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CONTRIBUTION TO THE STUDY OF THE INFLUENCE OF CUTTING TEMPERATURE IN HARD TURNING

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Abstract: *The rise in temperature during a machining process is due to a combined effect of the phenomena of dissipation of plastic energy in different zones of deformation and the phenomena of friction. Knowledge of the temperature in machining allows the development of new cutting tools (composition of the material of the tool, geometry, coating, etc.), the increase in tool life in order to reduce the cost of production industrial. In hard turning and by the very principles of cutting, which are quite different than for the usual turning of untreated materials, very high temperatures appear during work (between 500 ° and 1500 ° depending on the case) in the areas contact between cutting edge and workpiece. This leads to softening of the machined material in the areas of contact with the tool. The first factor is the thermal conductivity of the cutting material. For finishing work, a cutting material with low thermal conductivity is the first choice. The temperature during the cutting process is transferred to the shear zone, this which improves the cutting process.*

Key words: *Temperature, deformation, friction, tool, production cost, chips, stresses.*

1. INTRODUCTION

In a machining process, among the parameters which can be determined experimentally and which are frequently studied in the case of turning, the forces in the tool-part torque, the temperature and the residual stresses. The temperature that forms as a result of friction in the tool / part pair has an influence on the tool life. The temperature measurement is a very difficult process because of the complexity of the geometry of the tool, the knowledge of the cutting temperature is very important because it has a great influence in the choice of materials and the optimal conditions of machining. The heat produced in these different zones, is transmitted to the chip, the tool and the workpiece. Currently, the quantification of the level of heat generated constitutes competition in the fields of academic and industrial research.

The analysis of the temperature in the cutting area is very complex and difficult. Indeed, the strong thermal gradients and the movement of the different antagonists (part, tool and chip) require a temperature measurement system which takes into account all these specificities. There are several ways to go about determining the temperature of the cutting edge of the tool. In our approach we limit ourselves to the measurement of this temperature by a thermocouple.

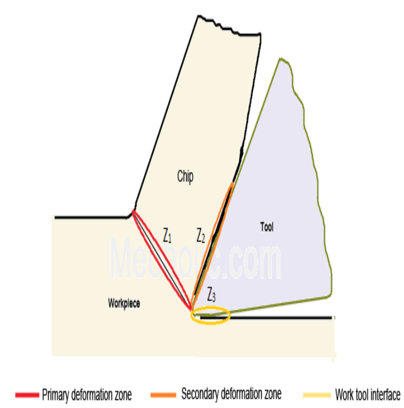

Fig. 1. Different areas of production and heat transfer in machining. [1]

The advantage of thermocouples is the simplicity and flexibility of construction and use for simple acquisition at a lower cost. There are several types of thermocouples, the most common are standard and dynamic thermocouples.

This type of thermocouple is generally used in tribology. This method is based on the

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Seebeck effect. The principle is to take two bodies in relative motion as two parts of a thermocouple.

2. TEMPERATURE MEASUREMENT TECHNIQUES

Different methods are used to measure the temperature rise in machining the use of thermocouples, the infrared camera, metallographic analysis, the use of fine powders with constant melting temperature and the use of thermo sensitive paints [2], [3] applied to machining.

- Thermocouples are used in two ways:

Small thermocouples inserted in the cutting tool.

- Natural thermocouple formed by the part and the tool themselves.

Thermocouples are the most widely used, but they remain imprecise and only provide an average temperature at the tool-chip interface. To have complete information on temperature distribution, other techniques should be considered.

3. EXPERIMENTAL APPROACH

3.1 Test specimen

The tests are carried out by turning on cylindrical steel specimens “diameter 80 mm and length 280 mm” of different hardnesses. The plots were taken in soft shouldered jaws. For gripping the jaws, a reach of 80 mm was machined which leaves a machinable length of 200 mm. The two faces were straightened and an external turning was carried out to a depth close to 3 mm to eliminate the layer brute [4].

