UPDATES IN MACHINE TOOLS TECHNOLOGY

Dan POPESCU[1,*]

[1)] PhD Student, Department of Electrotechnics, University of Craiova, Romania

Abstract: *Numerical controls have a great role in increasing the efficiency of the electric drive of the machine tool, thus in the energy saving. Measurements were done for two of those (one equipped with numerical control and a converter for the asynchronous motor of the main drive, and another with no numerical control and with a converter for the D.C. motors of the main drive). Measurements were done using a kit which was specialized in acquiring and handling energetic data. This project presents the diagrams resulted from the measurements in a comparative study. The monitored parameters were the following: actual values of voltage and currents during the three phases, the content of harmonics, or the frequency spectrum for all three phases, the frequency of the feeding voltage, active and reactive power, energy, and the power factor.*

Key words: *numerical controls, active and reactive power, energy, converter.*

1. INTRODUCTION

Lately, the technical needs in the area of mechanic processing of materials have evolved. The increased complexity of the machine and of the workpiece calls for more qualified and more thorough manpower. These two attributes are usually dominated by human subjectivism: tiredness, neglect, inattention, lack of promptitude in critical situations – which make humans imperfect operators. In time, mankind was prone to discover methods of avoiding unpleasant situations during the productive process. One of these methods was automation, with its top element, numerical control [7]. Numerical controls are mainly necessary for increasing work productivity while maintaining high precision. It is because of this need that they have continuously evolved, until human error was eliminated from the execution of workpieces. As shown in their name, computer assisted numerical controls(CNC) have as main element a computer, similar to a pc, not very powerful, but adapted to industrial needs (increased protection for adapting to the environment and an operating safety suited to demands) .

2. SOME ASPECTS OF OPERATION OF MACHINES EQUIPPED WITH CNC

A CNC system also consists of a peripheral connection unit, an external memory, an interface between the computer and the machine and a control panel. All these equipments (system hardware) function according to the basic software. The software is based on Windows NT [9], which is compatible with the numerical control software, for starting and operating, of the original manufacturing equipment. Likewise, the software of the programmable automatic machine is integrated in the basic software. The interface between the electronic computer and the machine tool ensures functions like: accomplishing compatibility between the form in which commands are transmitted to the executing parts of the machine tool and the form in which the information is used by the computer, transmitting power signals for commanding the driving parts (relay, servo valves, contacts, etc.), receiving discreet or continuous signals from different transducers from the machine tool(representing the size of the displacement of frames, tool wear, amplitude and frequency of vibrations, temperature- in case of adaptive control), generating stop signals, which provide a tact frequency used by the computer to issue a new value for the reference position(this is also called service frequency).

For instance, let's consider a *Sinumerik 840* numerical control made by *Siemens*, with which a lathe is equipped. The lathe is placed in a light mechanical processing department and it provides the serial production of the pieces which are to be produced. The lathe is also equipped with a tool storage space, thus ensuring low time intervals for the execution of technological operations. The processing programs are stocked on a memory card. The command system of the machine consists of [9]:

- the control panel, which includes the operator panel, the display, the control panel of the machine, keyboard and mouse;
- mains infeed module (MS), which provides energy for the drive modules, the regenerative feedback**,** braking or braking resistance modules; if the internal braking resistance is not sufficient, additional pulsed resistor modules can be installed. The mains infeed

* Corresponding author: bd. Decebal, 107, Craiova, Romania
Tel: 0040766694801
E-mail address: *popescumincu@yahoo.com* (D. Popescu)

module is equipped with radio interference filters. The network voltage is 400 V±100%, and the intermediary continuous current voltage is 600 V. The power factor for the block is cos φ = 0.98.

- the numerical control unit (NCU);
- supplies power for the axis modules − it generates continuous tension for the convertors of the motors;
- blocks of the feed drive digital system, one for each axis, depending of the configuration of the machine tool. They hold tension and frequency PWM convertors, ensuring high energetic performances.

