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INTERRUPTED MACHINING TESTS OF CERAMIC CUTTING TOOLS

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ABSTRACT
This paper deals with ceramic cutting tools availability during interrupted machining. Experiments will be provided at special fixture - interrupted cut simulator. This simulator was constructed at Department of Machining and Assembly, FME VSB-TUO within frame of project Czech Science Foundation. Like testing cutting tool materials will be chosen ceramic cutting tools from ISCAR Company. Criteria were number of shocks to totally destruction of edge (or very closely) and dependence at cutting speed and feed.
Keywords: Ceramic Cutting Tools, Machining, Interrupted Cut, Number of Shocks

1. INTRODUCTION
All cutting tool edges are liable to wear during machining. To this extent tool wear is figured from start to end of tool life. Tool life is time, when cutting tool work from clamping to total wear, and is calculated in minutes. It is applicable, when edge machining metal within parameter limits, as is quality, required design etc. [3]
The choice of the right cutting tool is critical for the highest machining achievement. Choice of material and cutting geometry are largely simulated. Vibration generated in machining induces the early termination of tool life. This may be, for example, due to poor tool holder stiffness or when a tool is when the chuck is held incorrectly [4].

2. CHOISE OF CUTTING MATERIALS
Measuring was provided at 4 kinds of ceramic cutting inserts from ISCAR producer (fig. 1). There are 2 types of aluminum oxide based (IN11, IN22) and 2 types of silicon nitride based (IS8, IS80). We had IN23 type also, but it had the similar material structure like IN22. We do not test this cutting material.

Figure 1. Testing cutting inserts (IN11, IN22, IN23, IS8, IS80)

Table 1. Characteristic of Cutting Materials

Marking	Properties	ISO
IN11 ALUMINIUM OXIDE	White ceramics ($AL_2O_3+ZrO_2$) with high tenacity and wear resistance. It is determination for cast iron turning at high speeds, without cooling.	K01-K10 S01-S10
IN23 (IN22) BLACK CERAMIC	Black ceramics (AL_2O_3+TiCN) recommended for semi roughing and finishing machining of grey cast iron, without cooling.	K05-K15 H10-H30
IS8 ALUMINIUM OXIDE	Silicon nitride based ceramic ($Si_3N_4+Al_2O_3+Y_2O_3$) recommended for middle application during turning. Can usage for interrupted cutting.	K01-K20
IS80 SILICON NITRIDE CVD coating	Silicon nitride based ceramic ($Si_3N_4+Al_2O_3+Y_2O_3$) with CVD Si_3N_4 coating. Determine for turning and milling	K01-K20

3. USING FIXTURE – INTERRUPTED CUT SIMULATOR

Experiments, provided with regard to the special fixture-interrupted cut simulator (fig. 2). It was constructed at Department of Machining and Assembly within the framework of a project by the Czech Science Foundation. The main parts of this simulator are (fig. 2) [1, 2]:

- Fixture body (1);
- Workpieces (2);
- Exchangeable mouldings (3);
- Clamping gussets (4);
- Safety circles with screws (5);

Fixture assembling proceeded in the following way: the body was clamped to the lathe and then with clamping gussets workpieces. Where necessary, the bottom is reinforced by exchangeable mouldings and screw up safety circles. We are now ready for tests.

Proportions of simulator are [1, 2]:

- Total length 900 mm;
- Machining length (length of workpieces) 600 mm;
- Valve diameter 230 mm;
- Work piece's profile 60x50 mm;

Machining diameter ranges from 280 to 235 during machining. An exchangeable molding (their variable thickness) is a big advantage of this fixture. Diameter (cutting speed) is relatively constant during the entirety of the tests.

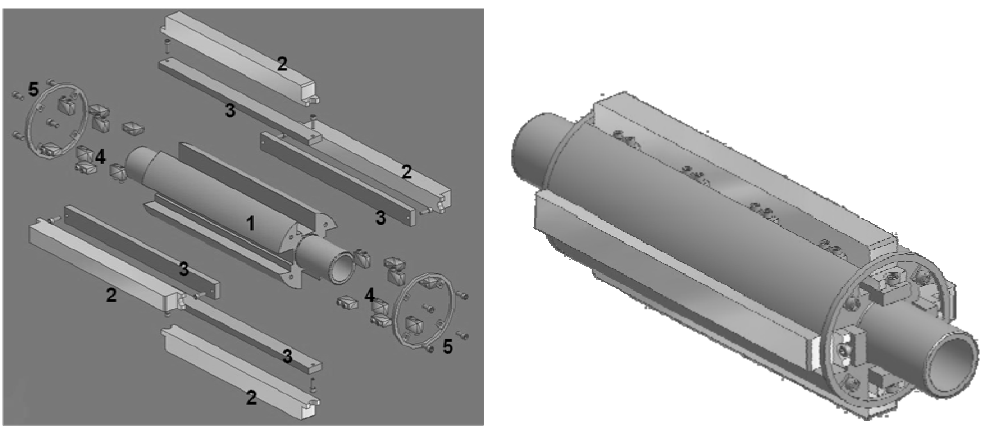

Figure 2. Scheme of Interrupted Cut Simulator [1]

Prior to the first measuring of new work pieces, it is necessary to machine the first chip. This chip does not have a constant cross cut and could be defaced by whole metering (Fig. 3).
With regards to ISO 3685 (Tool Life Testing of Single Point Turning Tools), the follow cutting geometry was selected:

