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Experimental Testing of Ceramic Cutting Tool Inserts at Irregular Interrupted Cut

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***Abstract*—**Paper is dealing by testing of IN23 ceramic cutting tools at irregular shocks at special fixture - interrupted cut simulator. Standard tests provided at fixture were at regular interrupted cut at 4 slats by 90°. These new tests will be at irregular cut for 1 slat, 2 slats against each other, 2 slats side by side, 3 slats and 4 slats. The main goal is check if irregular shocks have influence at mechanical and thermal shock at tool life of cutting inserts.

***Keywords*—**Test, Ceramic Cutting Tool, Irregular Interrupted Cut.

I. Introduction

THESE are called "strip test" [1], [2]. The product is a cylinder in which the milled grooves 4 (60x48x600mm) and these grooves are inserted strips. The product is clamped on one side of the chuck and on the other side of the tip of the tailstock sleeve. When increasing the spindle speed is also growth centrifugal force. To avoid loose leaf from the plant, so the rails are clamped with the clamping wedges (4 wedges per sheet) and define the replaceable pads. Another protective element is a protective ring on both ends of the product.

II. Fixture Description and Measuring Preparation

The product was designed for cutting speed in the range v_c = 120-400m.min^{-1}, but we were forced vibration through active use high speed v_c = 250m.min^{-1}. The measurements are combined varying number strips (see Fig. 1), causing a different balance of and thus different run out and vibration. The product is first clamped, and then inserted into washers and moldings. Spacers provide working on getting the same diameter and thus provide a constant cutting speed. Strips of material to be tested are clamped wedges and then tightening the pads defines the outer screws. Wedges are (like the groove in the preparation) on one side angled. Tighten the screws wedges pushing away from the groove and tighten the clamping force bar. After firmly clamped to put a security ring is clamped, which is located at both ends of the product and it is bolted with four bolts.

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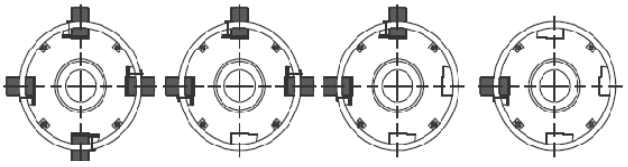

Fig. 1 Placement bolts in fixture scheme

Before making the measurements must be aligned strips by cutting the first depth chips in order to guarantee a constant depth of cut during testing. The first (alignment) splinter does not influence the results. Align rails also helps balance against vibration system, the distance from the center rail machining will be constant [3], [4].

III. Cutting Parameters and Cutting Geometry

Before the measurements were cutting parameters established by the manufacturer inserts, as experienced investigators and, if it is possible machine. Different combinations of bars in the preparation done to the machine vibration and therefore, we were forced to reduce speed machines and limit parameters. The product is machined diameter D = 260mm and cutting parameters were the same for both types of material to be machined:

- Feed f = 0.2 and 0.32mm
- Cutting speed v_c = 204m.min^{-1}
- Depth of cut a_p = 1mm

For normalized platelet shape SNGN 120712T was used tool holder CSRNR 25x25M12-K and geometry processing ISO 3685. The holder is designed for external mounting square ceramic inserts [5]. The geometry of the cutting tool ceramics:

- Rake angle γ_o = 6°
- Clearance angle α_o = 6°
- Angle the blade λ_s = - 6°
- Angle of the blade κ_r = 75°
- Point angle ε_r = 90°

IV. Experiments Evaluation

In the experiment, we measured the length of machined measuring tape (resolution of 1mm), according to which it is then recalculated the number of shocks that lasted inserts to wear. With increasing cutting speed decreases with increasing feed or number of shocks. Limiting factor was therefore wear inserts, which resulted in breaking the blade or blades brittle failure. Cone edge is reflected immediately change the sound processing, increased sparks from a place of cutting, increased vibration and immediate change in surface roughness. Fragile

violations blade was apparent degradation of surface roughness and occasional twinkle.

Calculate the number of shocks:

$$R = \frac{n \cdot l}{f} [-] \quad (1)$$

where:
R is number of shocks [-]
n is number of bolts in fixture [-]
l is machined length [mm]
f is feed [mm]

Inserts were during measurement for better clarity described numerals 1 to 8. On each plate were tested three edges of a different number of strips, another shift and another material. Inserts were designated periods (1-3). The following tables show the values measured on each edge of the right side of the table are calculated averages of measured values that were used in the charts. Number of impacts is converted from a machined length.

