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TOOL LIFE TESTS OF CERAMIC CUTTING TOOLS AT SLIDE TURNING

ZKOUŠKY TRVANLIVOSTI NÁSTROJŮ Z ŘEZNÉ KERAMIKY PŘI PODÉLNÉM SOUSTRUŽENÍ

Abstract

This article is focused on tool life tests of indexable ceramic cutting inserts at slide turning - cast iron 25P. Five types of cutting materials were tested in total (571, D210, D230, D420, D460) and their tool life was monitored at constant cutting parameters – at slide turning on a turning lathe CMM SLIVEN. Criterion of tool wear was set at VBBmax = 0,6 mm and after every 5th machined workpiece was recorded the conditions of cutting edge. The cast iron 25P was machined material, used for car engines. This work was created in order to meet demand the Saint Gobain Advanced Ceramics Ltd company, Turnov which is producer of these supplied ceramic tools.

Abstrakt

Článek je zaměřen na zkoušky trvanlivosti břitových destiček z řezné keramiky při podélném soustružení litiny 25P. Bylo testováno celkem 5 druhů řezných materiálů (571, D210, D230, D420, D460) a sledována jejich trvanlivost při konstantních řezných parametrech při podélném soustružení na soustruhu CMM SLIVEN. Kriterium opotřebení bylo stanoveno na VBBmax = 0,6 mm a po každé 5. obrobeném obrobku byl zaznamenán stav ostří nástroje. Obráběným materiálem byla litina 25P, používaná pro válce motorů osobních automobilů. Tato práce vznikla za účelem vyhovět poptávce firmy Saint Gobain Advanced Ceramics, s. r. o. Turnov, který je výrobcem dodaných keramických nástrojů.

1 INTRODUCTION

The contracting authority supplied semi-product of machined materials and five kinds of ceramic cutting inserts. If it has not been achieved criterion of tool wear after machining 30 pieces of inserts (see below), the tests were suspended and the number of pieces to criterion of tool wear was approximated. The tool life was determined as follows [3, 4]:

$$T = t \cdot p \ \text{[min]} \quad (1)$$

$$t = \frac{l_1 + l_2}{n \cdot f} \quad (2)$$

where:

t – machining time [min],
p – number of machined pieces [-],
l_1 – machining length of the first chip [mm],

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l_2 – machining length of the second chip [mm],
n – spindle speed [min^{-1}],
f – feed [mm].

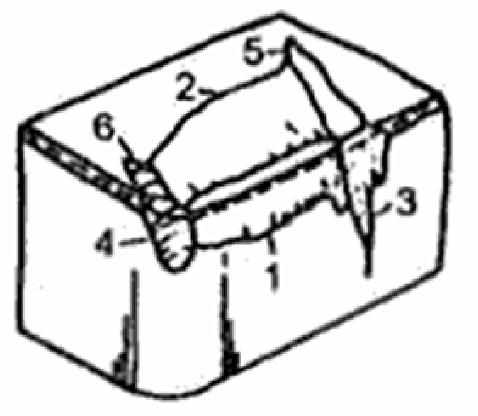
Tool life (cutting edge) is the period during the tool is working from clamping to edge tool wear and it is calculated in minutes. The cutting edge tool life is influenced by variety of loads which tend to change the geometry of the edge.

The tool wear tests belong to one of the basic parameters of machining technology. The results of successful application, which were obtained in practise, mark ably increase the quality of production and also indirectly affect the position of the enterprise in the sharp competition. That experimental determination of life can provide add information about cutting process in next tests.

2 METHODOLOGY DESIGN – TESTING TOOLS

Tests were conducted for indexable cutting inserts which were supplied by contracting authority. The criterion of tool wear, in accordance with ISO 3685 standard, was chosen **VB_{Bmax} = 0,6 mm** [1]. If the 30 sleeves were machined and the critical value of tool wear was not reached, the tests were stopped. A picture of a cutting insert was taken on the microscope after each 1^{st}, 5^{th}, 10^{th}, 15^{th}, 20^{th}, 25^{th} and 30^{th} machined sleeve.

