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PRECISE MACHINING AND RESIDUAL STRESSES

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Abstract*: A surface is a layer with its own structure and properties. Machined surfaces affect the functional properties of produced surfaces. These properties are affected by many factors, e.g., by cutting temperatures, friction, deformations in the primary deformation zone, the secondary deformation zone, and the surface layer of the transient (machined) surface, by cutting edge radius, cutting tool geometry, work hardening, residual stresses, cutting environment, etc.*

Keywords: *precise machining, hard machining, surface integrity, residual stresses*

1. Introduction

Machining of workpieces must meet high surface requirements. Machined surfaces affect the functional properties of the surfaces that are produced. The type of surface that a machining operation generates and its characteristics are of great importance in manufacturing

The integrity of a machined surface is a combination of various characteristics that describe the functional properties of the surface. This means that surface integrity describes the topological aspects of the surface and their physical and chemical properties, as well as their mechanical and metallurgical properties and characteristics.

Surface integrity is important in finishing manufacturing operations, because it affects the properties of the product, such as its fatigue strength, corrosion resistance, and service life. Defects caused during component manufacturing can be responsible for defects of the machine.

2. Precise machining and residual stresses

Residual stresses are important characteristics of surface integrity. Residual stresses have an enormous effect on the surface integrity of machining parts. They may cause these parts to break, and can lead to catastrophic accidents in the use of machines.

Basically, cutting produces two types of residual stress distribution in the surface layer. On the surface there are either tensile or pressure stresses. In the direction away from the

surface the reverse type of stresses are produced. These basic types of stress distribution may by complicate by the effects of various factors.

The maximum temperature in a machined surface layer is in the machined surface. There is a rapid drop in temperature in the direction from the machined surface. Due to the irregular temperature distribution, the irregular heating of the material affects the residual stresses created by irregular plastic deformation.

These complicated processes in machining sometimes result in very complex residual stress distributions.

Some experimental results of Dept. of Manufacturing technology CTU in are presented:

Cutting process: Slab milling. Cutting tool (ISO): 100B08R-S90AP15D, sintered carbide inserts – APKX 1505 PD EER-F. Work material: Alloy Al-Mg-Si (6995 – T6). Cutting conditions: Depth of cut 0,4 mm, feed per tooth 0,05, 0.1 mm, cutting speed 800, 1200, 1600 $m.min^{-1}$, down milling.

Sample 1 - Depth of cut 0,4 mm, feed per tooth 0.1 mm, cutting speed 800 $m.min^{-1}$, Fig. 1.

Sample 2 - Depth of cut 0,4 mm, feed per tooth 0.1 mm, cutting speed 1200 $m.min^{-1}$, Fig. 2.

Sample 3 - Depth of cut 0,4 mm, feed per tooth 0.1 mm, cutting speed 1600 $m.min^{-1}$, Fig. 3.

Sample 4 - Depth of cut 0,4 mm, feed per tooth 0,05 mm, cutting speed 800 $m.min^{-1}$, Fig. 4.

Sample 5 - Depth of cut 0,4 mm, feed per tooth 0,05 mm, cutting speed 1200 $m.min^{-1}$, Fig. 5.

Sample 6 - Depth of cut 0,4 mm, feed per tooth 0,05 mm, cutting speed 1600 $m.min^{-1}$, Fig. 6.

Each experiment was repeated four times. The experimental results are for practical purposes identical.

