Journal of International Scientific Publications: Materials, Methods and Technologies

Volume 8, ISSN 1314-7269 (Online), Published at: http://www.scientific-publications.net

CONTRIBUTION TO TURNING HARDENED STEEL

Karel Osička, Josef Chladil, Milan Kalivoda, Jan Otoupalík

Faculty of Mechanical Engineering, Brno University of Technology

(Technická 2896/2, 616 69 Brno, Czech Republic)

Abstract

The article discusses the issue of finish turning of hardened materials in the production of bearing rings. In this area grinding technology is commonly used, what has several advantages. This technique ensures mass production in tolerance grade IT 4 to IT5 and the average arithmetical mean deviation of the profile in the range of Ra = 0.4μm and Ra = 0.8μm. Possible cross cut further improves the tribological properties of friction surfaces. Certain disadvantage is at increased internal stress in the surface layer, what is a consequence of grinding technology. Alternative technologies may be turning wits tools of cubic boron nitride, which may replace to some extent grinding technology.

The article further discusses the technological experiment with the tools of cubic boron nitride and describes in detail the results and analysis of experiments. The experiment was conducted on turning machines with CNC control, where in the cutting conditions such as cutting speed, feed rate, cutting width of the blade can be accurately set and at the same time it is possible to watch the cut of the tool. The necessary condition is also sufficient rigidity of the system - machine tool, cutting tool and workpiece. On the tools the face and flank wear were evaluated and from partial graphical representations wear curves were compiled. These diagrams are the basis for the compilation dependency of tool life vs. cutting speed for each size of the wear. The article presents the basic results that have been achieved. The data of arithmetic mean deviation of Ra profile, which was statistically processed, was also obtained during the experiment.

Key words: *hardened steel, bearing ring, turning, removable insert, cutting speed, feed*

1. INTRODUCTION

Replacement of grinding operation employs technologists of many companies already for a long time. The only processing that could be used instead of grinding might by turning [6]. The results so far show the applicability of new kinds of cutting materials [3]. However, number of tests and their evaluation has to be run before decision to use them in practice [1], [4]. This contribution is trying to find advantages at the use of turning operation instead of grinding and to compare results. Innovation of technological processes at the hardened steel processing is based on the introduction of technology – turning [2], [5], [8]. The major attention is devoted to results in surface integrity as surface roughness and stresses occurred underneath the surface [9].

2. THE METHODOLOGY OF THE EXPERIMENT

Essential part of the methodology consists of appraising of materials used for processing, characteristics of cutting tools and their materials, machine tool and measuring equipment.

2.1 Material of machined parts

Bearing steel 14 109 and 14 209 according to standard CSN 414109 and CSN 414209 are used for testing. These standards correspond to ISO equivalents: ISO 100Cr6 and 100CrMnSi6-4.

The material composition according to ISO 683-17 is shown in Table 1.

Tab. 1: Composition of workpiece material

Mark	Composition %						
	C	Si	Mn	Cr	Mo	P	S
100Cr6	0.93 –1.05	0.15-0.35	0.25-0.45	1.35-1.60	max.0.1	0.025	0.015
100CrMnSi6-4	0.93-1.05	0.45-0.75	1.0-1.2	1.4-1.65	max.0.1	0.025	0.015

The hardness in the hardened and tempered state: 59 – 62 HRC.

2.2 Used machine

Experiment of machining was performed on the lathe SP 280 SY with a continuously variable speed. This is a CNC machine with a rigid structure and a suitable range of feed and speed parameters for the tests. The working space of the machine is shown in Fig.1.



Fig. 1 The working space of the machine

2.3 Cutting tools used for experiment

For turning of hardened material the insert of cubic boron nitride type CNGA 120404 S 01020 L1B CBN10 from SECO Tools AB was used. This insert was selected as the best from materials CBN060K and CBN160C. Experiment of the insert selection has been published [7].

2.4 Measuring equipment

Roughness measuring device used for experiment was TR 100. The measurement of each sample may be performed 5 times in various random locations on the workpiece. The measuring instrument is shown in Fig. 2.