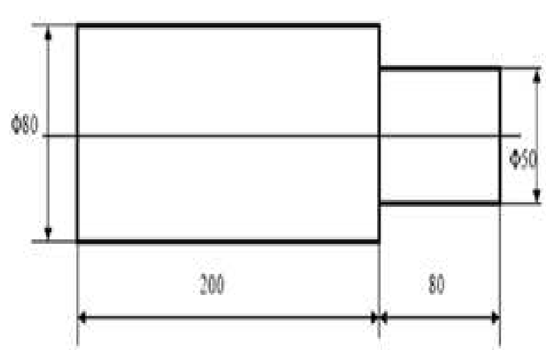

Fig. 2. Test specimen.

4. MACHINING STUDY

The machining was carried out without lubrication on a parallel model lathe brand “TOS TRENCIN”, with a power of 6.8 Kw from the technological hall of the Abou Bekr Belkaid University in Tlemcen, Given the influence of a large number of parameters for each result, we had to define a design of experiments where each parameter varied independently of the others. Our objective was to qualify the cutting conditions associated with each type of insert for hard steel. Beyond this qualification, we also expected the analysis of the results to quantify the influence of the input parameters on the results, to acquire a first knowledge base under controlled conditions of hard turning.

Our observation focused on the cutting temperature and wear to determine the limits of the range of use of the tool-material pair, it is a question of determining a domain of validity for the production of a surface under good technological conditions according to of the three parameters: cutting speed Vc, depth of cut ap and feed rate f.

5. CUTTING CONDITIONS

The suitable cutting conditions were determined according to the requirements and recommendations of Sandvik [5], [6], [7], [8], [9]. The Vc = 90, 100, 150 and 180 m / min; f = 0.08, 0.11, 0.14, 0.20 and 0.28 mm / rev; ap = 0.25, 0.5, 0.75, 1.0 and 1.5 mm. The tests were carried out dry. Our experimental variation intervals of the elements of the cutting speed, for the type P10 and P35 inserts are respectively: Vc = 65, approach is based on the instrumentation of a turning tool holder using a Figure thermocouple. The thermocouple is used to determine the local temperature with different inserts and different cutting conditions, during a machining operation.

The thermocouple used is surrounded sufficiently far from the cutting area so as not to be influenced by variations in the tool / chip contact area. However, it must be placed close enough to have the maximum precision in estimating the heat flow.

Fig. 3. Temperature measuring device.
(a) workpiece , (b): plate, (c): thermocouples and (d): measuring device.

The thermocouple consists of a 0.3 mm thick sheet of copper, cut to the shape of the wafer housing, to which a 0.35 mm diameter constantan wire is soldered. The two wires of this thermocouple are connected to brass terminals maintained at room temperature. The measurements are recorded on a special digital thermometer which allows us to directly read the value of the temperature measured. The copper / constantan thermocouple "type T" has an average sensitivity of 50 µV / ° C and is linear up to 300 ° C. Copper has the advantage of being ductile in order to optimize the thermocouple / wafer contact [10].

6. CUTTING TEMPERATURE ACCORDING TO CUTTING CONDITIONS

The objective of this campaign is to see the evolution of the specific cutting temperature over time and to observe its pace for different values of cutting speeds. It should be noted that during this test, the advance and the depth of cut remained constant [11], [12]..

7. MEASURES THE TEMPERATURE AS A FUNCTION OF THE CUTTING SPEED Vc

The influence of the cutting speed on the temperature field was studied for the two metallurgical states "with and without heat treatment" of the machined material, for a feed "f = 0.08 mm / rev" and a depth of cut "ap = 0.5mm". The machining tests were designed in hard turning with two tool materials types P10 and P35. The results of the temperature variation as a function of the cutting speed, for the two tested tool materials are shown in Figures 4 and 5. Analysis of these results shows that the type P10 inserts induce higher temperatures; this is due to the increased cutting speed.

