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THE WEAR OF CUTTING TOOL ON NUMIRICAL COMMAND MACHINE; APPLIED TO A LATHE EMCO COMPACT 5 CNC

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ABSTRACT

In machining, the cutting tool penetrates into the workpiece applying a big effort with the aim to remove the metal. One can say that the lifetime of the cutting tool dependents on several parameters such as cutting speed, in feed depth and the feed speed. The careful choice of cutting parameters requires preliminary tests, especially when the machine is didactic with low power. In this context, the employed technique consists in measuring the cutting force, by varying the cutting conditions. A method for evaluating wear of the tool is used together with a camera and Toupview software. Curves have been plotted in order to choose the necessary cutting parameters during machining of two different materials (cast iron and bronze). The obtained results are significant and coherent with theory.

KEYWORDS: Cutting Speed, Flank Wear V_B, Feed Speed F, Lifetime T, Model Taylor Gilbert

INTRODUCTION

When talking about competitiveness in productivity, one should know the materials to be used, their shaping and machining facilities. It is also necessary to make extensive studies that allow a significant time saving and consequently of reducing the cost and increasing the quality of manufactured products [1]. It will be judicious to have a strict and estimated control. Research is still still ongoing to enable the control of cutting tools during machining in order to:

Reducing the risk of incidents and their severity and to detect the cause;

Make maximum use of the cutting tool.

The tool wear affects the size and quality of the workpiece surface and it is also one of the important criteria for determining the lifetime of the tool. Several methods have been applied to detect the wear of the cutting tool, there between, the cutting force. Kessler tables have proven their performance by measuring simultaneously the three efforts in the X, Y, Z axis [2 - 4].

In this work, a similar technique is used, given that there is the factor of congestion and low power of the machine. A sensor has been established on the structure to be investigated, which is in our case a high speed steel cutting tool (HSS). The sensor is a strain gauge used for detecting the deformation of the tool subjected to the cutting force. At the above surface the tool is in tensile stress, while at the below surface the tool is in compression stress. The necessary electrode for the acquisition of information during the machining is amplified by an electronic interface. The applied force value to the tool is obtained directly from the deformation captured by these strain gauges.

In fact, an indirect method has been applied with the aim to measure the cutting force [5] in dependence of cutting parameters such as cutting speed, in feed depth and feed speed. To consolidate this study, a wear evaluating method of the tool using a camera coupled to Toupview software has been used. The corresponding lifetime at a given speed is thus determined by the following criteria ISO 3685 [6]. Based on this, one can develop a continuous surveillance system of the state of the tool during the cutting process. The plotted curves are in agreement with bibliographic references [7 - 9]. They serve as abacuses to students in their scientific training to better use the lathe and thus to master the cutting parameters without grave incidents and without damaging the tools and the machine structure.

THEORY AND MATHEMATICAL FORMULAS

The cutting time of a tool is defined as the ability to produce surfaces with the same dimensions and quality during the limited time despite its resulting degradation. According to ISO: the cutting time is the time required to reach a criterion of specific life [5].

The useful life of each tool is fixed by calculating the theoretical life, using mathematical model (Taylor, Gilbert ...) [6].

$T = C_v \times T^n \times f^x \times a^y$ Taylor Generalized model where:

T is the cutting tool lifetime; **V** is the Cutting speed;

F is the feed speed; **a** the cutting depth; **n, x, y** are exponents

By fixing the feed speed **f** and the cutting depths **a** under a specific test, the equation becomes as follows:

$T = C_v \times V^n$ Simplified Taylor model, in Log:

$Log\ T = n \times LogV + LogC$ a straight line equation y = ax + b.

One can determine for each cutting speed, an appropriate lifetime. But the problem is not yet solved, there must be other machining incidents; such as the sudden failure of the cutting edge, unusual wear etc…

The permanent measuring of the tool wear which can only change when it reaches a critical value generally estimated to V_{Bmax} = 0.6mm for roughing and to 0.3mm for finishing. However, it stills a particular problem to detect using direct methods given that the cutting environment is hostile.

