Particularities Regarding the Wear of SPMR150612-P30 Metallic Carbide Inserts

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Abstract
Metal cutting processes still present a high weight in obtaining various parts needed for the industry, both due to the quality of the surfaces and especially to the dimensional and geometric precision. The cutting tools are in continuous development and their wear is a constant concern of the researchers. Standardization of wear forms has become a necessity and ISO 3685/1993 is an example in this regard. However, the measurement of the average wear on the cutting tool flank is not detailed in the standard. This question naturally arises "In how many points should wear be measured on flank so that the average values are as close to reality as possible?". If in the case of a uniform wear the approach is simple, not the same thing happens when the wear is non-uniform. This paper analyzes in detail a non-uniform wear on the flank of a metal carbide plate mechanically fixed and through experiments proposes the optimum interval of making the measurements so that the average of values is as close to the average of the finer used interval, in this way significantly reducing the time spent on measurements.

1. Introduction

The obtaining of the metal parts by cutting is, for the moment, the modality with the highest weight in all the mechanical processes. A significant number of specialty papers have dealt with the cutting process in order to understand the relations and phenomena that occur when the cutting layer crosses into the chip [1, 2, 3, 4] in order to find ways to increase the quality of the processed surfaces but especially the dimensional and geometric precision. The paper [3] logically summarizes the phenomena that occur in the cutting process and groups them into primary actions that cause effects (Figure 1).
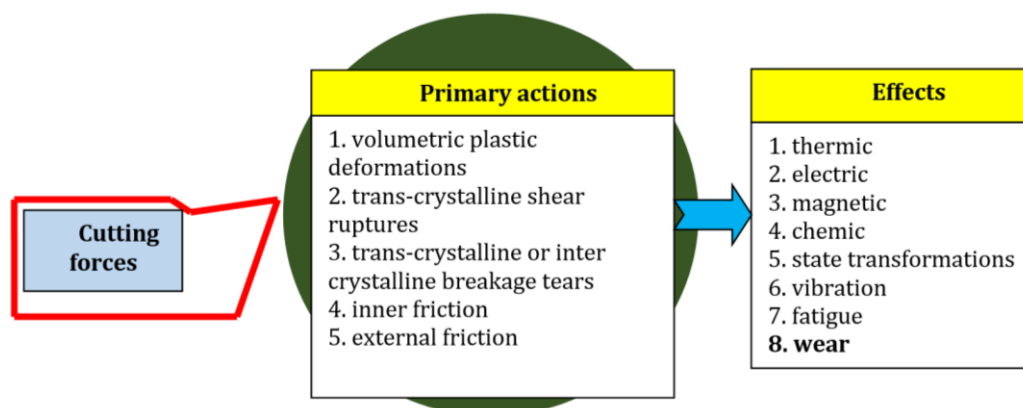

Fig. 1. Identification of primary actions and effects during cutting, according to [3]

The effect with the most important consequences is that of wear because it causes the decrease of cutting tool life. Also in the work [3] it is shown that the cutting process is a primary system with a degenerative loop where the wear is both an element of entry and an element of exit from the system.
Some effects, such as the electric one, that appears during metal cutting processes with good

electricity conductor cutting edges, reports the quality of the cutting edge (according to [5]). The bibliographic sources [3, 4] show that when cutting the same material under the same conditions, the electric cutting current is also depending on the wear of the cutting edge.

The importance of the permanent study of the cutting tool wear is also highlighted in papers [6, 7, 8].

Figure 2 shows the wear characteristics of the cutting edge on the flank of the cutting tool, according to ISO 3685/1997. The flank wear presents the highest interest because it appears on any type of cutting edge and represents the criterion used in determining the tool's life.

As presented in Figure 2, according to ISO 3685, the worn part of the cutting edge is divided into three main areas:
- area C – the corner wear;
- area B – the flank wear;
- area N – the notch wear.

The cutting tool life is determined by the two main wear parameters measured in B area:
- VBMAX – the maximum wear;
- VBB – the average wear.

The source [2] recommends the next values VBB = 0.3 mm and VBMAX = 0.6 mm.

