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RESEARCH

Tribological Characteristics of Superhard Ti (C, N) Coating Deposited on Milling Cutters

The aim of this work is to determine wear resistance of the superhard Ti (C, N) coatings deposited on milling cutters.
Milling performance of the coated mills was appreciated in terms of wear width and the axial force. The axial force was measured using a resistive strain transducer with a Hotinger type strain gauge.

Keywords: *superhard Ti (C, N), coated mills.*

1. INTRODUCTION

The durability of the cutting tools is to a great extent determined by the tribological characteristics of the active cutting edge. Great forces and temperatures appear at the cutting level of the tool, depending directly on the characteristics of the processed material, the cutting speed, the depth of cut, the qualities of the cooling and lubrication liquid.

The wear of the tool manifests itself particularly on the main machined surface and on the crank table and this is intensified by the appearance of the false cutting edge.

More wear mechanisms are admitted, out of which the most important are abrasive wear, adhesion, the superficial thermic fatigue, and oxidation. In the case of cutting tools covered with hard thin films, we also deal with layer adherence.

The covering of cutting tools made of cemented carbide with hard films of Ti (C, N) provides an important growth of the cutting in resistance to wear. The false cutting does not form on such films.

According to ISO 3685 – 1977, the usual criteria for the appreciation of the cutting tool's wear are the following: the average width of the wear on the base surface and the depth of the crater formed on the machined surface.

The researches were concentrated on the tooth milling cutter made of cemented carbide and covered with a Ti (C, N) film. The coating of the mill has been made by a team of researchers from the National Institute for Optoelectronics and the researches referring to their characteristics were accomplished by the staff at Petroleum-Gas University.

Taking into consideration the construction and destination of the tooth milling cutter, whose durability was of prime interest, the following parameters of measurement were used:

- The axial force which develops at the beginning during the process, a force which grows as the cutting of the tools wears;
- The width of the resulted flat on the main surface.

These parameters are established for both the uncoated mills and the coated ones, using the same production process. Moreover, the possible exfoliation of the hard film on coated mills was also kept under observation.

2. EXPERIMENTAL DETAILS

The tooth milling cutters used in these attempts have a diameter of 12 mm and 12 teeth (see figure 1).

The experimental attempts of metal removal were executed with a universal milling FUS 200 machine, on which the measuring transmitter was added in order to measure the axial force necessary to the movement of the raw material (see figure 2).

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Figure 1. Representation of tooth milling cutter

The support of the sample is fixed above the table on the vertical slide of the milling machine. The sample is set up in a crank slot which shifts according to the resistive strain transducer mounted on the table.

In order to get this crank slot, rigidity and friction reduction were taken into consideration.

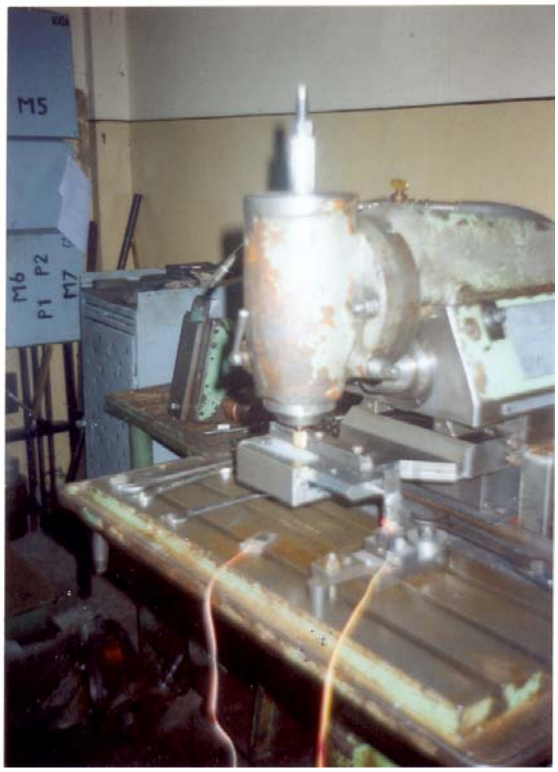


Figure 2. Representation of the work surface for the milling machine

The tooth milling cutter was fixed in the chuck of the vertical head of the milling machine. Before processing the material, the transducer was calibrated on the various magnifying scales of the bridge. The obtained characteristics were linear.