V. Results for 4 Slats

In preparation were clamped four machined rails and were monitored surges which will last plate in the destruction or deterioration of the leaf surface. This test represented to us regularly interrupted cut.

TABLE I
MEASURED VALUES FOR MATERIAL 15 128 AND 4 SLATS

	IN23, 15 128, 4 slats, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	5323	106 460	783	9788
2	5338	106 760	776	9700
3	5317	106 340	798	9975
Φ	326	106 520	786	9 821
σ	8.8	177	9.2	115

TABLE II
MEASURED VALUES FOR MATERIAL 12 050 AND 4 SLATS

	IN23, 12 050, 4 slats, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	1870	37400	1023	12788
2	1883	37660	1004	12550
3	1892	37840	1017	12713
Φ	1882	37633	1015	12683
σ	9.0	181	7.9	99

The graph is shows that for both materials at a higher feed rate decreased number of shocks that lasted plate. The material 15128 is a rapid decline in the number of shocks to the plate and more than 10 times and also there is a large quarry plate. The material 12 050 the number of shocks to change shift changes less significantly, the wear plates are of similar type and chipping of the tool tip. A lower feed value should insert more lasting material 15128 and vice versa at higher feed on the plate was better for materials 12 050 Fine sparking platelet we usually signaled the approaching breaking tools. Only for material 15128 and feed 0.2mm impairment test was terminated surface roughness strips.

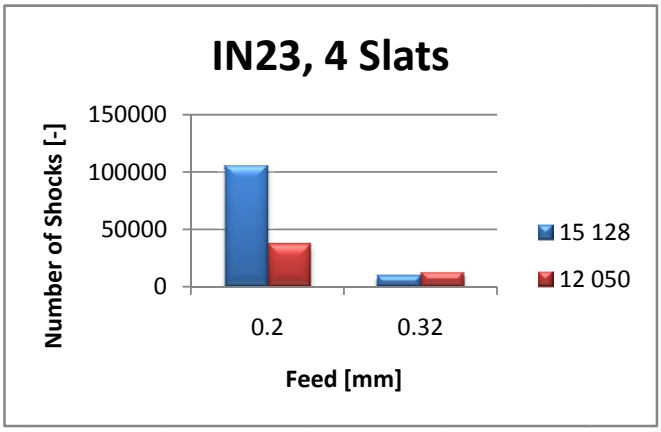

Fig. 2 Dependence of number of shocks on feed at 4 slats

VI. Results for 3 Slats

In preparation for these measurements were clamped three bars and a blank space was already worn rail clamped to achieve a better balance of the product. Cutting parameters were maintained as in the previous case. Here he was interrupted by irregular cut.

TABLE III
MEASURED VALUES FOR MATERIAL 15 128 AND 3 SLATS

	IN23, 15 128, 3 slats, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	2439	36585	657	6159
2	2464	36960	644	6038
3	2457	36855	635	5953
Φ	2453	36800	645	6050
σ	10.5	158	9.0	85

TABLE IV
MEASURED VALUES FOR MATERIAL 12 050 AND 3 SLATS

	IN23, 12 050, 3 slats, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	2285	34275	1187	11128
2	2276	34140	1203	11278
3	2293	34395	1196	11213
Φ	2285	34270	1195	11206
σ	6.9	104	6.5	61

When moving the plate is 0.2mm for the two materials is about 35 000 shocks. Doing better but the material was 15 128 Plate under a microscope in both cases showed chipping tool tip. Feed 0.32 showed a slightly larger margin endurance pads. Compared to the previous shift hit better on the plate material 12050, where 11206 withstand shocks. The material 15128 6050 plate withstand shocks. Also, in this shift occurred for breaking cutting edge, it was just obvious. Before fracture plate was also noticeable fine sparks from plates.

