Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 100 (2015) 328 – 333

Procedia Engineering

www.elsevier.com/locate/procedia

25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM 2014

Cutting Material Influence on the Quality of the Machined Surface

Jana Moravčíková*

Slovak University of Technology, Materials Science and Technology, Paulínska 16, Trnava 917 24, Trnava

Abstract

The aim of this paper is analyze of machined surface after grinding. A type of used abrasive significantly influences the machined surface quality. Studied was the influence of selected types of abrasives: 98A60K9V, 99BA60K9V, 49C60J9V on the integrity of the machined surface selected materials. Four different steels: C45, C55, 54SiCr6 and 50CrV4, were used for analyses in two states (after hardening and delivered state). These steels are used in production significantly. Surface quality evaluation is performed using a contact roughness measurement and microstructure analysis. The results of this experiments show that there are differences between different abrasive machined surfaces.

Peer-review under responsibility of DAAAM International Vienna

Keywords: Microstructure analysis; Quality of surface; Abraiding agents

1. Introduction

The requirements of the surface quality of the materials, as well as new materials with different properties are continuously increase. Grinding is in the production process costly item, so efforts in this area focused on reducing costs and increasing of productivity. By grinding may be a number of favourably influences the some properties such as the size and orientation of the residual stresses, which ensure resistance of the surface to the environment, the functionality and the desired lifespan of the entire part [1]. Achieving the desired properties but is mainly dependent on the correct choice and compliance of cutting conditions, on selection of abrasive material and binder, on methods of clamping tool, and others, which is the subject of experiments. The interest of many researchers was to study the influence of these different parameters on the quality of the machined surface [2], [3], [4], [5], [6], [7],

* Corresponding author. Tel.: +421-906-038326.
E-mail address: jana.moravcikova@stuba.sk

Peer-review under responsibility of DAAAM International Vienna
doi:10.1016/j.proeng.2015.01.375

[8] and [9]. Influence of grinding process to degradation properties of parts reported in the literature [10] and influence of grinding process to degradation properties to chemical-heat treated part reported in the literature [11].

The intensification of production processes and continuous expansion of advanced materials brings the new requirements to grinding wheels. The grinding wheels must guarantee the achievement of high accuracy and quality of machined surfaces [5]. Abrasive materials and binder materials continually undergoing development and now there are highly productive grinding technologies, which ensure the favourable mechanical and thermal stresses of grinded surfaces [6], [12]. These technologies have higher acquisition costs, but provide the required quality of machined surface, high durability and tool life, reduced maintenance costs and energy consumption. This leads to a recovery of investment due to of higher productivity.

A type of abrasive has a big influence on the machined surface quality. The criterion is the surface roughness parameter Ra, hardness and surface microstructure of the steel samples. For realization of experiment are proposed tree types of abrasives and four different steels in two states - after hardening and delivered state.

Roughness plays an important role in various processes and is widely measured. To surface roughness measure was used the Surtronic 3+ produced by Taylor-Hobson company. Sampling length was L_C = 0,8 mm and evaluation length L_n = 4 mm. Pick up type variable reluctance Stylus 112/1502: Diamond tip radius 5μm.

The Vickers hardness test was used to hardness determine of samples according to EN ISO 6507-1. The ZWICK 3212 measuring device was used to determine macrohardness using the 10 kp load. The microhardness was measured on all samples after grinding to determine of possible surface layer strengthening by grinding. The Buehler Indentamet 1100 device was used to microhardness measuring by using of 0,1 kp load.

To observation and documentation of microstructure of metallographically prepared samples in cross-section perpendicular to grinded surface the optical microscope Neophot 32 with installed of digital camera was used.

2. Materials and experiment conditions

The C45, C55, 54SiCr6 a 50CrV4 steels were suggested to experiments. The C45 steel was suggested because is defined as standard material for machining processes and rest suggested steels have mutually comparable carbon content, but different alloying elements. Suggested steels are in different state of microstructure:

- delivered state,
- hardened state.

