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Wydział Inżynierii Mechanicznej, Zakład Inżynierii Produkcji
STOWARZYSZENIE INŻYNIERÓW I TECHNIKÓW
MECHANIKÓW POLSKICH – Koło Uczelniane UTP

85-789 Bydgoszcz, ul. Kaliskiego 7
tel. (0 52) 340-87-47, fax. (0 52) 340-82-45,
e-mail: tomasz.paczkowski@utp.edu.pl

Elementary Study of the Machinability During Drilling of Stainless Steels X2Cr18Ni8

Studium obrabialności stali nierdzewnej X2Cr18Ni8 poddanej wierceniu

JOZEF JURKO[1]
IVAN MRKVICA[2]
TADEUSZ ZABOROWSKI[3]

Precise and reliable information on the machinability of a material before it enters the machining process is a necessity, and hypotheses must be tested through verification of actual methods. This article presents conclusions of machinability tests on austenitic stainless steels X2Cr18ni8and describes appropriate parameters for the cutting zone during the process of drilling. The article focuses on the analysis of selected domains through four basic some parameters of steel machinability.

Keywords: drilling, cutting zone, plastic deformation, stainless steels, machinability, machined surface,

Przed wdrożeniem nowych tworzyw konstrukcyjnych do procesu obróbki skrawaniem niezbędne są precyzyjne i niezawodne informacje o ich obrabialności, przy czym powinny być one sprawdzone aktualnymi metodami. W artykule przedstawiono wnioski z badania obrabialności austenitycznej stali nierdzewnej X2Cr18Ni8, opisano także właściwe parametry strefy skrawania w procesie wiercenia. W artykule skupiono się na analizie czterech podstawowych parametrów obrabialności stali w wybranych zakresach.

Słowa kluczowe: wiercenie, strefa skrawania, odkształcenie plastyczne, stal nierdzewna, obrabialność.

[1]prof. dr inż. Jozef Jurko (jozef.jurko@tuke.sk)
[2]dr inż. Ivan Mrkvica (ivan.mrkvica@vsb.cz)
[3]dr hab. inż. Tadeusz Zaborowski (tazab@sukurs2.pl)

Introduction

The study of metal cutting can be accessed in several ways. When analyzing the theoretical foundations of cutting metals to describe these regularities and phenomena: regularities and processes of formation of particles on surfaces cut, regularities wear process of cutting-tools, regularities drive the cutting process, cutting zone phenomena [1, 7]. The current development in the theory of knowledge is characterized by cutting the fact that the study area are the cutting zone, which are in the close proximity to transformation of layer of material removal to chip. This approach is not correct. Since the that formed during cutting complex dynamic phenomena, the field should in theory be extended to the cutting technological properties of machine-tool-object-fixture, and in particular the continuity properties of the elements with the rules of the system mentioned above [3].

Stainless steels are fundamentally subdivided by their chemical composition and metallographic structure [4, 10, 12, 13]. Austenitic steels are the most extensive and thus the most important category of stainless steels. Several kinds of these steels are known, which differ among themselves in their carbon, nickel, and sometimes in their titanium content. Titanium is an important element, which increases the steel's resistance to intercrystalline corrosion.

Experimental procedure analysis and results

The experiments were performed in laboratory conditions and verified in real conditions during manufacture. The set-up used (Figure 1) contained the following components: CHIRON FZ 12 CNC machine, a new design the cutting tool of the cutting edge tool: screw drill with diameter d=10 mm.

Figure 1. Technological System - clamping tool by the blade, tool clamped (below)

The materials to be machined were type of austenitic stainless steels with chemical composition listed in Table 1.

Table 1: Chemical composition of austenitic stainless steels

Chemical composition of steel X2Cr18Ni8, %							
C	Cr	Ni	Mn	N	Si	P	S
0.2	17.6	7.8	1.6	0,03	1.0	0.045	0.030

The dimension of each piece was of dimensions 100 x 60 x 20 mm. The cutting process employed was the cutting speed was defined at intervals of v_c =20 to 50 m/min, the feed was advanced from intervals of f=0.02 to 0.1 millimetres, and cutting depth a_P=5.0 mm , and dry machining.

Researching the cutting zone (the interaction between the tool, the workpiece, and the chips) is to capture its state at the moment of the creation of the chip (the so-called root of the chip), shown in Figure 2b. Cutting zone testing and analysis under a microscope (Figure 2a) shows that different regions of smoothly-formed chips can be described.

a)

b)