- cutting edge angle : $\kappa_r = 45°$;
- cutting edge inclination : $\lambda_s = - 6°$;
- rake angle : $\gamma_o = - 6°$;
- clearance angle : $\alpha_o = 6°$;
- included angle : $\varepsilon_r = 90°$;

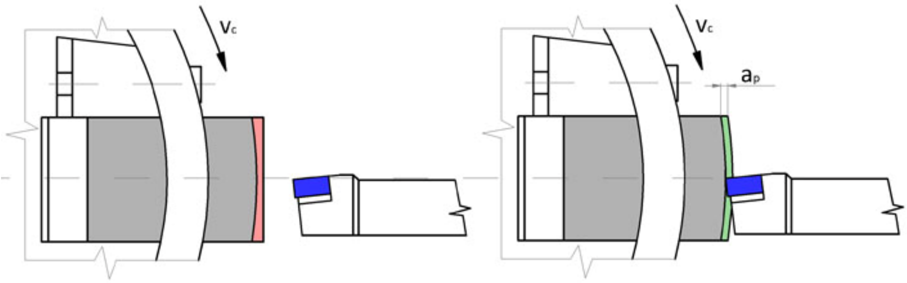

Figure 3. Regulation of New Work Pieces [1]

This was achieved with the tool holder (CSRNR 25x25M12 – K) and the cutting insert (SNGN 120716 T02020).

4. MONITORING OF SHOCKS NUMBER

The parameter, which was monitored, is number of shocks leading to cutting tool destruction. The Shock number was determined from follow equation:

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

R – number of shocks [--];
l – cutting length [mm];
f – feed [mm];

5. EVALUATION OF RESULTS

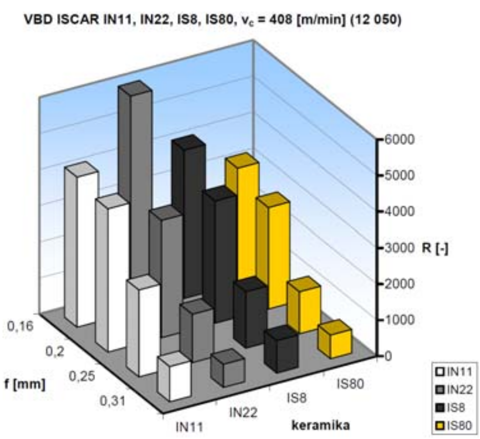

Figure 4. Dependence of numbers of shocks for vc = 408 m/min

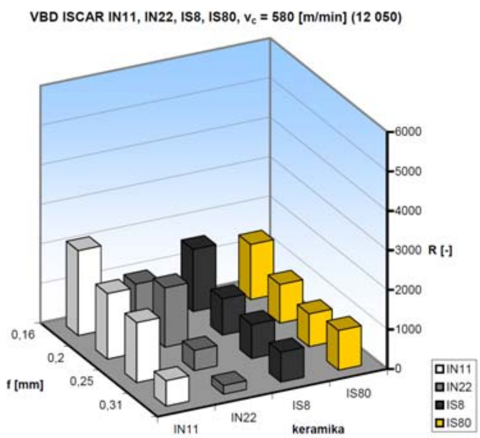

Figure 5. Dependence of numbers of shocks for vc = 580 m/min

With respect of timely and material severity and with respect of experience of team was choose maximal numbers of shocks 6000. If the insert survive this number insert is allowed to “indestructible” and testing process is stopped. To this criteria respond for each feed rate other cutting length. After achievement of this length was testing finish.
Machining material of workpieces was standard steel 12 050 (C45). All values were measured 5 times and in graphs are arithmetical means. Maximal number of shock, as we can see at fig. 4 and fig. 5 achieve only aluminum oxide based ceramic IN22 at the lowest feed rate and lowest cutting speed. Numbers of shock decreasing with increasing feed and higher values are at cutting speed 408 m.min^{-1}. At cutting speed 580 m.nim^{-1} were relatively similar number of shock at all cutting parameters and were very low in comparison with lower cutting speed.

6. CONCLUSION

Cutting edge durability and cutting condition optimization depend on many parameters. It is not easy to determine the exact areas. Every cutting process is unique [7].
The submitted paper deals with the problems of tool life tests of ceramics cutting tools at interrupted cutting. Experiments were provided on a fixture for along turning. This fixture was constructed at the Department of Machining and Assembly at VSB – Technical University of Ostrava.
The purpose of these tests was to contribute to greater use of ceramic materials. The tests documented that ceramics cutting tools are acceptable for interrupted cutting procedures. The arithmetical mean deviation of the profile (Ra) is adequate.
Ceramics cutting tool producers took a big step ahead. They advanced durability while retaining strength and hardness. Manufacturers recommended their products as a solution for the tasks of interrupted cutting. Cutting tools from ceramic and other efficient materials do not outperform classical cutting tools (HSS, sintered carbides) and they are no universal uses for all kinds of workpieces [5, 6].
In order to obtain more objective and more accurate results, it is necessary to do more tests with regard to more extreme cutting conditions, various workpiece materials and other ceramics cutting tool manufacturers [1, 2]. At present, the loadability and stiffness of the machine tool does not allow for more demanding cutting conditions. In particular, machine tool stiffness is the basic premise for measuring right and objective values. [4]

7. REFERENCES

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