Exactly one cutting edge was tested on the indexable cutting inserts at each time and if the tool life sufficed (nearby 30 sleeves) the test was not repeated anymore. If the tool life was low, the test was repeated in order to take any other external influence of the question (rigidity of the system, clamping, inhomogeneity of the machined material, etc.) including the human factor.



Legend:

1 – flank tool wear of cutting tool, 2 – cratered tool wear, 3 – toothing tool wear, 4 – tool wear of point, 5 – external tool wear of the front surface of cutting tools, 6 – internal toothing formed by chip.

Fig. 1 The external signs of tool wear [2]

2.1 Machine Tool

The machine tool CMM SLIVEN (Fig. 2) was used for machining. The machine tool has rigid structure that provides a sufficient clamping. The machine tool reaches a maximum of 2000min^{-1} and the engine power is 6kW.

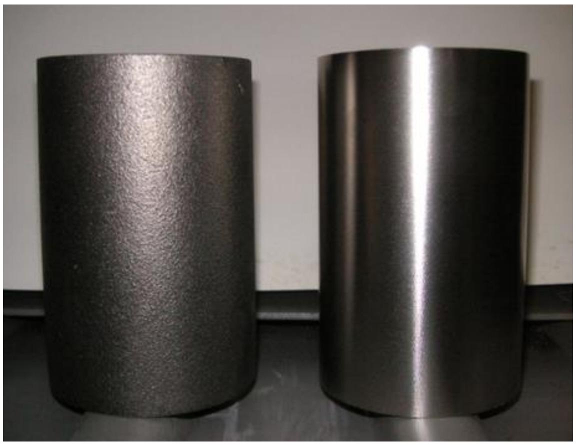
Fig. 2 Machine tool CMM SLIVEN

2.2 Machined Material

As the machining material were used sleeves for car engines (Fig. 3) which were supplied by the contracting authority. It is a 25P class of material. Because sleeves had a conical shape it was necessary to machined cylindrical surface and the same diameter (Fig. 3). If we did not do, a constant depth of cut a_p should not be maintained during tests.

Tab. 1 Chemical Composition of the Material

C [%]	Si [%]	Mn [%]	P [%]	S [%]	Ti [%]	Cu [%]
2,8 ÷ 3,3	1,8 ÷ 2,5	0,6 ÷ 0,8	0,5 ÷ 0,8	< 0,1	0,03 ÷ 0,1	≤ 0,8



The workpiece before machining (left) and after machining (right).

Fig. 3 Machined semi-product (sleeve car engine)

2.3 Cutting Parameters

Cutting parameters were selected on the base of experiences and consultations of the resolver team with a contracting authority. The aim was to get as near as possible to real operation conditions.

- cutting speed v_c = 422 m.min^{-1},
- feed f = 0,4 mm,
- cutting depth a_p = 2 mm.

3 TESTS OF SELECTED INDEXABLE CUTTING INSERTS

After the tests it was carried out an evaluation of individual cutting inserts. The number of machined sleeves that were machined by given material was assessed and the tool life was assessed too for each indexable cutting inserts. If the material did not reach the criterion of the tool wear we made an approximation of the number of machined pieces [5].

The results of measurements are showed in the following table. The number of machined cutting inserts is in the left column and the type of material is in the top row.

Tab. 1 Size of tool wears for each indexable cutting insert

	571	D210_2	D230_1	D420_1	D460_1
0	0	0	0	0	0
1	0,13	0,17	0,14	0,21	0,23
6	0,15	0,2	0,14	0,31	0,32
10	0,25	0,22	0,17	0,37	0,38
15	0,24	0,18		0,44	0,38
20	0,29	0,19		0,53	0,47
25	0,32	0,24		0,59	0,53
30	0,32	0,23		0,62	0,59
[pcs.]	**44**	**39**	**10**	**27**	**31**
[min]	**14,23**	**13,83**	**3,54**	**9,58**	**11,00**

Dependence of tool wear on the number of machined pieces (cutting inserts) is shown in Figure 4. We cut off two layers with 2 mm depth of cut (on the each sleeve). The polynomial approximations third procedures for materials that have not reached the criterion of tool wear are on the following graph (Fig. 5).