To grinding experiments the commercially available grinding wheels was used with dimension T1 250x32x76 which have different abrasive and the same grit size. Grinding wheels marked 98A60K9V, 99BA60K9V, 49C60J9V were used.

All tests were carried out with the following parameters: roughing cut: cutting speed v_c = 30 m.s^{-1}, feed rate v_f = 8 mm.min^{-1}, depth of cut a_p = 0.03 mm; finishing cut: cutting speed v_c = 25 m.s^{-1}, feed rate v_f = 3 mm.min^{-1}, depth of cut a_p = 0.01 mm;

.Types and steel state before grinding, grinding parameters and subsequent experimental techniques used in the analysis were designed to a comprehensive analysis of the steels surface after grinding. The aim was to obtain comprehensive information about the impact of used grinding wheel on the properties of the surface layers of the material after grinding.

3. Experiments and results

The prepared samples were evaluated by above mentioned experimental methods. The results are presented in next.

3.1. Hardness measuring before grinding

The average measured hardness values HV10 of analysed samples are presented for all analysed materials in Fig. 1. Separate material states have a mutually comparable hardness values, however the hardened state achieve higher hardness values as the delivered state.

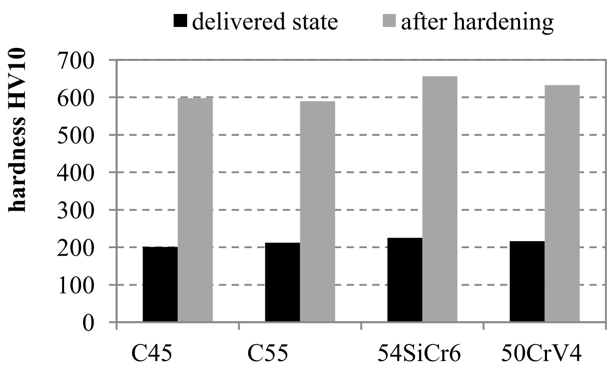

Fig. 1. Samples hardness HV10 before grinding.

3.2. Surface hardness measurement after grinding

The average measured values of microhardness of delivered state samples are presented in Fig. 2. The average measured hardness values of hardened samples are shown in Fig. 3. Both figures document the increasing of surface hardness for all materials and used grinding wheels.

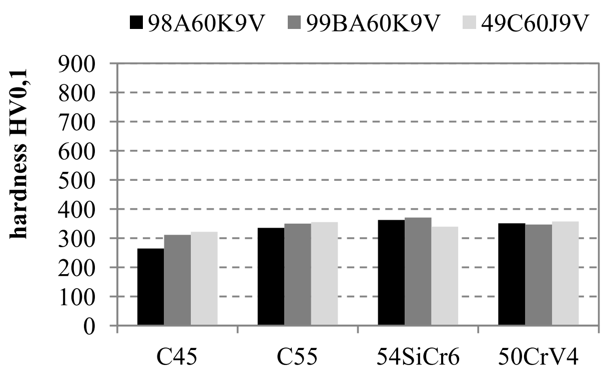

Fig. 2. Surface sample microhardness HV0,1 after grinding - delivered state.

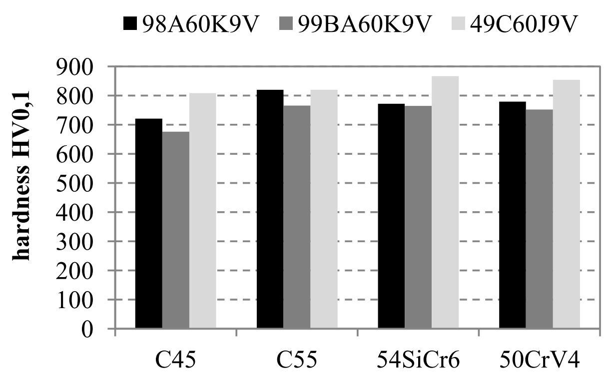

Fig. 3. Surface sample microhardness HV0,1 after grinding - state after hardening.