An important feature of this numerical control is the compatibility with the programs of Programmable Logic Controllers [6]. The basic aspect of this numerical control is an industrial PC and a PCI base line for connecting peripherals, which can reach 33 MHz, included in the panel, which is also called a MCI panel (movement control interface), developed by Siemens.

The input/output modules and the feed drive modules are connected with a Profibus 12 MBaud base bus.

The motors are asynchronous, with a relatively small power, coupled on the main frame with an encoder. For a lathe which is equivalent to the Romanian SNB 400, NEF 400, the motor is only 2.5 kW, while the traditional lathe above has a 7.5 / 6 kW asynchronous motor. This can easily be explained as the feed drive was oversized, meant to execute a series of universal operations, with roughing of the materials, as material economy was not an issue.

Nowadays the situation tends to change, because of the pressing need to save costs and resources in all industrial fields. Numerical controls make it easier to correlate the main axis speed with the displacement speed, the number of operations necessary, thus minimizing energy loss.

Numerical control programming is developed by mechanical processing specialized personnel, with the purpose of obtaining the desired project, when complex operations are to be executed. In practice, the programming is made by the operator of the machine.

The different programs are stocked in the external memory of the machine; the operator extracts them, he modifies the parameters, he introduces the tool corrections, then the program is executed.

In some cases (for example, oxi-gas cutting machines with numerical control [11]), the cutting program is easily executed, with the operator not knowing details about tool machine programming.

The ACAD design is executed in the projecting compartment and converted from a *dwg* format in a *dxf* format. Then a specific soft converts it into instructions for the machine.

The program is then sent in the memory of the machine, the operator selects it and cutting can begin.

From the above we can conclude that as numerical controls evolve, they become more and more accessible to operators and projecting engineers from factories. The difficulties remain for software developers, who have to find more and more accessible, reducing costs by reducing work time, reducing energy consumption by optimizing drive control, and reducing expenses with personnel training.

Numerical controls also have a great role in increasing the efficiency of the electric drive of the machine tool, thus in the energy saving. First of all, they assess a machine which is extremely well built. This machine must be precise, in order to ensure the meeting of processing demands, it must not have friction or displacement during steering.

The direct consequence is a smaller power needed for the drive. Second of all, numerical controls allow choosing and respecting an optimal working condition for the advance and for the splinting, also forcing the static frequency and tension changers, which also increase their efficiency, to have an economic energetic state.

These were also the conclusions of the measurements that were done, because the equipment allowed comparison between the same types of machines, some of them with numerical controls and some without.

3. COMPARATIVE MEASURING

Measurements were done for the vertical lathe SC 27 CNC (equipped with numerical control and *Fanuc* converter for the asynchronous motor of the main drive) and for the vertical lathe SC 27(with no numerical control and with a V.3.5. *Electrotehnica* converter for the continuous power motor of the main drive), which will be next referred to as *machine* 1 and *machine* 2. Measurements were done using a kit (AR-5 network analyser) which was specialized in acquiring and handling energetic data. We must mention that the two machines executed the same operation (finishing).

The boring dust resulted from the processing was compared and dimensions or the chips were found to be similar. This project presents in a comparative study the diagrams resulted from the measurements. The monitored parameters were the following: actual values of tensions. In the case of active powers, in the most charged phase, the energy consumption is three times higher for machine No. 2, and this ratio is also maintained in the case of reactive powers, disfavouring the non-upgraded machine, currents during the three phases, the content of the harmonics or the frequency spectrum for all three phases, the frequency of the feeding tension, active and reactive power and energy, and the power factor.

