SOME ASPECTS ABOUT PROCESSING PRECISION AT THE STEELS CUTTING WITH TOOLS FROM EXTRA-HARD CERAMICS

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ABSTRACT :

In this paper is presented the influence on the processing precision, expressed by deviation of shape at circularity of the tools materials from extra-hard ceramics, using different cutting regimes. Tools were used as plates from different types of ceramics (CC650, CC670) and had the same geometry and the wearing on the setting surface V_B=0.

There was cut by turning a rod of steel of type Rul1 (100Cr 6) thermic treated having the hardness 60-62 HRC. There are analyzed and explained the results. By using of tools from extra-hard ceramics there can be obtained dimensional processing precision and of shape at the machining of hard steels similarly to that's obtained by turning, in some cases of finishing this operation can be avoided because it is more expensive with 50%.

KEYWORDS : processing precision, mixed ceramics, cutting regime.

1. INTRODUCTION

Obtaining of high dimensional and shape precisions, in the conditions of processing of some materials with better characteristics of hardness and tenacity or even thermical treated, presumes to assure of some restrictive conditions about the used equipment, the tool's material and the parameters of the cutting regime.

The equipment must to take part from a precision class compatible with the precision class of the tool. The cutting tool have to assure a superior thermo-mechanic resistance having a small wearing degree and a thermic stability with the maintaining of a hardness more than 2000 Hv at higher temperatures.

The assuring of these requirements was possible by the utilization of a lathe with numerical command type Torno Romi Centur, with a great power and a rigid construction that protects the ceramic tool against vibrations at high cutting speeds and which offers the possibility to adjust the rotation and to maintain constant the cutting speed with the variation of the work-piece diameter.

There were processed cylindrical work-pieces from alloyed steel Rul1 (100Cr6), a work-piece for each tool and the turning with different regimes was made for each work-piece with 10 mm lengths. The used tools have the shape of plates from mixed polycrystalline ceramics of CC 650 type (Al_2O_3 +Tic) and CC 670 (Al_2O_3 + SiC) the silicon carbure in the shape of fibers. These plates are very hard and thermo-resistant produced by Sandvik Coromant firm.

The deviations of shape at circularity have been measured with a system of Taylrond Hobson Pneumo type, of Daewo Automobile Craiova Concern.

2. PAPER'S PURPOSE, EXPERIMENTAL CONDITIONS

The research had the purpose to establish the influence of the cutting regime on the processing precision, expressed by the deviation from circularity, a very important

parameter for a good functioning of the work-pieces from classes with a high precision [9] , These pieces are processed with tools from extra-hard materials that have the wears ten times smaller in the same working conditions toward the materials of ordinary tool [4,11]. The dimensional and shape precisions obtained at the processing with extra-hard tools from ceramics or nitrides of the hard alloyed steels are similar to that's achieved by grinding, and because of this many times this operation is avoided. [1,8].
The cutting regimes were being established taking into account the processing optimization, using different restrictive criterions. Restrictions for choosing the cutting regimes were:

- for the processing depth a_p

$$a_{po} \le a_p \le A_p \quad (1)$$

in which A_p is the processing supplement, a_{p0} is the minimum depth under which the cutting can not be achieved and when appears a great friction between tool and work-piece;

- for working advance f_n:

$$f_n^2 \le \frac{8R_z r_\varepsilon}{1000} \quad \text{sau} \quad f_n^2 \le \frac{R_y r_\varepsilon}{125} \quad (2)$$

- average roughness criterion R_a
-

$$R_a = 0{,}0321\ \frac{f_n^{\,2}}{r_\varepsilon} \quad (3)$$

where R_z is the surface roughness, R_y is the maximum height of the roughness profile and r_ε is the rounding radius at peak of the tool.

- for the cutting speed were chosen superior values to 80 m/min after [4,11,5], considered to be the inferior limit for tool from extra-hard materials.

The processing was made with speeds between 100-180 m/min, because the cutting forces can be reduced by 1,5-2 times, that provokes a decreasing of the tool's and work-piece's deformations and in the same time the increasing of the processing speed.
The restrictive relationships have been extended also for the installation's mode of the for ferrous and non-ferrous materials.

work-piece in the device considering the variants :

- for the work-piece fixed between peaks:

$$a_p^{\,X_{Fc}}\, f_n^{\,Y_{Fc}} \le \frac{48\ EIT_p K_1}{\lambda C_{F_c} l_p^3} \quad (4)$$