3.3. Surface roughness measure

The arithmetical mean deviation of the assessed profile Ra was measured on each sample in perpendicular lay. Each measurement was repeated three times. The measured values of roughness after grinding of samples in the delivery state and after hardening are shown in Fig. 4. The surface roughness of hardening state is shown in the Fig. 5.

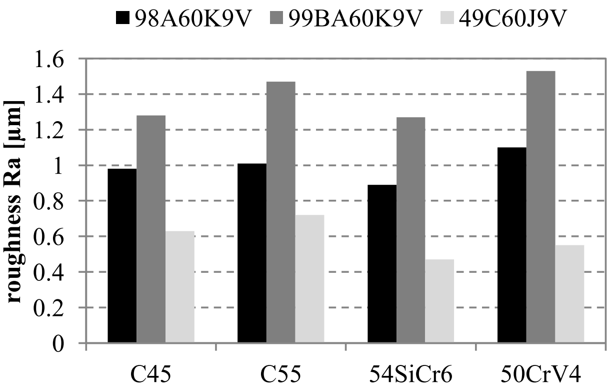

Fig. 4. Dependence of Ra to grinding wheels and sample materials after grinding – delivered state.

3.4. Depth of influenced surface layer determination

The surface microstructure changes was documented after grinding of the C55 steel in delivered state and hardened state too. This steel was chosen due to measured hardness or microhardness values of the surface after grinding as representative microstructures for surface microstructure change due to used different grinding wheels to various depths under grinded surface.

Grinded surfaces of the C55 in delivered state are shown in the Fig. 6, respectively in hardened state in Fig. 7.

The depth of microstructure changes of grinded surface of C55 steel samples in delivered state achieve average value 86 μm by using the 98A60K9V grinding wheel, 64 μm by using the 99BA60K9V wheel and 91 μm by using the 49C60J9V wheel.

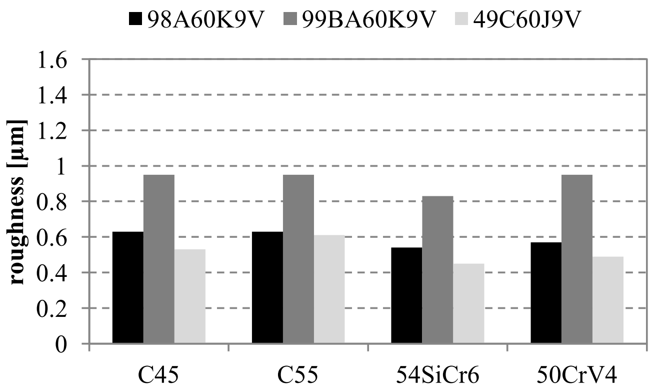

Fig. 5. Dependence of Ra to grinding wheels and sample materials after grinding - state after hardening.

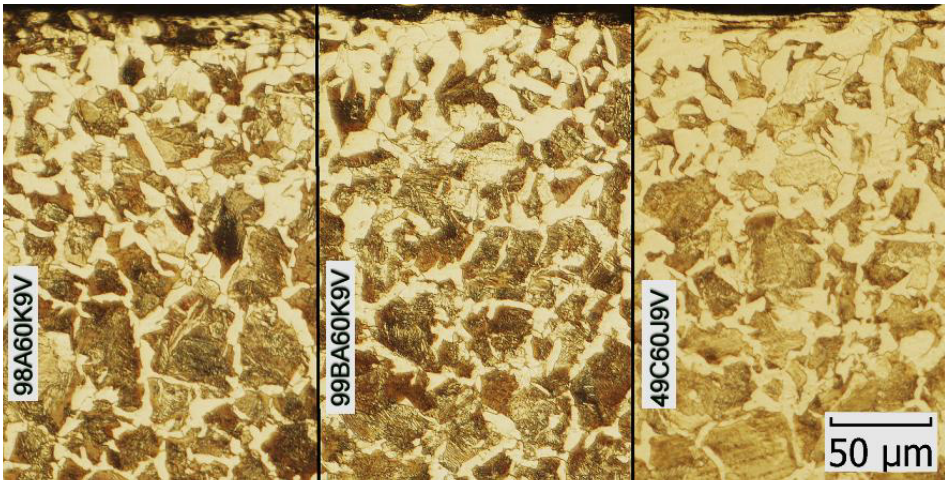

Fig. 6. Surface microstructure of the C55 steel samples in delivered state after surface grinding by using marked wheels.

