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INFLUENCE OF DIAMOND BURNISHING ON CORE HEIGHT AN TEN-POINT HEIGHT

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Abstract. *Diamond burnishing is a cold plastic forming process, which used as surface improvement finishing treatment after conventional chip removal procedures. This paper presents the experimental study of the impact of different burnishing parameters on 3D surface roughness on cylindrical low alloyed aluminium workpieces. To carry out comparative analysis, measurement of surface roughness was implemented before and after burnishing with an Altisurf 520 measuring device. The results enable a more accurate understanding of the processes that take place during the procedure and, for industrial applications, can help reduce machining time and costs by better defining the set-up parameters.*

Keywords: *3D roughness parameters; diamond burnishing; surface integrity*; *polycrystalline diamond tool.*

1. Introduction

Surface quality always plays a very important role in the proper design of machine parts with properties that can positively influence, for example, lifetime, wear and corrosion resistance, contact stiffness, vibration, etc. For traditional machining processes, many researchers have shown that the required surface quality can be achieved by setting the right parameter combinations [1–4]. For this reason, in this research work I study a non-cutting finishing method, the sliding burnishing which reduces the roughness parameters of the component and contributes to better corrosion resistance. This is due to the fact that, compressive residual stresses are formed in the near-surface layer, thereby increasing the microhardness of it. The process also results in increased fatigue strength, greater resistance to frictional fatigue, and reduced wear.

Several researchers have worked on analysing burnished surface roughness, in addition more and more scientists became convinced that the third dimension should be added to the surface analysis [1]. Korzynski et al. [5] investigated the influence of tool tip radius, burnishing force and feed on 28 different 3D surface roughness parameters in the case of machining austenitic stainless steel 317Ti. To plan and execute experiments they used the so-called Hartley plan, and the most important finding of their work is that with the applied setting parameters, all but one of the obtained equations is non-linear. The only linear equation concerns the S_{tr} roughness parameter, which is a measure of uniformity of the surface texture. Swirad also used Hartley plan in his study [6], but the input parameters considered in it include speed, force and line-to-line pitch. According to results, he observed that burnishing force exerts the greatest influence on the values of the indicators of the geometric structure. Kebede and Felho [7] used orthogonal L9 array Taguchi design to examine the impact of burnishing force, feed rate and number of passes on 3D surface roughness of medium carbon steel after CNC milling process. One of their important observations is the similarity of the responses between pairs of surface roughness parameters: S_q and S_a, as well as S_v and S_z, showed similar trends with the change of the burnishing parameters.

In this paper, I examine the effect of burnishing force (F), feed (f), speed (v), and number passes (i) on 2 kinds of 3D roughness parameters (S_k, S_{10z}) investigating the correlation between these setting parameters on low alloyed aluminium workpieces

2. Execution of diamond burnishing

During burnishing of cylindrical surfaces, a deforming tool moves under burnishing force over the surface of the workpieces which rotates at a given speed, thus elastic-plastic deformation takes place on the near-surface layer [810] as shown in Figure 1.

Purpose of the application of this finishing process to improve surface roughness, increase lifetime by increasing compression residual stress and hardness of the near-surface layer [12, 13]. In this experiment the surface of the workpiece was pre-machined by finishing turning set at $f_1 = 0.2$ than $f_2 = 0.15$ mm/rev, then the burnishing operation was executed with the same machine (E400 universal lathe) applying 3.5 mm radius PCD (polycrystalline diamond) tool and manual dosing oil, which kinematic viscosity was $\nu = 70$ mm^2/s.

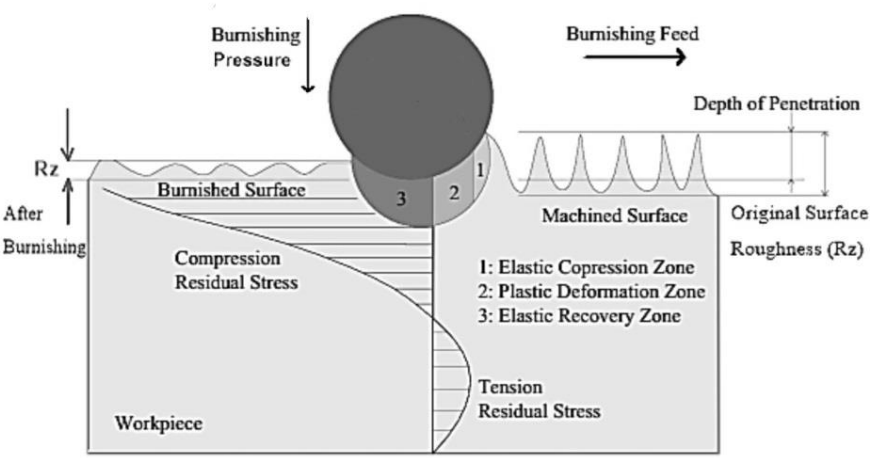

Figure 1. Schematic representation of burnishing treatment [11]

Table 1 contains the adjusted polishing parameters, which were determined based on the preliminary experimental work and taking account the mechanical properties of the burnished workpiece material.