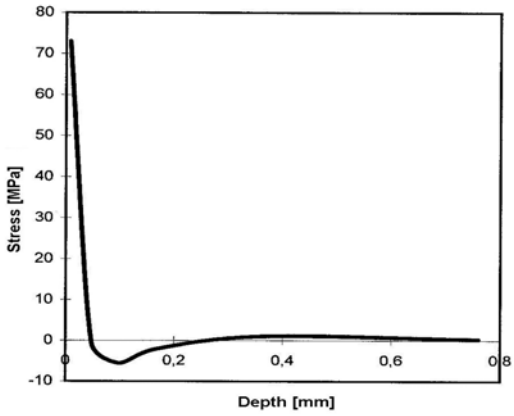


Fig. 1 Sample 1

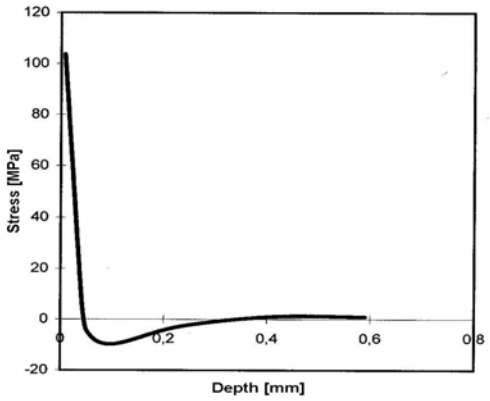


Fig. 2 Sample 2

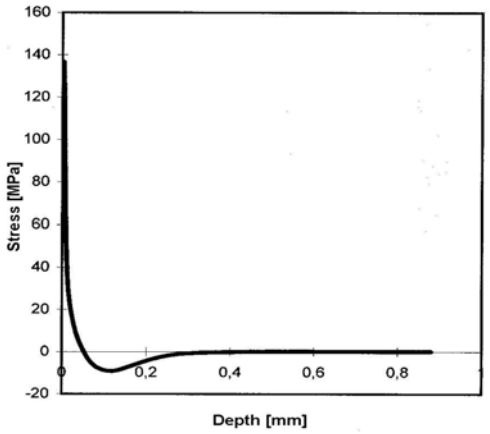


Fig. 3 Sample 3

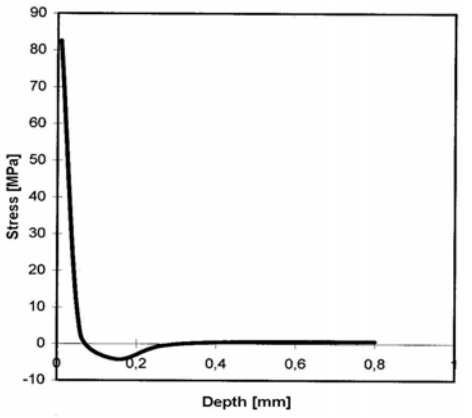


Fig. 4 Sample 4

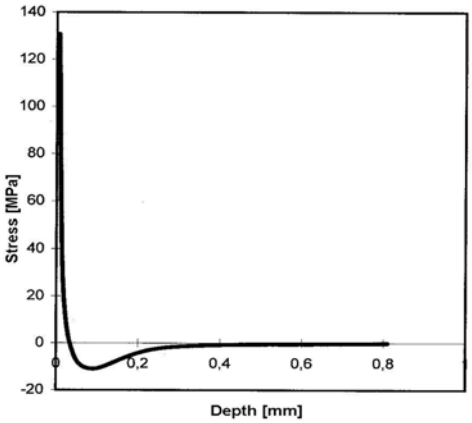


Fig. 5 Sample 5

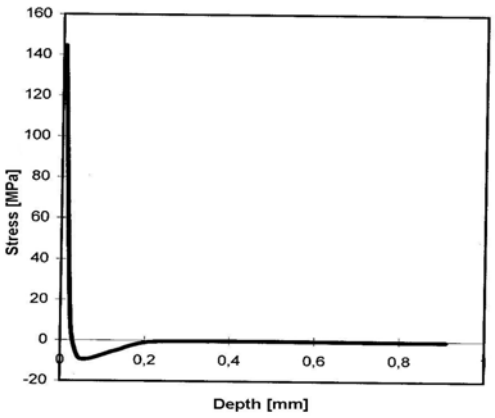


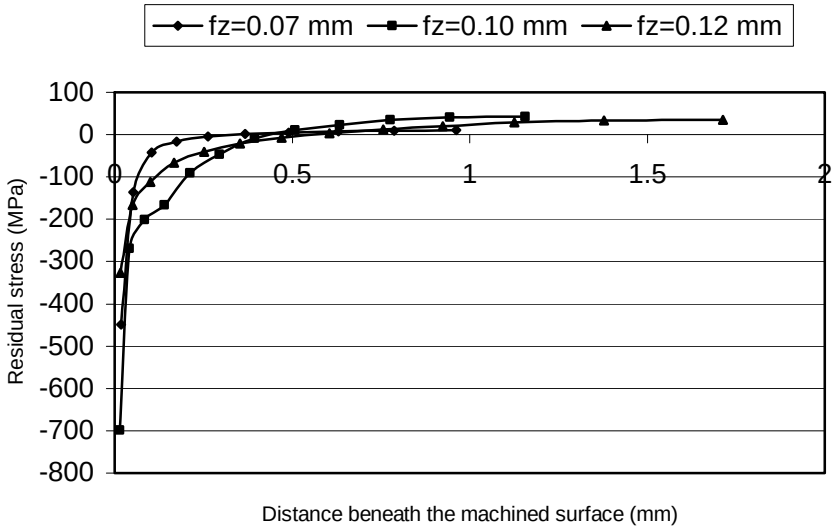
Fig 6 Sample 6

In down milling (feed per tooth 0,1 mm) tensile stresses were found in the range of 80 – 160 MPa. Tensile stress changes into pressure stress (approximately 10 MPa at the depth of 0,1 mm). Tensile stress increases with increasing cutting speed.