When the maximum wear does not exceed 30% of the average wear it is included in the average wear. When cutting certain materials, it may or may not appear, together with the flank wear, the crater wear on the rake surface. In Figure 3 is presented the crater wear, according to ISO 3695/1993, where:
- KT – crater depth;
- KM – distance between the cutting edge and the deepest crater point;
- KB – distance between the cutting edge and the back crater contour;
- KF – width of the land between the crater and the cutting edge;
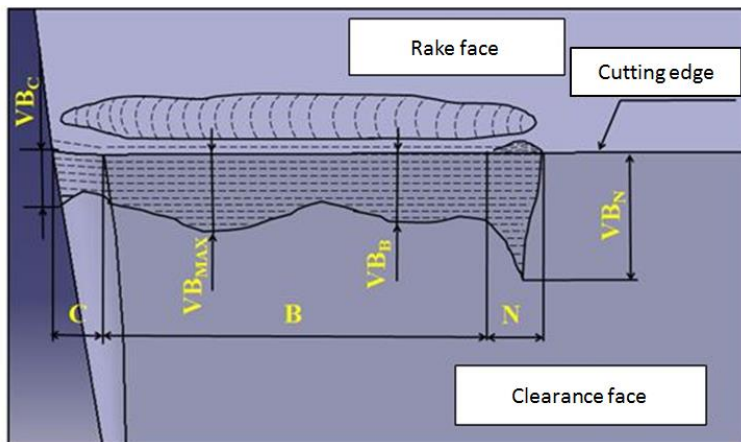- KE – radial displacement of the tool corner.

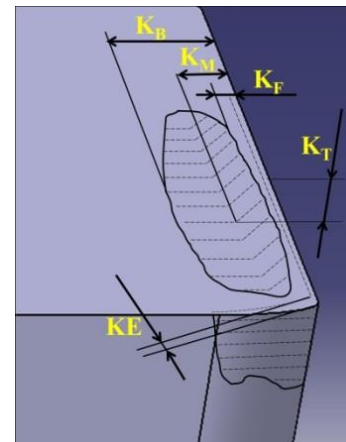Fig. 2. Flank wear characteristics, according to ISO 3685/1993

Fig. 3. Crater wear characteristics, according to ISO 3685/1993

The main causes of wear appearance, according to [1, 2, 3, 4] are:
- abrasive wear;
- adhesive wear;
- diffusion wear;
- oxidation wear (chemical wear);
- wear due to electrical current at cutting;
- fatigue wear (thermal stresses and / or pulsating stresses - determines the chipping of the cutting edge).

Details of the causes are also shown in the bibliographic sources mentioned above.

The ones mentioned above highlight the importance of measuring the average wear on the clearance face of the cutting tool.

2. Experimental Determination of the Wear Measurement Increment on the Clearance Face

In order to determine the optimum incremental step of measuring the wear on the clearance face of the cutting tool for the calculation of the average wear, a batch of six inserts of metallic carbide type SPMR150612-P30 was chosen, and the 1C45 steel was turned. The used tool holder determinate the next geometry: $\alpha = 5^0$; $\gamma = 6^0$; $\chi = 45^0$. No cutting fluid was used and it was cut to a wear on the clearance face of $0.6 \div 0.7$ mm.

The used cutting parameters for turning is shown in Table 1.

Table 1. Cutting parameters used for turning

Cutting parameters - no cutting fluids -	Carbide insert 1	Carbide insert 2	Carbide insert 3	Carbide insert 4	Carbide insert 5	Carbide insert 6
Cutting speed [m/min]	106.03	106.03	106.03	106.03	106.03	106.03
Cutting feed [mm/rot]	0.208	0.208	0.208	0.208	0.208	0.208
Cutting depth [mm]	2.5	2.5	4	2.5	2	2.5