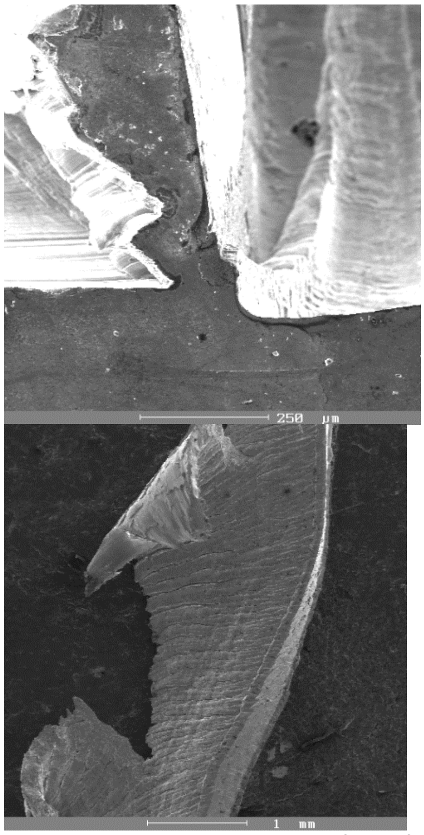

Figure 2. Cutting zone (a) and characteristic of chip formation (b) during drilling of steel X2Cr18Ni8

The process of cutting is the mutual interaction between the tool and the workpiece, which is controlled by many phenomena, which creates a synergistic[1] effect. It is important to define the shear level in the cutting zone. According [2] states, that the depth of the shear level follows the formula $0{,}05h \leq h_{SP} \leq 0{,}1h$, where h is the thickness of the cut section and h_{SP} is the depth of the shear level. We observe elements from the cut layer in the shear layer that have been displayed (they melt the cutting edge).

Chip formation is described through the theory of plasticity [3, 10, 17]. The presence of strain lines in chip formation is depicted in Figure 3. 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 results of cutting zone evaluation (Fig. 2) under cutting conditions (v_c=50 m/min, a_P=5 mm and f=0.02 mm) are a definition of shear level angle and the texture angle. For X2Cr18Ni8 steel Φ_I is 29 to 30°, $\Phi_{2.I}$ is 25 to 27° and $\Phi_{2.II}$ is 45 to 48°.

[1] Synergy is the coordination of several factors or agencies simultaneously involved in a complicated reaction

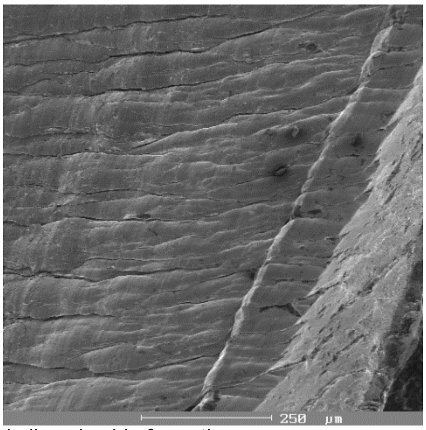

Figure 3. Strain lines in chip formation

In the course of material selection, the cutting process generally can arise from the traits which the workpiece material and the conditions of the cutting process [22]. This character is material machinability. According to [8] material machinability is a quality of the material that expresses its capacity to process the work piece from the point of view of its functional qualities. Creation and formation of chips and tool wear of the cutting edge of the tool influence the capacity of workpiece processing. According to [6] material machinability is expressed as a quality of the material, which is defined by the state of the cut surface, the creation and shaping of chips, the effect of cutting forces and the tool life of the cutting edge.

According to [12], material machinability is a quality of the object material, which expresses its qualitative state by yielding to the effect of the cutting wedge. According to [9] strain hardening, which arises are a result of the total amount of strain (intrinsic) and external forces, tends to achieve marginal values towards the beginning of fatigue interruption. A variable load means that plastic deformations appear in small regions and fatigue cracks begin in the slip layers. For strain hardening represents only the first measurable stage of the process of fatigue [7]. Austenitic Cr-Ni steels are, as a result of their higher ductility, more prone to surface strain hardening, which compared to construction steel can be up to 1.5 times as great. In a non-deformed state austenitic steels are not as hard as C45 steel, but in cases of great deformation they are greatly harder than ferritic-perlitic steel. Low thermal conductivity has a large significance in austenitic stainless steel turning [15]. It means the temperature which arises during the process of cutting on the touching plates of the cutting tool is poorly dissipated, which results in an increase in temperature on the touching plates, lowering the tools resistance to wear, reducing its tool life [18]. Every tool is damaged in the process of cutting. Wear mechanisms are activated in the cutting zone during the interaction of the elements of the cutting edge of the tool and the work piece, and under the influence of temperature, according to [14, 16] and by the fact that friction depends on the interaction of the clean metal surface between the front plate of the cutting edge of the tool and the chip, as stated by [20]. According to standard [23] we recognize four fundamental mechanisms of tool wear: adhesive wear, abrasive wear, fatigue wear, tribochemical reaction wear. The criterion VB_k=0.2 mm was applied during evaluation. The cutting process conditions were designed based on the needs of the material and on the operation of the finished surface [11]. The results of the long-term test after exhaustive analysis of selected data are show in Table 2.

Table 2: Tool Life Equations-results of measurements and planned experiments

Steel	Taylor equation [experimental]	Taylor equation [measurement]
X2Cr18Ni8	$T=\frac{5.22.10^{4}}{v_c^{2.3921}}$	$T=\frac{5.18.10^{4}}{v_c^{2.4106}}$
Cutting speed	Valued tool life (experimental)	Valued tool life (measurements)
20 m/min	40.31 min	37.85 min
30 m/min	15.28 min	14.24 min
50 m/min	4.51 min	4.15 min

Damage to the cutting edge of the tool in conditions (v_c=50 m/min, a_p=5 mm and f=0.02 mm) is characteristic of Figure 4. Under milder cutting conditions than given above, these belts of damage are not visible. As has already been shown, machining of austenitic stainless steels involves very low thermal conductivity, which dissipates heat very slowly from the cutting zone.

