TESTING CERAMICS INSERTS AT IRREGULAR INTERRUPTED CUT ON MATERIAL 14MoV6

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ARTICLE INFO

***Article history*:**
Received: 27.11.2015.
Received in revised form: 09.05.2016.
Accepted: 31.05.2016.

Keywords:
Interrupted cut
Ceramic cutting inserts
Mechanical shocks
Machining

Abstract:

This article deals with the test of removable ceramic cutting inserts during machining with an irregular interrupted cut. Tests were performed on a lathe, with a preparation which simulated an interrupted cut for us. By changing the number of slats mounted in the preparation, it simulated a regular or irregular interrupted cut for us. When it had four slats, it was a regular interrupted cut, whereas the remaining three variants were already irregular cuts. This paper examined whether it would have an irregular interrupted cutting effect on the insert and possibly how it would change the life of the inserts during an irregular interrupted cut (a variable delay between shocks).

1 Introduction

Nowadays there is the continuous development of machined materials. Therefore, it is also necessary to develop and to improve cutting materials too. These should resist high temperatures and forces during machining. Apart from selecting the right material, there is also a need in practice to select the appropriate cutting parameters recommended by the manufacturer for the cutting material. During the development of new cutting materials, these materials also are to be tested. One of the tests may be a measure of resistance to this material at the interrupted cut, especially if it is for new hard but fragile materials, such as ceramics [9, 11].

2 Experimental investigation

2.1 Preparation for the tests

For the tests there was chosen the testing method of longitudinal turning called “cylinder with paddles”. During an interrupted cut, the insert is stressed by mechanical and thermal shock. From a theoretical perspective, thermal shocks should have a little more negative effect on the cutting edge than the mechanical shocks. Tests can prove that by maintaining a constant temperature or preheating, the resistance of the cutting edge to shocks is increased [7, 8].

To examine deeply the influence of mechanical and thermal shock, the testing methodology was modified so as to compare regular interrupted cutting (4 clamped slats) and interrupted irregular cut (3, 2 or 1 clamped slats). This special preparation (see Fig. 1) consists of a cylinder with grooves in which we can clamp slats at a number from 1 - 4 (see Fig. 2) according to which we can provide the effect of the different time delays between shocks. This can also have an impact on the resistance to thermal shocks. The criterion for the termination of the test is destruction of the cutting edge or degradation of surface roughness.

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[6, 10] The simulator is set up from the body of the simulator (1), slat (2), exchangeable washer (3), clamping wedge (4) and safety ring (5).

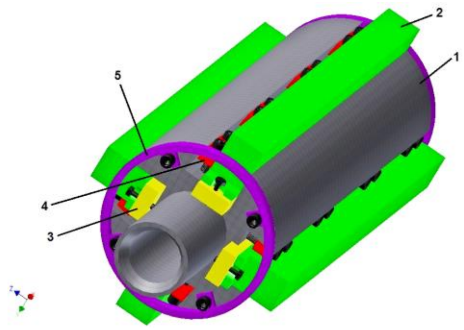


Figure 1. Sketch of simulator [5].

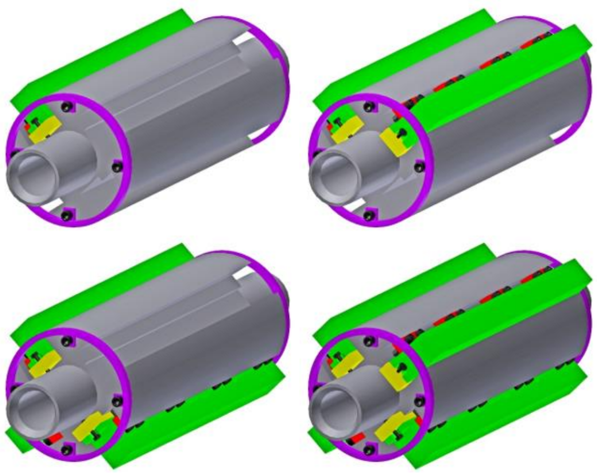


Figure 2. Scheme of preparation with 1 - 4 clamped slats [5].

