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A STUDY ON TYPES OF WEARS IN MILLING TOOLS

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Abstract: *The main aim of this work is to study the different types of wears caused during the milling processes and the causes. **T**ool wear can be described as the gradual failure of tools while the cutting operation is being performed regularly. This paper shows that there are different types of tool wears that occur in different conditions. The main occurrence of wear was seen due to mechanical friction, adhesion, high cutting temperature. Also the chemical wear was promoted due to cutting forces. By the study of wears caused wear patterns like rake face wear, flank wear, fracture, breakage and chipping were also observed. The research results are of great help in selecting the materials for the tools and the wear control in tool where high speed machining is required.*

Keywords: *Tool wear, Tool life, crater wear, flank wear*

I. INTRODUCTION

Milling tools are cutting tools typically used in milling machines or machining centers to perform milling operations. They remove material by their movement within the machine. Tool wear describes the gradual failure of cutting tools due to regular operation. It is a term often associated with tipped tools, tool bits, or drill bits that are used with machine tools. Types of wear include: flank wear in which the portion of the tool in contact with the finished part erodes. When the tool wear reaches an initially accepted amount, there are two options, to *resharpen* the tool on a tool grinder, or to *replace* the tool with a new one.

II. TYPES OF WEAR

- ***Crater wear***:

It consists of a concave section on the tool face formed by the action of the chip sliding on the surface. Crater wear affects the mechanics of the process increasing the actual rake angle of the cutting tool and consequently, making cutting easier. At the same time, the crater wear weakens the tool wedge and increases the possibility for tool breakage. In general, crater wear is of a relatively small concern.

- ***Flank wear:***

It occurs on the tool flank as a result of friction between the machined surface of the workpiece and the tool flank. Flank wear appears in the form of so-called *wear land* and is measured by the width of this wear land, VB, Flank wear affects to the great extend the mechanics of cutting. Cutting forces increase significantly with flank wear. If the amount of flank wear exceeds some critical value (VB > 0.5~0.6 mm), the excessive cutting force may cause tool failure.

- ***Diffusion wear on low cutting tools:***

A smooth cutting edge with a dark burned appearance very close to the edge will characterize diffusion wear. Cratering of the tool face will be visible. The temperatures created in the cutting zone are too high for the the tool material allowing it to diffuse into the work piece or the chips.

- ***Built Up Edge(BUE)***

This common problem is identified by work piece material sticking to the face of the tool. The BUE often leads to chipping of the tool cutting edges. BUE is caused by low surface feet per minute or poor shearing action of the work piece material. The work piece material is adhering to the surface of the tool due possibly to improper insert geometry or an affinity of the work material to the insert or its coating. BUE is also caused by coolant issues such as improper physical application of the coolant, insufficient anti-weld

- ***Chipping Wear***

This common problem is identified by sharp ragged edges on the used insert. The wear patter is irregular along the edge of the tool. Often, chipping wear leads to a catastrophic failure early in the life of the tool which masks the failure mode. Surface finish is usually streaked and uneven. Mechanical issues such as machine spindle or part fixture vibration will contribute to chipping wear. A tool holder with a large cantilever condition will cause harmonic vibrations to be amplified at the cutting edge. Excessive loads on the tool will cause chipping.

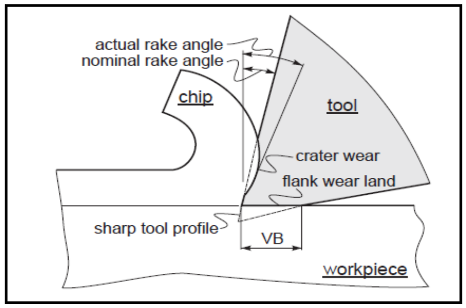

Fig1 Crater wear and Flank wear

- ***Flaking***

Flaking appears to be a large chip in tool. There will be one or two large areas missing the tool face. Flaking occurs on tools that are too brittle for the application, usually ceramic tools. It maybe caused by a sudden impact when the tool enters the work piece or if the tool is extracted during a heavy load.

- ***Fracture***

This wear pattern is the result of over use or severe overload. If it occurs very late in the life of the tool, other wear patterns probably existed such as Chipping, Crater, Deformation or Flaking and the tool was overrun Fracture wear is related to severe loads on the cutting tool such as hard spots in the work piece. Most of the time, this failure mode is caused by excessive speed or feed.

- ***Deformation Wear***

Deformation wear is always accompanied by a bulge of tool material in the flank / land area. This severe deformation is quickly followed by fracture. Deformation wear is caused by excessive temperatures in the insert due to high cutting forces, excessive speed, and excessive feed rate

III. TOOL LIFE

Tool wear is a time dependent process. As cutting proceeds, the amount of tool wear increases gradually. But tool wear must not be allowed to go beyond a certain limit in order to avoid tool failure. The most important wear type from the process point of view is the flank wear, therefore the parameter which has to be controlled is the width of flank wear land, VB. This parameter must not exceed an initially set safe limit, which is about 0.4 mm for carbide cutting tools. The safe limit is referred to as *allowable wear land (wear criterion)*, VB_k. The cutting time required for the cutting tool to develop a flank wear land of width VB_k is called *tool life*, T, a fundamental parameter in machining. The general relationship of VB versus cutting time is shown in the figure (so-called *wear curve*). Although the wear curve shown is for flank wear, a similar relationship occur for other wear types. The figure shows also how to define the tool life T for a given wear criterion VB_k.

