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ANALYSIS OF THERMODYNAMICAL PHENOMENAS OF STAINLESS STEELS BY DRILLING.

ANALÝZA TERMODYNAMICKÝCH JAVOV PRI VŔTANÍ NEHRDZAVEJÚCICH OCELÍ

Abstract

The paper described the phenomenas, which influencing on the twist drill of chisel cutting edge. Research and development of the phenomenas its very important for the next problem solution by drilling. The cutting part of twist drill is frequently the tool wear (for example fracture of cutting part) in the tool peak point and by chisel cutting edge. This is problems is very important and use for very difficult the machinability materials (for example stainless steels Cr18Ni8). The results of experiments verifying of the tools for the tool life of twist drill in practice. The temperature of a tool plays an important role in thermal distortion and the machined part's dimensional accuracy, as well as the tool life in machining. The paper described the experimental results of research works number 01/3173/06.

Abstrakt

Článok sa zaoberá analýzou javov, ktoré majú priamo vplyv na rezný nástroj pri vŕtaní. Skúmanie javov v zóne rezania pri vŕtaní je v súčasnosti veľmi významné. V zóne rezania dochádza k veľmi intenzívnemu poškodeniu na reznej časti nástroja. Tento problém má zvlášť mimoriadny význam pri vŕtaní ťažkoobrábateľných materiálov (napr. austenitická nehrdzavejúca oceľ Cr18Ni8). Výsledky experimentov boli zamerané na skúmanie termodynamických javov v zóne rezania, s cieľom eliminácie tepelného zaťaženia na reznú časť nástroja. Termodynamické vplyvy v zóne rezania hrajú významnú úlohu na výslednú presnosť rozmerov súčiastok a na životnosť rezných nástrojov. Článok je prezentáciou niektorých záverov z riešenia grantovej úlohy VEGA č.01/3173/06.

1 INTRODUCTION

Machining is an important manufacturing operation in industry. The purpose of a machining process is to generate a surface having a specified shape and acceptable surface finish, and to prevent tool wear and thermal damage that leads to geometric inaccuracy of the finished part. The thermodynamic approach to the activity at the cutting edge attempts to account for the energy consumed. Research has shown that at least 99% of the input energy is converted into heat by deformation of the chip and by friction of the chip and workpiece on the tool [1]. The interface at which the chip slides over the tool is normally the hottest region during cutting. The actual temperature is strongly affected by workpiece material, cutting speed, feed, depth of cut, tool geometry, coolant, and many other variables [1]. Due to the interaction of the chip and tool, which takes place at high pressures and high temperatures, the tool will always wear. The use of fluids in machining is well known. Among the functions of a cutting fluid, cooling and lubrication are generally regarded as the most important, since they directly relate to heat generation and tool wear. However, significant negative consequences for environmental health and safety are associated with the use of cutting fluids. In machining operations, mechanical work is converted to heat through the plastic deformation involved in chip formation and through friction between the tool and the workpiece. Figure 1 shows the subsequent dissipation of that heat in the chip, tool, and the workpiece by drilling.

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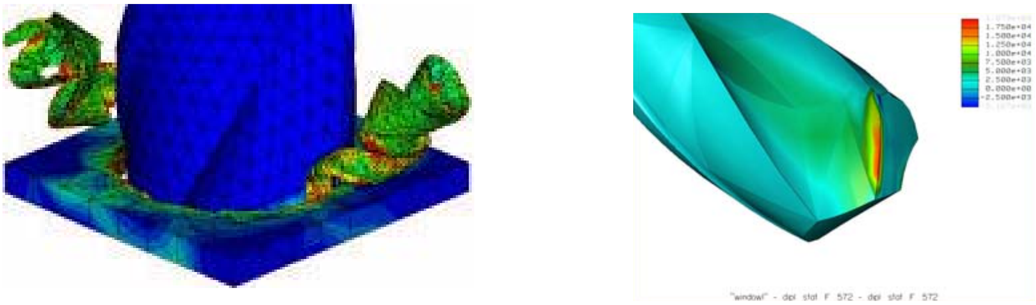


Fig. 1 Temperature in the tool, chip and workpiece

Most of the analytical methods for steady-state temperature prediction in machining were developed based on Merchant's model for orthogonal cutting, which gives the shear and friction energy in terms of the measured cutting forces, tool-chip contact length, and chip thickness ratio. The heat generated during the metal cutting process where the work being done on the tool insert transforms itself in the form of heat. A finite element model (FEM) 3-D model was developed for the simulation of temperature based on the estimated machining heat flux over the tool-chip contact area on a tool insert of a cutting tool. Heat is generated at the tool-chip interface in the quarter-circular area (heat source area) of the tool insert rake surface, and a portion of it flows into the tool, as shown in Fig. 1. The temperature distribution is obtained from the balance of the heat generated and transient thermal analysis for two cases: without and with heat pipe cooling. The real geometry of the cutting tool is chosen as the computational domain. To achieve more realistic and accurate simulation results, the model takes into account the real geometry of the cutting tool and the thermal resistance.

