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EXPERIMENTAL INVESTIGATION CONCERNING IFLUENCE OF THERMAL EXPANSION INSERTS ON PRECISION TURNING OF HARDENED STEELS

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Abstract:Experimental investigations concerning influence of thermal expansion inserts on precision turning of hardened steels have been presented in the paper. Experimental results concerning the influence of ceramic cutting edge wear on the temperature and on the machining accuracy have been also presented. Machining accuracy is described as profile deviation in longitudinal section (shape error).

Key words: precision turning, thermal expansion, accuracy of machining

1. Introduction

Total mechanical work that is produced in machining process is composed of:

- Work of plastic deformation,
- Work of external friction at the rake and the clearance surfaces,
- Work of internal friction

This work due to the elastic deformations and vibrations as well as the work caused by tearing the chip off and its bending, is almost totally transformed into heat. Besides the type of

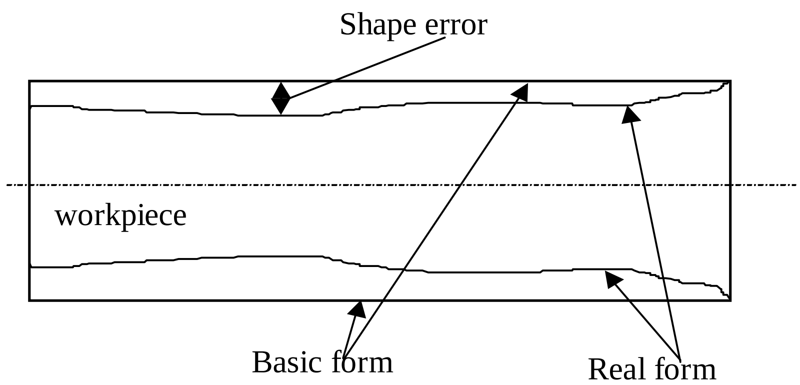

Fig.1. Shape error according to PN-78/M-02137

material and technological parameters such as: cutting speed, feed, cutting depth,the temparature is also influenced by the state of the cutting edge. Cutting edge wear appearing as the wear land of the insert clearance surface, causes the increase of the contact surface

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between the work piece and clearance surface and then the friction is increased as well as the amount of heat that is produced in cutting zone and finally the thermal elongation of the cutting edge occurs. As the time passes the heat flow in cutting zone is getting stable but the thermal inserts deformation, particularly its corner, reaches the fixed value.

As the result of the mentioned above factors, the cutting edge corner is not shifted along the straight line that is paralel to the feed direction but along a certain curve and its shape and increasing intensity depends mainly on cutting edge state. This factor creates the profile deviation in longitudinal section [2,3,5] (Fig.1).

While machining the hardened steels the cutting temperature may even exceed 1000 K [4]. As the result, the deviation value Δw that is caused only by thermal deformations of the cutting edge, can be even greater than 100 μm[1] which means the exceeding of the accuracy demandings for precise machining (for example : for IT6, diameter 30-50 mm the allowable deviation is equal to 16 μm).

2. Experimental results

Experimental investigations have been carried on the universal turning machine TUR560E. There have been machined sleeves made of bearing steel ŁH15 (60 + - 1 HRC). As the cutting edge the mixed ceramics has been applied with the main component of Al2O3. There have been aplied following cutting parameters: Vc=130m/min, f=0,08 mm/rev, ap=0,1 mm. While turning the following parameters have been also measured:

- profile deviation in longitudinal section both with contact and contactless sensor (pneumatic),
- cutting edge wear determined by VBc – the width of the wear land on the clearance surface,
- cutting temperature in the contact point of the insert corner with work piece by means of natural thermoelement

As the result the dependence of cutting temperature vs. cutting edge state, has been obtained (Fig. 2)

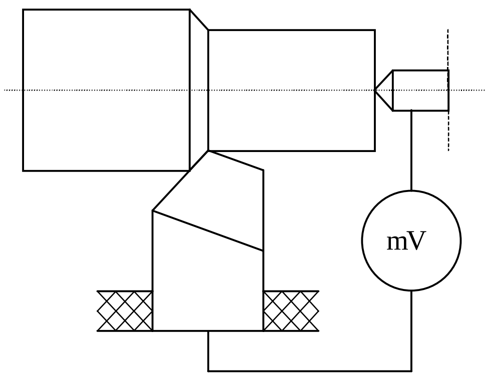

Diagram of temperature measurement

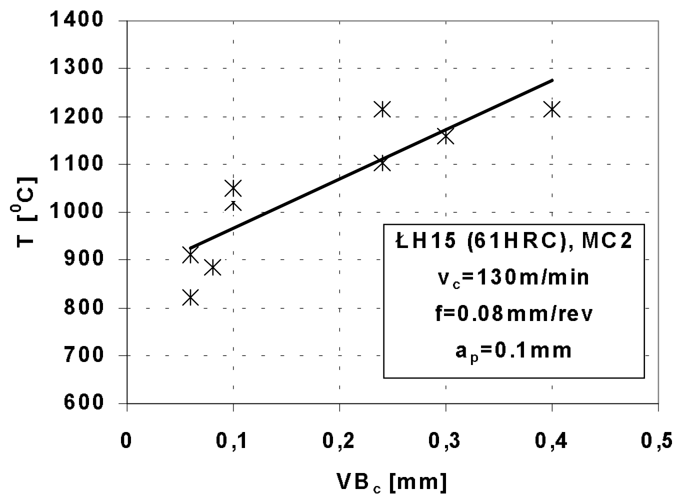

Fig.2. Influence of tool wear on cutting temperature

As it results from Fig.2 cutting temperature may vary in the range of 800 – 1200 0C. Considering the coefficient of linear expansion for gray ceramics ($\alpha = 7.7 \cdot 10^{-6} \cdot K^{-1}$) it is possible to determine, for the given temperature range, the value the insert changes its dimension while turning. Initial calculation proved that linear elongation of the ceramic insert may vary in the range of 70 – 120 μm. Such result concerns the case when the whole insert is heated to the certain temperature. In reality, high temperature is connected only with the insert corner (Fig.3).