It is of importance to notice that the direct methods are easy to apply apart from the machining process. But they are more difficult to apply if one wishes they occur during the machining process. When the choice is made, it is the indirect method for measuring the cutting force which is selected to deduce the tool wear.

EXPERIMENTAL PROCEDURE

Experimenting is the only way that allows one to reach the reality and thus to accomplish the continuous surveillance of the system. In this work the indirect method has been chosen given the available resources. Measuring the cutting force, the most usual way in such processes is also made. The idea is to plate a sensor on the tool (strain gauge) for measuring the applied force of the tool on the workpiece. When wear becomes abnormal, it appears as a friction, which leads to an excess in stress which results in tension detected by a voltmeter. The system calibration has been carried out with the aim to convert the output voltage value to a force unit. In order to better check the system, the practical parameters k, α, β resulting from the formula (below) have been determined. .

$F = k \times f^{\propto} \times a^{\beta}$ Applicable for steel cutting tools.

To be able to calculate the tangential cutting force in clearly defined working conditions in order to better locate and compare the practical results to the theory, tests have been carried out on two different materials where their specific cutting forces are known beforehand. The three parameters k, α, β can be deduced. The obtained results are satisfactory.

DESCRIPTION OF TEST

Testing Materials

The tests have carried out in the CNC Laboratory (Department of Mechanical Engineering University Med Boudiaf M'Sila) and in other laboratories of neighboring companies (Algal, Sonalgaz, inditex).

The tests have been carried out over long periods, repeated several times to ensure that the tests have been well conducted and thus obtaining good results. The equipment used during testing is as follows:

Machine Tool: Numerical control lathe with CNC compact low power calculator-type EMCO at the pin, shown in Figure 1.

Figure 1: CNC Lathe EMCO Compact Type

- The cutting tool used for tools turning is made from high speed steel (HSS) 444 S nuance and has the following geometry: α = 8 °; χ = 90 °; λ = 0 °. Its hardness = 64 HRC. The HSS has the following nuance (Z85DCWV09-04-02-01) AFNOR.
- The material to be tested is: a gray cast iron Ft20 (NF A 32-101standard), and a bronze (U-E9P) AFNOR nuance with the following mechanical properties: 8.5% Sn, 0.15% P, σ_r = 45daN/mm^2; σ_e = 30daN/mm^2, HB120.
- Measuring equipment: In order to measure the effort, the strain gauges bonded directly on the cutting tool are used according to tensile and compression stresses (Figure 2).

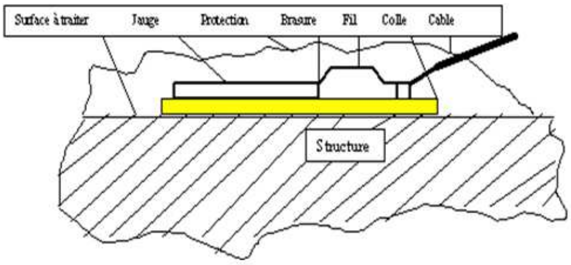

Figure 2: The Setting Up Of the Strain Gauge

For the measurement of wear, a (20x) objective profile projector equipped with two displacements X; Y table with a precision of 1 / 1000mm was used. Having compared the results with those of a camera coupled to (20 x) Toupview software shown in Figure 3, the second solution has been adopted.

Figure 3: Interface Acquisition of the Cutting Tool Wear

The method of evaluation is shown in Figure 4, which gives two corresponding values on the photo using a 1mm scale. The microscope magnification is 20 xs.

