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TREATING PROPRIETY THROUGH CUTTING OF METALS AND ALLOYS IN CRYOGENIC CONDITION

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ABSTRACT

It is known that a base function of cutting environments is to cool the cutting tools, the tooled area and the material that is removed under the shape of chip. But it is also known that beginning with the increase of the rate of work, especially during the processing of the materials that have a low machinability, the efficacy of the operation of cutting environment is declining. It is appearing the opportunity of increasing the efficacy of the used cutting environment.

1 The historic of treating through cutting using cryogenic environment.

The idea of increasing the efficacy of the cutting environment preoccupies the scientists since 1944. Thereby, Pahlitzsch analyzed treating metals through cutting in conditions of using a cutting environment with forced cooling, using a special cooling equipment till a temperature of 273 Kelvin. It was discover that only through cooling the common cutting environment it take place a rising durability of the tool with 24 % till 100 %, according to the treating conditions.

Subsequently it was born the idea of cooling the tool or the part machine until temperatures below 273 Kelvin for improving the cutting workability of certain alloyed steels with chrome, nickel, molybdenum, manganese, and titan. This thing leads to the appearance of cutting in cryogenic condition, namely to take advantage of a cutting environment at temperatures below 120 Kelvin.

In 1953, Bartle initiate the cutting in cryogenic condition research, using carbon dioxide as cryogenic liquid. The method is took and ameliorate by the “Carbon Dioxide CO.” under the name of “Ce-De-Cut” process.

In 1957, Delaney ameliorate the metal working below zero, whereon it was used a special cooling agent.

The phenomenon which accompanies the cutting at low temperature process was studied at full since 1958, by Kumabe and Masuko, which accentuate the arrangement of the deposits on the bit and the materials brittleness at low temperatures.

In 1967, the Japanese scientist Okoshi, test a new cooling environment: liquid nitrogen. This is used on large scale in cutting process because of the low temperatures which are achieved (77 Kelvin), because it isn’ t toxic and it has a small price.

In 1975, the Russian scientist Filonenko, use the cryogenic cutting method to lathe of a large scale of steels: carbon, stainless, established that this method is profitable, but it needs studies about the influence of the cryogenic environment on the phenomenon which accompany the cutting process.

2. The behavior of the materials at low temperatures

In conditions of temperatures below 120 Kelvin, the physic proprieties and the mechanical characteristics of the materials that are treated through cutting process, inclusive the tool, suffer a series of alterations. At the most of metallic materials it happens that the hardness and the resistance characteristics are rising and the plasticity characteristic is decreasing.

For austenitic stainless steels, the deformation in cryogenic conditions leads to the transformation of the residual austenite in martensite, which has effect on the functional characteristic of the piece through raising the tiredness resistance.

Considering the study of the behavior of negative temperatures for two materials: OLC45 and 7TiNiCr180 for which we will show diagrams of the resiliency variation with the temperature (diagram no 1), of the endurance and the linear extension variation with the temperature (diagram no 2) and of the force variation with linear extension (diagram no 3 and 4)

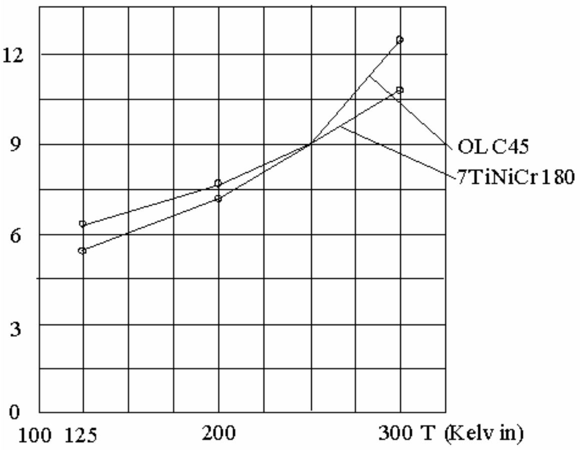

Figure 1: Variation of resiliency with the temperature.

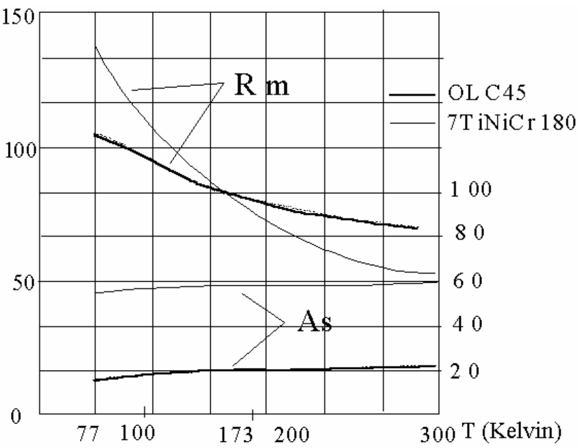

Figure 2. Endurance (Rm) and linear extension (As) variation with the temperature

