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SHOCK NUMBER DETERMINATION FOR DISAL D210 CERAMIC CUTTING INSERTS DURING INTERRUPTED MACHINING

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ABSTRACT
Ceramic cutting tools availability during interrupted machining was solution at this article, in the concrete ceramic DISAL D210 from Czech producer Saint Gobain Advanced Ceramic Turnov. Experiments were provided at special fixture – interrupted cut simulator. This fixture was constructed at Department of Machining and Assembly. Monitored parameter was number of shocks to totally destruction. The goals of tests were contribute to bigger using of these cutting materials at machining, especially at interrupted machining.
Keywords: Cutting Tools, Cutting Wear, Interrupted Machining, Number of Shocks

1. INTRODUCTION
For the highest machining achievement is critical choice of right cutting tool. Choice of material and cutting geometry simulate big part. Vibration generate in machining induce early ending of tool life. It may be for example poor tool holder stiffness or mistaken clamping [5].
Producers of ceramic cutting tools made during centuries big step ahead. Namely increasing tenacity at conservation of high fortress and hardness is advantage. Some producers of these materials advise cutting inserts for interrupted machining at present time [3].

2. CHOSEN CUTTING MATERIAL
Today, do not exist standardized vocabulary, like e.g. at sintered carbides or high-speed steel. Generally is accepting following graduation. There are two basic types of ceramics [1, 4]:

- Aluminum – Oxide based (Al_2O_3)
    - Pure
    - Mixed
    - Reinforced
- Silicon – Nitride based (Si_3N_4)

Like cutting materials we chosen products of Czech producer – Saint Gobain Advanced Ceramics Turnov. Like representative of cutting inserts we chose material DISAL D210. The producer characterize it’s product like mixed oxide ceramics based (Al_2O_3 + ZrO_2 + CoO). Offer besides of hardness and wear resistance at high temperature also higher toughness. This type is suitable for machining of grey cast iron, spherical as well as tempered cast iron, heat treated steel and high speed steel in a light interrupted cutting.

3. USED FIXTURE – INTERRUPTED CUT SIMULATOR

And now to several experiment, which was provided at special fixture – interrupted cut simulator (*fig. 1*). It was constructed at our department (Department of Machining and Assembly) within solution of Czech Science Foundation. Main parts of this simulator are:

- Fixture's body
- Work pieces
- Exchangeable moldings
- Clamping gussets
- Safety circles with screws

Fixture assembling proceed by follow way. Body was clamping to lathe and then with clamping gussets workpieces. In the case of need bottom by exchangeable moldings and screw up safety circles. We are ready for tests now. Proportions of simulator are:

- Total length 900 mm
- Machining length 600 mm
- Valve diameter 230 mm
- Work piece's profile 60x50 mm

Machining diameter differs from 270 to 235 during machining. An exchangeable molding (their variable thickness) is big advantage of this fixture. Diameter (cutting speed) is relatively constant during whole tests [2].

