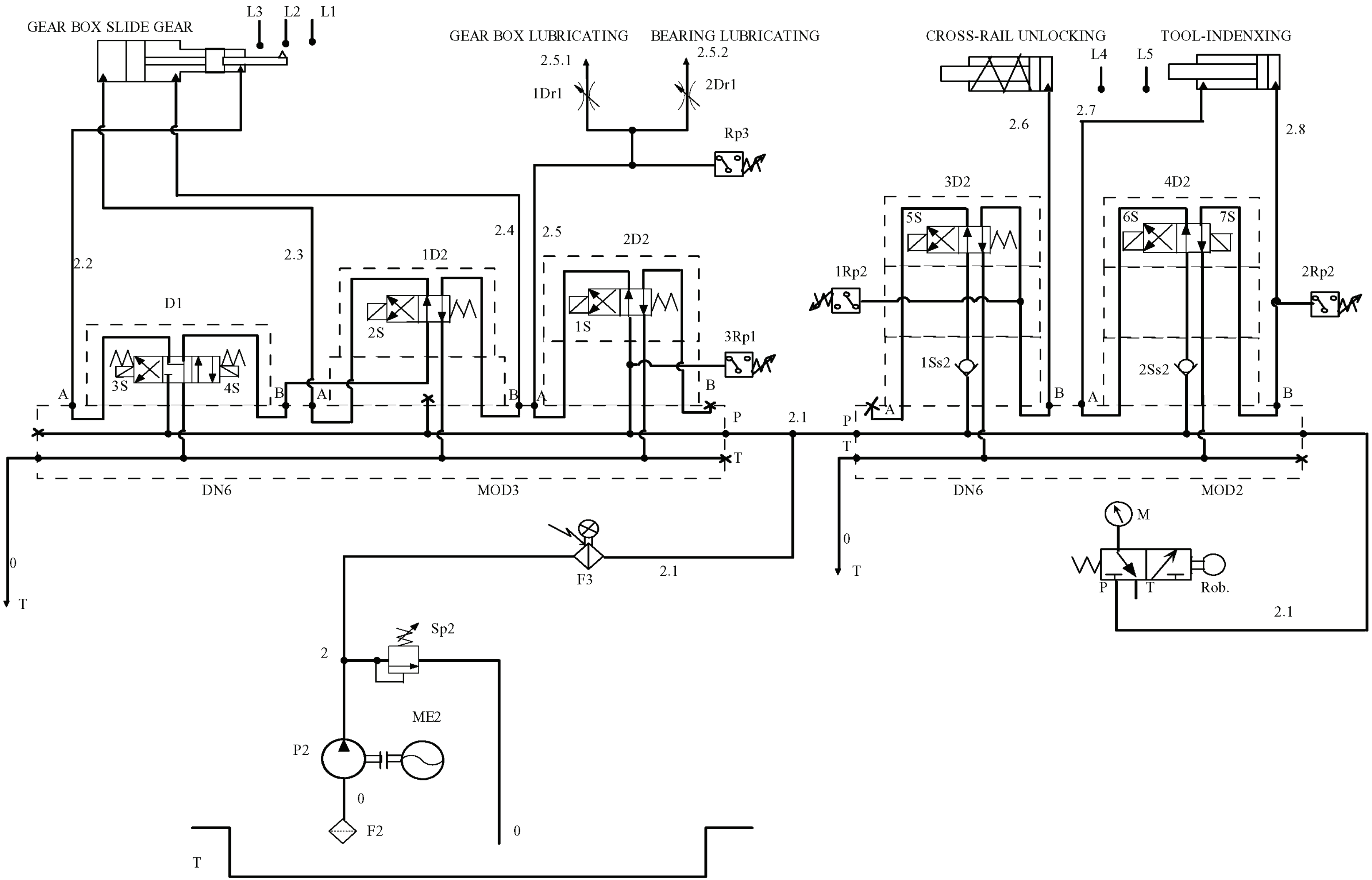

Fig. 2. The hydraulic system pump-module with apparatus from the machine tool.

After rebuilding and retrofitting, the vertical lathe becomes a CNC machine tool. For this reason, the feed trapezoidal screws from the slides and rams had been changed with ball screws. The cross rail positioning screws hadn't been modified.

2. HYDRAULIC INSTALLATION SCHEME

The hydraulic installation is designed and modularly made with new elements [1].

These new elements are: hydraulic unit for balancing the rams (Fig. 1) and hydraulic system pump-module with apparatus from the machine tool (Fig. 2).

The hydraulic unit for balancing the rams is equipped and fitted on a 200 l tank.

The pump *P*1 supplies all the time the balancing circuits. It is a vane pump, with controlled-volume and pressure valve. This is set at a lower pressure than the pressure in the pressure valves 1*Sp*1 and 2*Sp*1. The confirmation for the balancing pressure for every circuit is made by the pressure switches 1*Rp*1 and 2*Rp*1. Every ram has its own accumulator. The separation of the circuits is made with the two check valves 1*Ss*1 and 2*Ss*1.

