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INFLUENCE OF CUTTING TOOL FORM ON MORPHOLOGY MACHINED SURFACE AT STAINLESS STEEL Cr20Ni8Ti

Abstract:

This article presents conclusions of quality tests on austenitic stainless steels Cr20Ni8Ti and describes appropriate parameters for the machined surface at drilling. The paper present of real experimental results. The authors would like to thank in words the VEGA grant agency at the Ministry of Education SR for supporting research work and co-financing the projects: Grant work VEGA #01/0406/2003 and Grant work VEGA #01/3173/2006 and Grant work KEGA #3/7166/2009

Keywords:

machined surface, cutting zone, cutting tool, drilling

INTRODUCTION

Deformation behaviour of material during cutting expresses the evaluation and knowledge of material properties changes during the course of cutting deformation process. It enables to understand and to control this process. In the contribution are analysed the sources of stability and instability of deformation process and their influance on the chip shape and on the tool loading.

This paper is concerned with the topic of drilling. It will be of importance to teachers of Industrial Technology, those involved in machining research, and industrialists with an interest in process monitoring.

This paper will describe the machined surface morphology of Cr20Ni8Ti stainless steel. Stainless steels are often considered to be poorly machinable materials; materials with high elasticity are also difficult to machine. In drilling stainless steel with a pseudo-elastic coating material, machinability difficulties are caused by the high strength and work hardening rate of steel and the pseudo-elastic properties of the coating material, [2], [8], [9], [16]. The deformation effects were studied by analyzing HSCo steel drills.

The interface between stainless steel was examined with SEM (Scanning Electron Microscopy). 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. However, for its simplicity and commonality, the cutting geometries in drilling are extremely complicated and the process is terribly inefficient.

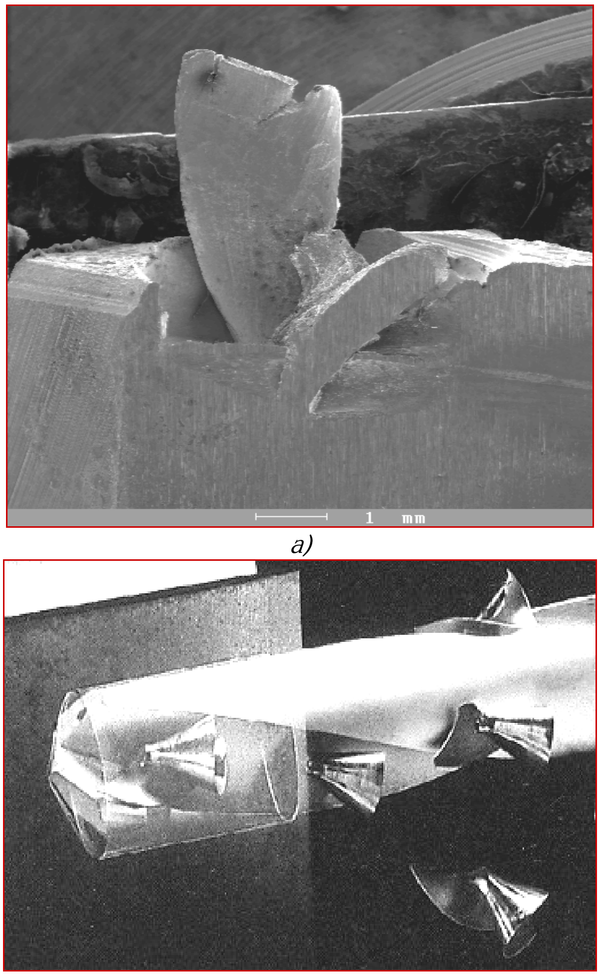
The effect of feed rate on chip formation was analyzed. The cutting tests indicated that cutting speeds of 50 m/min, a feed 0,08 mm/rev, and material HSCo drills can be applied, from a machinability standpoint. When effective cutting *speeds and feed rates were utilized, optimal tool life was achieved without several decrease in coating properties.*