2 LOADING IN CUTTING ZONE

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 . 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. Mechanism wear is characterise abrasion element and their disposal at concert pitch assistance abrasion forth cutting zone. General wear of cutting edge is generally results abrasion, plastic deformation and breakable breach. Bases ambit wear of cutting edge, that are results of loading factors, are initiate in the figure 2. About machining component out of stainless steel, be needed applied especially inserts of cutting tool (encourage their individual machinist cutting tools) about classic machining methods by your leave certain call, that herself differ by other material. Metal cutting of stainless steel herself deem generally past arduous, as metal cutting additional doped steel. Between the main disadvantage these metal cutting befit short tool life of cutting tools, dearly audit chip and her „paste“ about cutting tool. Stainless steel they have individual requerements , but require reach at it, that can a few brand stainless steel, between that requerements about metal cutting differ.

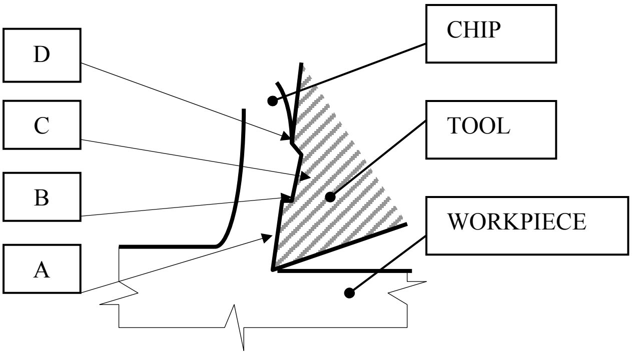


Fig. 2 Cutting tool wear zones, [1]
A-zone of mechanical loading of cutting edge, B-zone of thermal loading of cutting edge, C-zone of chemical loading of cutting edge, D-zone of abrasive loading of cutting edge

3 THERMODYNAMICAL PHENOMENAS

Clearance versus contact-time history of the wearing surfaces may also be an important factor in some cases. Adhesive wear is often characterized as the most basic or fundamental subcategory of wear since it occurs to some degree whenever two solid surfaces are in rubbing contact and remains active even when all other modes of wear have been eliminated.

The phenomenon of adhesive wear may be best understood by recalling that all real surfaces, no matter how carefully prepared and polished, exhibit a general waviness upon which is superposed a distribution of local protuberances or asperities. As two surfaces are brought into contact, therefore, only a relatively few asperities actually touch, and the real area of contact is only a small fraction of the apparent contact area, even under very small applied loads the local pressures at the contact sites become high enough to exceed the yield strength of one or both surfaces, and local plastic flow ensues. If the contacting surfaces are clean and uncorroded, the very intimate contact generated by this local plastic flow brings the atoms of the two contacting surfaces close enough together to call into play strong adhesive forces. This process is sometimes called cold welding. Then if the surfaces are subjected to relative sliding motion, the cold-welded junctions must be broken. Whether they break at the original interface characteristics, local geometry, and stress distribution. If the junction is broken away from the original interface, a particle of one surface is transferred to the other surface, marking one event in the adhesive wear process. Later sliding interactions may dislodge the transferred particles as loose wear particles, or they may remain attached. If this adhesive wear process becomes severe and large-scale metal transfer takes place, the phenomenon is called galling. If the galling becomes so severe that two surfaces adhere over a large region so that the actuating forces can no longer produce relative motion between them, the phenomenon is called seizure. All cutting tools wear during machining and continue to do so until they come to the end of their tool-life, the life of a cutting edge is counted in minutes and today tool-lives are often less then the old, established mark of fifteen minutes, but often quite a bit more as well. It is the productive time available during which the edge will machine components to be acceptable within the limiting parameters. In the early days of man tools, the tool-life parameter was simply when the tool could not cut any more. Today, the usual parameters are surface texture, accuracy, tool-wear pattern, chip formation, fig.3 and predicted reliable tool-life, the one applied depends upon the type of operation, finishing or roughing, and often the amount of manual control and supervision involved.