2.2 Machined material

On the slats, 14MoV6-3 steel was used. It is alloyed Mo-V steel resistant to high temperature and creep, which excels in high toughness resistance at temperature of about 580°C. The microstructure is greatly affected by heat treatment.

Table 1. Mechanical properties of 14MoV6-3 steel [1]

Mechanical properties	Rp 0.2 [MPa]	Rm [MPa]	A5 [%]	Hardness [HB]
14MoV6-3	min. 320	460 ÷ 610	20	197

2.3 Cutting parameters

The ceramic cutting inserts were tested under the following cutting parameters:

- cutting speed v_c = 204 m·min^{-1},
- feed 1 f_1 = 0,20 mm,
- feed 2 f_2 = 0,32 mm,
- cutting depth a_p = 1 mm,
- preparation diameter d = 260 mm.

Due to different numbers of clamped slats for the preparation, a maximal spindle speed of n = 250 min^{-1} was chosen, corresponding to v_c = 204 m·min^{-1}. By exceeding this RPM, very strong vibrations and the shaking of the machine were caused, even though the machine was properly anchored to the ground.

2.4 Cutting tool

The inserts were clamped to the tool holder CSRNR 25x25 M12-K. This is the tool holder for the square ceramic inserts (see Fig. 3).

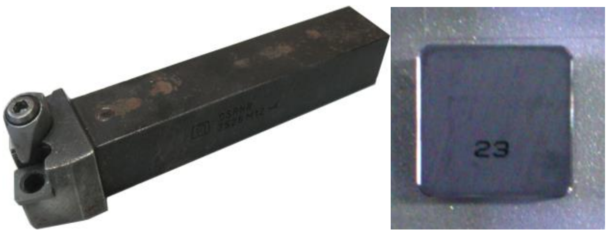


Figure 3. Tool holder CSRNR 25 x 25 and insert ISCAR IN23 [1].

The selected tool holder has the following geometry:

- rake angle γ_0 = -6˚,
- clearance angle α_0 = 6˚,
- cutting edge angle κ_r = 75˚,
- cutting edge inclination λ_s = -6˚,
- included angle ε_r = 90˚ [2].

Two different types of inserts were selected from the production of two worldwide companies. ISCAR IS8 - Nitride silicon ceramics (Si_3N_4) used for medium-duty turning and milling operations. Inserts can be used for an interrupted cut on cast iron and nickel-based alloys and super alloys. Recommended cutting parameters - cutting speed v_c = 400 ÷ 1 200 m·min^{-1}, feed f = 0,1 ÷ 1 mm [3].

ISCAR IN23 - Black oxide ceramics (Al_2O_3-TiC) used for machining of gray and nodular cast iron and hardened steels in medium to finishing cutting conditions. This is a little harder ceramic material [2].
SAINT-GOBAIN D210 - Mixed oxide ceramics (Al_2O_3, ZrO_2, and Co) - apart from hardness and wear resistance at high temperatures, it excels also in a little higher toughness. It is suitable for machining of graphite iron with lamellar graphite, graphite, spherical graphite, cast iron and malleable cast iron, structural, tempered and high speed steels during a light interrupted cut [1].
SAINT-GOBAIN D460 - Nitride ceramics (Si_3N_4 based) - exhibits very high toughness, high hardness and enables conventional machining with an interrupted cut and can be used with a coolant. This kind of ceramics is especially suitable for machining of all kinds of cast iron [1].

2.5 Lathe used

For the testing of ceramic inserts during an interrupted cutting, a TOS SN 55-7 lathe made in Czechoslovakia was used.
The main technical parameters of the machine:

- Maximal RPM n_{max} = 1440 min^{-1},
- Power of main electric motor - 7,5 kW,
- Maximal cutting diameter - 550 mm.