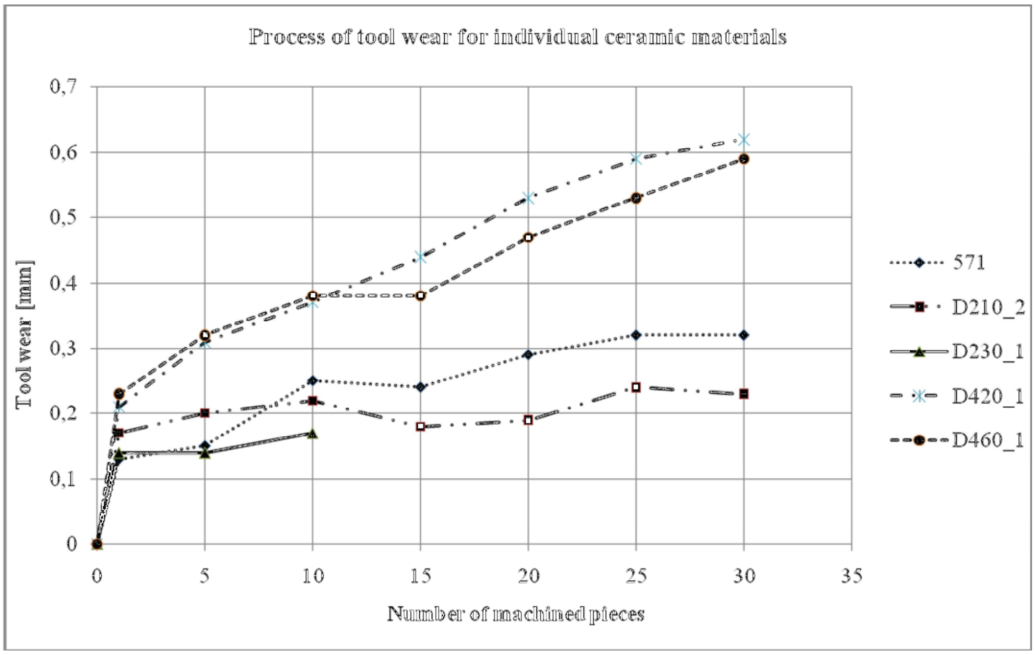


Fig. 4 Dependence of tool wear (growth) on the number of machined pieces

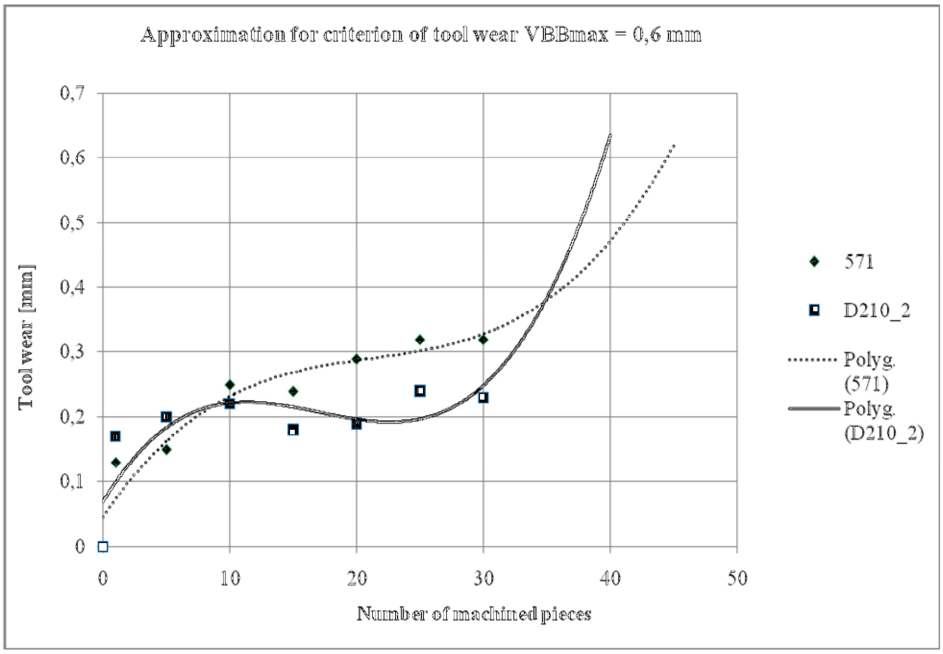


Fig. 5 Dependence of tool wear (growth) on the number of machined pieces - approximation

Tool life of individual indexable cutting inserts (Fig. 6) and the number of machined pieces (Fig. 7) is shown in the following charts.