Table 1, The numerical value of the examined burnishing parameters

No	F [N]	f [mm/rev]	v [m/min]	i [-]
1	15	0.05	50.54	2
2	25	0.05	50.54	2
3	35	0.05	50.54	2
4	25	0.01	50.54	2
5	25	0.1	50.54	2
6	25	0.05	35.71	2
7	25	0.05	71.43	2
8	25	0.05	50.54	1
9	25	0.05	50.54	3

3. Measurement of 3d surface roughness

3D roughness measurement of the turned and burnished surfaces on 3 areas of 2x2 mm – rotated by 120° - were conducted on Altisurf 520 surface profiler, equipped with a CL2 confocal chromatic sensor and MG140 magnifier. The results were evaluated with the Altimap Premium software, Figure 2 shows a state during the measurement process.

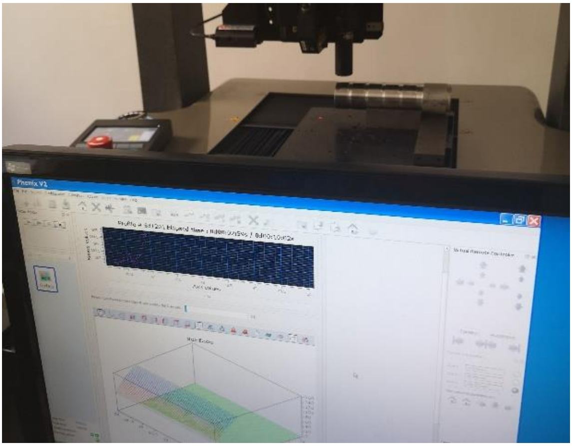

Figure 2. State during measurement

3D roughness parameters can be classified into 6 groups, from them a functional (S_k) and a feature parameter (S_{10z}) were examined. Core height (S_k) means the difference between the upper and lower levels of the core and its values are calculated from the linear curve (equivalent linear curve) minimizing the sectional inclination corresponding to 40% of the material ratio curve, as it can be seen in Figure 3. This parameter is suitable for evaluating friction, abrasion and lubricity for engine cylinder surfaces.

Ten-point height of surface (S_{10z}) is the average value of the heights of the five peaks (hill area) with the largest global peak height added to the average value of the heights of the five pits (dale area) with the largest global pit height.

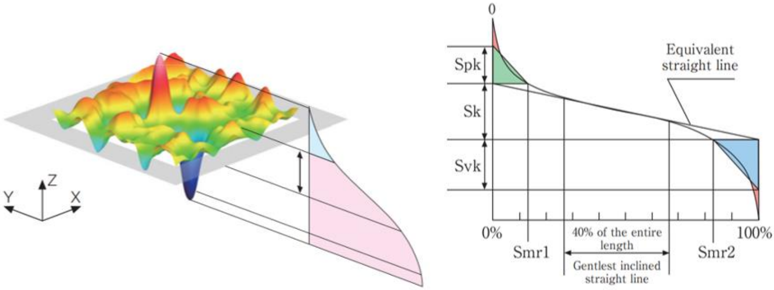

Figure 3. Identification of core height [15]

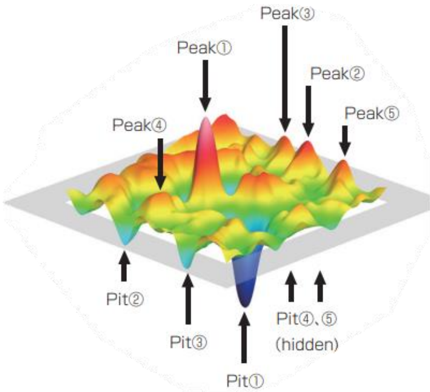

Figure 4. Identification of ten-point height [15]

4. Results and discussion

Table 2 summarizes the averaged values of the measured roughness parameters and contains dimensionless ratios that were created to make more illustrative the changes.

The calculations were made according to El-Taweel and El-Axir [16]:

$$\Delta\rho_{S_x}\% = \left(\frac{S_{x_{before}} - S_{x_{after}}}{S_{x_{before}}}\right) \cdot 100\%, \quad (1)$$

where:

$S_{x\ before}$	Surface roughness parameter measured after turning,
$S_{x\ after}$	Surface roughness parameter measured after burnishing,
$\Delta\rho S_x\%$	Percentage value of the calculated ratio.