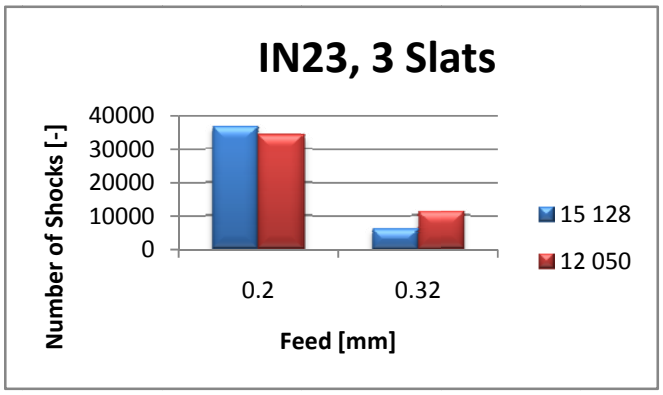

Fig. 3 Dependence of number of shocks on feed at 3 slats

VII. Results for 2 Slats

The product was removed from the previous measurements once the leaves and substitution. Machining were thus two bars located next to each other. In this case also were irregular intermittent cuts. For this test, alternating short and long time cooling inserts. In these variant tests to occurred largest imbalances product.

TABLE V
MEASURED VALUES FOR MATERIAL 15 128 AND 2 SLATS

	IN23, 15 128, 2 slats, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	3358	33580	824	5150
2	3374	33740	837	5231
3	3369	33690	818	5113
Φ	3367	33670	826	5165
σ	6.7	67	7.9	50

TABLE VI
MEASURED VALUES FOR MATERIAL 12 050 AND 2 SLATS

	IN23, 12 050, 2 slats, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	3579	35790	971	6069
2	3583	35830	982	6138
3	3590	35900	987	6169
Φ	3584	35840	980	6125
σ	4.5	45	6.7	42

During the test, where two strips were clamped in the preparation of material occurred at 15,128 to the great breaking the tool. The material 12050 occurred at the plate rather less breakage and displacement 0.2mm test was stopped due to deterioration of the surface roughness. In terms of the number of shocks was endurance pads with 0.2mm feed quite balanced and moved around 34000 shocks. With an increase in displacement to 0.32mm, the amount of shock significantly reduced, but the plate withstand both materials have approximately the same around 5500 shocks. The plate has improved endurance of a material 12,050 in both feeds.

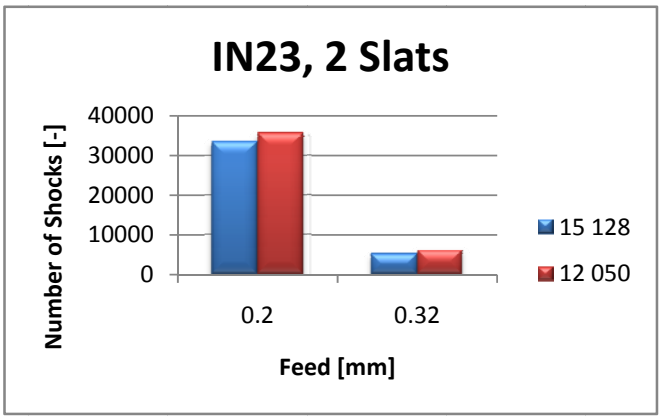

Fig. 4 Dependence of number of shocks on feed at 2 slats

VIII. Results for 1 Slat

The product was removed one more bar and substitution and remained only one that has been machined. Machining parameters remained the same and the plate was tested for two materials at two values of displacement. The plate was therefore subjected to one character during one rotation.

TABLE VII
MEASURED VALUES FOR MATERIAL 15 128 AND 1 SLAT

	IN23, 15 128, 1 slat, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	4913	24565	1342	4194
2	4895	24475	1349	4216
3	4888	24440	1367	4272
Φ	4899	24493	1353	4227
σ	10.5	53	10.5	33

TABLE VIII
MEASURED VALUES FOR MATERIAL 12 050 AND 1 SLAT

	IN23, 12 050, 1 slat, v_c = 204 m.min^{-1}			
	f = 0.2mm		f = 0.32mm	
	l [mm]	R [-]	l [mm]	R [-]
1	5146	25730	1538	4806
2	5137	25685	1526	4769
3	5159	25795	1519	4747
Φ	5147	25737	1528	4774
σ	9.0	45	7.8	25

When measuring with only one clamping bar with endurance pads with 0.2mm displacement was around 25000 shocks. Better on the material 12 050 during this displacement of deterioration in surface roughness and thus to stop the measurement. Displacement was 0.32mm on what terms tip damage worse, there occurred the breaking edge of both materials, but steel, 15 128 were breaking clearer. Plate withstand both shock material around 4500, but was greater endurance of steel 12 050.