The shape of the wear of six edges from six cutting plates, as well as a first measurement of them to stop the cutting process at a wear on the clearance face of $0.6 \div 0.7$ mm, in order to choose the representative wear for detailed measurements, was done with using the Mitutoyo microscope shown in Figure 4, with an accuracy of 1μm. The six shapes of wear are presented in Figures 5 ... 10.
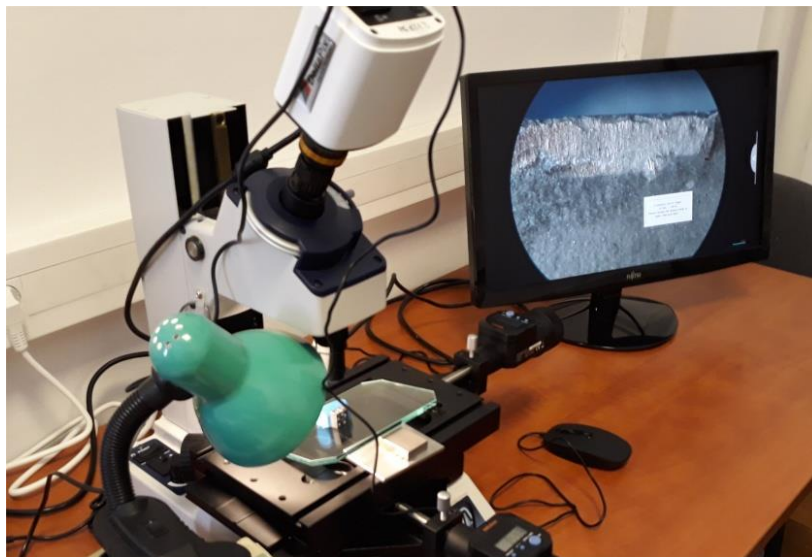

Fig. 4. Microscope for measuring the cutting tool wear

From the figures presented, it can be seen that the wear of the inserts 3, 4, 5 and 6 is uniform and the inserts 1 and 2 have non-uniform wear but the maximum wear is up to 30% higher than the average wear, which means that it can be assimilated into the average wear. To continue the measurements, the wear of the insert 1 was chosen because it has the highest degree of non-uniformity and at the same time it is noted the chipping of the cutting edge. In Figure 4 it can be observed the wear on the clearance face of cutting insert 1, which is presented also in Figure 5, more detailed. The measurements done with the increment of 0.025 mm, 0.05 mm, 0.075 mm, 0.1 mm, 0.125 mm, 0.15 mm, 0.175 mm, 0.2 mm, 0.25 mm, 0.3 mm, 0.4 mm and 0.5 mm, for insert 1, are centralized in Table 2.

Data from Table 2 are graphically represented in Figure 11.

It is noted that the measurements made with a increment of 0.1 mm best approximate the measurements made with a increment of 0.025 mm. In this way, instead of 109 measurements, only 28 measurements can be made and the percentage at the average value is 99.44% from the average value of the measurements made with the increment of 0.025 mm, which is acceptable.
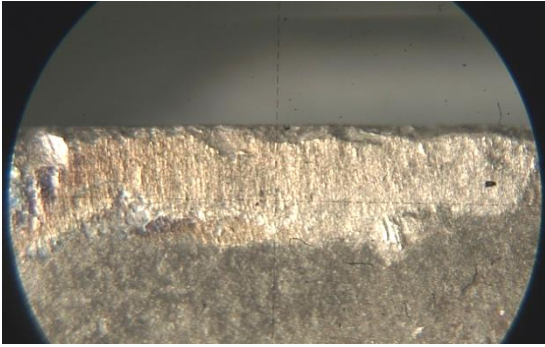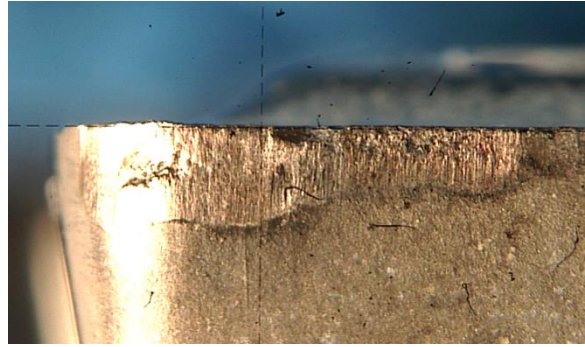
Fig. 5. Wear of insert 1