Frequency spectrums of the harmonics content of the voltage waves and the variation of harmonics while monitoring look like in Figs. 1 and 2. We can see that especially harmonics three and five are almost two times smaller for machine No. 1. This means in the case of machine No. 2, the superior harmonics of the flux and rotor current (of different orders and sequences) determine disturbing couples to appear [3]. The amplitude of those couples is independent of the charge, overlapping the asynchronous couple produced by the fundamental. If the feeding frequency is high, their effect is unnoticed. At small rotation speeds of the asynchronous motors, the swinging couples can produce an abrupt (or in several steps) movement of the engine rotor. Their presence actually limits the minimum speed at which the motor can be used. There are different ways to reduce the effects of these couples, either operating on the motor, or on the constructive plan of the convertors [1 and 2]. At low speeds, although the harmonics content increases, the effective value of the current decreases with the decreasing of the speed. All these couples, due to the superior harmonics, tend to decrease the maximum torque of the engine, in comparison to network feeding. This means that a reserve is necessary (variation of 10–15 % of the engine power), in order to handle the effects of the harmonics.

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Variation graphs of the actual values of currents looks like in Figs. 7 and 8.

During the most charged phase we can notice a significant growth of the absorbed current, especially when the machine plate breaks and accelerates.

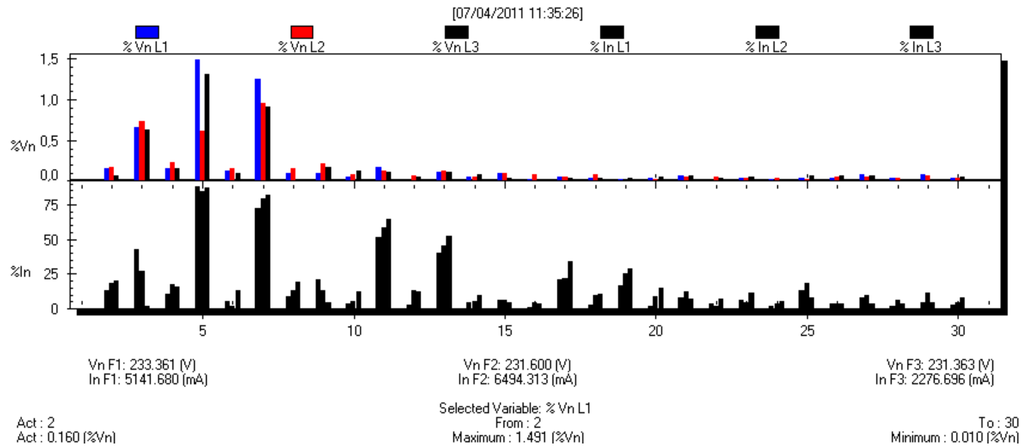

Fig. 1. Harmonics for machine 1.

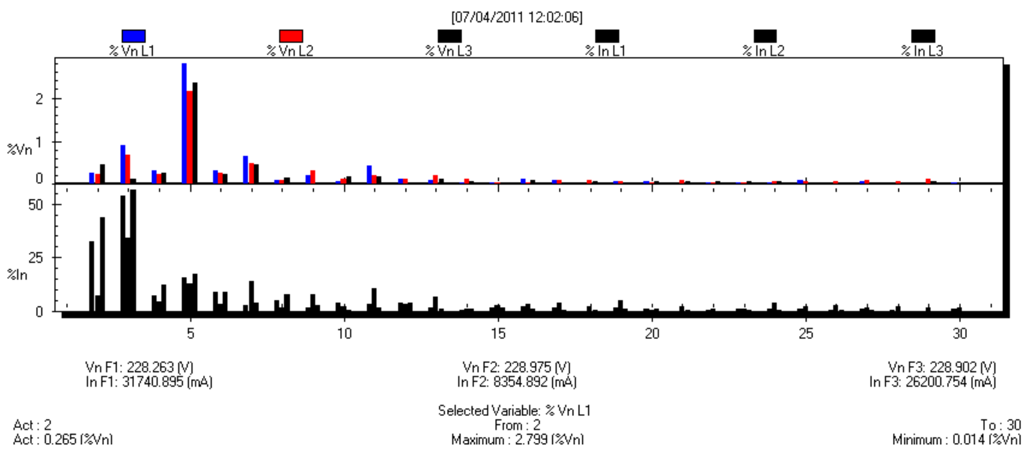

Fig. 2. Harmonics for machine 2.

