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THE WEAR MECHANISM OF A CARBIDE INDEXABLE INSERT IN THE CONDITION OF SEMI-FINISH MILLING OF ORDINARY CARBON STEEL

Abstract*: The analysis of the wear mechanism of a carbide indexable insert on the flank surface during end milling of ordinary carbon steel is presented in the article. Images of wear of the flank surface and the tip of the carbide indexable insert in the range from 3 to 60 minutes were obtained and recommendations were given on the durability of the cutting tool in the condition of high-speed semi-finish milling of flat surfaces.*

Key words*: milling, carbide indexable insert, wear, tip, flank surface.*
Language*: English*

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Introduction

The milling process takes place in more difficult conditions than turning. This is due to the variable removable allowance from the blank and the impact load on the cutting edge of the cutting tool element. As a result of the combination of these factors, the cutting part of the tool is subject to wear.

Wear causes a decrease in the length of the cutting part of the tool and is measured according to various criteria, for example, on the flank surface. Wear of the cutting tool affects the dimensional accuracy and the quality of the machined surface of the parts, therefore, a large number of scientific papers have been devoted to the analysis of the wear mechanism of carbide indexable inserts during milling of metallic and non-metallic materials, for example [1-10].

In this article, based on a review of various scientific articles, gaps were filled in the detailed description of the wear mechanism of carbide indexable inserts with a protective coating applied by physical vapor deposition (PVD) on the flank surface during semi-finish milling of ordinary carbon steel.

Materials and methods

The milling of rectangular blanks was carried out on a CNC milling machine of the DMC 635 V ecoline model. Blanks made of A 107 ordinary carbon steel were processed. An end mill with a diameter of 50 mm with a clamped-on of four carbide indexable inserts was adopted as a cutting tool. The carbide indexable insert (APMT 1604PDER-FM (China)) was an 85 degree rhombus with a HS5130 protective coating. The carbide indexable insert had the following geometry: cutting edge length – 17.2 mm, diameter of the landing hole – 4.4 mm, insert width – 9.25 mm, insert thickness – 4.76 mm, radius at the tip – 0.8 mm, rear angle – 11 degrees. Images of the carbide indexable insert and the end mill assembly are shown in the Fig. 1.

a b c

Figure 1. The cutting tool used in steel milling: a – carbide indexable insert, b and c – general view of the end mill with installed carbide indexable inserts.

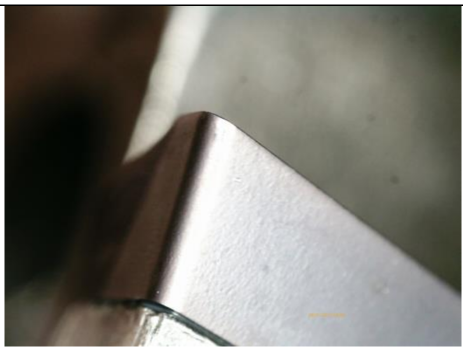
Semi-finish milling was carried out in the following cutting modes: milling depth – 0.3…0.5 mm, speed of rotation of the milling cutter – 2000 rpm, feed rate – 1800 mm/min. Machining was performed using ECOCOOL SOLUBLE 30 VR coolant. Wear of the carbide indexable insert was recorded every 3 minutes of the steel milling process in the time ranges from 0 to 21 minutes and from 39 to 60 minutes.

