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# TECHNICAL AND ECONOMIC CONSIDERATIONS ON THE PURCHASE OF A CNC MACHINE TOOL

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***Abstract:*** *This paper introduces some aspects to be taken into consideration when a company has to acquire a machine tool. Money is a precious asset and you need to spend it wisely when you have to repair an aging piece of equipment, when you need to remanufacture components within the unit or when it is necessary to replace equipment. The choice of the machine tool type to be purchased depends on a number of factors also related to production requirements, not only to machine price, such as: cost of devices, tools, control devices, machining, cost of the possible training courses, cost of necessary arrangements (foundation, electrical connections, air, water, etc.), possible guarding and fencing of the auxiliary spaces intended. It insists in particular on the purchase of heavy and very heavy duty machine tools from the category of universal and CNC type machine tools. These machines are complex ones, they take a large volume in the industrial spaces and their prices are high, exceeding sometimes the amount of millions of dollars. Taking into account only these latter remarks, a technical and economic study should be made prior to any such acquisition.*

***Key words:*** *3R policy, costs, technical & economic study, heavy duty machine tools, remanufactured machine tools, machine tools as an investment.*

## 1. INTRODUCTION

One of the modern strategies when dealing with machine tools is the 3R policy (Repair-Remanufacture-Replace):

- Repair: action taken to bring a defective or degraded component back to full serviceability;
- Remanufacture: action taken to remove a component and substitute it with a direct serviceable replica which provides improved functionality; original component is not necessarily defective;
- Replace: action taken to remove defective or degraded equipment and substitute it with a direct serviceable replica; everything is changed.

To decide the future of the existing equipment in companies of machine tools it is necessary to consider both planning and driving factors (Tables 1 and 2).

*Table 1*

**Planning Factors**

| Factors | Some examples |
|---|---|
| Time | • Time to repair vs. time to replace<br>• Time to replace vs. time to remanufacture<br>• Short term vs. long term |
| Operations | • What is the impact?<br>• Can a change be made? |
| Resources | • Availability of repair skills and equipment<br>• Availability of spare parts |
| Cost | • Cost of repair vs. remanufacture vs. replace<br>• Cost of downtime<br>• Cost of additional spares |
| Function | • Is a change in function required? If yes: remanufacture or replace |

*Table 2*

**Driving Factors**

| Factors | Some examples |
|---|---|
| Indicators | • Run time<br>• Event based (time *t* since last…..)<br>• Data driven (MTBF) |
| Warnings | • Sensory (see, smell, hear, touch)<br>• Temperature<br>• Current draw<br>• Vibration<br>• Available memory |
| Operational | • Volume<br>• Product profile<br>• Product type<br>• Operating profile |
| Technological | • Lack of support<br>• Improved functionality/efficiency |
| Legislative | • Energy<br>• Incentives (Penalties) |
| Financial | • Older components are more expensive to purchase<br>• Older components are more expensive to support |

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When planning one should always consider the following:

- Identify the need to change;
- Plan the change (emergency, short term, medium term, long term);
- Seek input from "experts";
- Plan the funds;
- Remain flexible for the unplanned.

This paper introduces a technical and economic study to be considered when it comes to purchasing a machine tool. It insists in particular on the purchase of heavy and very heavy duty machine tools from the category of universal and CNC type machine tools.

## 2. GENERAL CONCEPTS

If it comes to buying a machine tool to meet certain technical requirements, one should take into consideration the fact that such an investment will pay off in a period of 5-10 years, usually. One should examine to what extent, following up the acquisition, the prime cost and/or the time needed for each piece can decrease and to what extent the machine loading throughout the next 10 years will be ensured. In some cases, this review can even entail giving up the purchase and transferring the production to other existing machines or even to other partners [1].

### 2.1. Providing raw material (CM)

The machine tools are usually used for machining the cast, forged or rolled semi-products. If the same type of semi-finished product is used till the moment of machine purchasing, then there are not any problems. If one moves to a new type of semi-finished products, one should review the price and the possibility to supply them.

