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STUDY OF CHANGES IN A MACHINED STAINLESS STEELS SURFACE DURING DRILLING

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Abstract: *This article presents conclusions of machinability tests on a new C18Ni9N stainless steel with nitrogen compared with experimental results for Cr18Ni8 stainless steel and describes appropriate parameters for the cutting zone during the process of drilling. Significant results from experiments have been achieved under the following cuttting conditions: cutting speed* v_c*=60 m/min, depth of cut* a_p*=2.75 mm and feed f=0.06 mm per rev., defining shear level angle* Φ_l*. For Cr18Ni9N steel* Φ_l *is 37 to 38°and for Cr18Ni8 steel* Φ_l *is 35 to 36°. Another important conclusion drawn from the experiments is the possibility to recommend cutting conditions to quality after cutting with surface roughness parameters for Ra=0.85 µmat certain cutting conditions.*
Key words: *drilling, temperature, tool life, residual stress*

1. INTRODUCTION

Precise and reliable information on the machinability of a material is an essential input and prerequisite for the machining process, especially in the view of newly applied technological components, such as: new manufacturing machines, news structures and materials in cutting tools, new methods in machining technology and new materials applied in part manufacturing. The main characteristics of austenitic stainless steels are defined by their austenitic structure and include in particular high toughness, low thermal conductivity and high workhardening co-efficient (Agapiou, 1988). From a machinability point of view, the most important characteristic is the workhardening. Low thermal conductivity of austenitic stainless steels is the primary cause of undesired/catastrophic formation of chips in narrow shear surfaces (Dolinšek,S. 2003).Material machinability is presented very often on the basis of examination of cutting tool durability, expressed in v_c-*T* dependency. Cutting tool wear depending on machining time is studied to define this dependency. The interaction between tool and chip can be effectively studied using Scanning Electron Microscopy (SEM). The heat produced is associated with the heat field distribution in the chip (60-80 %), on the machined surface (20-15%), on the tool cutting edge (12-3%) and into air (8-2%) at drilling of stainless steels. The author (Dautzenberg,J.H. et al., 1983) shows a dependency of average cutting wedge temperature (as measured by thermal camera).

2. DRILLING OF STAINLESS STEELS

Drilling is one of the oldest and most common machining operations. The tools themselves have not changed much over the centuries, but the cutting materials and machine tools that employ them have. Tool wear influences the quality of surface finish of the products produced and thus, if unnoticed, can cause high costs. The economical tool life can not be benefited from without tool wear monitoring.

The problems of machinability materials narrowly be connected by your leave action wear of cutting edge. Wear of cutting edge is assistance combination of loading factors, that affect of cutting edge (Usui,E. & Hirota,A., 1978). Tool life of cutting edge is impact all loading factors, that they have aspiration alter geometry of cutting edge. Wear is accordly interact between cutting tool, workpiece and cutting conditions of machining (Tlusty,J. & Masod,Z., 1987).

3. EXPERIMENTAL PART

3.1 Technological system

The experiments were performed in laboratory conditions and verified in real conditions during manufacture. The set-up used contained the following components: a VMF-100 CNC machine new design of screw drill from sintered carbide with hydraulic holder. Diameter of screw drill 5.5 mm.The materials to be machined were type of austenitic stainless steels with chemical composition listed in Table 1. The dimension of each piece was 40x40x180 mm. The cutting process employed was drilling of holes with dry machining, and the cutting speed defined at intervals of 30 m/min to 80 m/min, the feed advanced from intervals of 0.02 mm per rev. to 0.14 mm per rev.

3.2 Experimental results and discussion

Cutting zone is a summary term from the region during cutting. To properly describe the cutting zone it is necessary to describe the regions and test parameters (Clift,S.E. et al., 1990): primary plastic deformation zone, secondary plastic deformation zone, tertiary plastic deformation zone, machined surface, its properties and integrity and the gradually-deformed region of the cut layer. The first zone between the chip and the workpiece, called the shear layer, divides the non-deformed region from the deformed chip under the angle of the shear layer, (indicated by Φ_l) which is defined as identical to the boundary angle of deformation.

The results of cutting zone evaluation under cutting conditions (v_c=60 m/min and *f*=0.06 mm per rev.) are a definition of shear level angle. For Cr18Ni9N steel Φ_l is 37 to 38°, for Cr18Ni8 steel Φ_l is 35 to 36°. Also important are the values of the depth of the plastically-deformed material (of the chip), the flow zone and the strain hardness of the machined surface for the defined experimental conditions v_c=60 m/min, and *f*=0.06 mm per rev., shown in figure 1. The presence of strain lines in chip formation is depicted in figure 1.