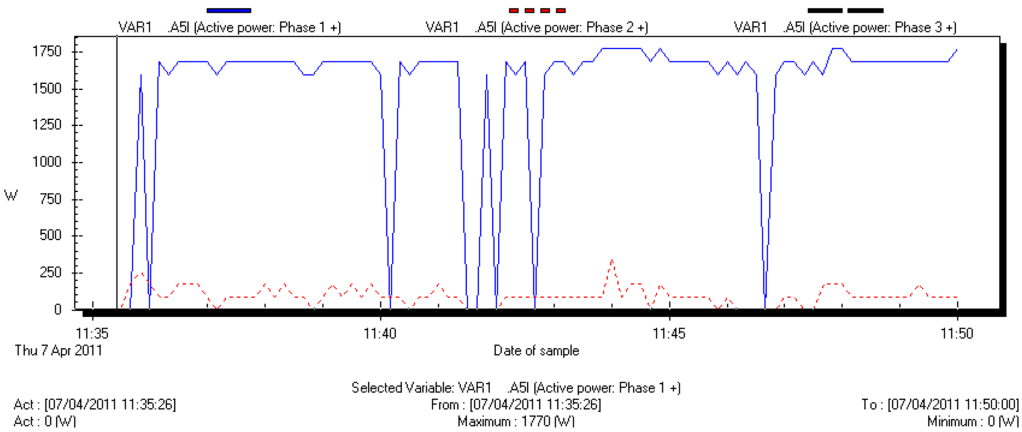

Fig. 3. Active power for machine 1.

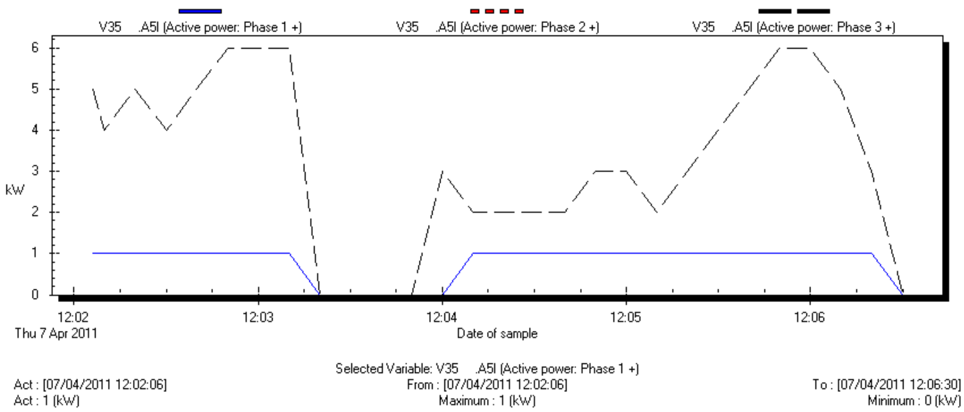

Fig. 4. Active power for machine 2.