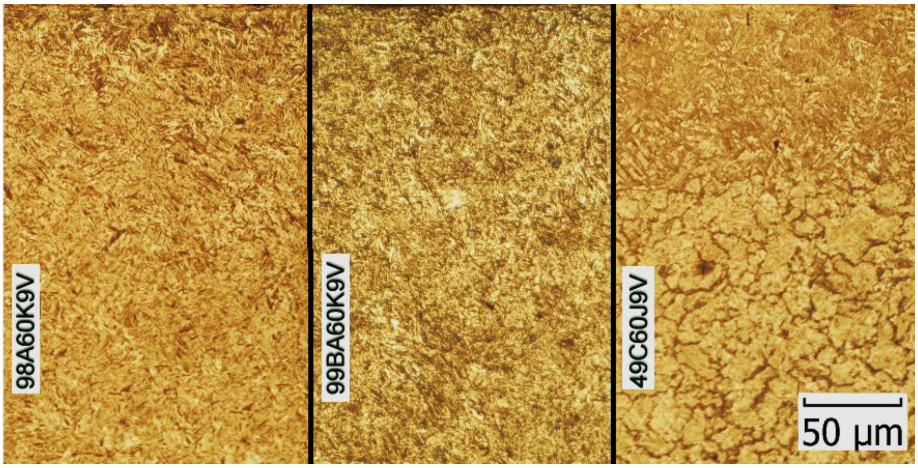

Fig. 7. Surface microstructure of the C55 steel samples in hardened state after surface grinding by using marked wheels.

The depth of microstructure changes of grinded surface of C55 steel samples in hardened state achieve average value 65 µm by using the 98A60K9V grinding wheel. The surface microstructure contains coarser martensite. After grinding surface by using the 99BA60K9V wheel was not exactly determined influenced layer, therefore we cannot determine with certainty the influenced layer thickness. This grinding wheel influences the grinded surface to very small depth which caused the minimal internal stresses in the grinded layer. The 99BA60K9V wheel was determined as better grinding wheel with compare to others. The 49C60J9V grinding wheel influences the C55 steel surface to the average 109 µm depth. Fine martensitic microstructure on the influenced surface was determined. This grinding wheel probably induced in the influenced layer highest tensile stresses which are negative influence to the grinded surface. The 49C60J9V grinding wheel is not useable to surface grinding of hardened C55 steel.

Conclusion

Analyses of grinded surfaces determined, that surfaces of hardened samples after grinding achieve a lower roughness with compare samples in delivered state (annealed state) due to higher hardness of samples. Lowest roughness was measured on 54SiCr6 steel in delivered state and hardened state too.

Hardness measurements determine that the grinding of surface layers all analysed steels is increase the surface hardness. Metallographic analysis of samples in delivered state confirmed the presence of supersaturated ferrite and grain size refinement. This proves that partially austenitisation of the surface became during grinding of surface. The austenite was cooled and transformed to the new structure in influenced surface layer. Maximum depth of influenced surface layer was measured on samples in both states after using the 49C60J9V grinding wheel. Strengthened surface layer these samples has induced unfavorable tensile stresses which can initiate and propagate crack, toughness and corrosion resistant are decrease. The surfaces grinded by 99BA60K9V and 98A60K9V wheels were influenced too, but depth of influence was lower. Best from used grinding wheels was determined by using the 99BA60K9V for both analysed states of materials. This grinding wheel has a highest purity of abrasive particles and good thermal transfer properties for effective heat remove during grinding from surface.