	Chemical element	Steel Cr18Ni8	Steel Cr18Ni9N
Chemical composition *wt* in %	carbon	0.2	0.04
	chromium	18.0	18.0
	nickel	8.0	9.0
	manganese	2.2	1.6
	titanium	-	0.6
	nitrogen	-	0.06
	phosphorus	0.03	0.04
	sulfur	0.03	0.03

Tab. 1. Chemical composition of stainless steels

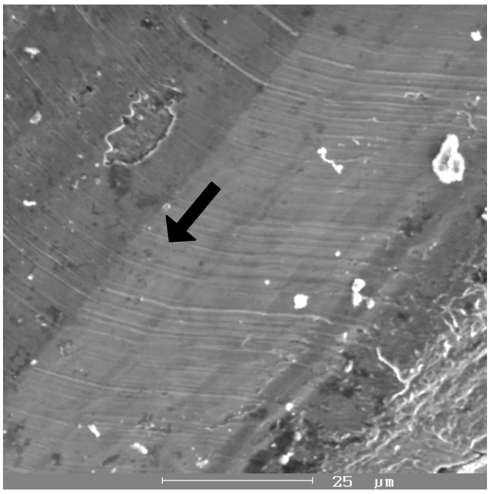

Fig. 1. Strain lines in chip formation,
steel Cr18Ni9N, v_c= 80 m/min, f= 0.06 mm per rev.

The strain line field extended to the region of plastic deformation, the machined surface, and the cut layer (the chip). Strain lines represent an extensive high-intensity deformation. The process of cutting is the mutual interaction between the tool and the workpiece, which is controlled by many phenomena, which creates a synergistic effect.

Heat in the cutting zone influences deformation and friction in the removal of the cut layer. Results during drilling of stainless steel in the form according question

$$\Theta_m = C_1 . v_c^{C_2} \tag{1}$$

The temperature range was from interval 80 °C to 600 °C. Table 2 shows the measured and calculated values for a new stainless steel.

Steel	Feed f [mm per rev.]	
Cr18Ni9N	0.02	0.06
	$\Theta_m = 17,44 . v_c^{0,82}$	$\Theta_m = 20,42 . v_c^{0,88}$
	0.10	0.14
	$\Theta_m = 24,76 . v_c^{0,91}$	$\Theta_m = 26,86 . v_c^{0,94}$

Tab. 2. Equation´s of average cutting wedge temperature

The edge preparation will determine the residual stress pattern near the machined surface in figure 2. The criterion VB_k=0.3 mm was applied during evaluation (Venkatesh,V.C. & Satchithanandam,H.A. 1985). The cutting process conditions were designed based on the needs of the material and on the operation of the finished surface.

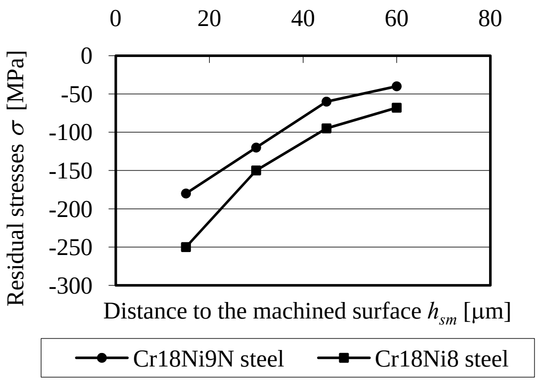

Fig. 2. Residual stresses on the machined surface
v_c= 80 m/min, f= 0.06 mm per rev.

Taylor Tool Life Equations for individual types of stainless steels are:

$$T = \frac{987,15.10^4}{v_c^{2,64}} \text{ for steel Cr18Ni9}$$

$$T = \frac{925,36.10^4}{v_c^{2,32}} \text{ for steel Cr18Ni8}$$

Defined coefficients for kinetic machining of austenitic stainless steels, where by Cr18Ni9N steel K_v=0.68-0.73. The machinability of Cr18Ni8 steel is worse about 20 % that than for a new Cr18Ni9N steel.

Very good results were mainly achieved when cutting speed was 60 m/min and the feed was 0.06 mm per rev..The roughness value for the outer surface, *Ra*, reached around 0.85 µm. Similar roughness in the outer surfaces of the individual type is not based on differences in the quality of the outer surface.

Before drilling, the hardness of the basic structure of Cr18Ni9N stainless steel was measured at 198 HB. After drilling, outer surface hardness was measured and the results is outer layer hardness increased by 15 to 20 % for Cr18Ni9N stainless steel.

4. CONCLUSION

It is important for both theory and practical applications that essential conclusions come from measurement and analysis. Results were acquired under laboratory conditions and performed in praxis. The conclusions are as follows: defined average cutting wedge temperature and tool life for a new design of cutting tool.

For a new stainless steels with nitrogen are as follows : defined residual stresses, coefficient of kinetic machining and described of plastic deformation on the machined surfaces.

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