The cutting edge of an insert in a finishing operation is worn out when it can no longer generate a certain surface texture. Not a lot of wear is needed along a very small part of the insert nose for the edge of an insert to need changing. In a roughing operation wear develops along a lot longer part of the edge and considerably more wear can be tolerated as there are no surface texture limitations and accuracy is not close. The tool-life may be limited when the edge looses its chip control ability or when the wear pattern has developed to a stage when the risk for edge breakdown is imminent.

The selection of the right cutting tool is critical for achieving maximum productivity during machining. Especially the choice of tool-material and cutting geometry are important. But however right the tooling is, if the machining conditions are not up to standard, especially as regards cutting data and general stability, optimum tool-life will not be reached.

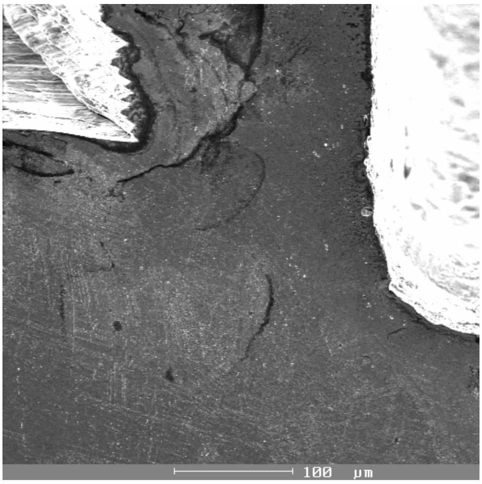


Fig.3 The cutting zone

Vibrations and lack of rigidity in tool holders and clamping will prematurely end many cutting edges.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. Wear is the result of interaction between tool, workpiece material and machining conditions by drilling in figure 4.

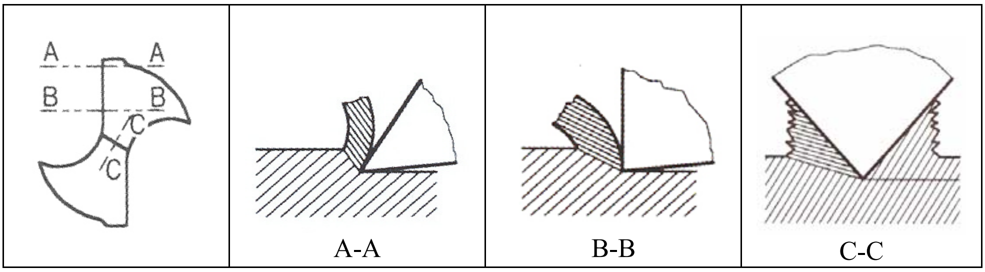


Fig.4 Interaction the workpiece-the twist drill on the local zones of tool

The cutting proces is interaction between cutting tool and workpiece. Every material has a internal energy, which in cutting proces change. This is energy has the main influence on the results by drilling. On the start is defined internal energy E_t of cutting tool, the next is defined internal energy of workpiece E_w. The themodynamic phenomenas is orientated on the problems of research of thermodynamic fields fig.5 and definition the motion energy between interaction two materials influence, from fig.6 of thermal analysis on the cutting edge.The results from analysis is equation model

$$E_w + E_t \Rightarrow surface\ conditions\,(quality, precision, tension) \tag{1}$$

$$E_w = function\,(microstructure, chemical\,condition) \tag{2}$$

$$E_t = function\,(microstructure, chemical\,condition) \tag{3}$$

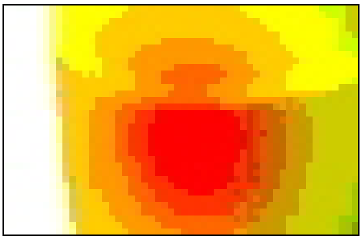
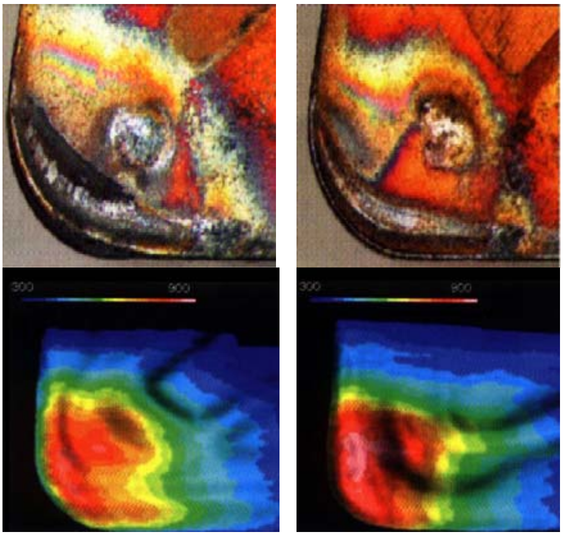