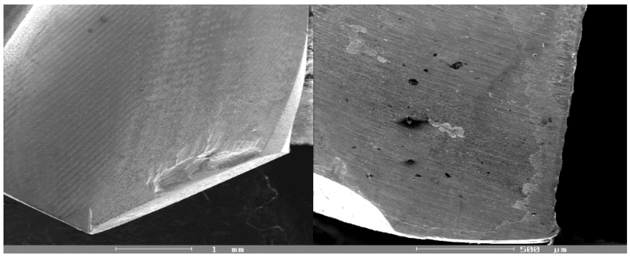

Figure 4. Face plate damage to cutting edge

One of the associated phenomena in the measurement of dynamic characteristics is the testing of thermal effects in the cutting zone, mainly measured on the cutting section of the tool [5, 21]. Heat in the cutting zone influences deformation and friction in the removal of the cut layer. The magnitude of the heat depends on the cutting time, but after a certain interval it no longer increases in the tool (this is characteristic of turning). This effect of heat has an important significance in the study of damage to the tool cutting edge and cutting edge wear [21]. The heat produced is associated with the heat field distribution in the chip (75-82 %), on the machined surface (12-14%), on the tool cutting edge (4-6%) and into air (5-8%). Figure 5 shows the thermal effect on the tool cutting edge under defined cutting conditions and with markings from the thermal camera, which document the dispersal of temperature on the face plate, and figure 6 shows thermal effect by the cutting conditions. The final markings document a temperature range from 480 to 670° C.

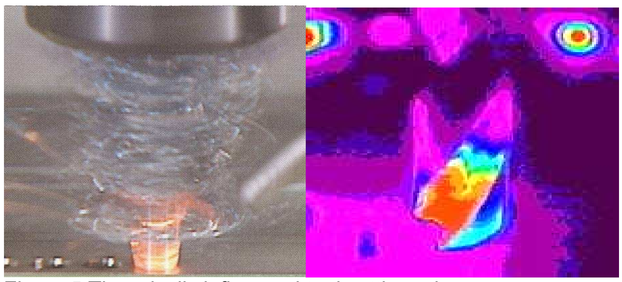

Figure 5 Thermically influenced tool cutting edge

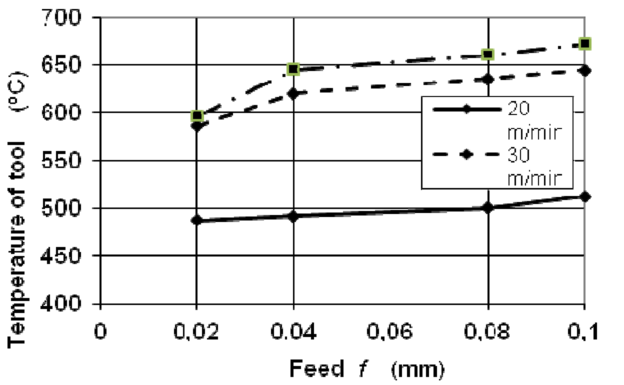

Figure 6. Dependence means temperature on the cutting conditions

The micro geometry of the outer surface is characterised by micro geometric chipping [13, 19]. For evaluating the outer surface after turning and defining the cutting process conditions, the following parameters were used in the investigation: the outer surface roughness parameter Ra [μm] was measured on two measuring tools, a HOMEL TESTER T 1000CThe measured results are documented in Table 3.

Table 3: Measures parameter values for outer surface roughness Ra (μm)

		Cutting speed (m/min)		
		20	30	50
Feed *f* (mm)	0.02	4.36	4.15	3.16
	0.04	3.97	5.35	3.26
	0.06	4.92	7.25	3.58
	0.08	6.75	7.65	4.85
	0.1	9.64	8.75	5.21

Conclusion

Results were acquired under laboratory conditions and performed in praxis. The conclusions are as follows: defined tool life equation following Taylor, defined the equation for the cutting strength components, designed a model to generate chips, thermal analysis for the cutting process in the cutting zone, confirmation of surface strain hardening (change in mechanical properties) after cutting. The machinability of austenitic stainless steel is two to three times worse that than for C45 on the basis of its chemical components: mainly chromium, nickel and other component elements. The basic factor involved with oversized blunt tools is high temperature in the cutting zone. In order to increase the tool life of the tools' cutting heads, it is necessary to lower this temperature. The wear of cutting tools may also affect the selection of appropriate geometry, mainly the positive angle of the front of the tool as well as the required high surface quality of the tool's effective area. Recommend the preferred use of cutting tools with laminated surface sintered carbides when it is necessary to secure high rigidity and machine-tool-fixture-workpiece system stability.

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