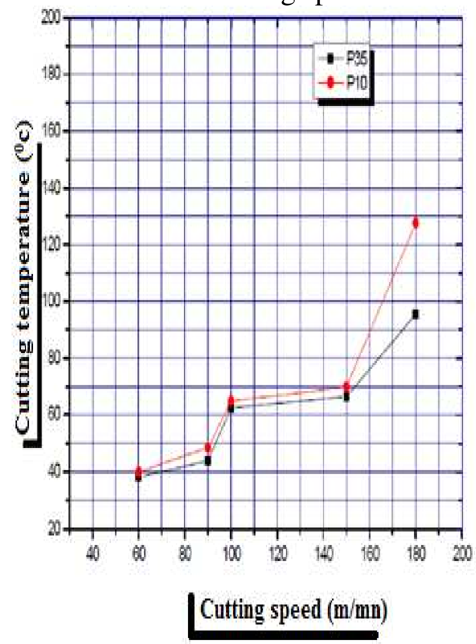

Fig. 4. Influence of the cutting speed on the cutting temperature obtained with type P10 and P35 inserts, sample XC18 (as delivered) at f = 0.08 mm / rev and ap = 0.5mm.

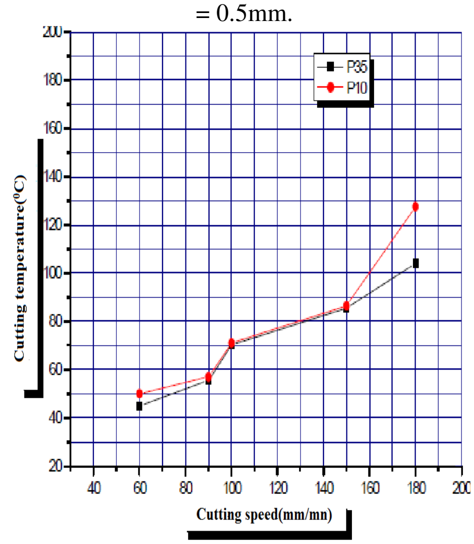

Fig. 5. Influence of the cutting speed on the cutting temperature obtained with Type P10 and P35 inserts, sample XC18 (hardened) at f = 0.08 mm / rev and ap = 0.5mm.

8. MEASURES THE TEMPERATURE AS A FUNCTION OF THE ADVANCE f

In order to study the impact of the advance on the temperature field, we practice the same experimental procedure for the two metallurgical states "with and without heat treatments" of the machined material, for a cutting speed Vc = 150 m / min and a depth of cut ap = 0.5mm. The machining tests were designed in hard turning with two tool materials types P10 and P35. The results of the variation of the advance as a function of the temperature thus obtained are presented in Figures 6 and 7.

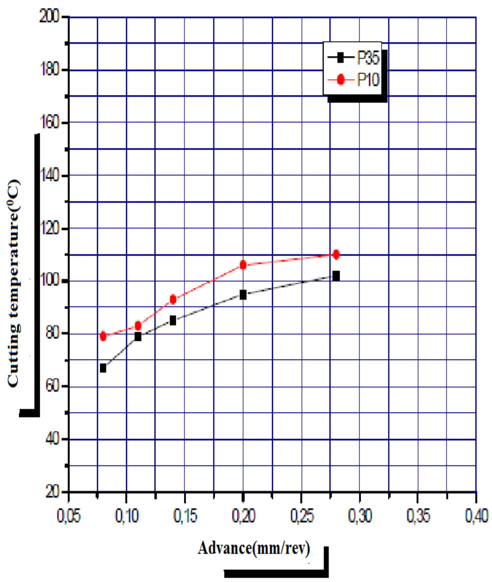

Fig. 6. Influence of the feed rate on the cutting temperature obtained with type P10 and P35 inserts, sample XC18 (as delivered) at Vc = 150 m / min and ap = 0.5mm.