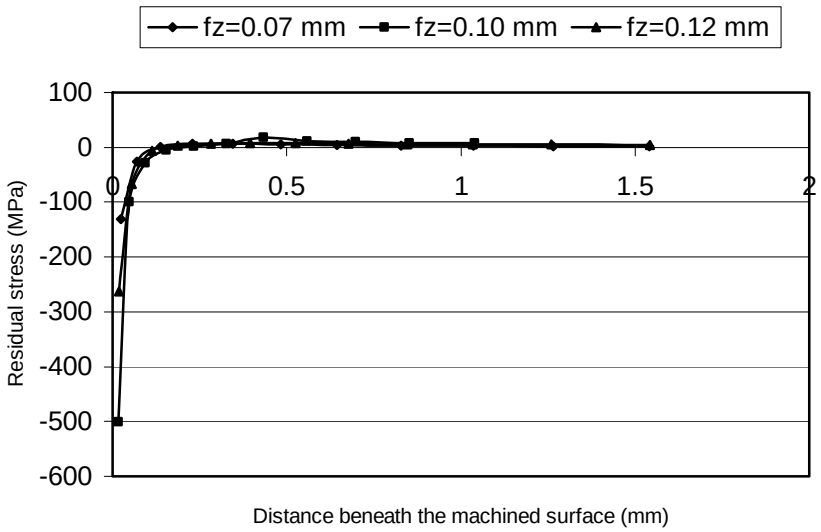
For a lower value of feed per tooth (0,05 mm), a similar stress distribution was found. Lower feed per tooth was not fond to produce any effect.

Different results were obtained in hard milling – see Fig. 7. The compressive residual stress produced in the machined surface of hardened steel was likely caused by a predominantly mechanical, rather than thermal effect.

(a) v_c = 115 m/min



(b) v_c = 140 m/min



(c) v_c = 160 m/min

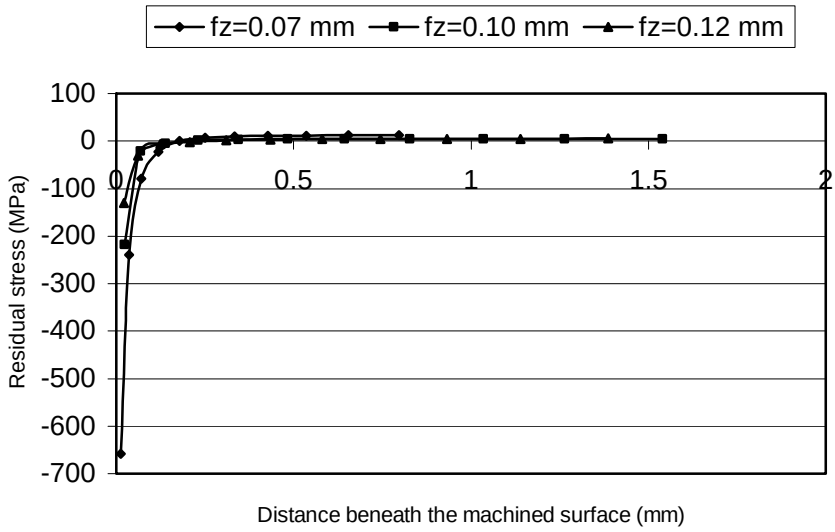


Fig. 7. Course of residual stresses after hard milling CSN 14 109.4 hardened steel (60 HRC) with square CBN – R290 12 T3 08 E CB50 cutting insert

3. Conclusion

Surfaces and their properties are as important as the bulk properties of the material. They also come into contact other components during processing or during their life. Consequently, their geometric and material properties can significantly affect surface features, fatigue, wear, life, friction, corrosion, etc. Residual stresses, as very important surface integrity factor, may differ with respect to many factors.

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