The slope of the wear curve (that is the *intensity* of tool wear) depends on the same parameters, which affect the cutting temperature as the wear of cutting tool materials is a process extremely temperature dependent. Parameters, which affect the rate of tool wear are *cutting conditions* (cutting speed V, feed f, depth of cut d), *cutting tool geometry* (tool orthogonal rake angle) and *properties of work material* From these parameters, cutting speed is the most important one. As cutting speed is increased, wear rate increases, so the same wear criterion is reached in less time, i.e., tool life decreases with cutting speed If the tool life values for the three wear curves are plotted on a natural log-log graph of cutting speed versus tool life as shown in the right figure, the resulting relationship is a straight line expressed in equation form called the Taylor tool life equation:
$VT^n = C$

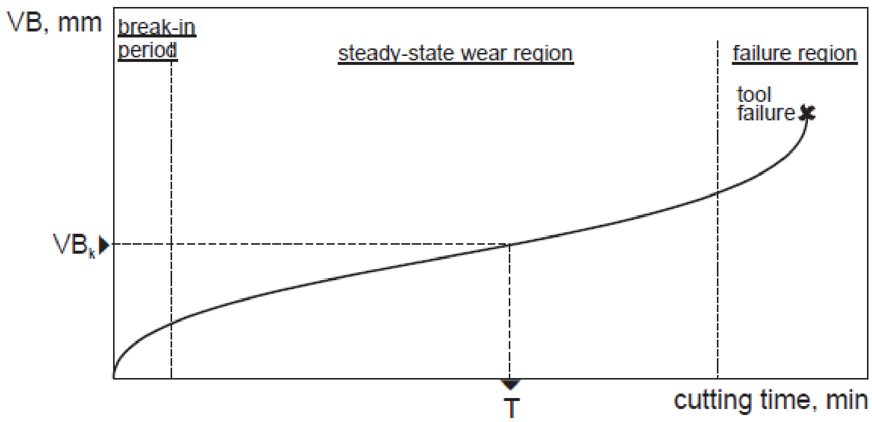

Fig 2Flank wear as a function of cutting time. Tool life T is defined as the cutting time required for flank wear to reach the value of VB_k

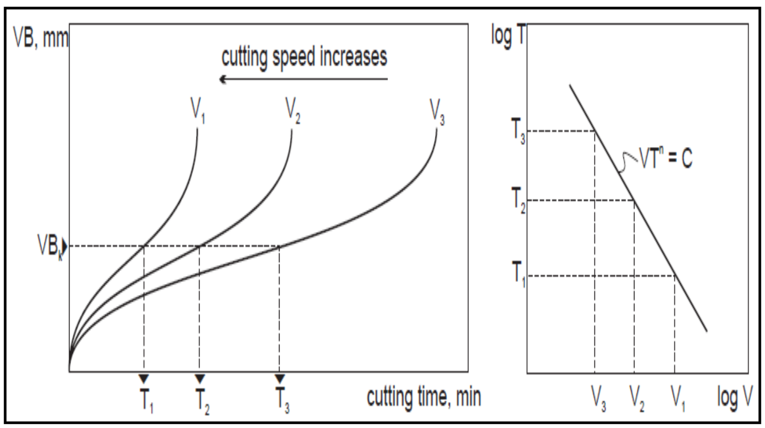

Fig 3 (Left) Effect of cutting speed on wear land width and tool life for three cutting speeds. (Right) Natural log-log plot of cutting speed versus tool life.

Where n and C are constants, whose values depend on cutting conditions, work and tool material properties, and tool geometry. These constants are well tabulated and easily available. An expanded version of Taylor equation can be formulated to include the effect of feed, depth of cut and even work material properties.

IV. WEAR CONTROL

As it was discussed earlier, the rate of tool wear strongly depends on the cutting temperature, therefore, any measures which could be applied to reduce the cutting temperature would reduce the tool wear as well. The figure shows the process parameters that influence the rate of tool wear:

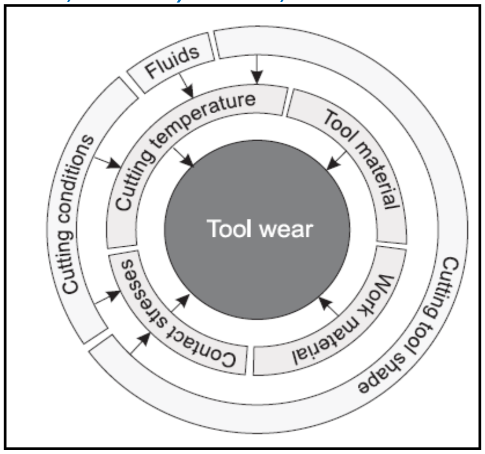

Fig 4 Cutting tool wear as a function of basic process parameters

Additional measures to reduce the tool wear include the application of advanced cutting tool materials, such as *coated carbides*, *ceramics*, etc.

V. CONCLUSION

- Based on the results obtained in this work, the following conclusions can be drawn for the face milling process with conditions similar to those used here
- If the cutting speed is varied it has a great influence on the tool life, not mattering the variation in feed velocity or feed per tooth
- The most important factor influencing the tool wear and tool life is the frequency of entrance of the cutting edges of tool
- There is very less influence on work piece surface roughness when the parallel land of the cutting edge is much larger than the feed per tooth

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