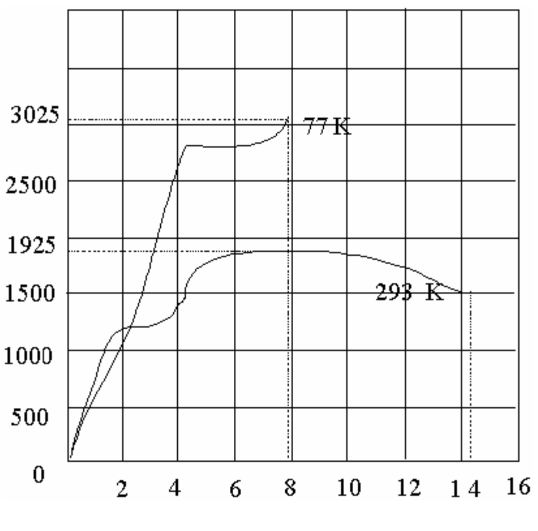

Figure 3: Force variation with linear extension for OLC45

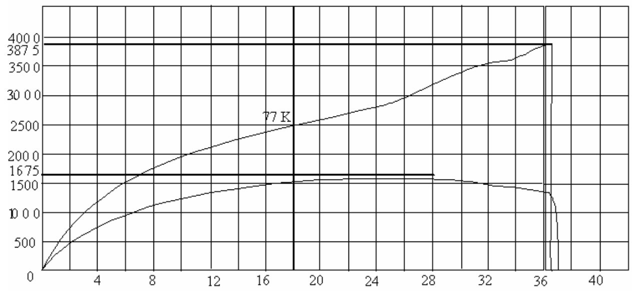

Figure 4. Force variation with linear extension for 7TiNiCr180

Given the room temperature, at 77 Kelvin, the breaking endurance increase for 2,5 times for 7TiNiCr180 and for OLC45 for 1,5 times. In the same conditions, the linear extension decrease for both materials. Of course that in the deformation process or cutting process the strength of materials is low, accordance with the temperature.

This increasing of the endurance characteristic is favorably for the deformation process in case of deep camber known that in certain situations it is necessary to increase the semi-product endurance. The impact elasticity is decreasing for both materials with the decreasing of the temperature.

From the analysis made till present time result that not all the metallic or non-metallic materials changes in the same proportion the technological proprieties and the mechanical characteristics. There are materials whereon the cooling influences in insignificant, so that it is recommended, in all cases, to execute the determination of the material behavior at low temperatures and only after that will be established the suitability of using the cryogenic technology.

3. The influence of the cryogenic temperature over the phenomenon’s which accompanies the cutting process

The increasing of the tool’s durability at the cryogenic cutting is because of decreasing the mechanical stress outcome the diminution of the plastic deformations and because of the diminution of the thermal loading to the cutting tool.

Thereby does not appear or relevant decrease some tear forms specific to the high temperatures such as: diffusion tear, oxidation and adhesion.

The refrigeration of the semi-product material is increasing, sometimes, his fragility and the quality of the worked surface in increasing because of diminutions of the plastic deformation which are accompanying the process of discharging the deposits formed on the blade and because of maintaining the exact geometrical parameters of the cutting tools in a long period of cutting.

The results of this processing method take to the conclusion that using the cryogenic environments leads to intensification of the metals and alloys treating processes and increase their efficiency. Cutting in cryogenic environment increase the efficiency of the treating processes and in some cases is the only possible treating method.

The main characteristic of the cutting processes in cryogenic environment, in case of cooling the part's material consist in passing the material's particle from the tenacious status to the fragile status and as result of decreasing the plastic deformations which are accompanying the treating process. Thereby it was determined the proportion of the discrepancy coefficient K_C in the purpose of highlighting the proportion of plastic deformation from the cutting area

The mathematical model of the discrepancy coefficient can be express through an exponential function such as:

$$K_C = a_0 \theta^{a_1} \gamma^{a_2} v^{a_3} x^{a_4}$$

where:

θ = temperature = 293 à 173 [Kelvin]

γ = releasing angle = 8 à 16 [degrees]

v = cutting speed = 2,5 à 15 [m/min]

x = cutting thickness = 0,02 à 0,14 [mm]

a_0 = constant of cutting conditions

a_i = multipliers

Analyzing the relation result that the diminution of the part's temperature (293 à 173 Kelvin) leads to diminution of the discrepancy coefficient.

4. Conclusions

The main phenomenon caused by the cooling of the tool and part is:

a) increasing the shearing stress of the tooled material;
b) increase the tender intensity of most materials;
c) changing the rubbing condition on the releasing surface and in the tool's edge area;

In conclusion, the characteristics of the cutting process in cryogenic cutting are influenced in various and complex mode, the result depending on the combination and the balance of the three phenomenon caused by the cooling process, as well as the quality of the thermal treatment of the tooled materials.

References

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