CHARACTERISTIC OF PRODUCT MATERIAL AND CUTTING PROCESS

Wear is the result of interaction between tool, workpiece material and machining conditions. The main load factors are: mechanical, thermal, chemical, abrasive. Apart from the static components of mechanical load, there are various dynamic ones from the chip forming process itself, as well as more emphasized ones from varying cutting depth, interrupted cuts and mill. The partly because of the mechanical loads with varying cutting depth and feed rate: abrasive wear in the form of flank and crater wear, BUE oxidation forming a notch, plastic deformation and fatigue with risk of fracture.Stainless steel predominantly contains high levels of chromium and nickel, typically 18Cr-8Ni wt%. Additional elements may be added to enhance performance, but the benefits and side effects are sometimes hard to understand. However, various parameters will be examined such as dislocations, stacking faults, grain size, solid solution and precipitation hardening. Corrosion resistance, ductility, good weldability and resistance to high and low operating temperatures are some of the many reasons for the use of austenitic steels. Chromium is the main deterrent to corrosion through a process called passivity, where chromium combines with oxygen in the atmosphere to form a protective oxide layer [20]. This is especially useful when the metal is scratched, as the oxide layer re-forms quickly, hence protecting it from corrosion. However, chromium is a ferrite stabiliser. To counteract this, nickel is added as an austenite stabiliser, so that the microstructure at ambient temperature is austenitic. The basic properties of stainless steel have been studied and can be found in the materials the strain-rate effect plays an important role in plastic deformation of materials, several investigators have focused on the strain-rate effect for stainless steel at low rates. Over the past decades, many researchers have indicated that the plastic deformation of materials under dynamic loading is very different from that under static loading. Dynamic plastic behavior is often found during the metal-forming process, vehicular accidents, and unexpected foreign impacts. Products made from stainless steel are not infrequently subjected to dynamic loading. Although some investigators [1], [4], [6], have studied the impact and shock-loading behavior of stainless steel is dynamic plastic deformation, mechanical behavior, and associated microstructural evolution are still insufficient. Abrasion wear is caused by the action of sliding chips in the shear zone, as well as by friction generated between the tool flank and workpiece. This wear is compounded by the part's hardness and strength properties, which also dictate appropriate machining speeds. Chemical wear is caused by a reaction between the tool and workpiece materials. Thermal wear refers to breakdown caused by temperature cycling of the tool's cutting edge between heating and cooling stages of the machining process, [3], [5], [7], [10], [11], [12], [19]. Impact wear is breakdown of the tool's cutting edge that occurs when mechanical loading exceeds the physical properties of the tool material, [2], [15], [18]. Optimum process of machining is a precondition of effective employing of optimal working conditions. When deciding on cutting conditions of various materials it is necessary to take into consideration the characteristics of material properties and cutting conditions. Machinability is one of such characteristics. In the current market there is a demand for high quality products of corresponding properties. Only materials with specific physical, chemical, mechanical and other properties can meet the criteria of resistance to various aggressive environment, thermal and heat influence and high mechanical load. When the conditions for either adhesive wear or abrasive wear coexist with conditions that lead to corrosion, the processes interact synergistically to produce corrosive wear. As described earlier, surface fatigue wear is a wear phenomenon associated with curved surface in rolling or sliding contact, in which subsurface cyclic shear stresses initiate micro-cracks that propagate to the surface to spell out macroscopic particles and from wear pits. Deformation wear arises as a result of repeated plastic deformation at the wearing surface. Producing a matrix of cracks that grow and coalesce to from wear particles. Deformation wear is often caused by severe impact loading. Impact wear is impact-induced repeated elastic deformation at the wearing surface that produces a matrix of cracks that grows in accordance with the surface fatigue description just given. The complexity of the wear process may be better appreciated by recognizing that many variables are involved, including the hardness, toughness, ductility, modulus of elasticity, yield strength, fatigue properties, and structure and composition of the mating surface, as well as geometry, contact pressure, temperature, state of stress, stress distribution, coefficient of friction, sliding distance, relative velocity, surface finish, lubricants, contaminants, and ambient atmosphere at the wearing interface. Tool wear is the product of a combination of load factors on the cutting edge. The life of the cutting edge is decided by several load, which strive to change the geometry of the edge.