3 Results

During the tests we observed the number of shocks that would last until the insert was broken off or until the surface roughness of the tested slats was worsened. After stopping a running measurement, we measured the cutting length. The results were recorded into the table and the length was calculated on the number of shocks on the inserts using the formula below. In the tables below, the average value of the three measurements is written.

$$R = \frac{x.l}{f},$$

where, R……the number of shocks [-],
x……the number of slats in the preparation [-],
l……the cutting length [mm],
f……the feed [mm].

3.1 ISCAR IS8

Table 2 shows that the insert ISCAR IS8 has the best mechanical shock resistance (Fig. 4 and 5) with the feed f = 0.2 mm and the maximum number clamped. Accordingly, the insert ideally operates during a regular interrupted cut. [4]

Table 2. Values recorded with the IS8 insert [1]

Feed f [mm]	No. of slats [-]	Length l [mm]	Number of shocks R [-]
0.20	4	1 276	25 513
	3	1 315	19 725
	2	1 305	13 053
	1	1 026	5 132
0.32	4	1 045	13 063
	3	1 153	10 806
	2	879	5 496
	1	1 088	3 401

In general, we can say that ISCAR IS8 insert used for the material 14MoV6-3 exhibited very low resistance to mechanical shocks.

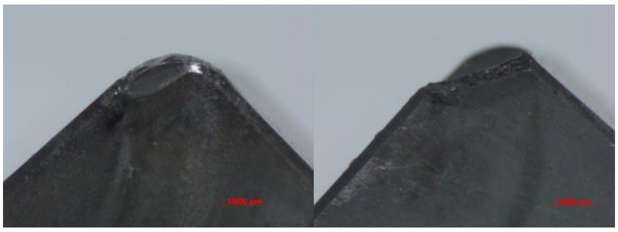


Figure 4. Wear of insert IS8 f = 0.2 mm (left), f = 0.32 mm; 4 slates [1].

Figure 5. Wear of insert IS8 f = 0.2 mm (left), f = 0.32 mm; 1 slats [1].

Fig. 6 shows that by decreasing a measurable time delay between shocks, the resistance of the IS8 insert to the interrupted cut is increased (the best resistance were achieved with the maximum number of clamped slats in the preparation). The insert exhibits better properties with the lower feed. An increase in measured values appears to be very constant.

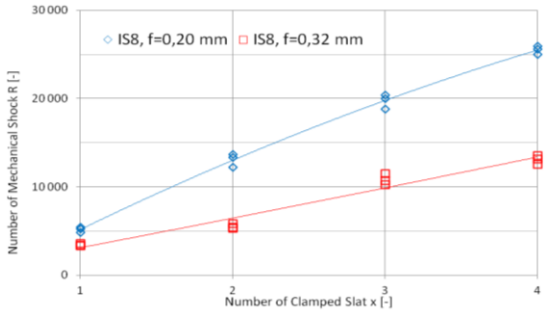


Figure 6. Dependence on number of shocks according to the number of IS8 insert.

3.2 ISCAR IN23

Table 3 shows that the ISCAR IN23 insert has the best mechanical shock resistance with a feed f = 0,2 mm and with four clamped slats (Fig. 7 and 8). Therefore, the insert ideally operates during a regular interrupted cut.

Table 3. Values recorded with the IN23 insert

Feed f [mm]	No. of slats [-]	Length l [mm]	Number of shocks R [-]
0.20	4	4 126	82 520
	3	2 453	36 800
	2	3 200	32 003
	1	4 565	22 827
0.32	4	786	9 821
	3	645	6 050
	2	826	5 165
	1	1 353	4 227

In general, we can say that ISCAR IN23 insert used Ad, and the material 14MoV6-3 exhibited very high resistance to mechanical shocks.