Fig. 2 The measuring instrument

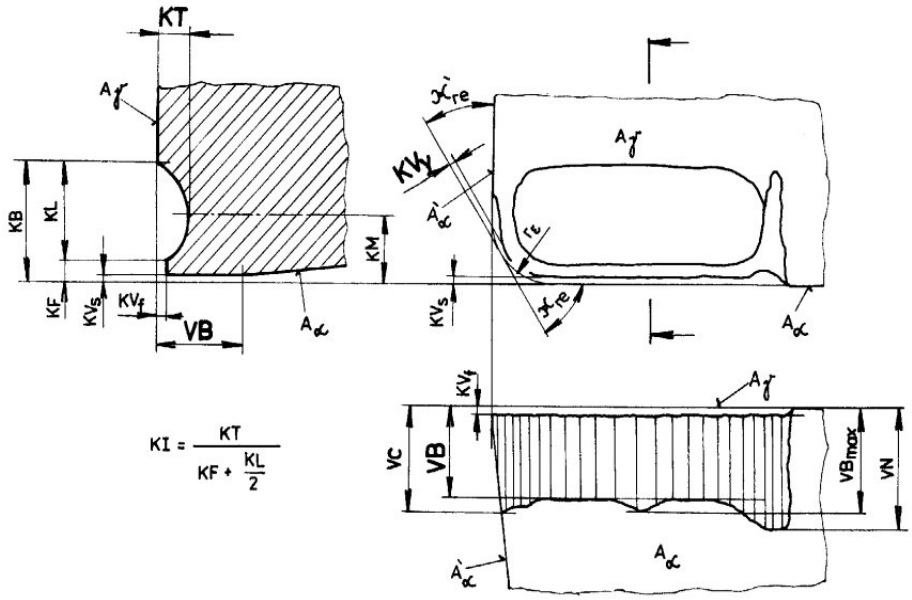


Fig. 3 Flank wear - VB of inserts

The flank wear of inserts VB according to Fig.3 was evaluated for specific cutting speed and time during machining.

3. THE EXPERIMENTAL PART

A part of the experiments are cutting conditions and measurement conditions. The results from experiments are entered into tables for a graphic evaluation. The results include statistical data measurement of Ra and the plot of VB wear versus time.

3.1 Cutting conditions used

Cutting speed v_c = 125, 141, 158, 177, 198 m · min^{-1}

Cutting feed f = 0.05 mm

Depth of cut a_p = 0.2 mm

3.2 Results of statistical data

The statistical data to the arithmetic mean deviation of the profile Ra for different cutting speeds are shown in Table 2. After each machining 6 random Ra values are measured. Number of cuts for each cutting speed was 11.

Tab.2: Ra statistical data for each speed

Cutting speed v_c (m · min^{-1})	125	141	158	177	198
Median Ra	0,315000	0,310000	0,285000	0,290000	0,280000
Estimate of the mean value “Ra”	0,303333	0,315758	0,294242	0,30697	0,312424
Estimate of the standard deviation “s”	0,069533	0,078858	0,086684	0,080421	0,131114
Confidence limit of the mean values mh1	0,320557	0,335291	0,315714	0,32689	0,344901
Statistical tolerance limit Ls1	0,4424	0,473474	0,467609	0,467812	0,574653

Table 2 shows that even with increasing cutting speed the estimation of the Ra mean value remains relatively stable at about 0.3.

3.2 The results graphically display a photo wearing

Fig. 4 shows a plot of flank wear VB vs. time t for the cutting speed of 125 m · min^{-1}.