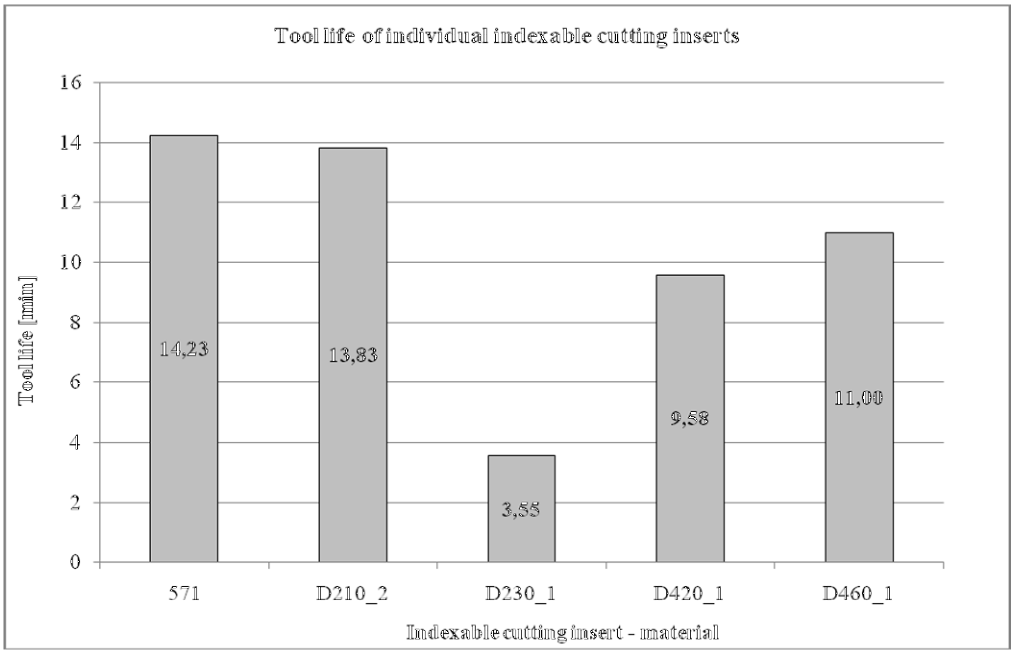
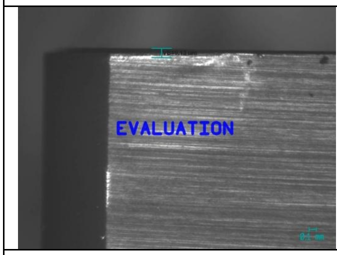
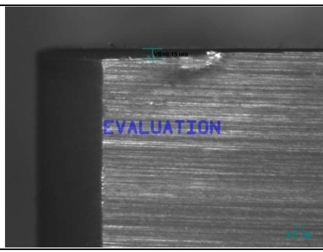
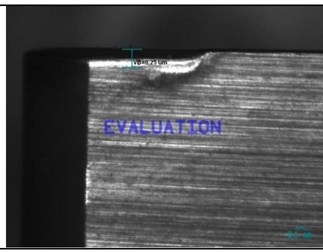
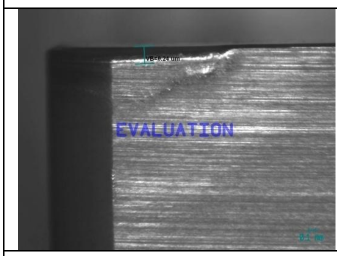
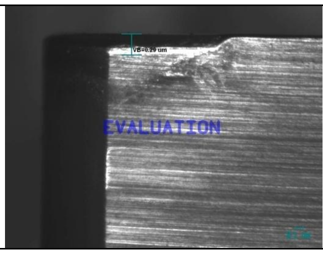
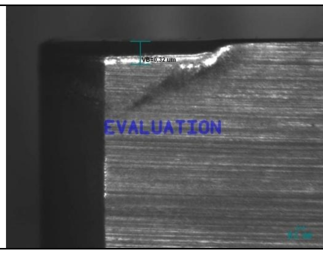
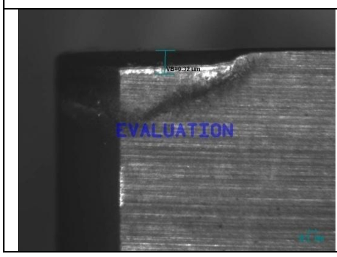


