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Wear Analysis of Tool in Milling YTL7D Steel

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Abstract: *In the process of milling die steel YTL7D, the properties of high hardness and high wear resistance of the workpiece material led to that the tool Subjected to severe wear, and the life of the tool is lower. In this research, the wear law of rake face and flank face of the ball end mill was discussed. And the tool wear mechanism in the process of milling YTL7D steel is revealed in this paper, to provide a theoretical guidance for the development of rational process and follow-up studies.*

Keywords: *YTL7D steel hardness wear*

I. Introduction

Mould is a kind of important technological equipment with great potential in the machinery industry, many product components need using mould forming process, especially some parts with complex shape and difficulty to process, mould plays an irreplaceable role in many fields, has become an indispensable economic field in the national economy . Most of the moulds are made from hardened steel, its hardness is mostly about HRC 50, with the characteristics of difficult processing, high cost and low production efficiency [1] . Along with the advancement of science and technology, the development trend of mechanical products towards the direction of much more precision, as well as the requirements of product features' diversification and aesthetic appearance, which make the mould surface structure more complex and surface precision and machining difficulty higher and higher. As more and more new technology was put into the mould industry, mould manufacturing industry has become an important part of the high-tech industry. As for exploring the tool wear mechanism for milling difficult machining steel materials, it has been a hot research fields, and one of the focused problems in mould manufacturing industry.

Ball end mill is applied widely in mould industry, designed specifically for complex surface machining, especially for mould cavity. Decreasing tool wear rate and improving tool life have a practical significance to reduce production cost for the enterprise.

II. Material

The rapid development of mould industry will inevitably lead to the huge market demand of die steel material, YTL7D is one of the widely used die steel material. YTL7D steel is a Chinese steel grade, a type of patent die steel. Rockwell hardness is more than HRC58, it is a kind of die steel with high hardness, high wear resistance and good toughness. Under the condition of high load stamping YTL7D steel can maintain good characteristics, suitable for plastic mould with high wear resistance and cold extrusion mould.

YTL7D steel belongs to cold work die steel. The chemical parameters are as follows:

Elements	C	Cr	Si	Mn	W	Mo	V
Mass fraction	0.72	6.7	0.85	0.45	0.50	1.60	1.78

Delivery hardness<=HB215 Hardness of HRC: 58-63

Cutting performance for YTL7D steel is poor, the degree of tool wear is high. In the process of cutting, the chips were generated along with a large amount of heat, which made the tool at high temperature state. At the same time, there was a considerable pressure and relative motion between tool and chips and workpiece, which made the tool wear inevitable.

III. Wear mechanism category

Under the condition of high speed milling, there are high temperature, high pressure, friction, adhesion and chemical reaction between the tool and the workpiece, which seriously affect the durability of the tool. Tool wear rate is an important measurement index of tool durability. Normal production process, in order to increase productivity or reduce the production cost, it is necessary to make sure that tool life have a reasonable value [2] .

Reducing cost and increasing productivity are the starting point of studying tool wear. Workpiece and tool material, processing parameters, tool parameters and other conditions are essential causes affecting the rate of tool wear. Under the condition that the material has been confirmed, choosing reasonably tool and making corresponding cutting process planning can effectively reduce tool wear. In the normal machining process, the main types for tool wear includes abrasive wear, adhesive wear, diffusion wear and oxidation wear etc [2] [3] ...

Abrasive wear, also known as a hard point wear. It has something to do with the hardness of workpiece, the harder of material the larger the number of hard points, and the more obvious about the wear. Cutting speed is another important factor that affects abrasive wear, and the abrasive wear is the main cause about tool wear at the low speed. Cutting temperature, material hardness and the 'affinity' of between the materials are the main factors for the occurrence of adhesive wear; Temperature is the key factor affecting the diffusion wear, the higher the temperature, the faster the diffusion of chemical elements. Diffusion wear and adhesive wear often occur together. Oxidation wear, also known as chemical wear, under the condition of high temperature, forming oxide layer through oxidation reaction on the tool surface, those oxide layers are easily worn out and generated again. In addition to the above four kinds of wear types, there are still hot cracking wear.

IV. Wear analysis of milling experiment

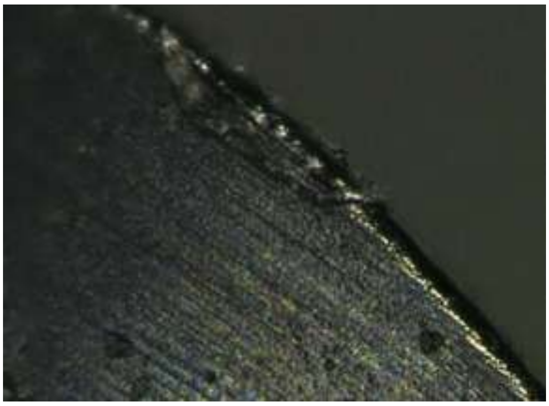
4.1 Experiment process

Using experimental tool to process YTL7D steel by semi-finishing. After the experiment, By means of optical microscope and scanning electron microscope to observe tool wear's areas, and analyzing the tool wear mechanism.