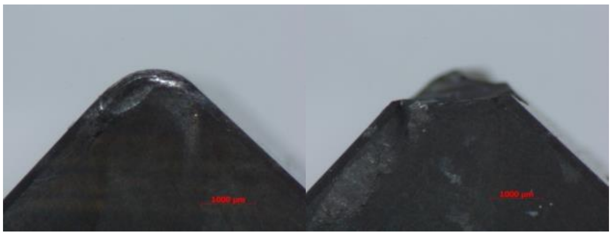


Figure 7. Wear of insert IN23 f = 0.2 mm(left), f = 0.32 mm; 4 slats [1].

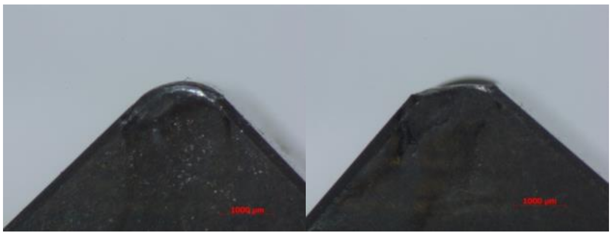


Figure 8. Wear of insert IN23 f = 0.2mm (left), f = 0.32 mm; 1 plate [1].

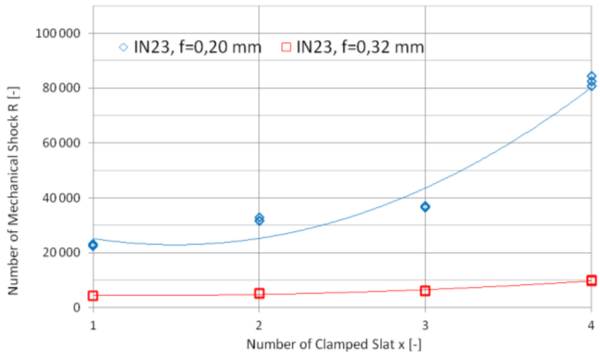


Figure 9. Dependence on number of shocks according to the number of the IN23 insert.

From Fig. 9 it can be seen that with a decrease in delay between shocks, the resistance of the IN23 insert against the interrupted cut is increased (the best resistance values were achieved with a maximum number of clamped slats in the preparation). This increase is very obvious with a lower feed f = 0.2 mm, with a higher feed, this increase is not so (heavily) marked. With a higher feed, the number of slats has not a big impact on resistance. The better properties of the inserts are exhibited with the lower feed. With a higher feed, the resistance of the insert to mechanical shocks is rapidly decreased and we can state that the IN23 plate is not suitable for the machining of the material at a higher feed.

3.3 SAINT-GOBAIN D210

Table 4 shows that the SAINT-GOBAIN D210 insert has the best mechanical shock resistance (Fig. 10 and 11) with a feed f = 0.2 mm and with four clamped slats. Therefore, the insert ideally operates during a regular interrupted cut. With a little higher feed of f = 0.32 mm, the insert has the best resistance to mechanical shocks using four or two slats.

Table 4. Values recorded with insert D210

Feed f [mm]	No. of slats [-]	Length l [mm]	Number of shocks R [-]
0.20	4	1 887	37 733
	3	1 247	18 700
	2	1 423	14 233
	1	700	3 500
0.32	4	763	9 542
	3	290	2 719
	2	820	5 125
	1	533	1 667

In general, we can say that the SAINT-GOBAIN D210 insert used on the material 14MoV6-3 reached an average resistance to mechanical shocks at a lower feed. At a higher feed, the insert exhibited a low resistance to mechanical shocks.

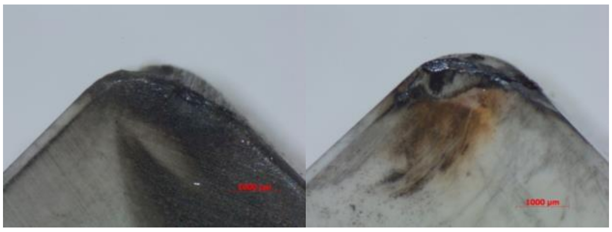


Figure 10. Wear of insert D210 f = 0.2 mm (left), f = 0.32 mm; 4 slats [1].

