Tracking of the development wear of cutting tools with different geometry during parting-off

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Abstract. The article deals with the tracking of the wear development of cutting tools made from sintered carbide during parting-off of steel C45 (ČSN 12 050.1). For experiment were selected inserts from two producers of cutting tools with different geometry. The parting-off was realized in the workpiece axis and the whole experiment was divided into two parts, parting-off to zero and parting-off to pre-drilled hole into material. The experiment was evaluated on the principle direct microscopic method and was observed the wear on the flank of cutting tool VBB. Tests were realized in cooperation with Pramet Tools Šumperk, Czech Republic.

1 Introduction

Parting-off is one of the special turning methods, where is required special cutting tools. The aim of every process of machining is to achieve the best results in terms of the quality of surface and the durability of the cutting tools. During parting-off is payed attention especially to toughness and strength of tool and formation and leaving of chip. Parting-off of bigger diameter of workpieces or production of deeper grooves can cause very strong vibrations, which influence surface and lifetime of cutting tool. This is associated with chip formation, when unsuitable formation the chip winds up on cutting tool and damages it. During parting off is very important to become conscious of the cutting tool moves from maximal diameter to its axis, where the cutting speed is zero and after separation of the component, a small pin was created (figure 1). [1, 2]

Grooving or parting-off cutting tools are designed in different shapes and geometry with respect to build up edge, which is typical mechanism of wear for these methods. Creation of build up edge is confirmed for machining of softer materials, like as steel C45. The build up edge causes pulling up of the parts of cutting tool. The wear on the flank and creation of the groove on the rake are caused by high cutting speed. For parting-off is important to set up suitable entry conditions (e.g. width of cutting tool, clamping, type of inserts or cooling), which ensures durability and quality of surface. [2, 3]

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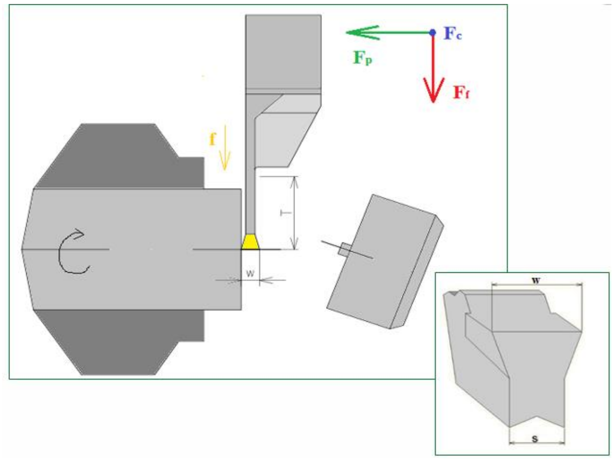


Fig. 1. Parting-off [2].

2 Design of experiment

Experimental part was focused on the tracking of behaviour wear of cutting tool with different geometry during parting-off of material C45 (ČSN 12 050.1) about diameter 80 mm. The inserts were made from sintered carbide, width w = 3 mm, from producer Pramet Tools and Iscar (table 1). The insert marked G362-AA-U02-P14 is designed with bevel and is suitable for production grooves with mechanical stress and parting-off during high cutting speeds, where is not the creation of build up edge. Tested ISCAR inserts are designed with bevel and without it and with different geometry. For all type of inserts were tested two samples due to statistical evaluation. All cutting tools were clamped into blade (ISO X). The clamping was ensured by cutting force into self-locking bed. During parting – off was used cooling for smoother machining.

Table 1. Tested inserts [4].

Producer	Insert	Geometry	Grade	Substrate	Coating	Sample	Figure
Pramet	LCMR 031602	CM	T8330	087	P523	A1, A2	
	G362-AA-U02-P14	P14	T8330	087	P523	B1, B2/ E1, E2	development
ISCAR	DGN 3102J	J	IC808	-	-	C1, C2	
	DGN 3102C	C	IC808	-	-	D1, D2 / F1, F2	

Due to previous tests, when there was not significant wear for cutting tools above or below workpiece axis, cutting edge was set up into the workpiece axis. The experiment was divided into two parts – parting-off to zero diameter of workpiece and for parting-off with pre-drilled hole.

2.1 Parting-off to zero (ø 80 mm – 0 mm)

For the economic point of view, for the both cases were designed procedure of parting-off for one cycle (figure 2a parting-off to zero and figure 2b parting-off with pre-drilled hole). In table 2 there are cutting conditions. Feed rate and width of cutting tool was constant. Due to designed cycle of parting-off was wear measured in interval t_{As} = 2,5 min

Table 2. Cutting conditions.