### 2.2. Costs of machining operation (CP)

Depending on the machine type, its degree of automation and the skills of the staff, one can determine the time needed to make a work piece on this machine. This time can be higher at the machine purchasing moment but it decreases as the worker becomes familiar with the new controls. After a while, a minimum and steady value of the time for a work piece can be reached [1]. In the case of CNC machines, it is preferable to purchase machines with the same type of equipment as those already existing in the respective plant, enabling the workers to shorten the time necessary for learning how to operate. In the first stage, the times can be calculated according to cutting mode parameters and to machine characteristics.

### 2.3. Labor Cost (CW)

Machine tools workers and operators are paid in conformity with their skill level. In case of the special machine tools, on which a single type of work piece is machined throughout the whole lifetime of the machine, the worker has especially the role to supervise the production process and maybe to change the tools; his skill level is a low one. In the case of universal machines without CNC equipment, the workers shall be skilled, as they are the owners of some control and adjustment methods that require specific knowledge of geometry, trigonometry, strength, cutting, etc. These workers will be the most expensive ones. For modern machine tools, equipped with CNC, even if the "machine" takes over much of the control and adjustment functions and the worker is not very skilled, one must take into account the fact that the labor costs will also include the invisible part of the process, namely the cost of the programmers.

### 2.4. Other costs

In a factory that uses machine tools, besides the costs mentioned above, there are also other expenses not at all negligible.

We can mention, for example: machines maintenance department, tool sharpening workshops, staff involved in purchasing, control, advertising, accounting, management, cleaning and security activities. A part of these activities can be outsourced but only to the extent of cutting down expenses. Depending on production type, company size and its importance on the market, these costs can add to the above mentioned costs values between 50% or even 500%. Some of these expenses can be reduced by purely technical criteria.

Therefore, it will be preferred that in a company exist as few as possible suppliers of spare parts for the electric, electronic, hydraulic and pneumatic components of the machine tools. It is preferable that all CNC machines or most of them to be provided with equipments originating from only one manufacturer.

### 2.5. Investment cost

When purchasing a machine tool, the investment includes: cost of the machine, cost of devices, cost of the possible training courses, cost of necessary arrangements (foundation, electrical connections, air, water, etc.), possible guarding and fencing of the auxiliary spaces intended for tools, control devices, etc. One should not neglect the price of the machine transport from manufacturer's site and the commissioning cost. This activity, if performed by the manufacturer, makes usually the subject matter of a separate contract besides the machine sale contract. The above mentioned costs can amount up to 10–20% on machine costs.

### 2.6. Necessary space in workshop

Machine tools are placed in closed spaces, preserved against bad weather, often thermo-regulated spaces. Besides the space actually occupied by the machine, one should keep in mind that there are also spaces needed for access, for tools and jigs storage, buffer spaces for semi-finished products and parts, etc. These other spaces can represent up to 200% of the space occupied effectively by the machine. Each square meter costs and is included in the total rent. The value of this rent depends on country, zone, owner, type of production, etc. and is not at all negligible. This space must be reduced in different ways.

Thus for two gantry milling machines [2] one will prefer the solution with displaceable gantry instead of movable table, the latter solution requiring , for the same overall size, a twice bigger space for assembling. In case that a new building is necessary for locating the new machine, one will take into account the surface purchased or rented, the cost of the building and the associated expenses.

## 3. APPLICATION. PURCHASE OF A NEW MACHINE TOOL

For example, we shall take into consideration the case of a vertical lathes user [3]. The production needs require a lathe able to turn work pieces with a diameter up to 2 800 mm and a height up to 800 mm at the most. This machine will be employed for forged parts of the same type as those currently made on other machines. In the respective factory there are both universal and CNC machines provided with equipment "A" type.

The market offers three types of machines that are suitable for the intended machining operations [4]:

- universal machine with two vertical rail heads and a side one, marked with VL CC or index 1 in the paper (Fig. 1).
- brand new machine with numerical control with vertical rail head and "B" type CNC equipment, marked with VL CNC N or index 2 in the paper (Fig. 2).
- remanufactured machine, with numerical control, marked with VL CNC SH or index 3 in the paper. The machine can be remanufactured and provided with "A" type CNC equipment (Fig. 3).

The main features of the machines above and the specific costs, expressed in € are shown in the Table 3.

It is believed that new devices are not necessary because the devices already existing in the plant are consistent with any of the three machines.