The other pieces of the hydraulic installation are on the machine tool, on frame and on the columns (vertical beams).

The simple pump *P*2 (Fig. 2) provides the following functions: changing the speeds range; lubrification the pinion and the crown gear, the main table bearing and the gear box bearings; unlocking the cross rail and indexing position of the tools.

The distributors *D*1 and 1*D*2 ensure the positioning of the hydraulic linear engine for slide gears shifting. The distributor 3*D*2 implements the function of blocking-unlocking the cross rail for positioning the cross rail on the column. The distributor 4*D*2 implements the function of indexing-unindexing the turret head. These functions can be implemented only after the stopping of the lubrification, actting the distributor 2*D*2.

The pressure switch 3*Rp*1 confirms the using of this distributor. The pressure switchs 1*Rp*2 and 2*Rp*2 confirm the unlocking, respectively the indexing. The (non-adjustable) pressure switch *Rp*3 confirms the correct lubrification pressure while the main chain is functioning (the table rotation).

The vertical feed chains from the two rams have electric brakes. Although, even they don't work simultaneously, a permanent balancing is necessary to keep the last commanded position [2, 3]. In this case, when a ram is not working, its balancing system becomes a blocking system. The presence of the accumulators facilitates this function. It is recommended to use security blocks for these. The blocks ensure the tightness of the functioning circuits, but also the possibility of a quick intervention for discharging.

The balancing hydraulic installation for the two rams is a separated unit with own tank. On the tank there are put all the elements necessary for balancing. The other pieces of the hydraulic installation are on the machine tool's frame. The tank oil is on the frame, too.

This hydraulic installation represents the cheapest version of retrofitting of this kind of machine tool.

3. THE MATHEMATIC MODELLING OF THE BALANCING HYDRAULIC UNIT [4, 5]

Considering the balancing system, which is represented in Fig. 3, for the up phase, which is the most loaded, the following relations can be written:

$$\begin{aligned} & M\frac{\mathrm{d}v}{\mathrm{d}t} + b\times v + M\times g + F_f = p\times S + F \\ & Q = S\times v + \frac{V}{E}\times\frac{\mathrm{d}p}{\mathrm{d}t}. \end{aligned} \tag{1}$$

In relation (1) is noted: M – movable assembly's mass; v – instantaneous speed; t – time; b – linearity coefficient of losses of force proportional with speed; g – gravitational acceleration; F_f – reduced friction force; p – instantaneous pressure; S – active surface's balancing piston; F – force of the feed chain (*LCA*); Q – instantaneous discharge of pump; E – modulus of elasticity of oil that is used; V – medium oil's volume of the balancing cylinder.

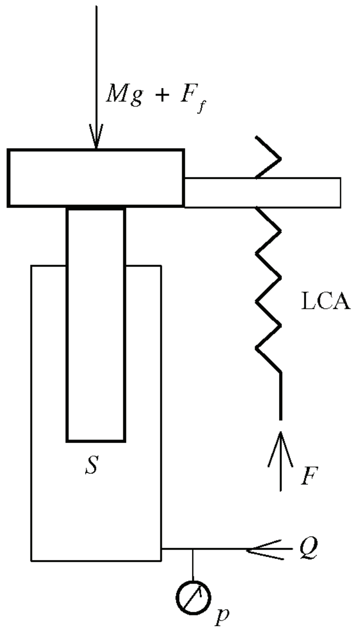

Fig. 3. Simplified hydraulic scheme.

If is derivated and the necessary substitutions are done the (2) relation will be obtained:

$$M\frac{\mathrm{d}^2v}{\mathrm{d}t^2} + b\frac{\mathrm{d}v}{\mathrm{d}t} + \frac{S^2\cdot E}{V_M}v = S\frac{Q\times E}{V_M}.. \tag{2}$$

Now, knowing all these can be done the system's simulation to calculate the speed in connection with time.

In Fig. 4 is presented the cross rail speed characteristic obtained after simulation; the time is measured in seconds, and the speed is measured in m/min.

It is observed that, for the initial discharge of pump, the maximum speed of the hydraulic system is 6 m/min. The maximum speed of the feed chain *LCA* is 4 m/min.

The answer time of the hydraulic system is approximately of 0.02–0.03 s and that is enough.

Using these relations, the characteristics of the feed chain and of the hydraulic elements is obtained the correct dimensions of the hydraulic installation, for both rams.

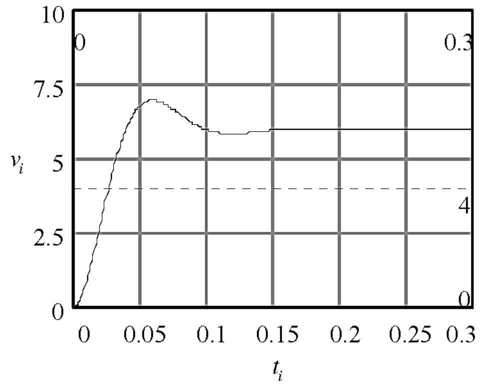

Fig. 4. The cross rail speed characteristic.