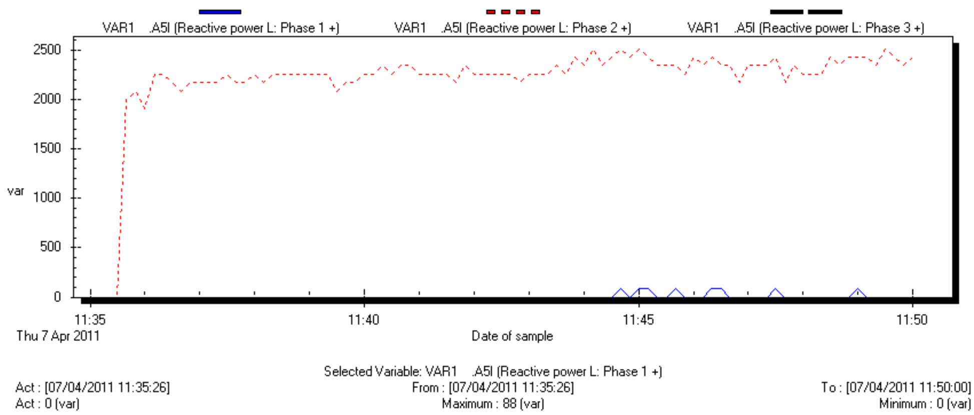

Fig. 5. Reactive power for machine 1.

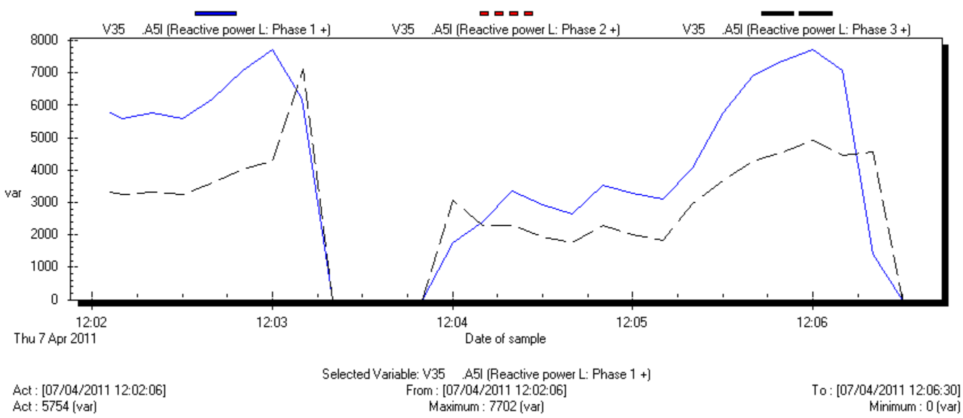

Fig. 6. Reactive power for machine 2.

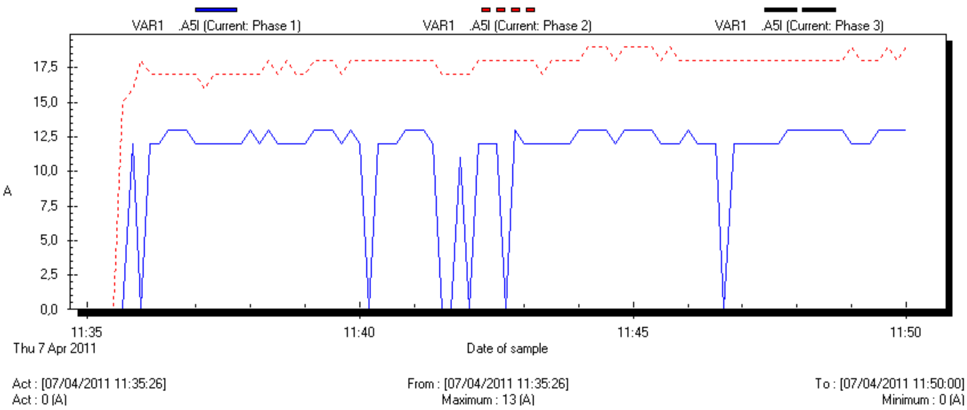

Fig. 7. Current consumption for machine 1.