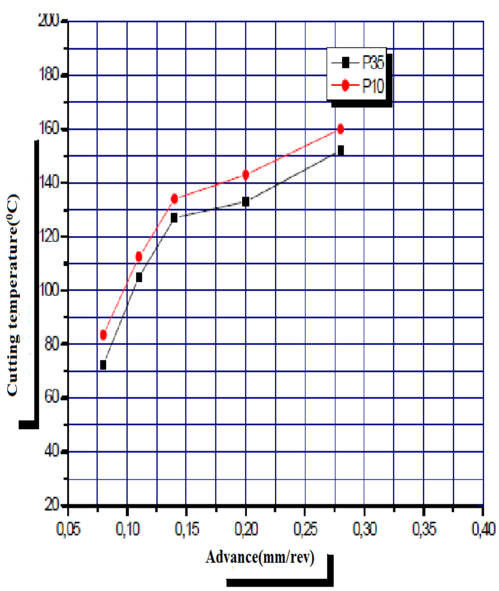

Fig. 7. Influence of the feed rate on the cutting temperature obtained with type P10 and P35 inserts, sampleXC18 (hardened) at Vc = 150 m / min and ap = 0.5mm.

9. TEMPERATURE MEASUREMENT AS A FUNCTION OF THE DEPTH OF CUT ap

As previously, the same study was made to identify the influence of the depth of cut on the temperature field and that for the two metallurgical states (with and without heat treatment) of the machined material, for a cutting speed of 150m / min, an advance of 0.08mm / rev. The machining tests were designed in hard turning with two tool materials types P10 and P35, the influence of the cutting depth on the temperature, is presented in figures 8 and 9.

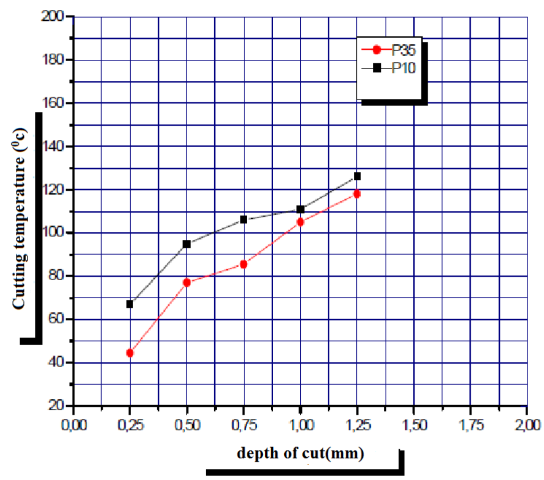

Fig. 8. Influence of the depth of cut on the cutting temperature obtained with type P10 and P35 inserts, sample XC18 (as delivered), at Vc = 150 m / min and f = 0.08 mm / rev.

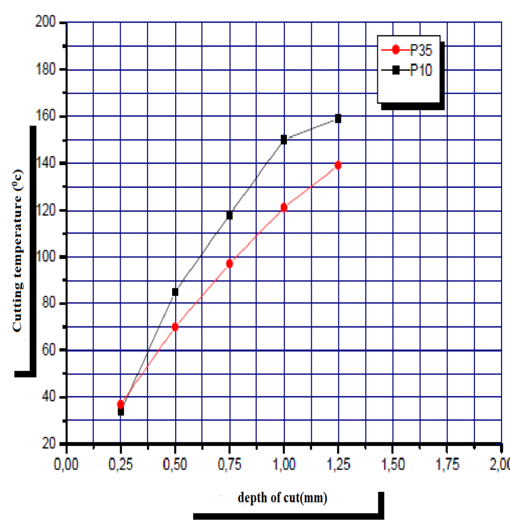

Fig. 9. Influence of the depth of cut on the cutting temperature obtained with type P10 and P35 inserts, sample XC18 (hardened), at Vc = 150 m / min and f = 0.08 mm / rev.

10. INFLUENCE OF THE CUTTING TIME ON THE FLANK WEAR VB

To understand the advantages and limitations of each cutting material, it is important to know the amount of flank wear that acts on the tools, this is the most common type of wear and is also the most desirable wear since it is more predictable and stable. It is due to the abrasion exerted by the hard constituents of the material of the part. The following figure10 illustrates the development of flank wear as a function of machining time.