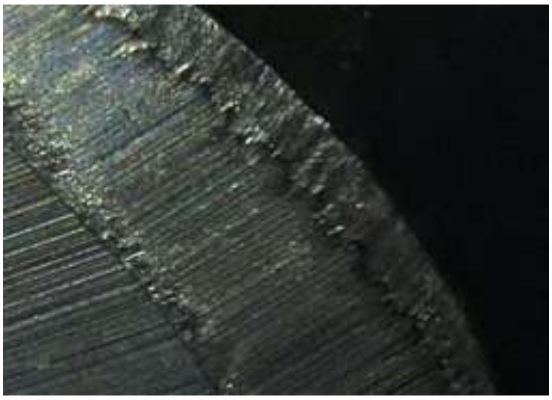
This experiment was conducted in Germany extron's machining center, using double-edged ball end mill with diameter 6mm and plus coating. The main milling parameters are: spindle speed 4000r/min, axial depth 0.05mm, radial depth 0.1mm, feed rate 750mm. Taking two tools numbered 1 and 2 to mill 16m and 30m length respectively, and observing its wear condition of rake face and flank face.

4.2 results and discussions

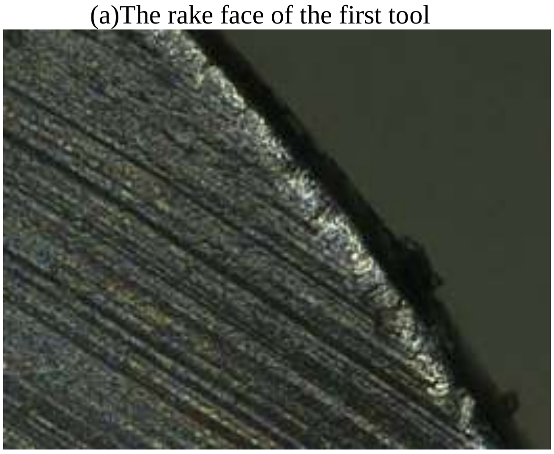
Under normal circumstances, wear will be occurred over the rake face and flank face in the milling process. The rake face is in the high cutting pressure and high temperature, it is easy to occur crater wear and chipping phenomenon. The intense friction between flank face and machined surface makes flank face produce a wider wear band. Generally, the wear band's height value VB of flank face is used to judge the degree of wear [3] .



(a)The rake face of the first tool



(b)The flank face of the first tool



(c)The rake face of second tool

(d)The flank face of second tool

Figure1The wear condition of rake face and flank face

In this experiment, the main failure modes of tool belong to normal wear. Figure 1 shows us the wear morphology of the tool rake face and flank face, rake face mainly occurred chipping phenomenon, and flank face appeared severe wear band. Because of small depth of milling, the wear height value of rake face is small, but the wear degree is pretty severity. The 2nd tool rake face appeared severe chipping phenomenon, its reason lies in the rake face was under high pressure and high temperature condition for a long time, the strength of cutting edge was weakened, and leading to chipping. Meanwhile, chips across rake face, causing scratch, the coating with cracks can easily be worn out. The wear band of the flank face is relatively wide, and the wear height VB is quite high, with the ongoing of cutting process, the flank wear will soon from stable wear into a state of rapid wear. In the milling process, coating was gradually wear away, the strength and hardness of the tool were weakened, wear acceleration, hard object of the workpiece and built-up edge scored out of the grooves in the flank face, that is abrasive wear.

In order to further analyze the wear condition of the tool, the microscopic observation of the flank face of the first tool was carried out through EMS, as shown in figure 2 and figure 3.