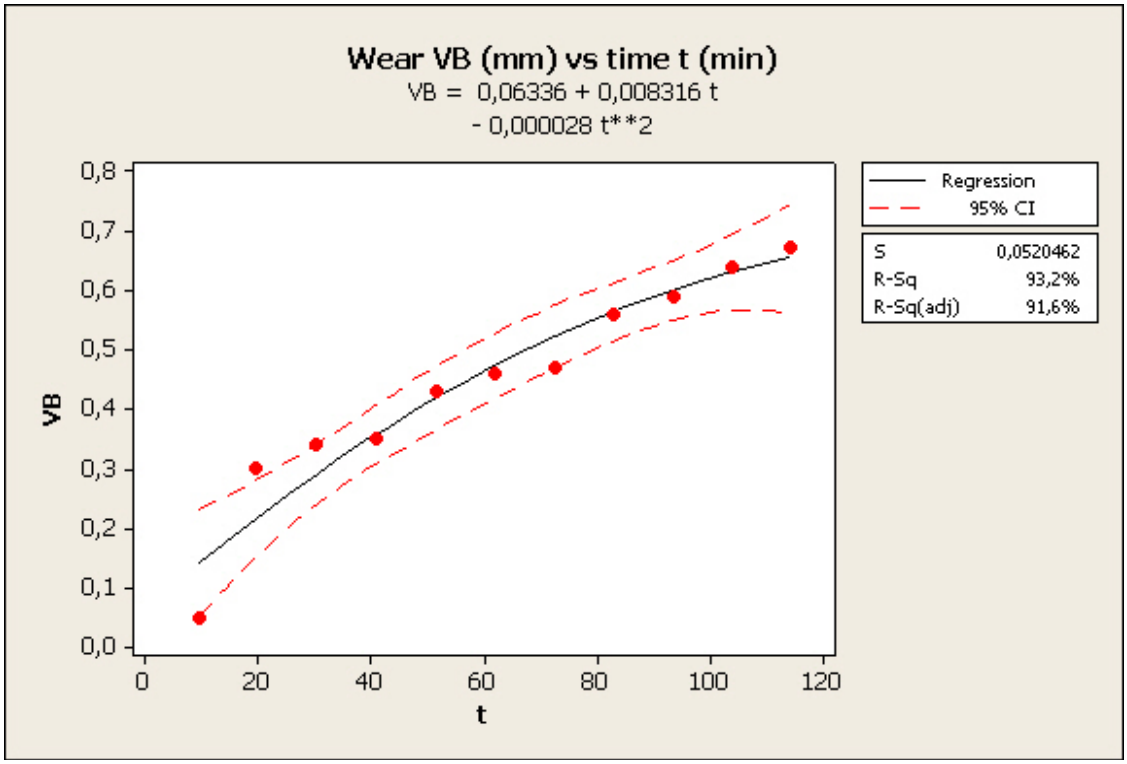
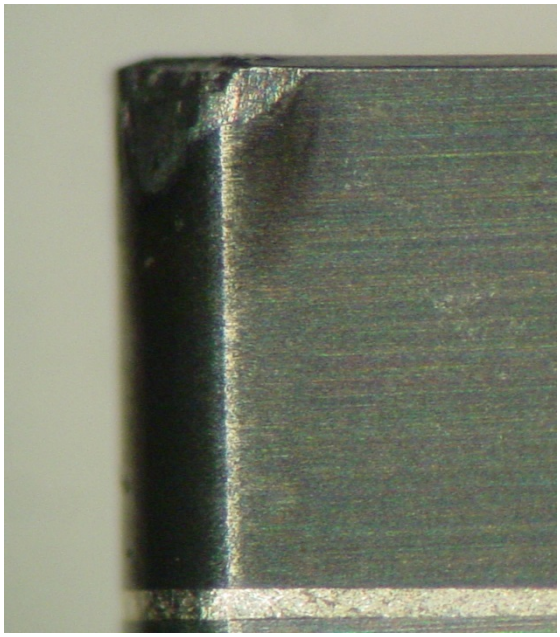
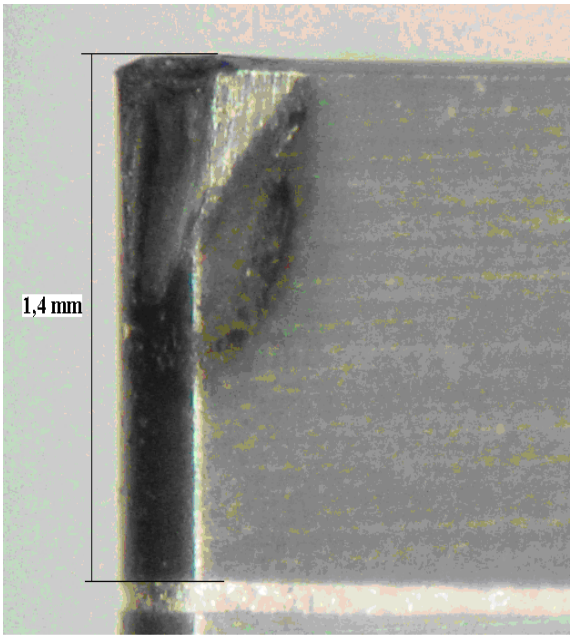