Table 2, The results of S_k and S_{10z} with the calculated ratios of the experiment.

No.	**S_k [µm]**		**$\Delta\rho_{S_k}$ [%]**	**S_{10z} [µm]**		**$\Delta\rho_{S_{10z}}$ [%]**
	before	**after**		**before**	**after**	
1	3.2382	2.2516	30.4675	5.0187	3.4009	32.2354
2	2.9783	0.8761	70.5838	4.4061	2.6265	40.3894
3	0.8095	0.9067	-12.0074	3.4399	2.1603	37.1988
4	0.8347	0.9178	-9.9557	2.6209	2.3119	11.7898
5	0.8441	1.0632	-25.9576	2.8703	3.4611	-20.5832
6	3.2769	0.9292	71.6439	4.4580	2.6404	40.7716
7	3.0443	0.9465	68.9091	5.2193	2.7146	47.9892
8	3.4675	1.3365	61.4564	3.7883	2.7620	27.0913
9	3.6189	1.0423	71.1984	3.7851	3.7113	1.9497

The higher the value of the dimensionless ratios, the greater the improvement due to burnishing process. Table 2 clearly shows that the most advantageous parameter settings were in the cases of marked "6" and "7" surfaces, while the most unfavourable parameter setting belongs to the "5" surface. Figure 5-6 show the topography of marked "6" and "7" before and after burnishing.

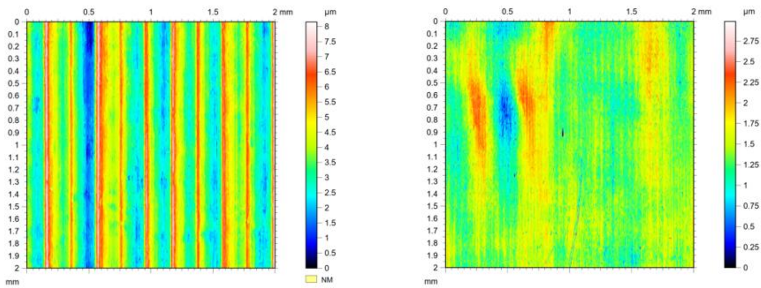

Figure 5. Surface topography of "6" surface before (left) and after (right) burnishing process

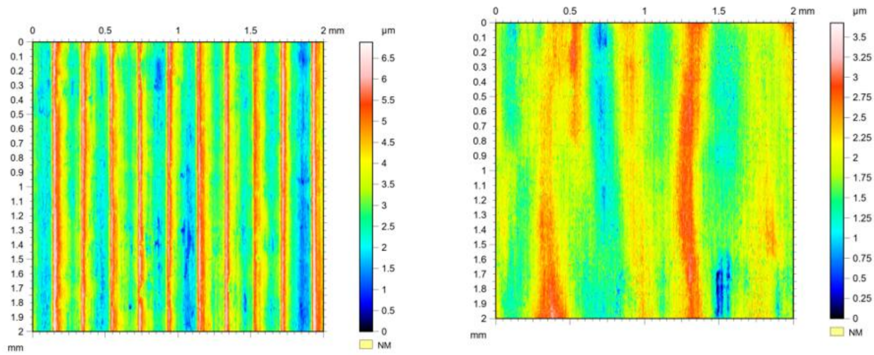

Figure 6. Surface topography of “7” surface before (left) and after (right) burnishing process

Effect of the examined burnishing parameters are presented in Diagram 1-4.