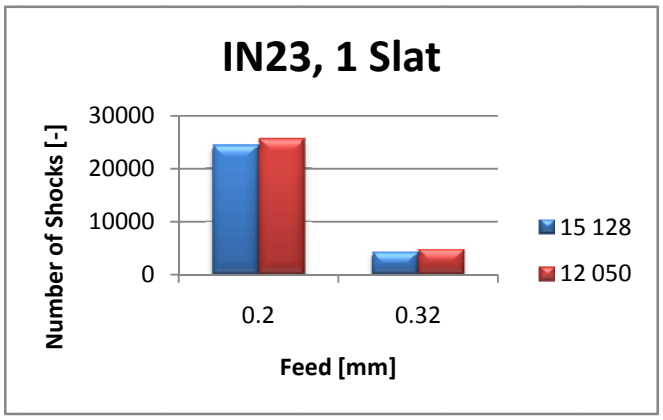

Fig. 5 Dependence of number of shocks on feed at 1 slat

IX. Conclusions

Machined with two types of materials, in the first case, a steel 15128, also known as fireproof. Other steel was 12 050, which is intended for refining. The test plate was used only once and that IN 23 from ISCAR. It is a black oxide ceramics intended for roughing to finishing operations [6]. The tests were chosen constant cutting depth (a_p = 1mm) and cutting speed (v_c = 204 m.min^{-1}). To move the selected two values 0.2 and 0.32mm. We watched turned length to breaking plates accompanied by changes in sound processing and possible sparks from tools or deterioration of the surface, where they began to create the rails fine "hairs" that could be seen with the naked eye, but it can also feel after crossing the rails finger. The values of the measurements were entered into tables and the length of the formula recalculated the number of shocks. Further graphs were prepared for comparison soak plates when changing feed or material. Followed by graphs, where the plates compared stamina when changing mail page which are accrued irregularities intermittent cutting.

The chart shows that a higher number of shift shocks always fell sharply in both materials. With the increase in displacement occurred in most cases, the fracture plate. The decreasing number of shocks mail moldings also generally declined. Only when machining material 12050 0.2mm and feed the results of the three rails and two more or less equal. The two plate rails lasted approximately 1,000 more smoothly.

In some cases, the removal of one bar big jump in the number of shocks, shocks sometimes differed very little. The biggest endurance in a regular cut with four leaves remained plate material at 15,128 and feed 0.2mm, where the number of shocks reached 106 520 Here too was a case where there has been the removal of a rail the largest declines in shock about the 70000th In this material, the plate is increasing displacement contrary to withstand at least two test materials and 9821 shocks. Looking at irregular cut on the plate was the best three strips of material at 15,128 and 0.2mm feed which amounted to 36800 impacts. Worst on the plate was the same material but with a higher feed rate, which exceeded the 4227 shock. Endurance steel plates at 12,050 held around the middle. When feed 0.2mm, the number of shocks to change the number of bars fairly balanced and moved around a value approximately 35000 shocks. When the test with one life is bar dropped to about 25,000 shocks. When increasing shift the plate on this material has been so balanced and number of shocks to the board declined. The most significant jump in the number of shocks is reflected in the change of the two rails. At one and two bars in the product is the best behaved plate material 12 050 Three and four bars have been better for the plate in the number of shocks in contrast material 15 128 After getting out plates of cut , this material appeared significant burrs . The material 12050 were almost none. Test results can also be used in the practice of attaching ceramic cutting inserts during machining interrupted cut both regular where the greater stamina and irregular , which is to be reckoned with smaller tool life.

The tests can be concluded that for the plate of oxide ceramics IN23 has irregular intermittent cut negative consequences in terms of persistence of shocks. Also, an increase in feed meant reducing the number of shocks. While reducing the number of bars in there to greater temperature fluctuations on the cutting edge due to the alternation of short and long time cooling the cutting edge. Larger temperature fluctuations are also likely signed on plate resistance against shocks during measurement.

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