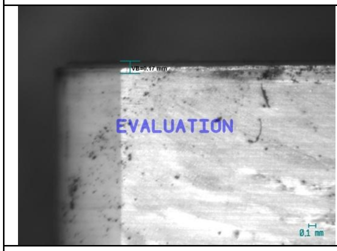
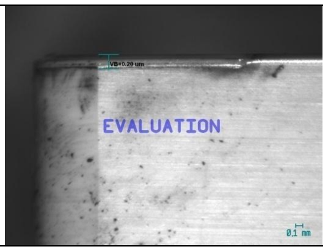
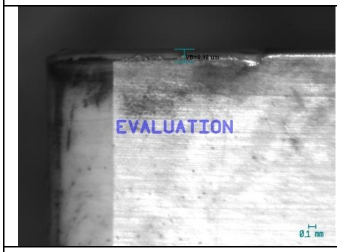
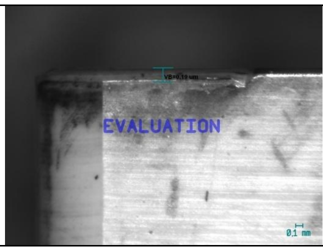
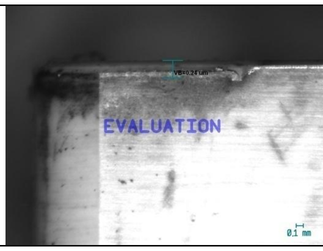
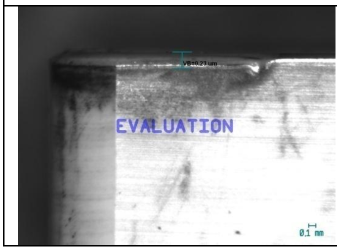
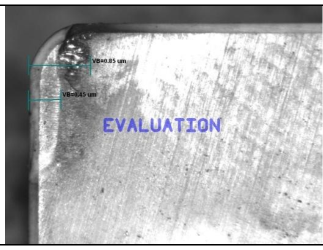
Fig. 6 Tool life of individual indexable cutting inserts