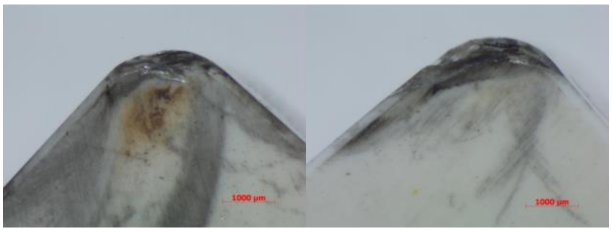


Figure 11. Wear of insert D210 f = 0.2 mm (left), f = 0.32 mm; 1 slat [1].

Fig. 12 shows that with a measurable time decrease in delay between shocks , the resistance of the D210 insert to the interrupted cut is increased (the best resistance values were achieved with a maximum number of clamped slats in the preparation). The better properties of the insert were reached with a lower feed. The increase of resistance to mechanical shocks is more obvious at a lower feed f = 0.20 mm. At a higher feed f = 0.32 mm, the D210 insert negatively reacted to the irregular interrupted cut. It was more than a measurable time delay between the shocks, and the measured results were considerably affected by the character of the cut.

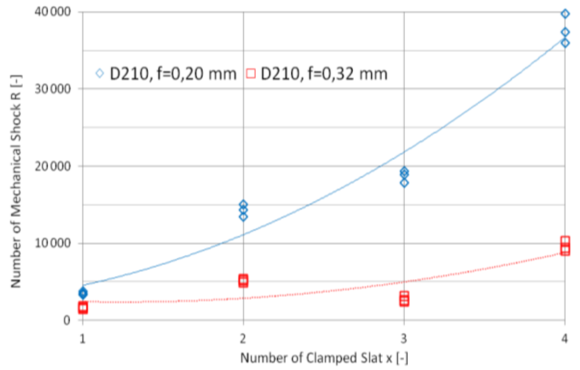


Figure 12. Dependence on number of shocks according to the number of insert D210.

3.4 SAINT-GOBAIN D460

Table 5 shows that the SAINT-GOBAIN D460 insert has the best mechanical shock resistance (Fig. 13 and 14) with a feed f = 0.2 mm and with four clamped slats. The insert, thus, ideally operates during a regular interrupted cut.

Table 5. Values recorded with the D460 insert

Feed f [mm]	No. of slats [-]	Length l [mm]	Number of shocks R [-]
0.20	4	3 177	63 533
	3	3 420	51 300
	2	2 800	28 000
	1	2 977	14 883
0.32	4	3 770	47 125
	3	4 315	40 453
	2	6 252	39 073
	1	9 665	30 203

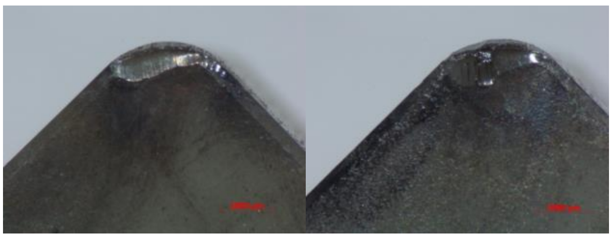


Figure 13. Wear of insert D460 f = 0.2 mm (left), f = 0.32 mm; 4 slates [1].

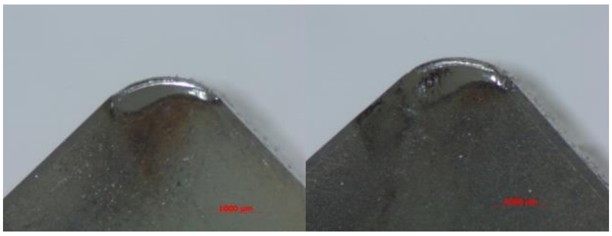


Figure 14. – Wear of insert D460 f = 0.2 mm (left), f = 0.32 mm; 1 slate [1].