Inappropriate choice of grinding wheel or improper cutting conditions combination leads to negative influencing of machined surfaces. This decreases the usability of them. The contribution suggested influencing of abrasive particles to grinded surfaces.

Acknowledgements

This contribution is a part of the VEGA project of Ministry of Education, Science, Research and Sport of the Slovak Republic, No. 1/0615/12 "Influence of 5-axis grinding parameters for geometric precision of cutting shank tool".

References

[1] M.-K. Ha, J.-S. Kwak, Y.-M. Hwang, J.-S. Chung, Machining characteristics of mold material in high-speed grinding. Journal of Materials Processing Technology 155–156 (2004) 1189–1195.

[2] L. Judong, Y. Wei, H. Songwei, X. Zhilong., Experimental Study on Grinding-hardening of 1060 Steel. Enenergy Procedia 16 (2012) 103–108.

[3] P. Puerto, R. Fernández, J. Madariaga, J. Arana, I. Gallego., Evolution of Surface Roughness in Grinding and its Relationship with the Dressing Parameters and the Radial Wear. Procedia Engineering 63 (2013) 174–182.

[4] T. G. Dobrescu, N. E. Pascu, C. Opran, A. M. Bucuresteanu, Subsurface Damage in Grinding Silicon Ceramics. Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, ISSN 2304-1382, ISBN 978-3-901509-91-9, CDROM version, Ed. B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2012, pp. 0121-0124.

[5] J. Kopac, P. Krajnik, High-performance grinding - a review. Journal of Materials Processing Technology 175 (2006) 278–284.

[6] Svoboda, O., 2012. Inovace v konstrukci rovinných brusek. (Inovation in surface-grinding machine construction) MM Průmyslové spektrum, Issue 3, pp. 62.

[7] J. Moravčíková, Z. Lipa, Experimental comparison of conventional and highly abrasive abrading agents. In: Annals of DAAAM and Proceedings of DAAAM Symposium. - ISSN 1726-9679. - Vol. 19, No.1. Annals of DAAAM for 2008 & Proceedings of the 19th International DAAAM Symposium "Intelligent Manufacturing & Automation: Focus on Next Generation of Intelligent Systems and Solutions", 22-25th October 2008, Trnava, Slovakia. - Viedeň : DAAAM International, 2008. - ISBN 978-3-901509-68-1, pp. 0907-0908.

[8] Z. Lipa, J. Moravčíková, Výskum parametrov superfinišovania. (Research of superfinishing parameters) In: Technológia 2005. Technology 2005. Proceedings of 9. International Conference. Bratislava, 13.-14.9.2005. - Bratislava : STU v Bratislave, 2005. - ISBN 80-227-2264-2. pp. 451-453.

[9] Z. Lipa, J. Moravčíková, Zvláštnosti procesov mikrorezania so zvláštnym prihliadnutím na superfinišovanie. Specifies of microcutting processes with extra observing on uperinihing. In: TRANSFER 2004, Využívanie nových poznatkov v strojárskej praxi (The use of new knowledge in engineering practice). Proceedings of International scientific conference. Trenčín, 16.-17.9.2004. Alexander Dubcek University of Trencin, 2004. - ISBN 80-8075-030-0. pp. 271-274.

[10] M. Hazlinger, R. Moravčík, Ľ. Čaplovič, Degradačné procesy a predikcia životnosti materiálov (Degradation Procceses and Life Time Prediction. Bratislava, STU, 2010. - ISBN 978-80-227-3334-2, 223 p..

[11] M. Hazlinger, R. Moravčík, Chemicko-tepelné spracovanie materiálov (Chemical-heat treatment). Bratislava STU, 2013. - ISBN 978-80-227-3924-5, 169 p.

[12] Denkena, B., et al., Grinding with patterned grinding wheels. CIRP Journal of Manufacturing Science and Technology (2014), http://dx.doi.org/10.1016/j.cirpj.2014.10.005.