- for the work-piece fixed with an end in universal and the other supported in a rotating peak which gives the greater rigidity J_p, (see rel. 8) :

$$a_p^{\,X_{Fc}}\, f_n^{\,Y_{Fc}} \le \frac{110\ EIT_p K_2}{\lambda C_{F_c} l_p^3} \quad (5)$$

- for the tool mounted in a console:

$$a_p^{\,X_{Fc}}\, f_n^{\,Y_{Fc}} \le \frac{3\ EIT_p K_3}{\lambda C_{F_c} l_{sc}^3} \quad (6)$$

From the relationships (4), (5), (6) ,l_p and l_{sc} are the work-piece's lengths respectively of the tool, C_{Fc}, λ, K_1,K_2,K_3 are correction coefficients, T_p is the tolerance of work-piece , E is the elasticity module and I is the inertia moment of the piece's section; X_{Fc}, Y_{FC} are the exponents of depth and respectively of advance.
Establishing the value of the piece's rigidity between peaks:

$$J_p = \frac{48\ EI}{l_p^3} \quad (7)$$

- and in universal and peak:

$$J_p = \frac{110\ EI}{l_p^3} \quad (8)$$

- and of the tool in console:

$$J_{sc} = \frac{3\ EI}{l_{sc}^{3}} \qquad (9),$$

it can be chosen the couple of parameters a_p and f_n so that the value of the elastic deformations in dynamic regime to not surpassed a certain fraction from the tolerance field T_p of the piece [10] , case in which the shape's deviations from circularity will be in the field limits.

For the cutting speed V_c, the longitudinal advance f_n and the processing depth a_p , have been established the following working values:

1. V_c=100 m/min ; f_n=0,06 mm/rot ; a_p=0,25 mm
2. V_c=100 m/min ; f_n=0,22 mm/rot ; a_p=0,25 mm
3. V_c=180 m/min ; f_n=0,06 mm/rot ; a_p=0,25 mm
4. V_c=18 m/min ; f_n=0,22 mm/rot ; a_p=0,25 mm

With these results was established that depth a_p has a small influence on the deviations from circularity and because of that, this parameter was maintained constant.

3. EXPERIMENTAL RESULTS

The results about dimensional deviations from circularity for considered tool's materials (CC 650, CC 670) are presented in graphics from fig.1 and fig.2 for which were established values from Table 1 and 2.

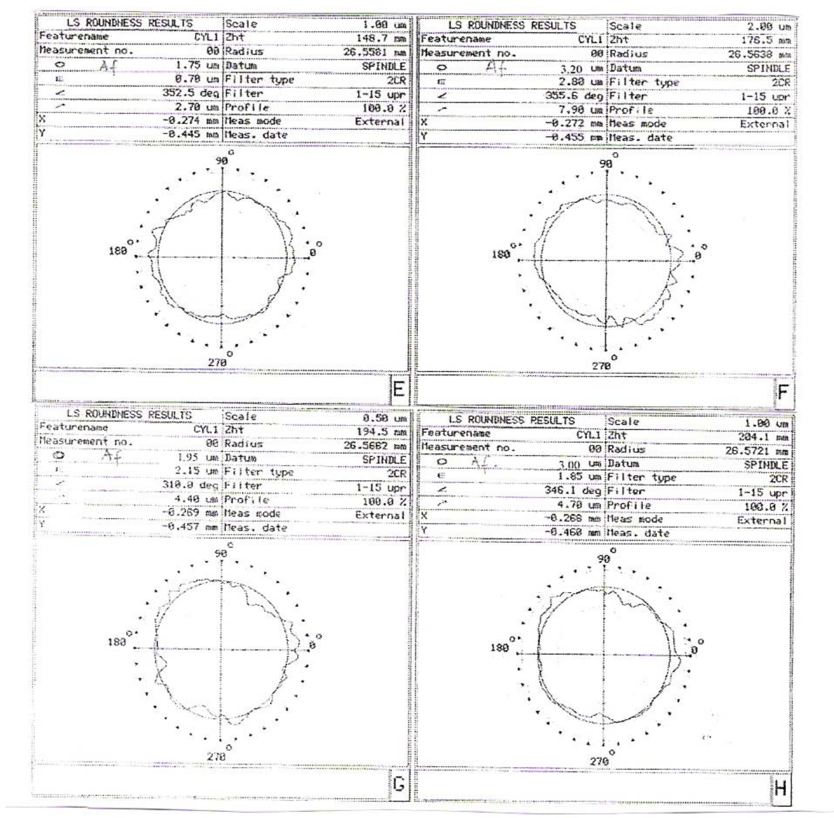

Fig.1. Deviations from circularity at the cutting of 100Cr6 (Rul1) steel with tool CC 650 with 4 regimes