EXPERIMENTAL PART

Drilling tests were carried out using a vertical machining centre equipped with 10 000 rpm, 16 kW spindle. The tests used and TiCN-coated high speed steel with cobalt (HSCo) drills with a diameter of Ø 6 mm, at a cutting speed of 50 m/min and feed 0,08 mm/rev were used without coolant. All experiments was realizated in practice by product in firm from Cr20Ni8Ti steel. 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. Primary plastic deformation zone (primarily an examination of phenomena associated with the creation and formation of chips, with the effect of the components of cutting force-the state of strain deformation, the location of the angle of the shear level, chip compression, the temperature field, chip shape, chip formation and separation, the effect of the components of cutting force). Secondary plastic deformation zone (primarily an examination of phenomena associated with friction and cutting wedge wear, and also with the generation of heat and temperature-the location of the grain angle, the contact length of the cutting wedge and the face plate, friction stress and scab creation (BUE), friction, the generation of heat and temperature, the mechanism of tool wear). Tertiary plastic deformation zone (primarily an examination of the phenomena associated with the shaping creation of the machined surface, its profile, morphology, qualities and inherited traits-contact of the machined surface and the worn side plate). Cutting surface, its properties and integrity. The gradually-deformed region of the cut layer. Researching the cutting zone (the interaction between the instrument, the work piece, and the cuttings) is to capture its state at the moment of the creation of the cutting (the so-called root of the chip), shown in Figure 1.



a)

b)

Fig.1 Cutting zone at drilling
a-chip root, mag 19x,
b-material destruction in front of cutting wedge

The process of cutting is the mutual interaction between the instrument and the work piece, which is controlled by many phenomena, which creates a synergistic effect. An understanding of the phenomena and domains involved arises from cutting zone experiments [13], [14]. It is important to define the shear level in the cutting zone. Weber states, that the depth of the shear level follows the formula $0.05h \le h_{SP} \le 0.1h$, where h is the thickness of the cut section and h_{SP} is the depth of the shear level. The size of this local *region was determined through the help of electron microscope analysis, and the results. We observe elements from the cut layer in the shear layer that have been displayed (they melt the cutting wedge). The thickness of the cut layer continually varies chip thickness h_1. Chip formation is described by Hencky and Zorev through the theory of plasticity. The strain line field extended to the region of plastic deformation, the machined surface, and the cut layer (the chip). Strain lines (the so-called Lüders-Černov lines) represent an extensive high-intensity deformation. Models of chip formation have been created by Weber, Oxley, Lee-Shaffer and others based on the theory of plasticity and the use of strain lines. It is our opinion that chip formation most closely follows the method of Oxley, which even accounts for the element of time in chip formation. From the standpoint of temperature effects in the cutting process, the cutting zone comprises a thermodynamic system whose state changes through heat transfer as a form of energy transfer. Thermal conductivity $A[W/K]=[kg\ m^2\ s^{=3}\ K^{-1}]$ expresses the capacity to diffuse heat in a specific environment. The specific thermal conductivity $\lambda\ [W/K\ m]=[kg\ m\ s^{=3}\ K^{-1}]$ as a material quality (or constant) expresses the capacity to diffuse heat through convection. It is especially characteristic for austenitic stainless steels that they have rather low values of specific thermal conductivity. For example, for C45 steel, $\lambda = 60\ [W\ m^{-1}K^{-1}]$ and for austenitic stainless steels $\lambda=18.7$ to $22.8\ [W\ m^{-1}K^{-1}]$, so its conductivity is three times worse in comparison with the reference material (C45 steel), which is often used in actual work. The variable temperature field appears mainly in the formation of individual chips, whose deformation is not homogenously concentric in the individual pieces connected to the later of intensively deformed material. According to Dehlinger strain hardening, which arises are a result of the total amount of strain 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 Oding, Cobkallo, Kuznetzova, Glikman and Techt strain hardening represents only the first measurable stage of the process of fatigue. 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. It means the temperature which arises during the process of cutting on the touching plates of the cutting instrument is poorly dissipated, which results in an increase in temperature on the touching plates, lowering the instrument's resistance to wear, reducing its longevity. This makes itself most apparent in the use of cutting instruments made from high-speed steel, whose firmness and thus resistance to wear drops sharply at higher temperatures. Sintered carbide instruments are not as sensitive to temperature on touching plates as high-speed steel, and can be used to attain higher performance, but in this case they have greater pressure stress, which directly influences the process of adhesive wear. The micro geometry of the outer surface is characterised by micro geometric chipping. For evaluating the outer surface after drilling . 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 instruments, a HOMEL TESTER T 1000C and a HOMEL TESTER T 6 D, the hardness of the outer surface layer was evaluated following Brinnell [HB] with the help of a hardness tester, the micro hardness of the outer surface layer was evaluated following Vickers [HV] with the help of another hardness tester, increased tension and morphology of the outer surface after cutting were evaluated after careful analysis using an x-ray microscope. On the figure 2 and figure 4 are define characteristic the machined surface morphology at drilling.*