Cutting conditions – parting-off to zero			
Ø 80 – Ø 25 mm		**Ø 25 – Ø 0 mm**	
v_c [m · min^{-1}] (const.)	180	n [min^{-1}] (const.)	2 300
f [mm]	0,14	f [mm]	0,14
w [mm]	3	w [mm]	3

2.2 Parting-off with pre-drilled hole

To exclude the impact of the build up edge testing was with modified semi-finished product. In axis of workpiece was pre-drilled hole of diameter 20 mm, so that cutting speed was constant. Due to save material and time consuming, the tests were tested with using cutting tools marked G362-AA-U02 a DGN 3102 C. Process diagram is shown in figure 2b. The cutting conditions were set up the same like as previous case, when cutting speed was 180 m · min^{-1}, feed rate 0,14 mm and width of cutting tools 3 mm. The wear was measured in interval t_{As} = 3,5 min after twenty grooves.

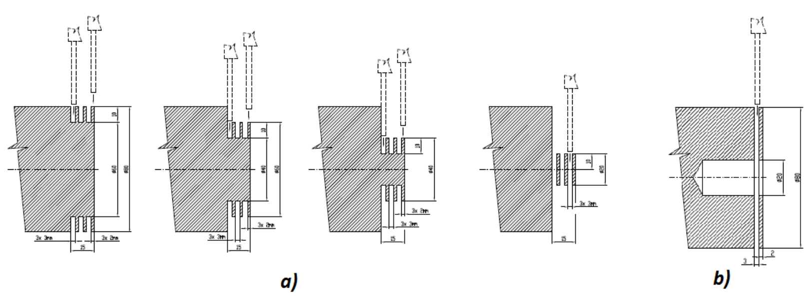
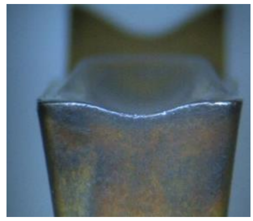
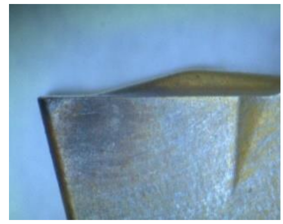
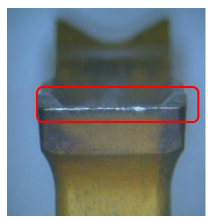
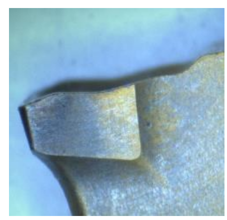
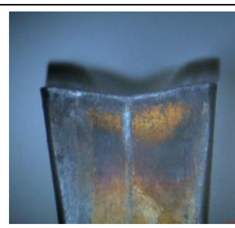
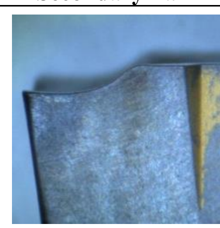
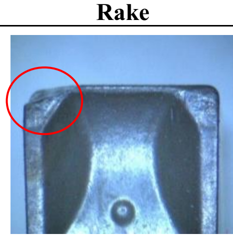
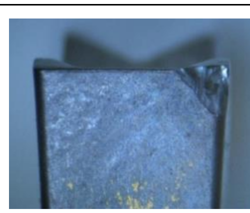
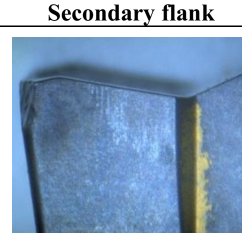


Fig. 2. a) Diagram of parting-off to zero **b)** Diagram of parting-off with pre-drilled hole.

3 Results and Evaluation

For evaluation of wear was used direct microscopic method. The wear size was determined by direct measuring of linear dimensions in different time intervals for parting-off to zero and pre-drilled hole. All measuring were realized by same ways. Critical value for flank wear was determined VBcrit = 0,2 mm. When the critical wear or interval of machining t_{As} = 30 min were reached, the tests were stopped and ended. In table 3, there are shown results for individual testing cutting tools. There is always shown the wear in final phase of parting-off to zero.

Table 3. Parting-off to zero.