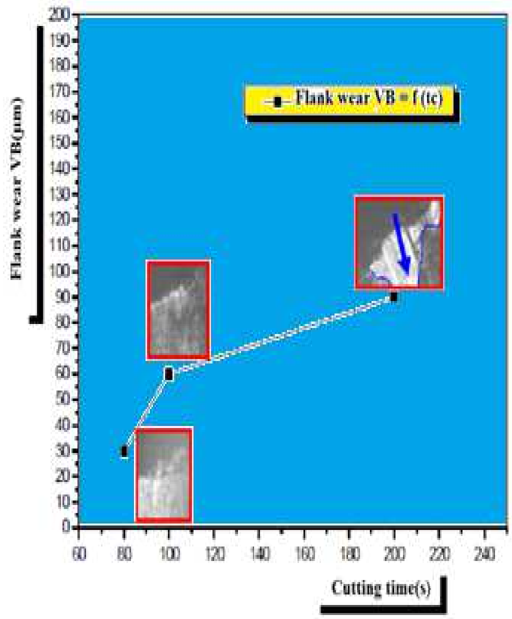

Fig. 10. Evolution of the flank wear VB as a function of the cutting time obtained with type P35 inserts, sample XC18 (hardened), Vc = 150 m / min, f = 0.08 rev / mm and ap = 0.5mm.

11. RESULTS AND DISCUSSION

The curves in figures 4 and 5 show that when machining with P35 type inserts the temperature reached by the thermocouple is visibly lower than that obtained by the P10 type tool, this is explained by the fact that the materials P35 tools used on the one hand have great resistance to wear and on the other hand the material to be machined has a very fine microstructure following the heat treatment which has been applied to it.

Analysis of the results in Figures 4 and 5 clearly shows that P10 type inserts induce higher temperatures, with increasing cutting speed.

Analysis of the curves obtained under identical experimental conditions for the two cutting materials shows that the performance of the P35 inserts greatly exceeds that of the P10 tool.

The increase in the depth of cut leads to an increase in the total quantity of heat released for the two cases studied.

As the amount of heat increases as the depth of cut increases, the engaged length of the cutting edge increases.

The higher contact improves heat dissipation in the tool body, as the volume of the active part of the tool increases.

The friction of the part against the flanked face reveals a frontal wear zone, the height VB of which is more or less regular.

The evolution of the flank wear VB for the tool material tested, we notice that the wear increases with the increase in cutting time.

The evolution of the wear of the two materials studied influences the roughness values. In fact, with the increase in the cutting speed, the wear increases and directly leads to the degradation of the surface condition.

12. CONCLUSIONS

Through this experimental study on the physical phenomena involved at the tool-part-chip interface and analyzes of the cutting products (part and chip), we have highlighted the complexity of the thermo mechanical mechanisms involved during cutting.

The analysis of the results could allow us to define optimal cutting conditions and metallurgical state allowing obtaining good surface conditions with favorable stress gradients to increase the fatigue resistance of machined parts and to reduce cutting forces; in order to reduce tool wear and increase its service life.

13. REFERENCES

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CONTRIBUȚIE LA STUDIUL INFLUENȚEI TEMPERATURII DE TĂIERE ÎN STRUNGIREA DURA

Rezumat: Creșterea temperaturii în timpul unui proces de prelucrare se datorează unui efect combinat al fenomenelor de disipare a energiei plastice în diferite zone de deformare și al fenomenelor de frecare. Cunoașterea temperaturii în prelucrare permite dezvoltarea de noi scule așchietoare (compoziția materialului sculei, geometrie, acoperire etc.), creșterea duratei de viață a sculei în vederea reducerii costurilor de producție industrială. La strunjirea dură și prin însuși principiile tăierii, care sunt destul de diferite față de strunjirea obișnuită a materialelor netratate, în timpul lucrului apar temperaturi foarte ridicate (între 500 ° și 1500 ° în funcție de caz) în zonele de contact dintre tăișul și piesa de prelucrat. Aceasta duce la înmuierea materialului prelucrat în zonele de contact cu unealta. Primul factor este conductivitatea termică a materialului de tăiere. Pentru lucrările de finisare, prima alegere este un material de tăiere cu conductivitate termică scăzută. Temperatura în timpul procesului de tăiere este transferată în zona de forfecare, ceea ce îmbunătățește procesul de tăiere.

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