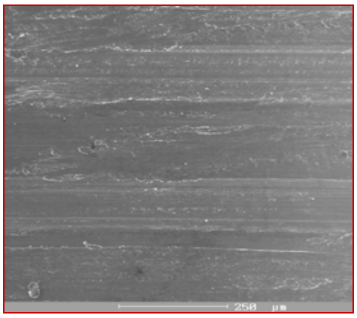


Fig.2 The machined surface morphology - the cutting tool HSCo, 8 % Co, mag. 90x, v_c=50 m/min, f=0,08 mm, steel Cr20Ni8Ti

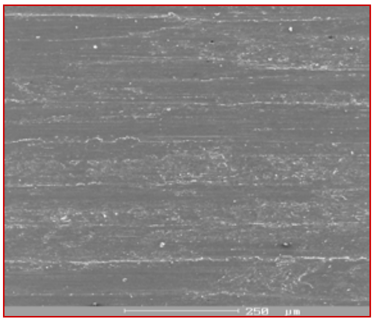


Fig.3 The machined surface morphology - the cutting tool HSCo, 8 % Co, TiN mag. 90x, v_c=50 m/min, f=0,08 mm, steel Cr20Ni8Ti

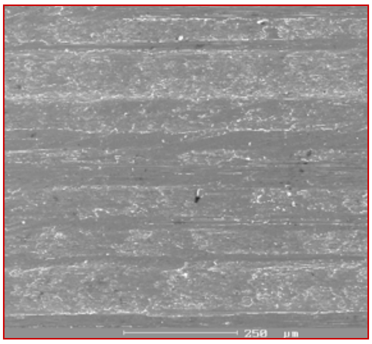


Fig.4 The machined surface morphology - the cutting tool HSCo, 8 % Co, TiAlN mag. 90x, v_c=50 m/min, f=0,08 mm, steel Cr20Ni8Ti

CONCLUSION

Machining is the world's most common manufacturing process, with 15 to 20% of the cost of all goods being attributed. Machining may either be the primary manufacturing process as in the aerospace industry, or a secondary process as in the machining of castings, forgings, and powder metals. Most automotive castings are liable to be machined on up to 30% of their surfaces. Also, machining can be an indirect manufacturing process as in the production of press tools used in the stamping of automotive body panels. In the education of both technologists and engineers the basic mechanics of machining are explored. However, due to its nature, students should have exposure to the many variables that change with both workpiece and tooling materials, as well as the actual shop floor variables. This is important since they affect not only tool life but surface finish, component performance and material removal rates. Drilling was selected because most students who do not have a machining background will be familiar with a standard "twist/jobber" drill.On the basis of experience, the authors recommend, for machining these types of steels, selecting criteria for automated production process based on the following order: For rough machining operations – in first position, forming of shavings, kinematic processes, dynamic processes and outer surface quality after cutting. For finished work, the criteria are set in the following manner: outer surface quality after cutting, forming of shavings, kinematic processes and dynamic processes. This article is the result or much research work on the part of the authors in this field and the article presents actual conclusions that are currently being successfully implemented in machine shops.

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