PRAMET			
LCMR 031602 – geometry CM			
Sample A1	**Rake**	**Flank**	**Secondary flank**
t_{AS}=12,5 min **VB_B=0,088 mm**			
The samples A1 and A2 were poorly formed the chips. Visible wear of insert has emerged after 10 min in the cut. It was breaking off of cutting edge and damage of secondary flank. Sample A2 was damaged due to the created build up edge on the cutting edge and the test was stopped.			
G362-AA-U02 – geometry P14			
Sample B1	**Rake**	**Flank**	**Secondary flank**
t_{AS}=5,1 min **VB_B=0,076 mm**			
ISCAR			
DGN 3102J – geometry J			
Sample C1	**Rake**	**Flank**	**Secondary flank**
t_{AS}=12,5 min **VB_B=12,5 mm**			
Competitive inserts formed chip very good and the whole process was quiet. There was abrasion wear and a plastic deformation at 9 minutes in cut. The test could continue with this insert. Due to time difficulty the test was stopped.			
DGN 3102C – geometry C			
Sample D1	**Rake**	**Flank**	**Secondary flank**
t_{AS}=7,5 min **VB_B=0,054 mm**			
Again, the chip formed very good with using competitive inserts. It was same cutting tool, but with different geometry. The test was for the both samples (C1, C2) prematurely stopped, because after 7 minutes the tip was damaged.			

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Sample B1 poorly formed the chip and it was winded up to tool (figure 3). Test was prematurely stopped, because on the insert was mechanical damage after six minutes in cut. Development of wear for sample B2 was similar to previous inserts. There were cutting edge break off and test was prematurely stopped.

Fig. 3. Forming of the chip – sample B.

Figure 4 is shown graphical development of wear during parting-off to zero.

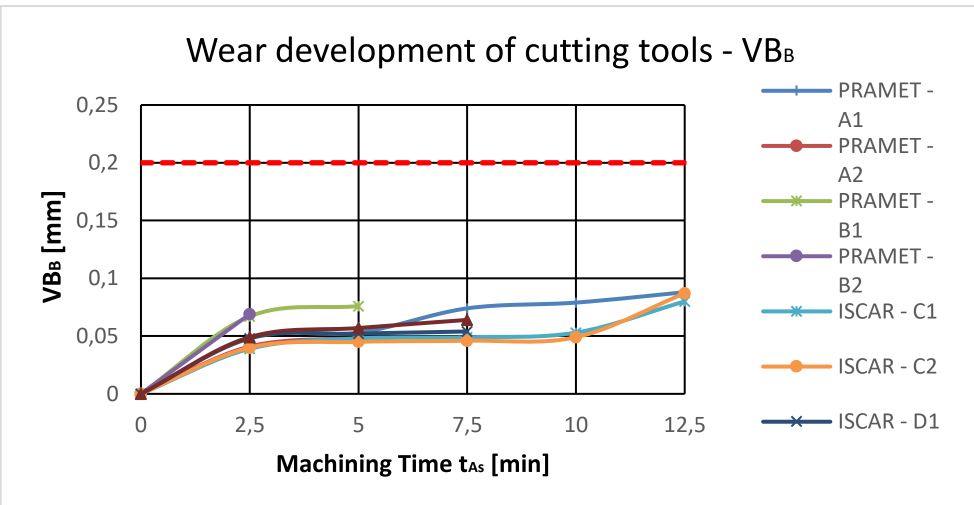


Fig. 4. Development of wear during parting-off to zero.

In table 4, there are results for testing cutting tools during parting-off to pre-drilled hole. Due to time difficulty were chosen two samples for testing (Pramet G362-AA-U02, Iscar DGN 3102C).

Table 4. Parting-off to pre-drilled hole.

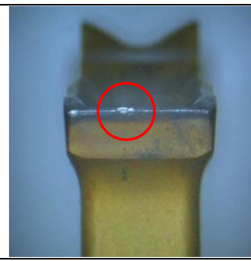
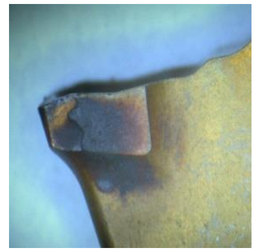
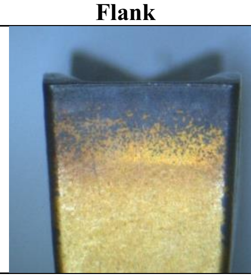
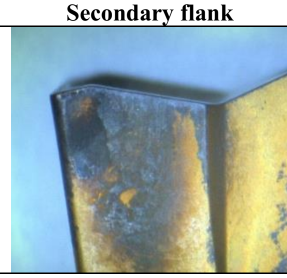
PRAMET TOOLS			
G362-AA-U02 – geometry P14			
Sample E1	**Rake**	**Flank**	**Secondary flank**
t_{AS}=31,5 min **VB_B=0,069 mm**			
In the case of a modified workpiece, the chip was wrong formed, wind up to cutting tool, created tangled mass of machined material. Better chip forming was measured when cutting tool was deeper into workpiece.The test was stopped after half hour of machining, when was recorded small break off.			
ISCAR			
DGN 3102C – geometry C			
Sample F1	**Rake**	**Flank**	**Secondary flank**
t_{AS}=31,5 min **VB_B=0,093 mm**			
In the first third of the diameter, there was wrong chip forming, parting-off process was attended by excessive noise. Still, the process could continue, cutting edge was not damaged, but due to time difficulty the test was stopped.			