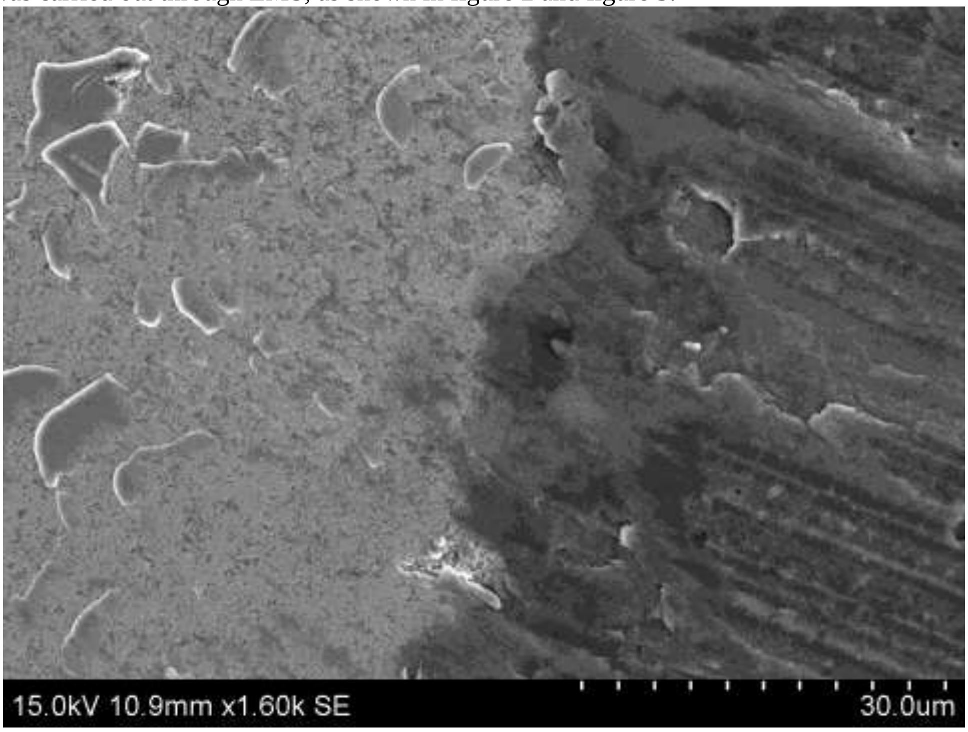


Figure 2 Wear morphology of the flank face

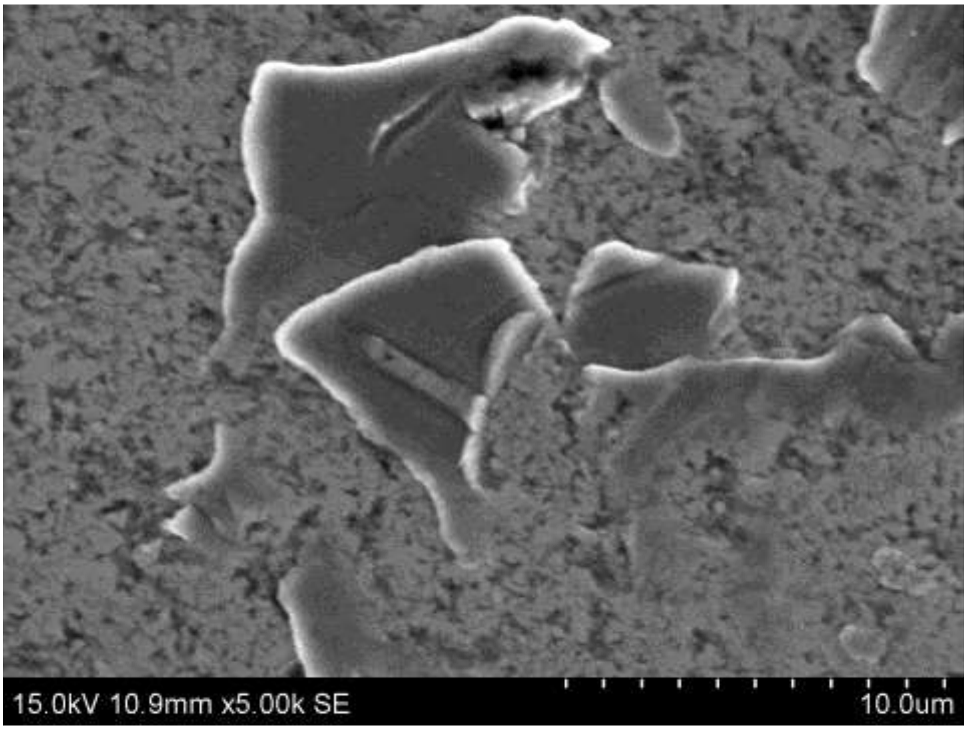


Figure 3 Denudation morphology of the flank face

According to the results observed under the scanning electron microscope, it shown us the wear failure forms of the flank face, which includes coating peeling, abrasive wear, micro chipping. Figure 2 shows that the tool surface appeared obvious strip scratches, which is the result of abrasive wear. Figure 3 is the coating denudation morphology. Milling is an interrupted cutting process, the cuts-over and cuts-off of the tool teethes would generate impact effect, as well as temperature changes, it accelerates the crack's growth of the coating. Under the effect of the cyclic mechanical load and the cyclic high stress caused the thermal load, the micro cracks were generated, finally the micro chipping phenomenon occurred after the material strength was severely weakened, to cause tool failure [5] [6].

V. Conclusions

In this paper, the mechanism of tool wear was arranged and analyzed, and the main wear mechanism of milling YTL7D steel was discussed, the cutting experiments verify that the main reason cause for the wear failure of rake face are chipping, coating peeling and abrasive wear for flank face. The high cutting stress caused by cyclic mechanical load and thermal load is also a major factor of tool wear.

To conduct the research of tool wear about milling YTL7D steel in the future, the milling force and heat should be focused as the research's starting point, to choose reasonable coating and tool material, to optimize tool parameters, and to set cutting parameters appropriately.

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