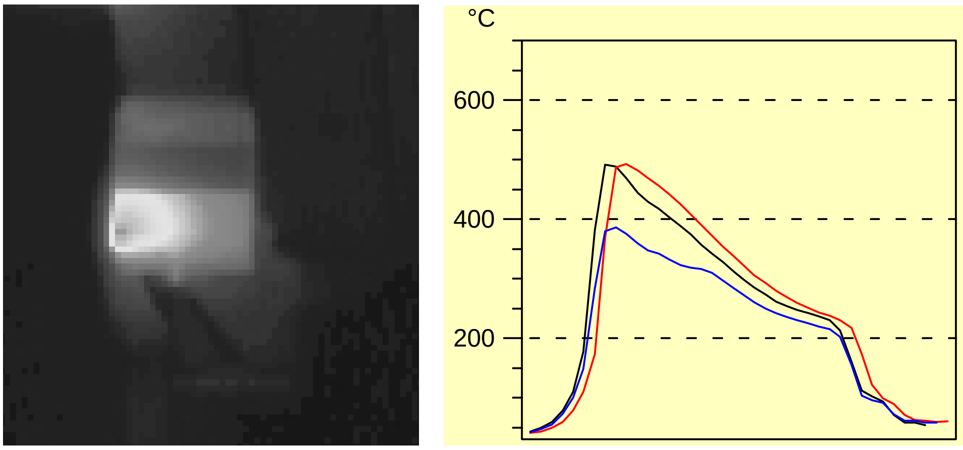

Fig.3. Distribution of temperature on insert

The temperature distribution on the clearance surface, after heating with concentrated energy beam, has been presented in Fig.3. This is the simulation of the real conditions where maximal temperature occurs at the contact of the cutting edge with the work piece (insert corner). On opposite side of the insert temperature reaches the value of 200 0C. This is the reason why during turning the smaller range of deformations has been obtained (Fig.3), comparing to approximate theoretical calculations.

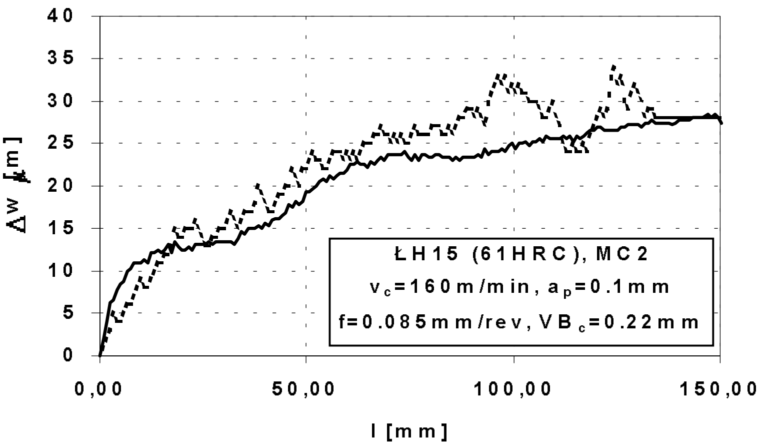

Fig.4. Shape error on the surface of workpiece for VB_c=0,22mm

For the cutting edge with wear coefficient of VBc = 0,22 mm, maximal profile deviation is equal to Δwmax = 30 μm (Fig.4) but for the cutting edge with wear coefficient of VBc = 0,31 mm, maximal profile deviation is equal to Δwmax = 50 μm (Fig.5). The greatest increase of profile deviation appears while entering the cutting edge into the work piece (the cutting edge is thermally shocked at this time). After certain time (depending on cutting conditions) the cutting process is getting stabilized and the profile deviation reaches its steady stable value.

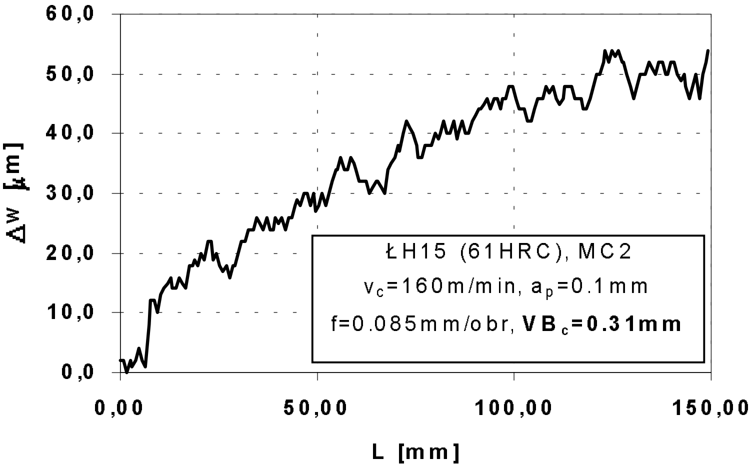

Fig.5. Shape error on the surface of workpiece for VB_c=0,31mm

3. Conclusions

Hardened steel is mostly machined in the process of finishing and precise machining, hence it is essential to provide the demandings considering the shape accuracy. As it has been stated in the paper, the factor limiting the wide implementation of precise turning are the problems connected with reaching the demanded shape accuracy that is measured by the profile error of the longitudinal section. As it has been shown the temperature in the contact point may even reach the value of 1200 0C and this is the reason of shape error occurring (profile deviation) in the range of 30 - 50 μm, according to the state of the cutting edge.

4. References

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