THE CRACK CHARACTERISTICS RELATED TO FRACTURE OF CHIP IN MACHINING

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ABSTRACT

The term machining is used to cover chip-forming operations. The main objective is the shaping of the new work surface. The whole volume of metal removed is plastically deformed and fractured. The characteristics of crack has significant influence on machining phenomena such as chip formation pattern (disposability of chip) machined surface integrity and tool wear. In order to examine the behaviour of crack, the "Quick-Stop" technique of tool in machining and SEM and TEM were used in this study.Based on the experimental results the fundamental mechanism of chip shapes formation is discussed in association with the deformation and fracture behaviour of the work material around the cutting edge of the tool.

KEYWORDS

Crack characteristics,metal cutting,chip shape.

INTRODUCTION

The importance of machining research to the industrial world has long been recognised, but has never been more essential then it is today, with the rapid increase in the use of computer-aided design and manufacture. It is vital, if high output rates and consistent quality from microprocessor-controlled machine tool are to be maintained,that cutting tools last for a given time and wear at a predicted rate. The feedstock itself must also machine in a consistent manner.

Steels are probaly still the most important engineering materials and much research has gone into the influence of composition on the machinability of steels. Most of this work has been directed towards determining tool lives. There is steel a need however for a fundamental understanding of the structural changes which take place in a steel when it is machined. Without this it would be impossible to microstructure will affect stresses and temperature generated during cutting, nor understand the interaction between workpiece and tool, which essentially determines the life of the tool and the machinability of the steel. Only a limited amount of imformation has been obtained from such samples in the past because most researchers have been restricted to the machining perameter. The SEM and TEM have been used in this work,mainly to study the crack chenges produced in the machining of steels to provide a picture that the chip shape is related to the crack.

EXPERIMENTAL PROCESS

A 6140 center lathe with a continuously variable spindle speed, was for the metal cutting experiments. All cutting was done without lubricant. High speed steel tool were firmly clamped into a tool holder designed to give the tool a 6°positive rake and a 8°flank clearance angle.The tool holder was set up in a "quick-stop" device so that chip sample or quick-stop sections could be obtained a required. Device uses a humane killer gun to rapidly fire away the tool holder, which is supported in the cutting position by a brittle shear pin. The section of work-piece containing the newly formed chip could then be removed with a hacksow and mounted in "Araldite"for microscopical examination. The workpiece materials used was in the forms of round bars of pure iron,pure copper,steels and brass.

EXPERIMENT RESULTS AND DISCUSSION

The essence of metal cutting is a process of deformation and fracture in materials [1]. In the engineering industry, the term machining is used to cover chip-forming operation, The maining objective of machining is the shaping of the new work surface,In the machining ,the whole volume of metal removed is plastically deformed.

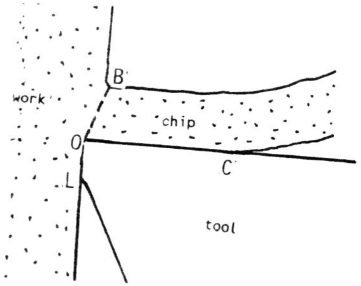


Figure 1.conventional of matel cutting action section through of cutting edge.

Fig.1 Shows conventional simple model of the action of metal cutting. A wedge-shaped tool moves asymmetrically through the work material, shear away a thin layer the--"chip"--which moves over the "rake face" of the tool, making contact for a distance oc. The chip is formed by shearing the work material in a zone close to the "primary shear plane" OB. The chip moves over the tool at a speed lower than the cutting speed.The cutting edge is initially sharp or slightly rounded but a "flank wear land " OL usually develops during machining. The new machined surface makes contact with the flank wear land continuously or intormittently .

Figure 2. Slip bands over the rake face of cutting tool,when cutting pure iron. (SEM)

Figure 2 . to show metal flow around corner of tool used to cut pure iron. The ship lines running from lower left to upper right in front of and below the sharp shear plane decrese in density with increasing distance from the tool tip. These slip lines form an angle of approximately 50 degree with the horizotal cutting plane, are spaced 5-15μm apart[2] study the structrue of the chip formed when cutting pure iron, using TEM. Figure 3. is a typical micrograph showing the very fine elongated ferrite cell structure numerous dislocation nets and tangle can be observed. The material of the chip had been very severly strain hardened.