In general, we can say that the SAINT-GOBAIN D460 insert used on the material 14MoV6-3 exhibited a very high resistance to mechanical shocks for both feeds.

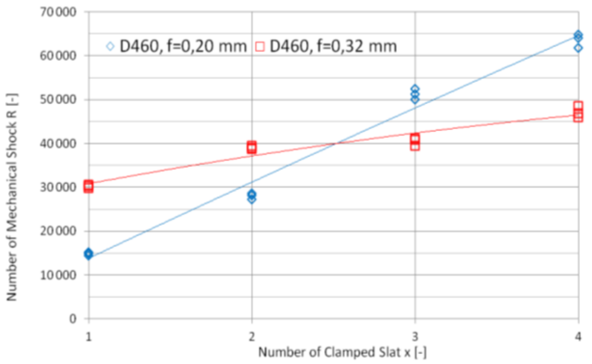
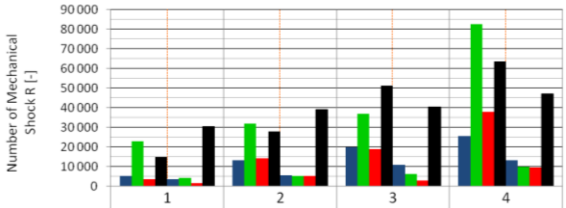


Figure 15. Dependence on number of shocks according to the number of D460 insert.

Fig. 15 shows that by decreasing a measurable time delay between shocks, the resistance of the D460 insert to the interrupted cut is increased (the best resistance values were achieved with a maximum number of clamped slats in the preparation). The insert exhibits better properties with a little lower feed, but only with a higher number of clamped slats in the preparation. With one clamped plate, the insert has better resistivity against mechanical shock with a higher feed f = 0.32 mm and more than f = 0.2 mm. In all other cases this phenomenon did not occur.

4 Conclusions

The best resistivity against mechanical shocks (see Fig. 16) was reached by the ISCAR IN23 insert (not for all types of shocks) and for a higher feed of f = 0.32 mm the SAINT-GOBAIN D460 insert has better properties (for all types of shock). Generally, we can say that the inserts have better resistivity against mechanical shocks with a maximum number of clamped slats.



	1	2	3	4
IS8, f=0,20 mm	5 132	13 053	19 725	25 513
IN23, f=0,20 mm	22 827	32 003	36 800	82 520
D210, f=0,20 mm	3 500	14 233	18 700	37 733
D460, f=0,20 mm	14 883	28 000	51 300	63 533
IS8, f=0,32 mm	3 401	5 496	10 806	13 063
IN23, f=0,32 mm	4 227	5 165	6 050	9 821
D210, f=0,32 mm	1 667	5 125	2 719	9 542
D460, f=0,32 mm	30 203	39 073	40 453	47 125

Figure 16. Number of shocks according to the number of slats.

They better cut with a regular interrupted cut with a minimal time delay between shocks. From all the results the SAINT-GOBAIN D460 insert is best suitable and most universal for all kinds of interrupted cuts for the material 14MoV6-3. The best value achieved have been with the ISCAR IN23 insert using a lower feed of f = 0.2 mm and a regular interrupted cut with a minimal delay between shocks (four clamped slats). The maximal value reached was 82 520 shocks (the average value).

Acknowledgement

This work was supported by the European Regional Development Fund in the IT4Innovations Centre of Excellence project CZ.1.05/1.1.00/02.0070, by Education for Competitiveness Operational Programme financed by Structural Founds of Europe Union in project Integrita CZ.1.07/2.3.00/20.0037 and by Student Grant Competitions SP2015/116 and SP2015/129 financed by the Ministry of Education, Youth and Sports and Faculty of Mechanical Engineering VŠB-Technical University of Ostrava.

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