Fig. 4 The wear VB vs time t for the speed of 125 m · min^{-1}

Fig. 5 shows the flank wear VB after 40 and 114 minutes of machining for the cutting speed 125 m·min^{-1}.



After 40 minutes of machining



After 114 minutes of machining

Fig.5 The flank wear VB

Maximum cutting speed used in the experiment was 198 m · min^{-1}. Fig. 6 shows a plot of wear VB vs time t.

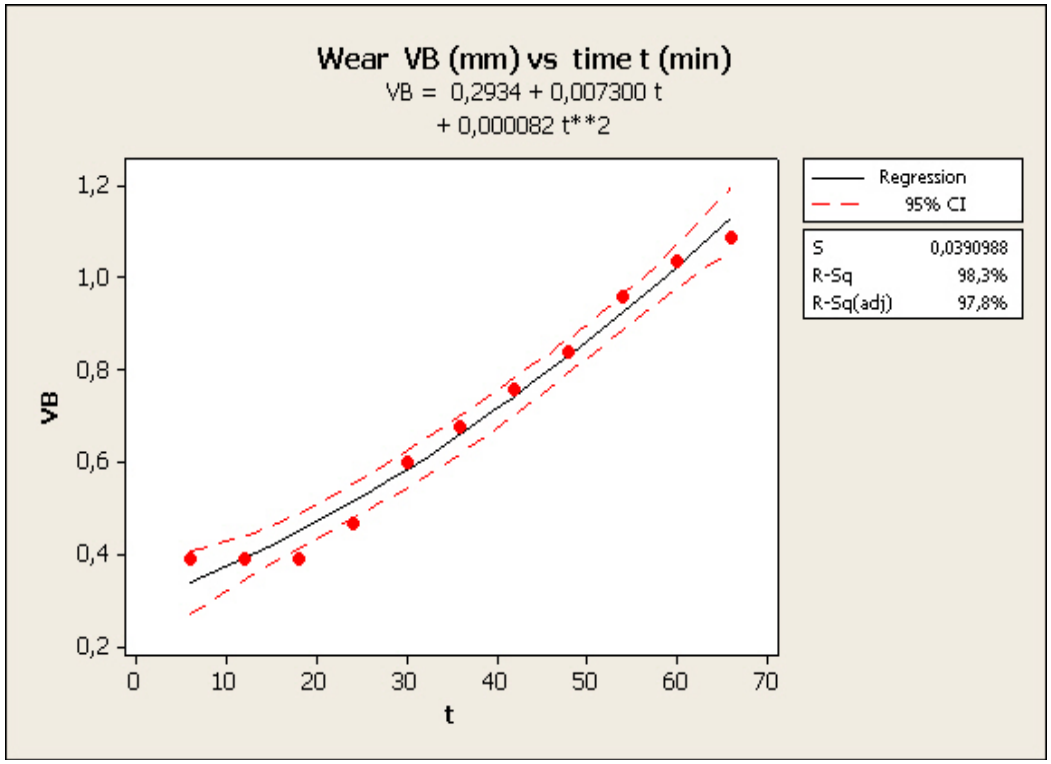
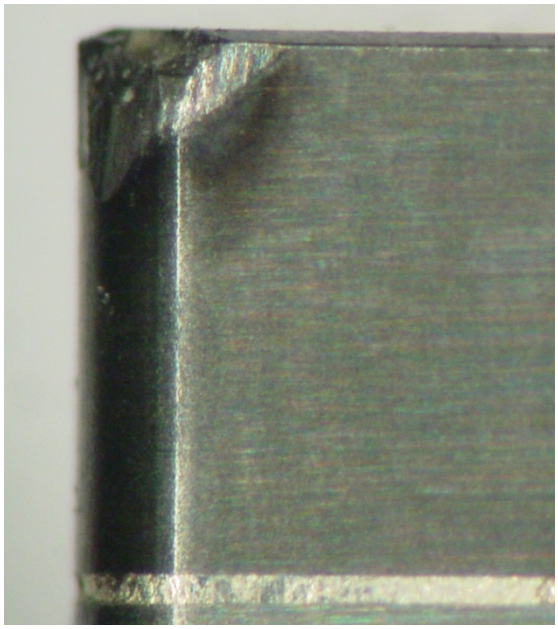
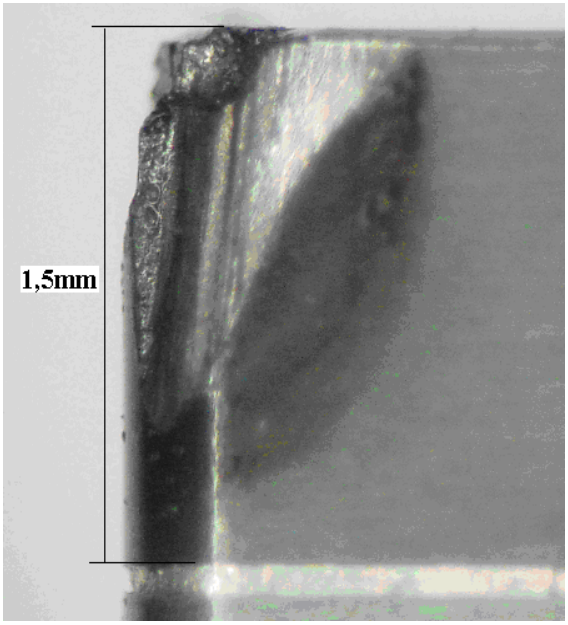