Fig.5 Thermodynamic fields in cutting part by corner point

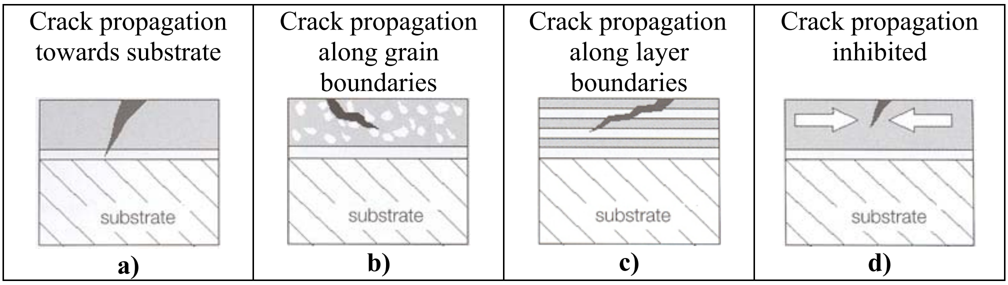


a) b)

Fig.6 Thermal analysis of cutting part with camera CCD

Figure 6a shows the heat on the insert in machining a workpiece (stainless steel) at a feed rate of 0.1 mm/rev, and a cutting speed of 60 m/min. Figure 6b shows the heat on the insert in machining a workpiece (stainless steel) at a feed rate of 0.1 mm/rev, and a cutting speed of 40 m/min. Therefore, the temperature distribution at some distance away from the primary deformation in the tool insert has a clear difference between the cases without and with a heat pipe. In addition, the shapes of both tool wear zones in the image confirm the assumed quarter-circular heating zone at the tool–chip interface at the tool insert rake surface in fig. 6. As shown in fig. 6a, an examination of the test results reveals that there is a direct relation between the crater-wear rate and the tool-chip interface temperature. It can be seen in Fig. 6b that there is sharp increase in crater wear after a higher temperature range has been reached for the tool insert without a heat pipe installed.

Note the location of the crater-wear pattern and the discoloration of the tool insert (loss of temper) as a result of high temperatures. The comparisons between the simulated and actual experimental data at different horizontal locations on the tool insert from the cutting edge. The internal energy is very important the coating insert, figure 7.



Crack propagation towards substrate — a)

Crack propagation along grain boundaries — b)

Crack propagation along layer boundaries — c)

Crack propagation inhibited — d)

Fig.7 Crack retardation in different coatings

4 CONCLUSION

The paper described the first problem solution, which orientated on the research of influence the internal energy of materials on the production forms by drilling.

Practice knowledges:

- ❑ Cryogenics and Coatings Cryogenic Processing works synergistically with coatings such as Titanium Nitriding (TiN). Coatings act to reduce the coefficient of friction between the tool and the metal being cut. Coatings typically do not fail by wearing off. The material under the coating fails due to repeated stress. Cryogenic processing acts to delay the failure of the material under the coating and therefore protects the coating. The use of cryogenic processing on high speed steel tooling is well known. High speed steel drills all respond to cryogenics. When sharpened, only 1/2 the amount of metal needs to be removed to achieve a sharp edge. This greatly increases the total number of pieces that a broach can cut in its lifetime.
- ❑ The finite element model (FEM) analysis of heat transfer behavior and machining experimental results in the present study demonstrate that the heat generated in machining can be effectively removed by the use of a heat pipe installed on a cutting tool insert. The experimental results also agree with the analysis in the sense that the installed heat pipe in a cutting tool has a significant effect on the temperature drop at the tool-chip interface, tool wear reduction, and tool life prolongation in machining. The results based on the comparison between heat pipe and non-heat-pipe dry machining demonstrate the feasibility of the concept of using a heat pipe for reducing the generated heat and the use of cutting fluids in machining.
- ❑ This paper package aim to model the metal cutting process in a thermodynamic way. The thermodynamic model is primarily concentrated and based upon the conditions at the flank face of the cutting tool. This improved cooling may be of an either active or a passive nature or a combination of both. Most of the existing models are hereby rather restricted and often just valid during very specific machining conditions.

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