The production was executed beforehand, without cooling.

The samples bear the shape of a universal iron, 25 mm in width and 2 mm in thickness, made of carbon steel, with a hardness of 145-165 HB.

The processing rhythm was the following: the cranking speed of the mill – 950 revolution/ minute, an advance of 12,5 mm/ minute and depth of cut – 0,5 mm/ pass.

The initial dimension of the cutting edge and the width of the flat that resulted during the wear process were measured on a metallographic microscope OLYMPUS B- 160M type and on an adequate mechanism of mill positioning. The adhesion of the Ti (C, N) film is established according to the aspect of the wear flat margins, in response to the dynamic repetitive necessities which appear during the cutting process.

The thickness of the hard film was established in the mill zone because the conditions for coating all mills were similar. On the mill generator, we executed an inclined flat with a 5° angle to the cylinder generator; afterwards it was drained in plastic mass and metalographically polished. Thus we obtained an amplification of penetrated coating width of 11,5 times.

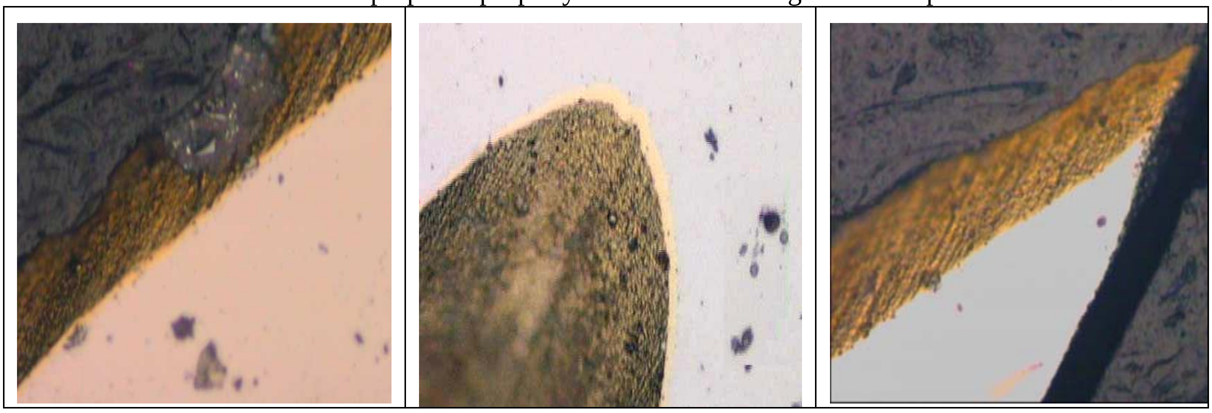
3. RESULTS AND DISCUSSION

3.1 Ti (C, N) film thickness

The Ti (C, N) film thickness is of 4 µm on the mills' tooth flanks, while in depth the thickness is of 2 µm. Figure 3 presents in this sense the coating film topography on the tooth flank and on tooth depth.

One should notice that the roughness on the tooth flank and on the tooth depth is maintained after its coating. A constant aspect is the transformation of the geometry of the tooth cutting edge. The excess metal on the cutting edge may lead to the exfoliation of the film when the cutting tool process begins if its adhesion is not the corresponding one.

In fact, the detachment of the excess metal was observed, but without noticing the exfoliation of the film, which shows that the mill was prepared properly for the coating and the deposit conditions.



a *b* *c*

Figure 3. Coating film topography X 50
a – on tooth flanks; b – on tooth depth; c – on the tooth point

3.2 The width of the tooth cut

The width of the cut was measured after a various number of passes, milling distances respectively, on both Ti (C, N) uncoated and coated mills.