Fig. 6 Wear VB vs time t for speed of 198 m · min^{-1}

Fig. 7 shows the flank wear VB after 24 and 66 minutes of machining for the cutting speed 198 m·min^{-1}.



After 24 minutes of machining



After 66 minutes of machining

Fig.7 The flank wear VB

Similar graphs were also obtained for the cutting speeds 141, 158 and 177 m · min^{-1}. All this data was the basis for creation of the graph, depending on the tool durability T vs cutting speed v_c. This graph is shown in Fig. 8.

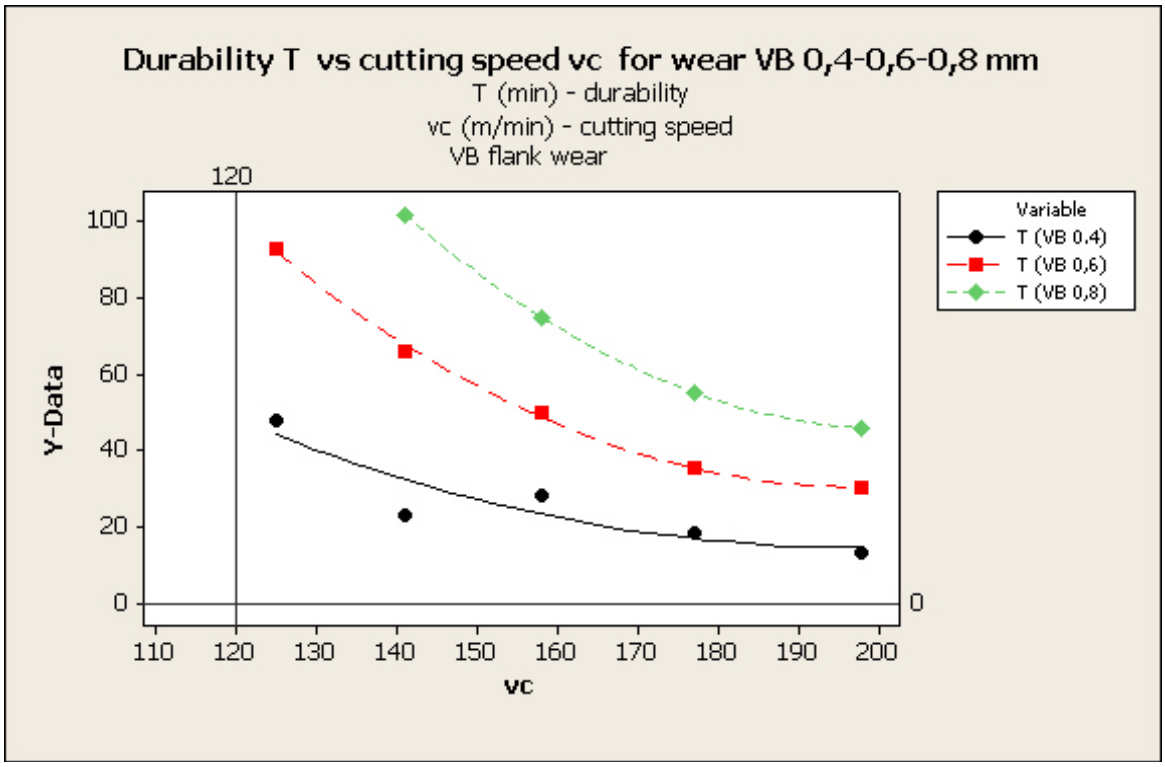


Fig. 8 The plot of tool life T vs cutting speed v_c

4. CONCLUSION

The experimentally obtained data were processed into graphical outputs and using the program “Minimat 15” the dependence of tool life vs cutting speed for different values of flank wear was then evaluated.

Furthermore, it can be said that at stated conditions the cutting feed and depth of cut remained relatively stable values of the average arithmetic deviation of the profile Ra. Bigger flank tool wear has not a major effect.

The experiment will continue with verifying cutting geometry of the "WIPER" cutting inserts and with measuring the residual stress using the "Barkhausen noise" method [9].

ACKNOWLEDGMENT

The work has been supported by the Department of Trade and Industry of the Czech Republic under grant FR–TI4/247. The support gained from this source is very gratefully acknowledged.

