16th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2012, Dubai, UAE, 10-12 September 2012

EVOLUTION OF ROUGHNESS PARAMETERS ALONG POLISHING TESTS OF PREVIOUSLY GROUND SURFACES

Irene Buj-Corral, Joan Vivancos-Calvet
Universitat Politècnica de Catalunya (UPC). Department of Mechanical Engineering. School of Industrial Engineering of Barcelona (ETSEIB), Avda. Diagonal 647, 08028, Barcelona, Spain

ABSTRACT
In polishing tests, precise determination of polishing time needed is difficult, since representation of surface roughness against polishing time leads to an asymptotic curve. In the present work, results of the polishing tests of previously ground surfaces are presented. Different roughness parameters were considered. Grinding wheels of 100 and 150 Norton grain size respectively were used. Cutting speed was 25 m s^{-1} and depth of cut was 0.02 mm. Two different feeds were considered: 9 m min^{-1} and 15 m min^{-1}. A polishing test was performed by means of corundum polishing pads of grain size 2500. Results show that, the higher the initial grain size of the grinding wheel, the higher initial roughness is as expected. Amplitude roughness parameters such as Ra and Rq decrease with polishing time. Regarding material percentage parameters, Rk and Rpk decrease more sharply than amplitude roughness parameters in the first 20 s of the polishing test, and afterwards decrease slightly. Rvk decreases more slowly than amplitude roughness parameters along the polishing test.
Keywords: grinding, polishing, roughness parameters

1. INTRODUCTION
In polishing tests, roughness parameters such as *Ra* usually decrease with polishing time [1, 2]. However, behaviour of other roughness parameters in polishing operations has not been widely treated. In previous works, results were presented about polishing tests of previously ground surfaces, as well as specifications of the polishing test [3, 4]. The aim of the present paper is to study evolution of roughness parameters of previously ground surfaces along a polishing test. First, steel blocks were ground, using different grain size of abrasive and different feed speed. Then surfaces were polished and roughness was measured at different polishing times. Roughness parameters *Ra, Rq, Rk, Rpk and Rvk* were studied.

2. MATERIALS AND METHODS

2.1. Materials
WNr. 1.2344 hardened steel blocks of hardness HRC 52, of 66 x 50 x 40 mm were machined. Machined area was 66 x 6 mm.

2.2. Methods
Grinding operations
Corundum grinding wheels of grain size 100 and 150 respectively were used. Cutting speed v_c = 25 m·s^{-1}; depth of cut p = 0.02 mm; refrigerant cooling. Feed speed fr = 9 and 15 m·min^{-1}. Grinding experiments are presented in Table 1.

Table 1.Cutting conditions in the grinding experiments.

Samples	Grain size	Feed speed (m min^{-1})
2344-100	100	15
2344-101	100	9
2344-102	150	15
2344-103	150	9

Polishing operations

An automatic polishing machine Mecapol P230 was employed. Corundum polishing pads were used with grain size 2500. Parameters employed in the polishing tests are presented in Table 2.

Table 2. Characteristics of polishing tests

Force (daN)	Speed (min^{-1})	Test time (s)	Total time (s)
1.5	50	10	100

Roughness measurements

A Taylor Hobson Taylsurf Series 2 roughness stylus profilometer with Taylor Hobson µltra software (v. 4.6.8) was used. Different roughness parameters were measured: *Ra, Rq, Rk, Rpk and Rvk*. Each measuring process consisted of first measuring roughness of the ground surface and then measuring roughness after different polishing times, in order to study the evolution of roughness parameters with polishing time. Ten measurements were performed in the longitudinal direction and five measurements in the transversal direction. In the present work, results in the transversal direction (perpendicular to the grinding direction) are presented.

3. RESULTS

Results for average roughness *Ra* are presented in Figures 1.

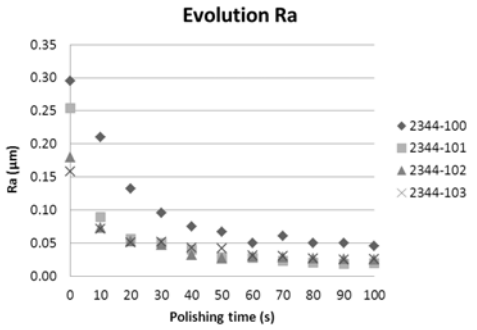

Figure 1. Roughness Ra in polishing experiments

According to average roughness *Ra*, time required to finish the polishing process is 40 s for samples 2344-101, 2344-102 and 2344-103, while time required to finish the polishing process for sample 2344-100 is 60 s. After this required polishing time, *Ra* roughness parameter does not remarkably decrease with more polishing time. Final roughness for sample 2344-100 is higher than that for samples 2344-101, 2344-102 and 2344-103. Results agree with those obtained by Wu and Wang, in which if initial roughness values is too high for a certain grain size of polishing abrasive, polishing abrasive grain is not able to reduce roughness to the expected value, since the polishing grains wear out before achieving expected roughness [1].

Amplitude roughness parameter *Ra* decreases with polishing time as expected. Initial *Ra* values are higher for samples obtained with high grain size than for those obtained at low grain size. When comparing two samples obtained with the same grain size, those machined at high feed speed present higher roughness than those obtained at low feed speed.

Figure 2 shows results for roughness parameters *Rq*, *Rk*, *Rpk* and *Rvk*.