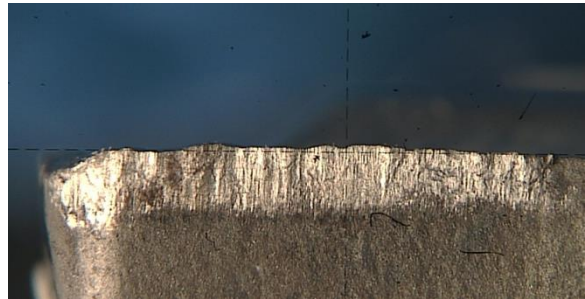Fig. 6. Wear of insert 2

Fig. 7. Wear of insert 3

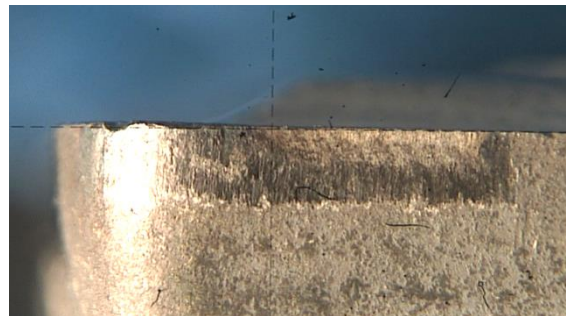Fig. 8. Wear of insert 4

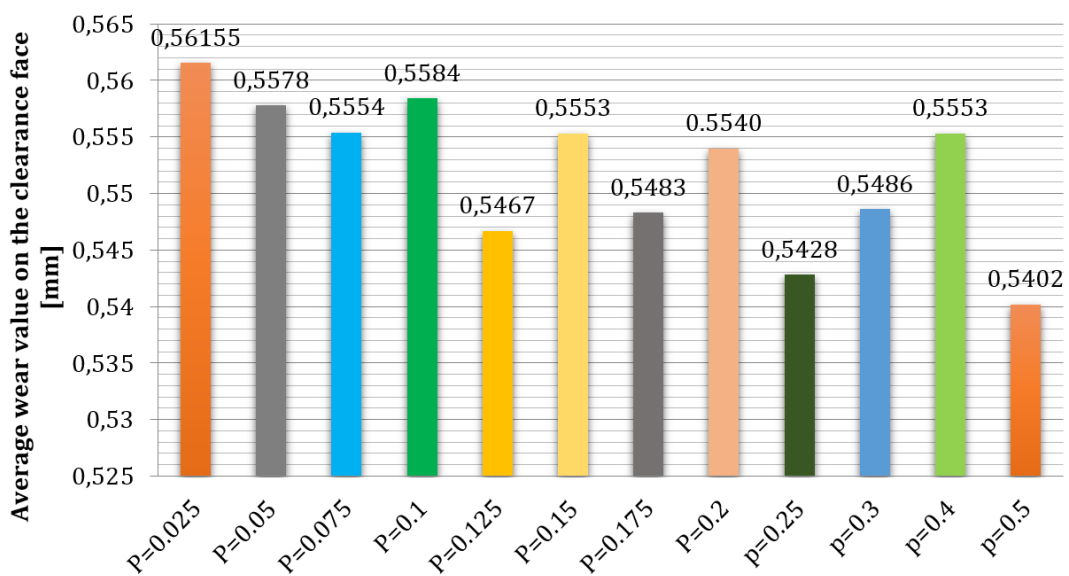Fig. 9. Wear of insert 5

Fig. 10. Wear of insert 6

Fig. 11. The graphical representation of the wear average values on the clearance face depending on the increment