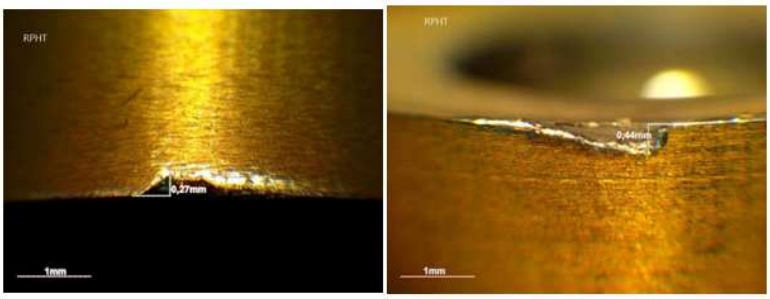

Figure 4: Measuring Principle Used For Wear Photo Collection *(Camera And Toupviewsoftwar*.

Cutting Conditions

After prior calculation taking into consideration the tool cutting conditions of resistance (at fracture and deformation) and due to the approximate calculation of the cutting force, the absorbed power is calculated during cutting so as to not deteriorate our machine. In this manner, one can modify cutting parameters without exceeding the available power of the spindle.

The tests have been carried out in dry conditions. The wear criteria adopted in this case is as follows: VB = 0.6mm to the blank, VB = 0.3mm for finishing.

TEST RESULTS AND INTERPRETATION

Figure 5 and 6, show that the force F increases relatively as a function of the feed speed f and the in feed depth a. On the other hand, it's well noticed that the applied force increases as a function of the material hardness.

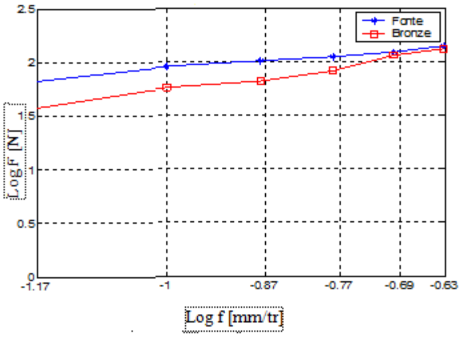

Figure 5: The Applied Force F as A Function of the Feed Speed F

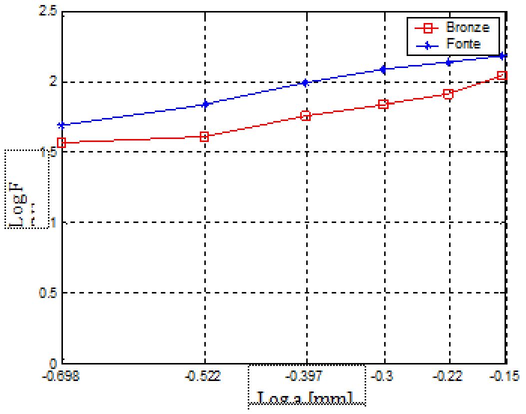

Figure 6: The Applied Force F as Function of the In Feed Depth A

Figure 7 shows the problem of the reported edge. It's shown that the wear decreases for certain feed speeds and becomes slightly constant when increasing the feed speeds, then quickly rises again. This enables choosing an appropriate advance speed. Figure 8 shows the increase of wear as a function of the applied force for a constant feed speed and for variable in feed depth.