Figure 3. Micro-bands from chip of pure iron. (TEM)

The cutting process produces a chip which will normally be three main types, according to the fracture behavior of chip [3]: a).A continuous chip which is formed by steady plastic deformation in the primary shear zone and is in contact with the rake face over a definite area. b). A continuous chip which forms over a built-up edge adhering to the rake face. c). A discontinuous chip which is formed by unsteady plastic deformation and periodic fracture on the primary shera plane.

Crack Behaviour Associated with the Continuous Chip .There are two main cracks associated with the chip shape formed (Figure 4):one forms below the flank race of the tool ,the shape of chip will be controted by this crack behaviour and other forms subsequently ahead of the rake face of the tool chip fracture involves nucleation of crack's and growth.Voids are fomed around the inclusions and interface of phases particularly at the brittle phase,the voids were connected and then micro-cracks formed [4,5].

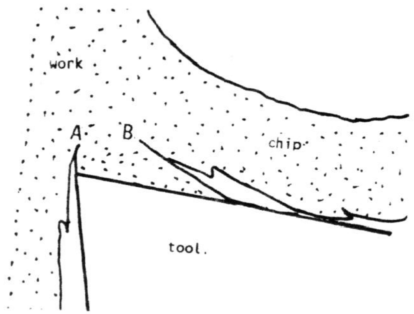


Figure 4. Scheme of the direction of two main cracks growth

When a ductile metal is cut so as to produce a chip in the form of continuous ribbon there is usually no evidence of fracture of crack formation (Figure 5) , but new surface is generated and this must involve fracture. From the direction of the required fracture (in the direction of cutting) ,it would seen that it take place a tensile stress acting at the tool corner [6].

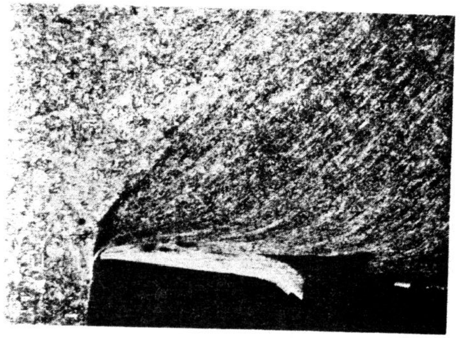


Figure 5 . Microstructure of continuous chip used to cut SAE 4140 steel showing crack growing along the primary shear zone.

Hence the chip in the vicinity of the tool corner must deform plastically in tension. As the strain continuous the tensile field of stress that is developed as a result of the curvature at the tool corner can thus produce the crack necessary in the development of the new face. [7]. However, the work materials in front tool corner is sujected to large compressive stress, and the micro-crack will be quenched upon reaching this zone during machining the continuous chip is produced.

A continuous chip which is formed by steady plastic deformation in the primary shear plane (Figure 1 OB) and is in contact with the rake face over adifinite area the crack formed below the flank face of the tool is not growth along the shear plane.

Crack Behaviour Associated with Dis Dontinuous Chip. During cutting steels,β-brass and aluminium alloys in certain condition the chip were completely discontinuous, because the horizontal and vertical comoponent of cutting force veried periodically. [8]. Figure 6 shows the pattern and microstructure of the discontinuous chip when machining a commercially aluminium alloy.

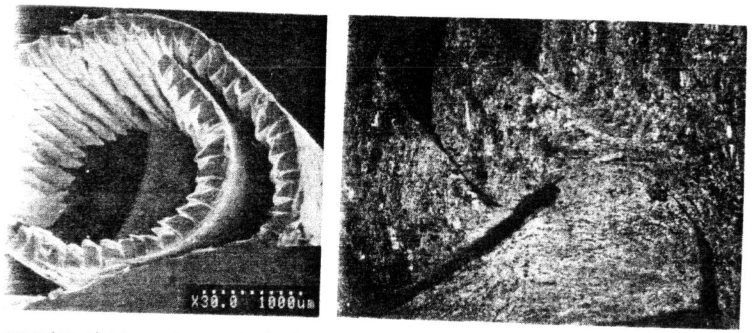


Figure 6. Scanning electron micrograph showing pattern and microstructure of discontinuous chip when machining Ly12 aluminium alloy.

When fracture failure occurs the load on the tool is released suddenly and it is driven rapidly forward by the elastic energy stored in the system as a result of tool deflection. The depth of cut is in effect,never zero,and hence the force do not drop to zero.

Experimental result shows the tool after its elastic motion has occured and metal is seem piled up the tool corner . As the tool moves forward metal is not removed by the normal shearing process represented but is rather extruded between the tool and free surface.