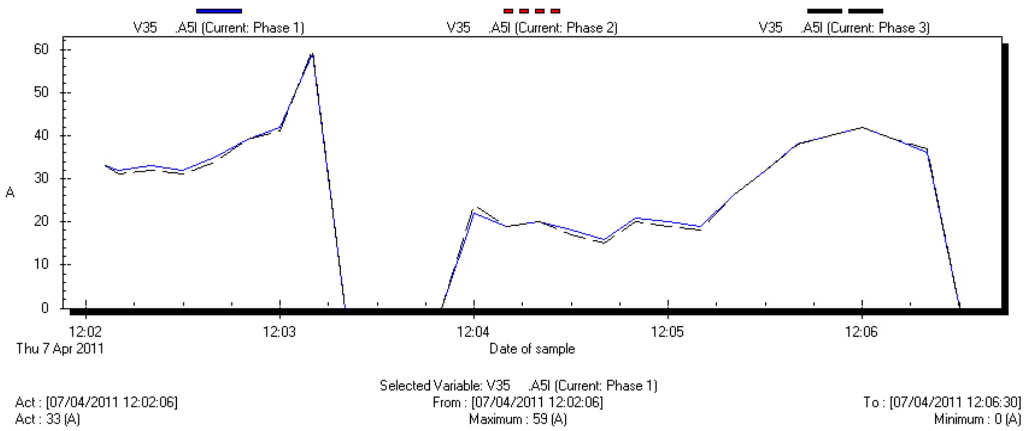

Fig. 8. Current consumption for machine 2.

4. ECONOMIC CONSIDERATIONS

These benefits are noticeable if we do a basic economic calculation- determination of the recovery period and the project profitability [5]. From the absorbed active power diagrams we notice a difference of about 3 kW in favour of machine 1. Considering that the machinery works in only two shifts, that the owner has proposed a moderate yearly profit, about 100 000 Lei (23 809 Euro) after he spent 560 000 Lei (133 333 Euro) on upgrading the machinery [10], by carrying the appropriate calculations we obtain the static indicators grouped in Table 1.

It should be noted that there are no additional maintenance costs because on one side the machinery is under warranty for a long period of time, and on the other side modern equipments are highly reliable.

The calculus of static indicators [5] shows:

$$T_{rec} = \frac{500\,000}{3\,594 + 100\,000} = 4.8 \text{ years.}$$

It is an acceptable recovery period, under five years, which confirms once more the profitability resulted from the machinery upgrades.

It may also be noted that the owner may not bear all modernization costs.

The costs decrease spectacularly by accessing European funds intended for energy saving.

5. CONCLUSIONS

We can conclude that as numerical controls evolve, they become more and more accessible to operators and to projecting engineers. Difficulties remain for software developers, who must find more and more accessible programmes, thus lowering the costs by reducing the work time, reducing the energetic consumption(by optimization of feed controls) and reducing expenses with personnel.

The boards of factories in the processing branch can easily decide the modernization of the existing machine tools, considering both the high productivity and the small amount of time in which the investment will be recovered. According to calculations, in all the cases we studied the investment is easily recuperated, thus attractive. The attractiveness increases as there are numerous European programmes in the energy field, according to which the investor only has to cover part of the investment. All these also contribute to general economic development, by creating and developing import, assembling and service firms, and also creating firms with connected activities. From all the above, we can conclude the following advantages of using static converters:

a. precise control of the energetic process and especially of the system's speed;
b. very low maintenance;
c. saving energy;

Table 1

Calculus of static indicators

No	Indicators	M.U.	Results
1	Economy by introducing CSF	kW / hour	3
2	Functioning hours	Hours / year	3840
3	Annual energy economy	MWh	11.98
4	The price/ energy	Lei / MWh Euro / MWh	311.98 74.28
5	The cost of the energy save / year	Lei / year Euro / year	3594 855.71
6	The cost of the installation	Lei Euro	560 000 133 333

d. smooth start/stop, without blows of controllable acceleration and deceleration;
e. almost inexistent noise.

The considerable progress in the field of electrical systems with variable speed made that the investment necessary for such systems to be just a fraction of the total cost of the energy used during their functioning.

Command pulse time modulation inverters, which eliminate the superior harmonics [4 and 8], have represented an important step in the establishment of the driving with an asynchronous motor as a solution for the future. This is why, while the static tension and frequency converters are being modernized, the balance is towards the driving with an asynchronous motor against the D.C. one.

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