Figure 4 presents the variation of the average width of the mill cut according to the milling distance. At first, the coated mills present a growth in the width cut, which is a consequence of the removing of the sharp coating of cut. Moreover, the width of these mills' cut grows much slower than with uncoated mills due to the qualities of the Ti (C, N) film.

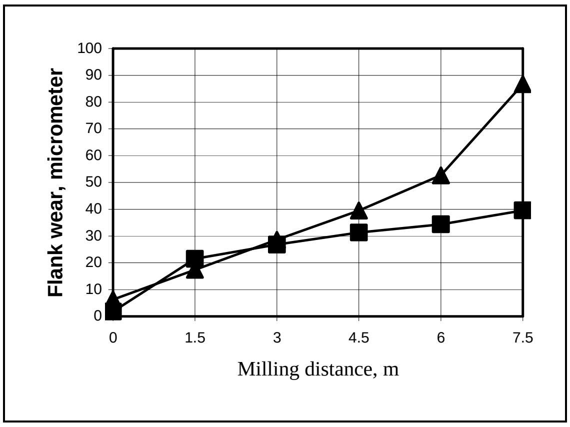


Figure 4. Flank wear vs. milling distance

▲ – uncoated mils; ■ – Ti(C,N) coated mils

3.3 The axial force of advance

The axial force of advance indicated by the transducer grows according to the milling distance. In this sense, the growth of the axial force is continuous with uncoated mills and at the maximum processing length there is a rapid growth in intensity, which indicates the destruction of the cut. During these tests great variations of the axial force were observed, variations caused by the appearance of the false cut. The appearance of the false cut on the edge of the cemented carbide cutting tools is not a characteristic of the mills only. The main form of cut destruction is breaking, as well as the exfoliation from the material on the main table (figure 6).

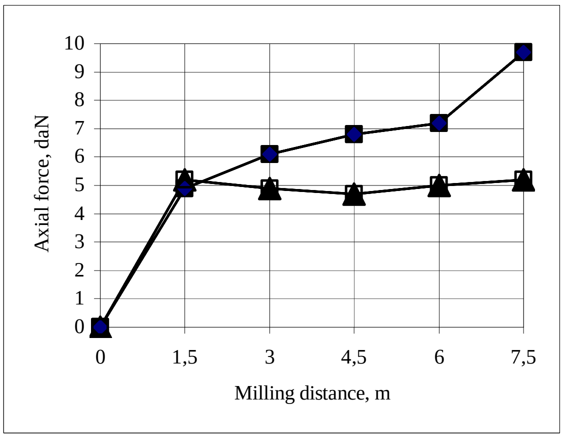


Figure 5. *Variation of axial force depending on the milling distance*

■ – uncoated mils; ▲ – Ti(C,N) coated mils

The axial force at Ti (C, N) coated mills is maintained at low levels, though at the beginning of the processing the diamond nose is removed. During the processing, the variation of the axial force with these mills is much lower. This indicates the fact that on the Ti (C, N) coated flank, a false cut would not form so easily. The maintenance on the crank table of the hard film makes the axial force of advance to be low. During the experiments, these mills did not record any destruction of the cutting edge.

Fig. 6: Reproduction of the used cut of the uncoated mill

4. CONCLUSIONS

1. By hard film coating the geometry of the cut is modified, as the width of the flat is reduced as a consequence of a film growth on the tooth.

2. The thickness of the coating film is not constant on the tooth surface, as the tooth presents minimum thickness levels in depth.

3. The wear process at coated mills begins by removing the fragile diamond noses off the cutting edge, without exfoliating the film on the crank table.

4. In the first production stage, the axial force of advance is similar in value for the two types of mills, and as the milling distance grows, the force differentiates, while the Ti (C, N) coated mills have the minimum value.

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