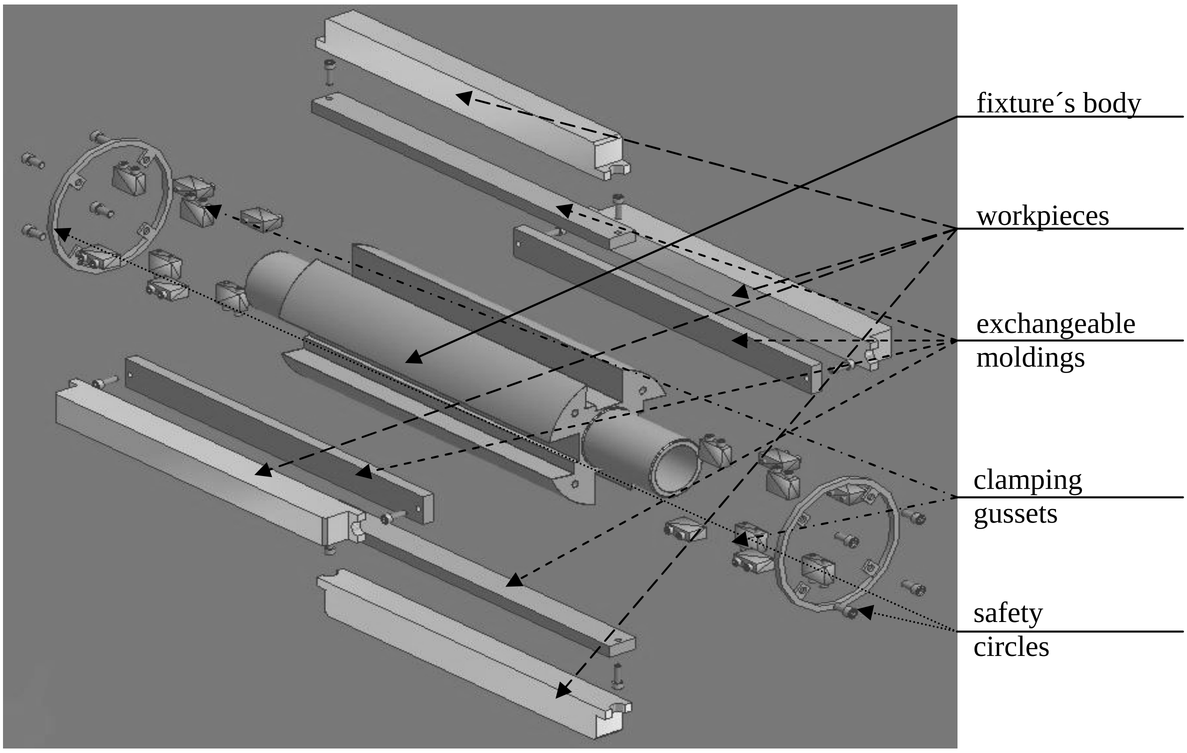
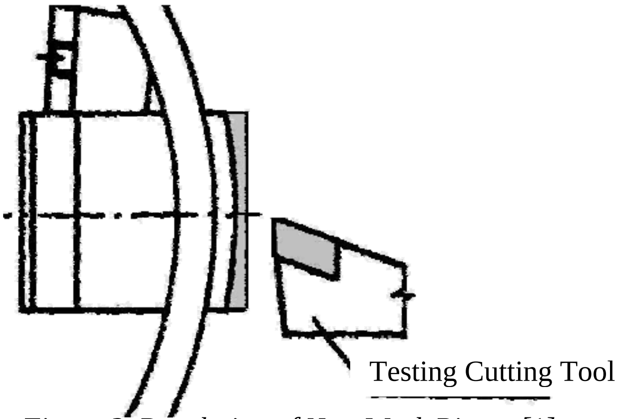


Figure 1. Scheme of Interrupted Cut Simulator [1]

With regards to ISO 3685 (Tool Life Testing of Single Point Turning Tools), was choice follow cutting geometry:

- cutting edge angle : $\kappa r = 45°$,
- cutting edge inclination : $\lambda s = - 6°$,
- rake angle : $\gamma o = - 6°$,
- clearance angle : $\alpha o = 6°$,
- included angle : $\varepsilon r = 90°$,

Before first measuring at new work pieces is necessary machining first chip. This chip have not constant cross cut and could be deface whole metasuring (fig. 2). This is small disadvantage of this fixture.



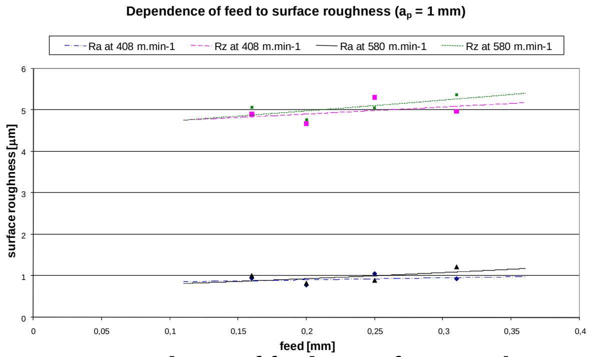


Figure 2. Regulation of New Work Pieces [1]

Figure 5. Dependence of feed to surface roughness

That was achieved with this type tool holder (CSRNR 25x25M12 – K) and with this kind of cutting insert (SNGN 120716 T02020). Materials of workpieces were 12 050 (Rm = 725 MPa).

4. MONITORING OF SHOCK´S NUMBERS

Parameter, which was monitoring is number of shocks to cutting tool destruction. Shock's number was determinate from follow equation:

$$R = \frac{4 \cdot l}{f}$$

, where: R – number of shocks [--], l – cutting length [mm], f – feed [mm].

We monitored number of shock to total destruction of insert. Approaching destruction was demonstrated change of tone (strong) during machining. We were constant cutting parameters – cutting depth and revolutions (let us say cutting speed) and changed cutting feed from 0,16 mm to 0,31 mm (table 1). We monitored surface roughness parameters Ra and Rz too. Values at tables are arithmetical mean of three measuring.

We determine border number of shock to 6000 shocks on based on actual experiences and consultation with producers of cutting inserts.