In this workshop, the rent is about 600 €/m$^2$, and the work is done over 600 shifts/year. The investment is made for the next 10 years.

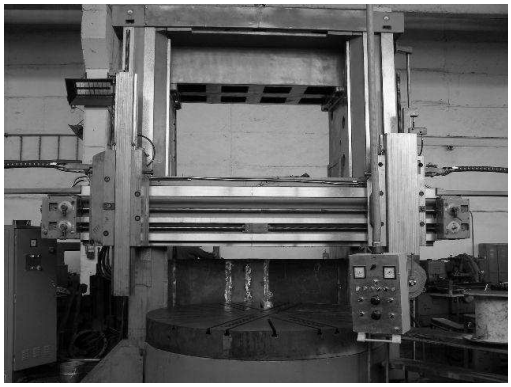

**Fig. 1.** Vertical Lathe VL CC.

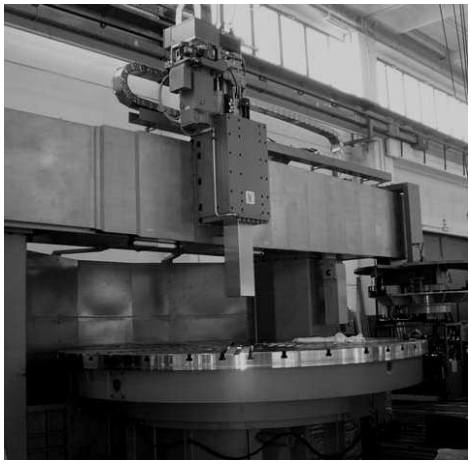

**Fig. 2.** Vertical Lathe VL CNC N.

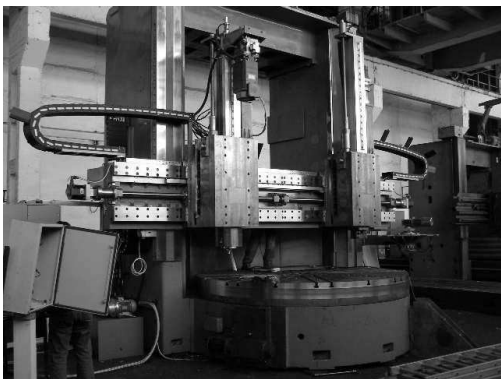

**Fig. 3.** Vertical Lathe VL CNC SH.

*Table 3*

**The main features of the machines and the specific costs**

| No. | Specification | VL CC | VL CNC N | VL CNC SH |
|---|---|---|---|---|
| 1. | Machine Cost (MTC) | 250000 € | 350000 € | 230000 € |
| 2. | Tools (TC) | 2000 € | 5000 € | 5000 € |
| 3. | Necessary surface in workshop | 39 m$^2$ | 46 m$^2$ | 46 m$^2$ |
| 4. | Production (Pieces) | 12 pc/shift | 8 pc/shift | 8 pc/shift |
| 5. | Machining Cost (MC) | 200 € | 120 € | 120 € |
| 6. | Machine Operator Cost (CW) | 120 € | 70 € | 70 € |
| 7. | Programmer Cost (CW) | 0 € | 25 € | 25 € |

**Calculation of the number of pieces that can be machined per year (P/Y).** If the model VL CC is selected, equipped with three rail heads, the production will be:

$$P_1 = 12 \times 600 = 7200 \text{ P/Y}. \quad (1)$$

In the case of CNC type lathes, equipped with only one rail head and a tool magazine, the production will be:

$$P_2 = P_3 = 9 \times 600 = 5400 \text{ P/Y}. \quad (2)$$

**Calculation of machining costs (€/Y).** For VL CC lathe, the annual machining costs are:

$$MC_1 = 200 \times 600 = 120000 \text{ €/Y}. \quad (3)$$

For CNC type lathes, the annual machining costs will be:

$$MC_2 = MC_3 = 120 \times 600 = 72000 \text{ €/Y}. \quad (4)$$

**Calculation of operator costs (€/Y).** In the case of a universal machine, the operator cost per year is:

$$CW_1 = 120 \times 600 = 72000 \text{ €/Y}. \quad (5)$$

For CNC machines, the cost includes the operator and the programmer too:

$$CW_2 = CW_3 = (70 + 25) \times 600 = 57000 \text{ €/Y}. \quad (6)$$

**The yearly production costs (CP/Y)** will be**:**
For CC machine:

$$CP_1 = MC_1 + CW_1 = 120000 + 72000 = 192000 \text{ €/Y}. \quad (7)$$

For CNC machines the result is:

$$CP_2 = CP_3 = 72000 + 57000 = 129000 \text{ €/Y}. \quad (8)$$

If an investment of 10 years is taken into consideration, the investments cost/year for the three machines is:
CC lathe:

$$(MTC + TC)_1 = (250000 + 2000)/10 = 25200 \text{ €/Y}. \quad (9)$$

Brand new CNC lathe:

$$(MTC + TC)_2 = (350000 + 5000)/10 = 35500 \text{ €/Y}. \quad (10)$$

CNC lathe remanufactured:

$$(MTC + TC)_3 = (230000 + 5000)/10 = 23500 \text{ €/Y}. \quad (11)$$

**Cost of annual rent LC for the surfaces occupied by machines.** In case of the universal vertical lathe, the rent is:

$$LC_1 = 600 \text{€}/\text{m}^2 \times 39 \text{m}^2 = 23400 \text{ €/Y}. \quad (12)$$

Regardless their version, CNC machines take the same surface; the rent cost for this surface is:

$$LC_2 = LC_3 = 600 \text{€}/\text{m}^2 \times 46 \text{m}^2 = 27600 \text{ €/Y}. \quad (13)$$

The vertical lathe CC makes possible the manufacturing of 7 200 pieces per year (P/Y) with a total annual cost (TCY):

$$TCY_1 = CP_1 + (MTC + TC)_1 + LC_1 = 192000 + 25200 + 23400 = 240600 \text{ €/Y}. \quad (14)$$

Related to the production of 7 200 pieces, the final cost per piece is:

$$PieceC_1 = TCY_1 \div 7200 = 33.41 \text{ €}. \quad (15)$$

CNC vertical lathes allow the manufacturing of 5400 pieces per year (P/Y) with an annual total cost:

$$TCY_2 = CP_2 + (MTC + TC)_2 + LC_2 = 129000 + 35500 + 27600 = 192100 \text{ €/Y}. \quad (16)$$

Related to the production of 5 400 pieces, the final cost per piece is:

$$Piece\ C_2 = TCY_2 \div 5400 = 35.571 \text{€}. \quad (17)$$

$$TCY_3 = CP_3 + (MTC + TC)_3 + LC_3 = 129000 + 23500 + 27600 = 180100 \text{ €/Y}. \quad (18)$$

Related to the production of 5 400 pieces, the final cost per piece is:

$$PieceC_2 = TCY_2 / 5400 = 33.35 \text{€}. \quad (19)$$

We can notice that the values are very close and that there is a small advantage of the remanufactured machine variant [5, 6]. From a technical standpoint, this one is by no means inferior to the brand new machine. The mechanical part is identical and, moreover, the manufacturer can equip it with the CNC wanted, "A" type and compatible with the equipment of the existing machines. Also in favor of the second hand machine is the fact that the delivery term is usually shorter.

The high cost of the universal machine results from the fact that it has got three rail heads, which enable a greater productivity: 12 pieces per shit compared to only 8 pieces in the case of CNC machines. The tools can be changed one by one during the stage when they do not operate. A tool changing in the case of CNC machines is automatically performed and requires machine stopping.

## 4. CONCLUSIONS

The choice of the machine tool type to be purchased depends on a number of factors also related to production requirements, not only to machine price.

When planning one should always consider the following:

- cost of repair vs. remanufacture vs. replace;
- cost of downtime;
- cost of additional spares.

Lately, the universal machines equipped with a complex mechanical part, with many kinematic chains, many gears and clutches and other systems of transmission, have prices comparable to the prices of second hand CNC machines. These ones, because of the simplifications brought by the modern drives and controls, allow the machining of complex surfaces, in terms of high accuracy and productivity, using a simple mechanical structure. High performance machine tools can be built on mechanical structures that are 10 to 15 years old.

The example above is purely theoretical, with probable values, helping to create a model of analysis of the opportunity to purchase a machine tool.

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