Fig. 7 Number of machined pieces for individual indexable cutting inserts

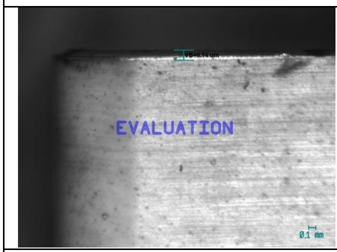
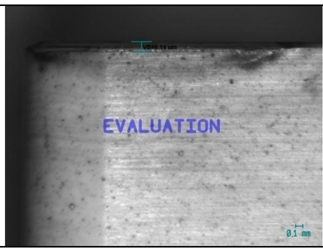
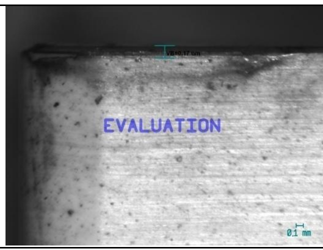
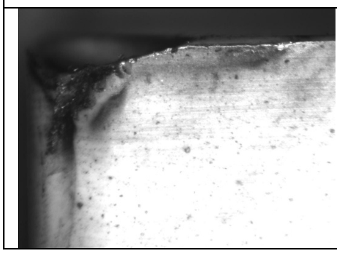
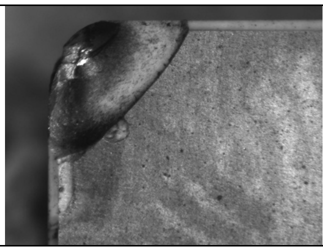
Tab. 2 Picture (tool wear) – 571 material

1st sleeve – after machined	5th sleeve – after machined	10th sleeve – after machined
		
15th sleeve – after machined	20th sleeve – after machined	25th sleeve – after machined
		
30th sleeve – after machined	Face	
		

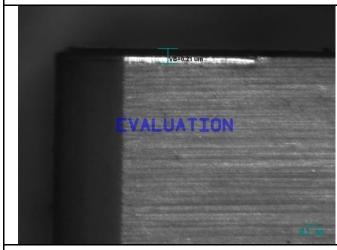
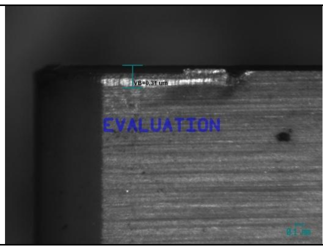
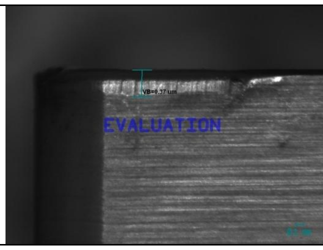
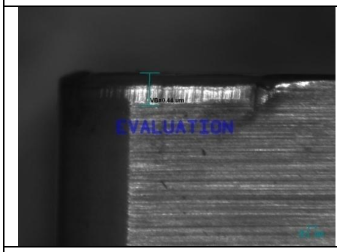
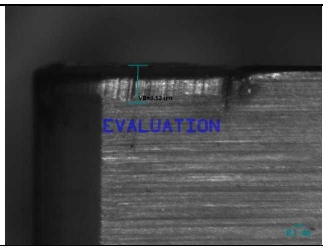
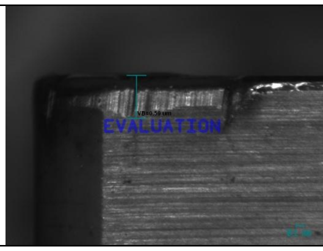
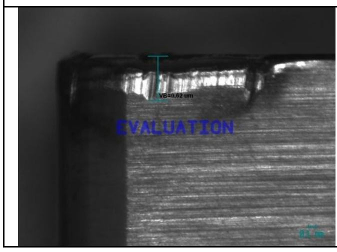
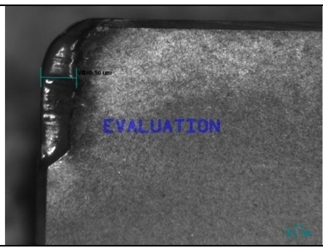
Tab. 3 Picture (tool wear) – D210_2 material

1st sleeve – after machined	5th sleeve – after machined	10th sleeve – after machined
		
15th sleeve – after machined	20th sleeve – after machined	25th sleeve – after machined
		