After evaluation of follow tables, we obtain follow graphs (fig. 3 to fig. 5).

Table 1. Measured values for cutting speed 408 m.min^{-1} and 580 m.min^{-1}

v_c = 408 m.min^{-1}, a_p = 1 mm					v_c = 580 m.min^{-1}, a_p = 1 mm				
f [mm]	**f [mm]**	**l [mm]**	**Ra [µm]**	**Rz [µm]**	**f [mm]**	**l [mm]**	**Ra [µm]**	**Rz [µm]**	**R [-]**
0,16	0,16	63	1,01	5,07	0,16	63	1,01	5,07	1563
0,2	0,2	128	0,83	4,77	0,2	128	0,83	4,77	2550
0,25	0,25	83	0,9	5,05	0,25	83	0,9	5,05	1320
0,31	0,31	80	1,22	5,37	0,31	80	1,22	5,37	1032

We can generally tell, that with increasing cutting speed or feed, number of shocks decreasing. Graphical dependence of feed to numbers of shocks is at figure 3. Spline is approximating like linear line. We can see that lines for both cutting speed decreasing almost parallel. Near of feed 0,4 mm will be impossible more machining.

We can tell that at lower feeds is number of shock higher at next figure 4 than at higher feeds. Line's inclination is relatively parallel, especially at feed f = 0,16 mm and f = 02 mm and at feed f = 0,25 and f = 0,31mm. This departure can be caused by inclusion at workpieces or defect at cutting inserts. Approximation splines were linear lines.

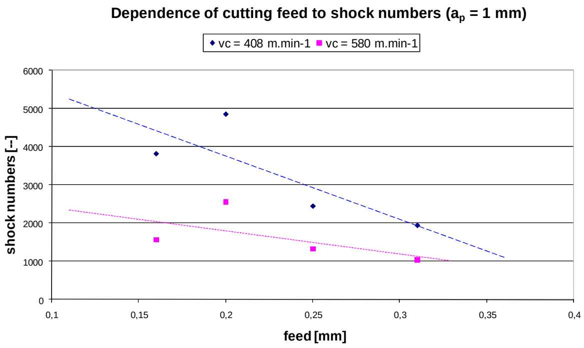


Figure 3. Dependence of feed to shock numbers

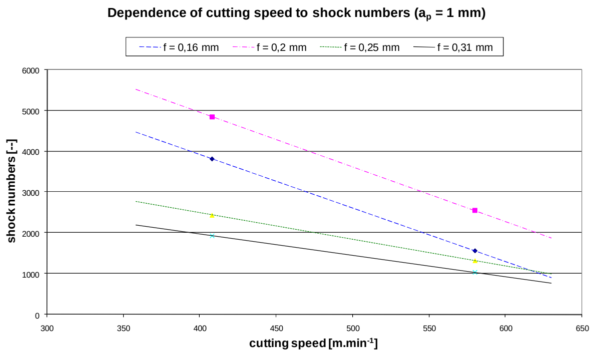


Figure 4 Dependence of cutting speed to shock numbers

How we can see at figure 5, surface roughness is very similar at both cutting speeds. With increasing feed surface roughness is increasing too, but accruement is not expressive. This is valid for both parameter of roughness Ra and Rz. Approximating spline is exponential, but can be linear. Surface roughness parameters were measured at MITUTOYO SJ401.
All measuring proceed minimal 5 times, especially of surface roughness measuring. Place of measuring was approx. 20 mm before end of cutting. Data in tables are arithmetical mean of 4 measuring (4 cutting edges were destroyed).

5. CONCLUSIONS

Cutting edge durability and cutting conditions optimizing are dependent at many parameters [4]. There are no easy determining exact areas. Every cutting process is unique. Submitted paper was dealing with problems of tool life tests of ceramics cutting tools at interrupted cut. Experiments were provided at fixture for along turning. This fixture was constructed at Department of Machining and Assembly.
These tests purpose were contributed to higher use of ceramic materials. Tests documented, than ceramics cutting tools are acceptable for interrupted cut. Roughness parameters Ra and Rz are adequate.
For more objective and more accurately result, must do more tests by higher cutting conditions, various workpieces materials and other ceramics cutting tool producers. Machine tool load and stiffness not allow higher cutting conditions. Especially machine tool stiffness is basic premise for measuring right and objective values.
Next test and result will provide and published at department at diploma, dissertation and habilitation thesis. Fixture simplified construction for along turning and facing turning is main target to future. These tests are very costlier and time consuming. Next tests are planning for other material (stainless steel, cast irons, etc.) and for insert from other producers.
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