During this extrusion the chip does not slide along the tool face but rather rolls down upon it. The shear stress on teh primary shear zone OB (Figure 1) which represents the region of plastic flow increase as extrusion proceeds,until a value sufficient to couse repture is obtained.Here it is evident that the process involed is not at all similar to ordinary continuous cutting.

Fracture and BUE Formation. There are two type of crack formation association a BUE,one forms below the flank face of the tool and other forms ahead of the rake face of the tool, (Figure 4).The crack below the flank face of the tool grows along the primary shear plane and is accompanied by severe plastic deformation which was calculated to be an effective strain of more than 3. This crack behaviour is very similar to that observed in the initial stage of shear type discontinuous chip formation , such as the position where the crack forms, the direction of the crack growth and the strain concentration in the vicinith of the crack tip. Other main crack to locate ahead of the rake face of the tool occurs along the band with severe plastic deformation in the secondary shear zone. Crack takes place due to shearing a certain distance away from the cutting edge of the tool.Figure 7 Shows a section through a Quick-stop specimen with a characteristic BUE formed when cutting steel at low cutting speed . The BUE is seen to be continuous with the work material from which it was formed, it is not a separate body of hardened work material over which the chip slides. The new work surface forms by fracture at A and the under surface of the chip by fracture at B (Figure 4). [4]observation shows that the single phase materials under all conditions and two phases materials under certain specific conditions exhibit only one main crack, at or near the tool edge, while second phase materials can possess two fracture regions.The BUE is a stagnant zone of chip,the top of which is sem-stable.Examination of the fracture zone reveala that fracture occurs by cracking of the second phase, followed by growth and finally necking of the matrix lamellae.

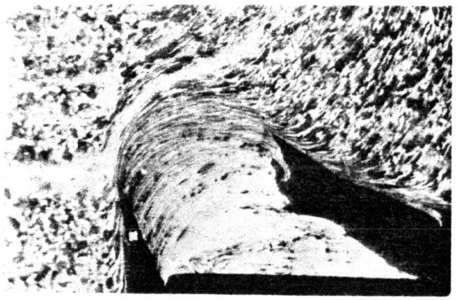
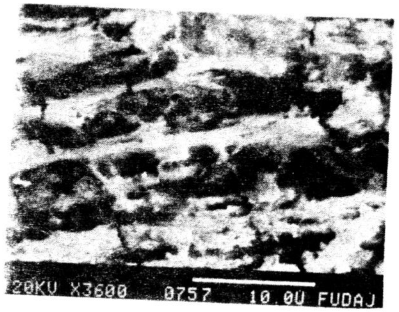


Figure 7. Microstructure of the BUE used to cut SAE 4140 steel.

The BUE is obviously a highly deformed body . The presence of pearlite in steels , therefore, is solely responsible for BUE formation. Nonuniformity of microcracks distribution in BUE indicates its complex stress, specially propose here that large number of microcracks gather at the boundary of primary shear zone and BUE body. At the boundary ,where interface of between ferrite and cementite ,a side of freeite appears a lot of void and microcracks[4.5.9] (Figure 8). Since scattered cracks propagate and connect each other in favour condition to a critical length. BUE will fracture and its fragments will be subsequently carried away by chip or left on the surface of the workpiece. Hence, the shape,size,number and distribution of the second phase particles will be the menace of stability of BUE. Surface quality on metal cutting is influnced directly by stability of BUE.

a



b

Figure 8.Microcracks growing along the interface of ferrite/cementite (a)and cross the cementite (b)in 0.2%C steel.

CONCLUSION

1. It is work-piece machined that the plastic deformation and fracture in metal cutting process.The plastic deformation has been taken place before the chip formation at a distance from tool edge.
2. Chip fracture involved crack uncleation and growth trandformation. Voids are formed around the inclusions and interface of phases .The voids were connected and then microcracks formed.It is plssible that some microcrack can be healed under large compression stress.
3. Morphology of chip depend on direction of crack growth and place of frature. Under a majority of cutting conditions, however, ductile metals and alloys do not fracture on the shear plane and a continuous chip is produced. Discontinuous chip will be formed when cracks growth and periodical fracture on the shear plane, that growth rate of crack is larger than the rate of chip flow. Discontinuous chip have a good disposability. It is necessary to process with automate.
4. There are two typies of crack formation associated with the formation of a Built-up edge: one forms below the flank face of the tool and another forms ahead of the rake face of the tool .Control of the chip shape is one of the problem confronting machinists and tool designers.

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