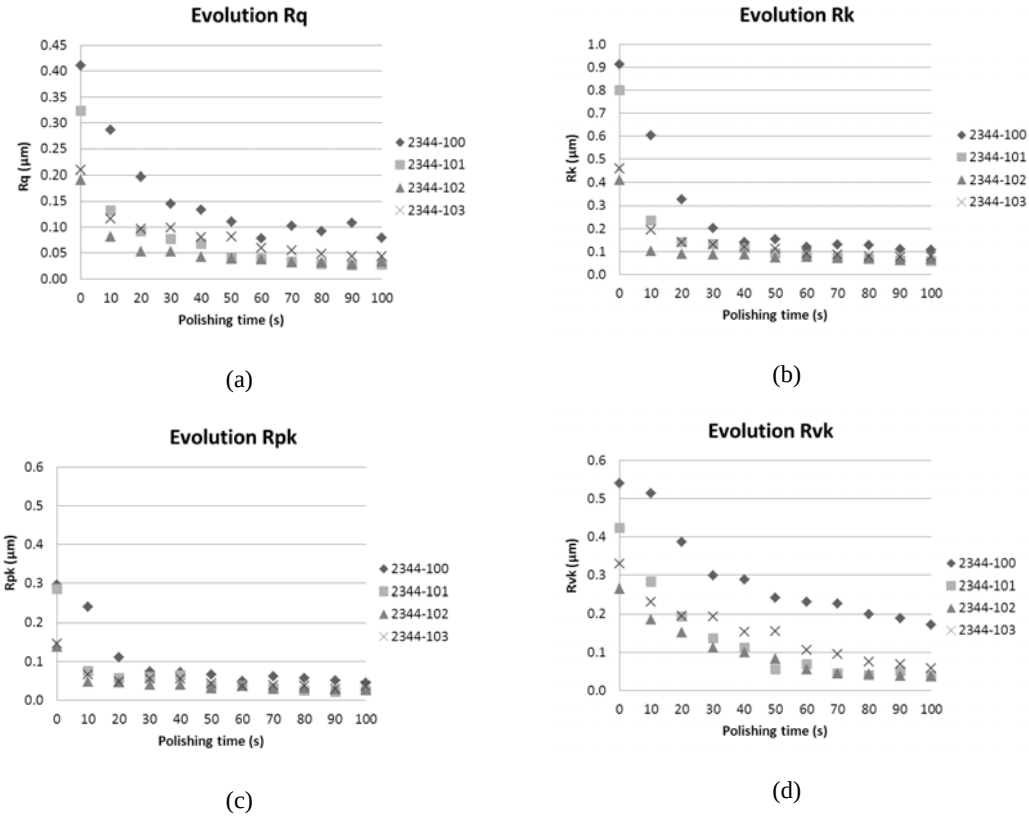

Figure 2.Roughness parameters in polishing experiments: a) Rq, b) Rk, c) Rpk, d) Rvk

Roughness parameter *Rq*, which is an average roughness parameter similar to *Ra*, shows the same behaviour than *Ra*. Material percentage parameters also decrease with polishing time. *Rk* and *Rpk* decrease markedly in the first 30 s of the polishing test, and then they decrease slightly. *Rvk* decreases in a smoother way along the polishing test. In this case, *Rvk* values of sample 2344-100 along the polishing test are higher than *Rvk* values for the rest of the samples. Polishing abrasive is not able to remove valleys of the initial ground surface.

In Figure 3 the magnified pictures (4x) of sample 2344-101 are presented:

Figure 3. Magnified photographs (4x) of sample 2344-101: a) ground sample, b) polished sample

Ground samples show marks in the longitudinal direction of the grinding machine. Polished samples present marks whose directions are randomly distributed on the workpiece's surface.

4. CONCLUSIONS

Amplitude roughness parameters *Ra* and *Rq* decrease with polishing time as expected. Regarding material percentage parameters, *Rk* and *Rpk* decrease markedly in the first stages of the polishing test, while *Rvk* decreases more smoothly than amplitude roughness parameters along the polishing test. If initial roughness is too high compared to polishing abrasive grain size, along the polishing test it is not possible to completely remove valleys from the previous grinding operation.

5. ACKNOWLEDGEMENTS

The authors thank Mr. Ramón Casado-López for his help with experimental tests, Mr. Alejandro Domínguez-Fernández for his help with roughness measurements and Mr. Oscar Baró-Rius for his help with data treatment.

6. REFERENCES

[1] Wu B.H., Wang, J.-J. A neuro-fuzzy approach to generating mold/die polishing sequences. Journal of Materials Processing Technology 209:3241-3250. 2009.

[2] Zhong Z., Venkatesh V.C. Semi-ductile grinding and polishing of ophthalmic aspherics and spherics. Annals of the CIRP, 44(1): 339-342. 1995.

[3] Buj-Corral I., Vivancos-Calvet J. Comparison of polishing time of previously milled samples at different cutting conditions. Proceedings of the 15th International Research/Expert Conference" Trends in the Development of Machinery and Associated Technology", TMT 2011, Prague, 2011, 61-64.

[4] Buj-Corral I., Vivancos-Calvet J., Casado-López R.: Methodology and adjustment of the test for determining the polishing difficulty degree of hardened steel surfaces, previously obtained by high-speed milling processes. Proceedings of the 14th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2010. Mediterranean Cruise, 2010, 37-40.