Figure 5 is shown graphical development of wear during parting-off to pre-drilled hole.

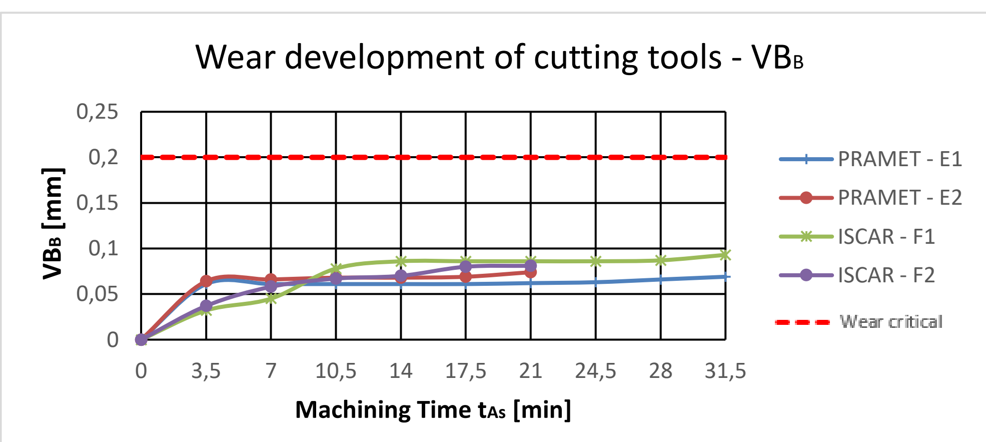


Fig. 5. Development of wear during parting-off to pre-drilled hole.

4 Conclusion

The aim of experiment was found out behaviour of removable cutting inserts made from sintered carbide during parting-off into axis workpiece. The experiment was divided into two parts, first was the evaluation the wear during parting-off to zero and parting-off to pre-drilled hole of diameter 20 mm. With decreasing diameter, decrease cutting speed and at this moment is danger of build up edge. The cutting tools were selected from offer firm Pramet Tools and Iscar.

The Pramet cutting tools with geometry CM stayed in the cut approximately 13 minutes. After ending test was measured visible break off of cutting edge, which was caused by build up edge. It is typical mechanism for parting-off during small cutting speed. The insert with geometry P14 formed long chip, which winded up to cutting tool and holder and caused damage cutting edge and the tests were stopped. Competitive inserts made by ISCAR with geometry J formed chip very good and had quiet process. The both samples (C1, C2) stayed in the cut 13 minutes and wear was determined like as abrasive on the flank. Due to time difficulty teste were stopped, but these inserts could continue in parting-off. The inserts wit geometry C had wrong wear development. On the first sample D1 with this geometry had break off on the cutting edge due to build up edge. The test with sample D2 was prematurely stopped, the insert ceased form. The samples G362-AA-U02-P14 (PRAMET) a DGN 3102-C (ISCAR) has bevel, which has a role to improve of inserts properties. In conditions of parting-off to zero (low cutting speed) vigorously decrease their durability. Machined material sticks on the insert and is created build up edge, which caused damage of cutting edge and prematurely stopped tests. Due to this reason these inserts were chosen for parting-off to pre-drilled hole, where cutting speed is still constant. The both cutting tools had very similar wear development. From the start of parting-off the chip wrong formed, this problem was removed after cut into workpiece and the whole process was quiet. The both type of inserts stayed in cut over the 30 minutes, then tests were stopped due to time and economic difficulty. The Pramet insert had visible break off of cutting edge, but it didn't influence its functionality. Competitive insert had very quiet process and better chip forming. The wear was only in abrasive form on the flank of cutting tool.

The experiment follows the recommendations, the grooves, where are shocks, dynamic stress and for parting-off outside the build up edge area (high cutting speed) is suitable used inserts with bevel.

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