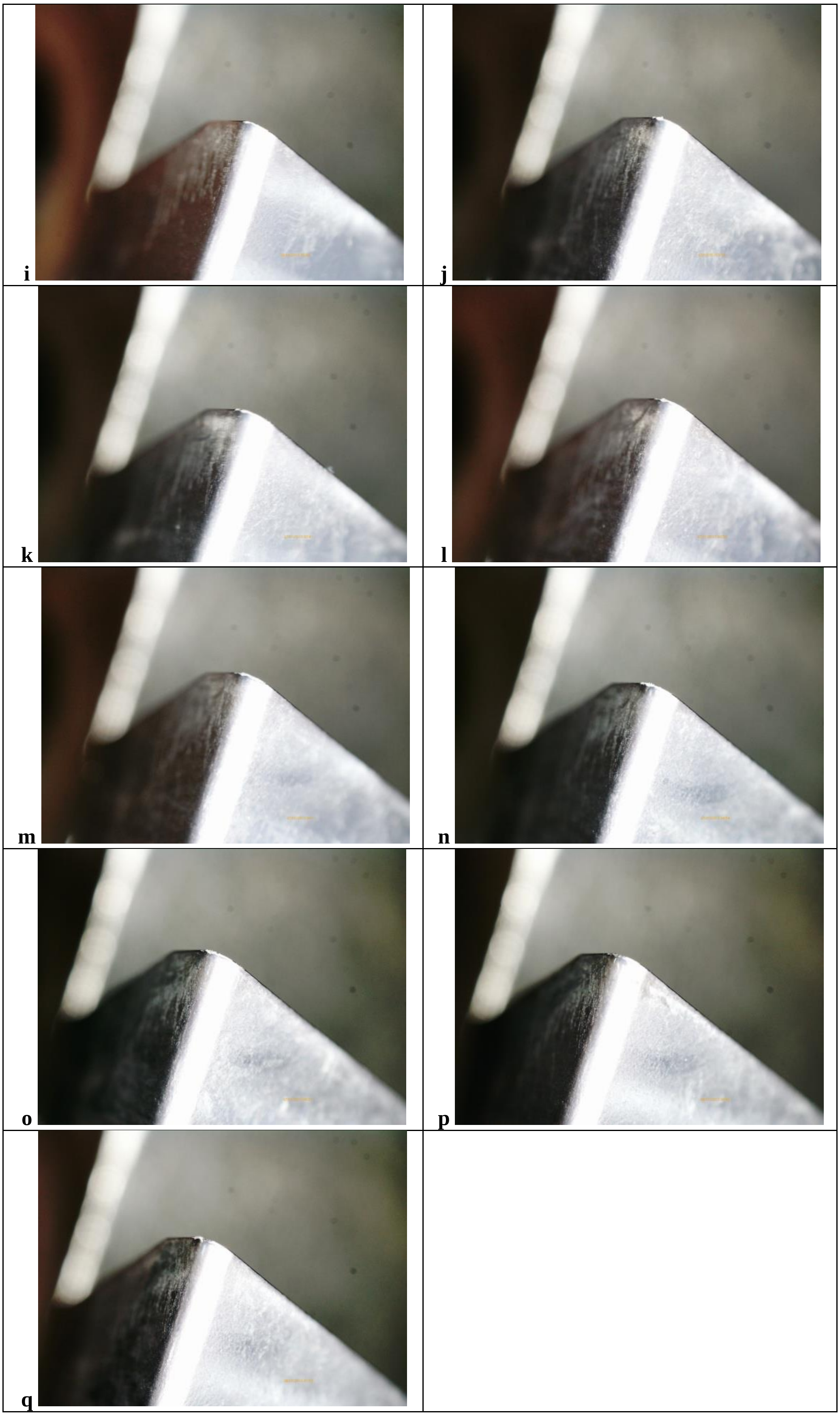
Results and discussion

The total milling length was 96280 mm in 60 minutes. The condition of the carbide indexable insert surfaces was determined by photographing them every 3 minutes of the steel milling process. The wear mechanism of the carbide indexable insert on the flank surface is shown in the Table 1.

The photos show the flank surfaces and the radius tip of the carbide indexable insert. At 6 minutes of milling, scratches appear on the flank surface and micro-chipping of a fragment of the blade length at the radius tip of the carbide indexable insert (the Figure 1, c). Over time, the area of scratches on the flank surfaces and the length of the blade micro-chipping at the radius tip of the carbide indexable insert increase. At 21 minutes of milling, wear is noted along the entire length of the radius tip of the carbide indexable insert (the Figure 1, h). Replacement of the carbide indexable insert is required, since the cutting edge responsible for the formation of the machined surface on the blank cannot provide the required surface roughness and accuracy of the resulting linear size. From 30 minutes on, an built-up forms on the cutting edge of the radius tip, which, on the one hand, to some extent protects the cutting edge of the carbide indexable insert from further wear, and on the other hand reduces the quality and accuracy of the part surface (the Figure 1, i-q).

Table 1. Wear of the carbide indexable insert on the flank surface.

a 	b 
c 	d 
e 	f 
g 	h 



In the images: a – carbide indexable insert before milling, b – carbide indexable insert after 3 minutes of milling, c – carbide indexable insert after 6 minutes of milling, d – carbide indexable insert after 9 minutes of milling, *e – carbide indexable insert after 12 minutes of milling, f – carbide indexable insert after 15 minutes of milling, g – carbide indexable insert after 18 minutes of milling, h – carbide indexable insert after 21 minutes of milling, i – carbide indexable insert after 30 minutes of milling, j – carbide indexable insert after 39 minutes of milling, k – carbide indexable insert after 42 minutes of milling, l – carbide indexable insert after 45 minutes of milling, m – carbide indexable insert after 48 minutes of milling, n – carbide indexable insert after 51 minutes of milling, o – carbide indexable insert after 54 minutes of milling, p – carbide indexable insert after 57 minutes of milling, q – carbide indexable insert after 60 minutes of milling.*

Conclusion

Based on the results of the experiment, the following conclusions can be drawn:

1. A visible change in the geometry of the carbide indexable insert on the flank surface is observed from the 6th minute of the steel milling process.

2. Wear of the carbide indexable insert is manifested in a violation of the integrity of the blade along the radius tip and the formation of scratches on the flank surface.

3. Up to 21 minutes of the semi-finish milling process, the radius tip of the carbide indexable insert wears out only on one side without violating the dimensional length of the blade. After 21 minutes of machining, wear was noted along the entire length of the radius tip of the carbide indexable insert. Thus, it can be said that after 21 minutes of semi-finish milling of critical parts, under specified cutting modes, replacement of the carbide indexable inserts is required.

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