30th sleeve – after machined	Face	
		

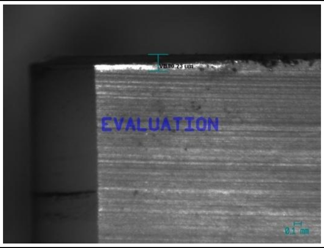
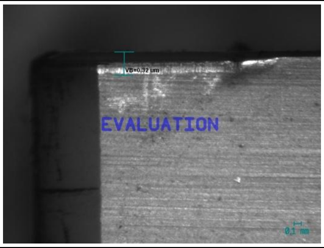
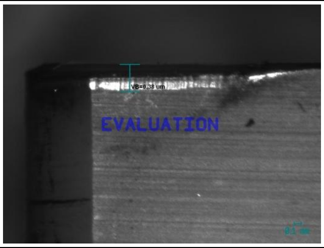
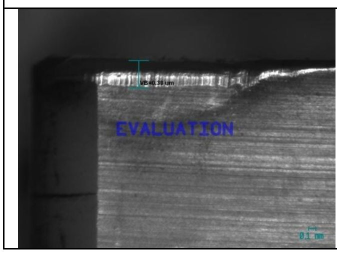
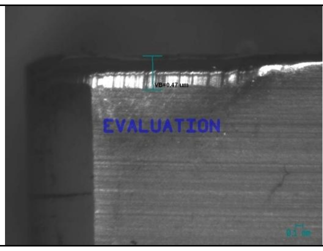
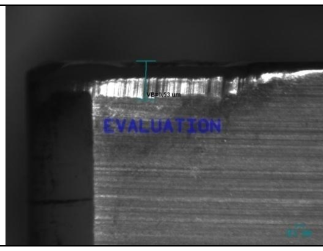
Tab. 4 Picture (tool wear) – D230_1 material

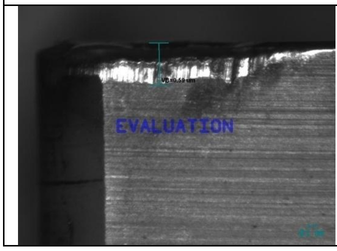
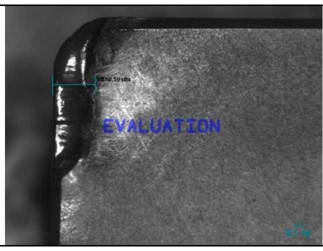
1st sleeve – after machined	5th sleeve – after machined	10th sleeve – after machined
		
15th sleeve – after machined	Face	
		

Tab. 5 Picture (tool wear) – D420_1 material

1st sleeve – after machined	5th sleeve – after machined	10th sleeve – after machined
		
15th sleeve – after machined	20th sleeve – after machined	25th sleeve – after machined
		
30th sleeve – after machined	Face	
		

Tab. 6 Picture (tool wear) – D460_1 material

1st sleeve – after machined	5th sleeve – after machined	10th sleeve – after machined
		
15th sleeve – after machined	20th sleeve – after machined	25th sleeve – after machined
		

30^{th} sleeve – after machined	Face	
		

4 CONCLUSIONS

The tests show that some materials cutting inserts are suitable for machining of cast iron at these parameters. Some of them are appropriate with a limited tool life and anothers are completely inappropriate.

The 571 materials achieved the best results (tool life - 14,23 min and the number of machined pieces – 44 after approximation), D210_2 (tool life – 13,83 min and 39 pcs.). Other materials in the order D460_1 (11 min, 31 pcs.) and D420_1 (9,58 min, 27 pcs.). The D230_1 material is at the end of the order (3,55 min and 10 pcs.).

The **571** material was running smoothly without any significant signs of vibrations. Machined surface was cold after machining. The **D210** material had a different chip flow in all directions, not as others which went away angle-wise 45° from the cutting edge toward the tail-stock. We recommend further testing this type of material because we want to confirm the expected tool life of the edge until criterion of tool wear. The **D420** material and **D460** had a similar process. The number of machined pieces approached limit level of 30 pieces. Both materials reached a criterion of tool wear. The **D230** material seems as inappropriate. The tool face always broke off. We recommend to doing a test these cutting inserts from a different batch.

It would be appropriate to do more tests - for more accurate results (with different cutting parameters). It would be appropriate to do new tests on materials which have been approximated (for the low number of sleeves) and refine the text of materials which cracked.

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