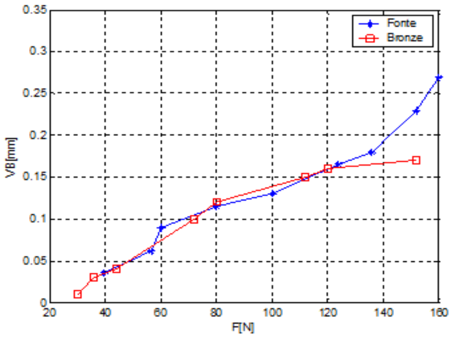

Figure 8: The Wear Function of Stress

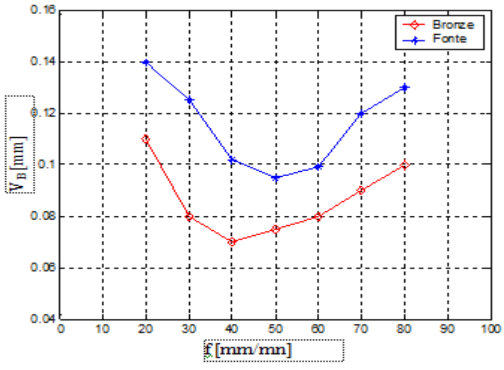

Figure7: Influence of Speed Ahead On Wear A =0.5mm
Vc = 24 M/Mn
T= 4mn

Figure 9: shows that wear increases significantly as a function of the in feed depth for a constant cutting speed.

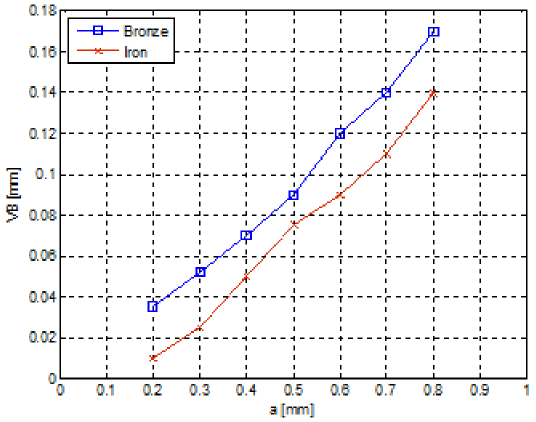

Figure 9: Wear V_B as Function of the in Feed Depth A.

Figure 10 shows the evolution of wear as function of time for defined speeds. The chosen wear threshold is V_B = 0.3mm. From the curve in figure 10, one can draw the Taylor straight line $T = C_v \times V^n$in the case of two kinds of materials (gray cast iron and bronze). It is thus possible to choose the appropriate cutting speed corresponding to the definite lifetime.

It is noted that for low cutting speeds Vc = 24m / min the wear criteria is reached for V_B = 0.3 mm after 32 minute. On the other hand for Vc = 42m / min and V_B = 0.3mm the wear criterion is reached after only 13 minutes.

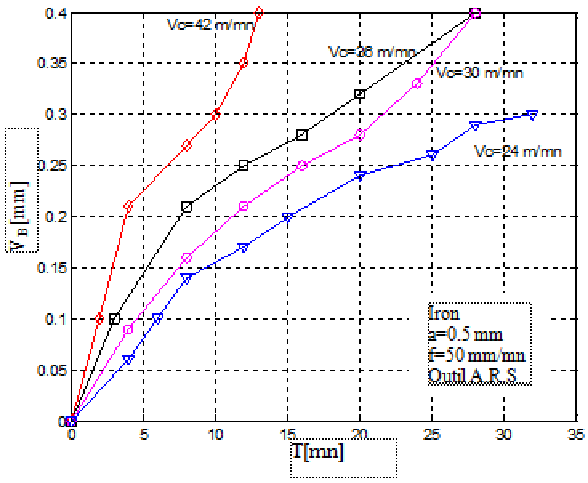

Figure 10: Evolution of Wear with Cutting Time A=0.5mm; F=50mm/Mn; V: Variable

$T = Cv \times V^k$ For the two types of materials. It is thus possible to choose the appropriate cutting speed for corresponding to the definite lifetime.

CONCLUSIONS

Measurement the evolution of wear remains a particular problem in scientific research. In fact, it is of importance to recognize that an intermediate measure might slow down the effects of wear, due to the temperature drop of tool despite its short duration.

The results for the variation of wear depending on cutting parameters are noticed to be close to each other, taking into consideration the influencing parameters which affect the measures such as:

- Incorrect Regrinding of the tool;
- inhomogeneity of the material to be machined;
- The change in temperature of the cutting tool during measurements;
- The components of the used machine used, etc...
- These curves are currently used by students in the practical sessions and pass without risk or incident recorded.

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