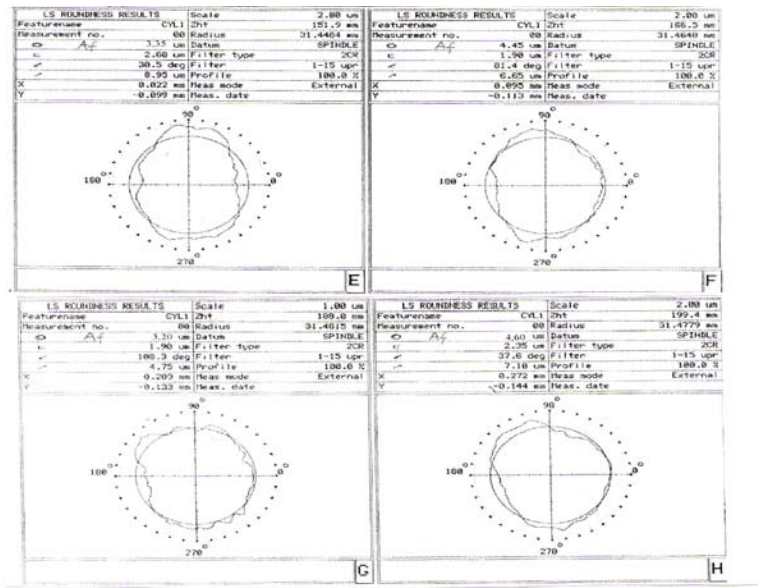

Fig.2. Deviations from circularity at the cutting of 100Cr6 (Rul1) steel with tool CC 670 with 4 regimes

Table 1. Shape's deviations A_f from circularity and the working regimes R for tool CC 650

Cutting regimes	Tool's material	CC 650 A_f [μm]
1/E	V_c=100m/min; f_n=0,06mm/rot; a_p=0,25mm	1,750
1/F	V_c=100m/min; f_n=0,22mm/rot; a_p=0,25mm	3,200
1/G	V_c=180m/min; f_n=0,06mm/rot; a_p=0,25mm	1,950
1/H	V_c=180m/min; f_n=0,22mm/rot; a_p=0,25mm	3,000

Table 2. Shape's deviations A_f from circularity and the working regimes R for tool CC 670

Cutting regimes	Tool's material	CC 670 A_f [μm]
1/E	V_c=100m/min; f_n=0,06mm/rot; a_p=0,25mm	3,350
1/F	V_c=100m/min; f_n=0,22mm/rot; a_p=0,25mm	4,450
1/G	V_c=180m/min; f_n=0,06mm/rot; a_p=0,25mm	3,200
1/H	V_c=180m/min; f_n=0,22mm/rot; a_p=0,25mm	4,601

4. CONCLUSIONS

From the presented data there can be drawn the following conclusions:

- with advance increasing increase the deviation from circularity;
- for the same value of advance, at the increasing of the cutting speed, the size of shape's deviation from circularity doesn't increase significantly because the cutting force decrease with the speed increasing;

- the processing depth a_p , has a reduced influence on the deviation from circularity in comparison with the classical processing with normal working regimes;
- the smallest deviations from circularity are obtained for mixed ceramic CC 650 with Al_2O, with a very fine granulation that can have 30-40% Tic. These ceramics have a great hardness until 2800 Hv, high conductivity 35W/mk easily spreading the heat from the blade's zone a good resilience, and because of quantities of Tic are resistant to thermal shocks that permits to use them for high cutting speed.

The small deviation from circularity for the same cutting regime for the mixed ceramic CC 650, see table 1 and 2, is also because of the high hardness at high temperature that confers a high resistance to wearing.

Obtaining of shape's precisions but also dimensional ones in the case of tools from extra-hard ceramic materials, has many explanations.

At first, mixed ceramic materials having termo-mechanic characteristics permits the increasing of the cutting speeds especially in the finishing phase and that determines the decreasing of the cutting forces as well as of the deformations from the processing system.

A second explanation is that the friction sliding coefficient between ceramic and the hardened steel is more smaller than in the case of other tools and as a result the radial component F_p of the cutting force decreases and the processing precision increases.

A third explanation is that the shape's and dimensional precision is high also because the wearing v_B on the depositing surface of the tools from mixed ceramic is very small because of theirs thermodynamic characteristics.

The general conclusion from this article is that the turning with tools from ceramic materials makes possible the obtaining of some shape's and dimensional precisions and of some small roughness comparable with that's obtained by grinding. Because of this fact this operation can be substituted with better economical performances.

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