Table 2. Measured wear values for cutting insert 1

No.	Increment step [mm]	Wear values [mm]	Average wear "VB_B" [mm]	Percentage of average wear to p = 0.025 mm [%]
1	0.025	0.372, 0.378, 0.434, 0.432, 0.450, 0.431, 0.441, 0.446, 0.459, 0.447, 0.462, 0.468, 0.472, 0.459, 0.464, 0.456, 0.458, 0.459, 0.480, 0.486, 0.483, 0.516, 0.535, 0.553, 0.559, 0.587, 0.615, 0.638, 0.652, 0.676, 0.684, 0.692, 0.686, 0.642, 0.631, 0.585, 0.595, 0.615, 0.610, 0.595, 0.596, 0.577, 0.591, 0.598, 0.608, 0.606, 0.613, 0.618, 0.624, 0.594, 0.582, 0.594, 0.599, 0.579, 0.584, 0.582, 0.598, 0.579, 0.591, 0.603, 0.604, 0.587, 0.591, 0.614, 0.619, 0.594, 0.590, 0.592, 0.593, 0.560, 0.533, 0.561, 0.563, 0.562, 0.566, 0.565, 0.570, 0.572, 0.567, 0.540, 0.543, 0.519, 0.504, 0.460, 0.458, 0.441, 0.436, 0.433, 0.451, 0.463, 0.469, 0.497, 0.499, 0.523, 0.551, 0.569, 0.585, 0.611, 0.621, 0.639, 0.643, 0.662, 0.658, 0.650, 0.643, 0.640, 0.639, 0.652, 0.654	0.56155	100
2	0.05	0.372, 0.434, 0.450, 0.441, 0.459, 0.462, 0.472, 0.464, 0.458, 0.480, 0.483, 0.535, 0.559, 0.615, 0.652, 0.684, 0.686, 0.631, 0.595, 0.610, 0.596, 0.591, 0.608, 0.613, 0.624, 0.582, 0.599, 0.584, 0.598, 0.591, 0.604, 0.591, 0.619, 0.590, 0.593, 0.533, 0.563, 0.566, 0.570, 0.567, 0.543, 0.504, 0.458, 0.436, 0.451, 0.469, 0.499, 0.551, 0.585, 0.621, 0.643, 0.639, 0.654	0.5578	99.33
3	0.075	0.372, 0.432, 0.441, 0.447, 0.472, 0.456, 0.480, 0.516, 0.559, 0.638, 0.684, 0.642, 0.595, 0.595, 0.591, 0.606, 0.624, 0.594, 0.584, 0.579, 0.604, 0.614, 0.590, 0.560, 0.563, 0.565, 0.567, 0.519, 0.458, 0.433, 0.469, 0.523, 0.585, 0.639, 0.658, 0.640, 0.654	0.5554	98.90
4	0.1	0.372, 0.450, 0.459, 0.472, 0.458, 0.483, 0.559, 0.652, 0.686, 0.595, 0.596, 0.608, 0.624, 0.599, 0.598, 0.604, 0.619, 0.593, 0.563, 0.570, 0.543, 0.458, 0.451, 0.499, 0.585, 0.643, 0.643, 0.654	0.5584	99.44
5	0.125	0.372, 0.431, 0.462, 0.456, 0.483, 0.587, 0.684, 0.585, 0.596, 0.606, 0.582, 0.585, 0.604, 0.594, 0.533, 0.565, 0.543, 0.441, 0.469, 0.569, 0.643, 0.640	0.5467	97.36
6	0.15	0.372, 0.441, 0.472, 0.480, 0.559, 0.684, 0.595, 0.591, 0.624, 0.584, 0.604, 0.590, 0.563, 0.567, 0.458, 0.469, 0.585, 0.658, 0.654	0.5553	98.89
7	0.175	0.372, 0.466, 0.464, 0.516, 0.652, 0.585, 0.591, 0.594, 0.598, 0.614, 0.533, 0.572, 0.458, 0.497, 0.621, 0.640	0.5483	97.64
8	0.2	0.372, 0.459, 0.458, 0.559, 0.686, 0.596, 0.624, 0.598, 0.619, 0.563, 0.543, 0.451, 0.585, 0.643	0.5540	98.66
9	0.25	0.372, 0.462, 0.483, 0.684, 0.596, 0.582, 0.604, 0.533, 0.543, 0.469, 0.643	0.5428	96.66

10	0.3	0.372, 0.472, 0.559, 0.595, 0.624, 0.604, 0.563, 0.458, 0.585, 0.654	0.5486	97.69
11	0.4	0.372, 0.458, 0.686, 0.624, 0.619, 0.543, 0.585	0.5553	98.89
12	0.5	0.372, 0.483, 0.596, 0.604, 0.543, 0.643	0.5402	96.20

3. Conclusions

Due to the measurements and experimental tries, the next conclusions can be drawn:
- the average wear together with the maximum wear on the clearance face of the cutting tool represents the main element for appreciation of the tools life and its most accurate measurement is a necessity;
- when turning 1C45 steel with six SPMR150612-P30 metal carbide cutting inserts, in four of them the wear on the clearance face was uniform and in two it was non-uniform but the maximum wear was higher up to 30% which allowed its inclusion in medium wear;
- the measurement of the wear with the increments in the range 0.025 ÷ 0.5 mm and the graphical representation of the values led to the conclusion that the measurements made with a increment of 0.1 mm give an error of only 0.56% compared to the measurements made with the increment of 0.025 mm, which is acceptable because the number of experiments is reduced by 74%;
- finally it is proposed that always, for the research of wear, its measurement should be made with a increment of 0.1 mm.

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