REFERENCES

Davim, J. Paulo. Machining: Fundamentals and Recent Advances. London: Springer, 2008, pp 361. ISBN 978-1-84800-212-8.

Forejt M., Piška M. Teorie obrábění, tváření a nástroje, vyd. 1., Brno: Akademické nakladatelství CERM, 2006, pp. 225, ISBN 80-214-2374-9.

Humár, A. Materiály pro řezné nástroje. 1. vyd. Praha: MM publishing, s.r.o., 2008. pp 240. ISBN 978-80-254-2250-2.

Jakubovičová, L.,Sága, M., Vaško, M. Impact Analysis of Mutual Rotation of Roller Bearing Rings on the Process of Contact Stresses in Rolling Elements. Manufacturing Technology. 2013. Vol. 13. Issue 1. pp. 50-54. ISSN 1213-2489.

Mádl, J. et al. Jakost obráběných povrchů. 1. vyd. Ústí nad Labem: UJEP, 2003. pp.180. ISBN 80-7044-639-4.

Maslov, J. N., Teorie broušení kovů, 1.vyd. Praha: SNTL, 1979. pp. 246.

Osička, K., Kalivoda. M, Chladil, J.; Mouralová, K., Otoupalík, J. Machining of hardened bearing steels. Journal Proceedings in manufacturing systems, 2013, Vol. 8, Issue 3, pp. 171-176. ISSN: 2067- 9238.

Shaw, M.C. Metal Cutting Principles, 2nd ed., Oxford university press, New York, Oxford, 2005, pp. 651, ISBN 0-19-514206-3.

Vashista, M., Gaddam, A., Paul, S. Study of surface integrity of ground bearing steel using Barkhausen noise technique, International Journal of Advanced Manufacturing Technology, Vol. 63, Issue 5-8, November 2012, pp 771-783.