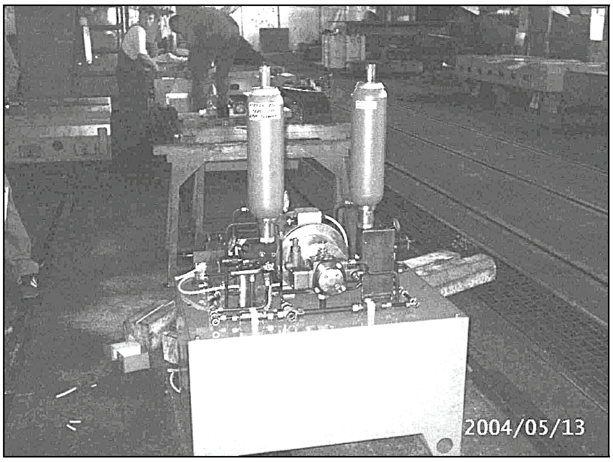

Fig. 5. The hydraulic unit for balancing the rams.

The hydraulic installation for balancing the both rams (Fig. 1) is achieved like a separate unit and it is presented in Fig. 5.

4. CONCLUSION

Rebuilding and retrofitting of the machine tools represent new solutions very useful today by many specialized company from USA and Europe [4].

Vertical lathes type SC 14 – SC 43 can be considered like the great demand machine tools for the Americans, Europeans, Canadians and Asiatic users. There are a lot of supplies for the Romanian rebuilt and retrofitted vertical lathes of this type.

Rebuilding and retrofitting of vertical lathes are a better activity than building a new one machine tool from a lot of reasons, such as:

- same elements of the structure and the main mechanical assemblies, such as frame, table, cross rails, columns, slides, are using a great amount of material and labour (work); for this reason, the price of a new machine tool will be greater than a rebuilt and retrofitted machine tool which will have these elements already repayment;
- retrofitting hydraulic installation will be designed in conation with the new trends using new apparatus with good performance data and compacted solutions;
- rebuilding and retrofitting machine tools will can be done by small companies not only the greatest one which have specialized apparatus; the “delicate” skills, like the guides’ finishing will be done by specialized company;
- when the hydraulic installation is rebuilding and retrofitting, it is recommended to do dynamic calculus, simulations on the computer, to check-up the performances especially for balancing systems.

The heavy vertical lathe that is presented in this paper it is drive and works without malfunctions for the user above one year.

Acknowlegment. The financial support of the National Consigliore of Scientific Research at the Ministry of Education and Research of Romania under Grant No. 1392/68/06 is gratefully acknowledged.

REFERENCES

[1] Prodan, D., Cristescu, C., Popescu, D. (2001). *Maşini-unelte şi prese. Elemente hidrostatice*, Edit. Printech, ISBN 973-652-388-8, Bucharest.

[2] Prodan, D., Bucureşteanu, A., Marinescu, D. (2001). *Cercetări teoretice şi experimentale privind sistemele hidrostatice de echilibrare utilizate la maşinile-unelte grele cu CNC*, Hydraulic, no. 3, July, pp. 20–23, ISSN 1453-7303.

[3] Prodan, D. (2004). *Hidraulica maşinilor-unelte*, Edit. Printech, ISBN 973-718-109, Bucharest.

[4] Prodan, D., Marinescu, S. (2005). *Refabricarea şi modernizarea maşinilor-unelte. Sisteme hidraulice*, Edit. Tehnică, ISBN 973-31-2255-6, Bucharest.

[5] Prodan, D., Constantin, G. (2004). *New solutions of the balance hydraulic systems in machine tools*, Proceeding of the 15th International DAAAM Symposium, Editor: B. Katalinic, pp. 373–374, ISSN 1726-9679, ISBN 3-901509-42-9, Vienna, November 2004, DAAAM International Vienna.

[6] Katz, R., Yook, J., Koren, Y. (2004). *Control of a non-orthogonal reconfigurable machine tool*, Journal of dynamic systems, measurement, and control, Vol. 126, June, pp. 397–405.

[7] Popescu, D., Predincea, N., Iacob, R. (2003). *A survey of flexible and reconfigurable manufacturing systems (RMS)*, International Conference on Economic Engineering and Manufacturing Systems, pp. 24, ISBN-973-635-215-3, Book of Abstract and CD – Proceedings, “Transilvania” University, Braşov, 23/24 October, 2003.

Authors:

Ph.D. Eng. Dan PRODAN, Assoc. Prof., “Politehnica” University of Bucharest, Faculty of Engineering and Management of Technological Systems, Machines and Production Systems Department, E-mail: prodand2004@yahoo.com

Ph.D. Eng. Emilia BĂLAN, Assoc. Prof., “Politehnica” University of Bucharest, Faculty of Engineering and Management of Technological Systems, Machines and Production Systems Department, E-mail: emiliabalan@yahoo.com

Ph.D. Eng. Nicolae PREDINCEA, Prof., “Politehnica” University of Bucharest, Faculty of Engineering and Management of Technological Systems, Machines and Production Systems Department, E-mail: predi@imst.msp.pub.ro