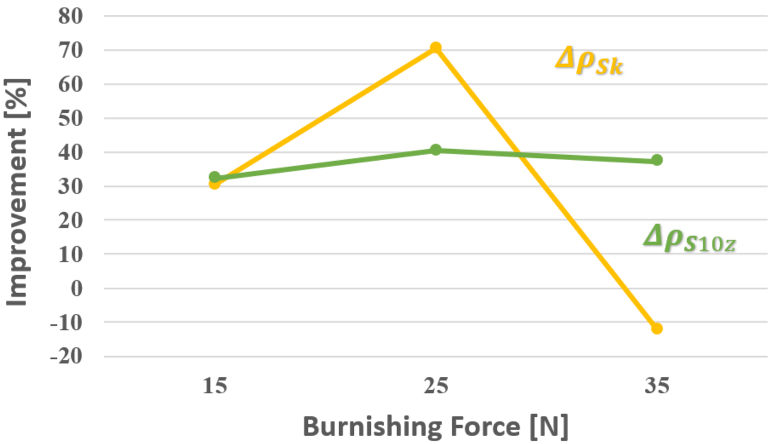

Diagram 1. Influence of burnishing force on the analysed parameters

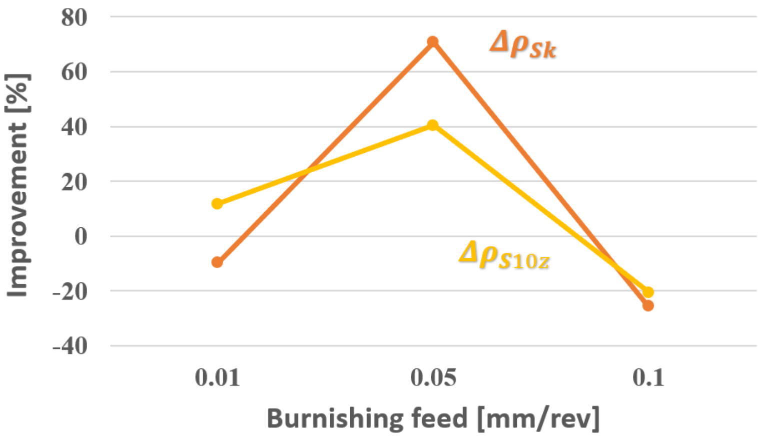

Diagram 2. Influence of feed rate on the analysed parameters

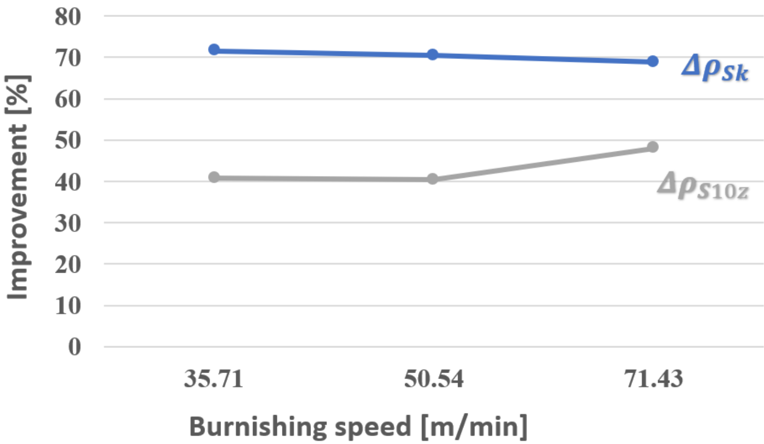

Diagram 3. Influence of burnishing speed on the analysed parameters

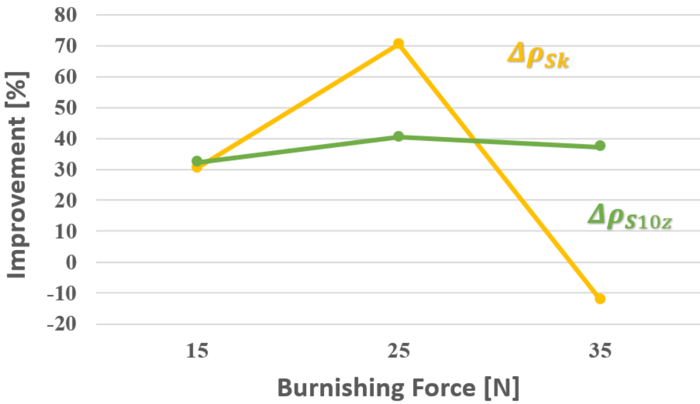

Diagram 4. Influence of number of passes on the analysed parameters

5. Summary

The paper presents the experimental investigation of burnishing process on cylindrical low alloyed aluminium workpieces, in which the analysed setting parameters were burnishing force, feed rate, speed and number of passes. The aim of the study was to examine the impact of these parameters on two different 3D surface roughness parameters: core height (S_k) and ten-point height (S_{10z}). Dimensionless ratios were designed to study the changes caused by burnishing and to make it even more obvious diagrams were created for each burnishing parameter. According to the measured, calculated and illustrated results, following statements can be made:

- As shown by the topography in Figures 6 and 7, the process corrected micro-threading caused by turning and reduced the distance between peaks and valleys.
- The most favourable changes in surface roughness were experienced in the cases of marked 6 and 7, when burnishing force was set to 15 N, feed rate was 0.05 mm/rev with 2 number of passes, while the speed was set to the higher values.

- Based on the diagrams, the middle values of the parameter ranges were the most advantageous and it can also be observed that changing the burnishing speed has only a small effect on the surface roughnes

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Вікторія Ференчик, Мішкольц, Угорщина

ВПЛИВ АЛМАЗНОГО ВИГЛАДЖУВАННЯ НА СЕРЕДНЄ ЗНАЧЕННЯ ВИСОТИ НЕРІВНОСТЕЙ ПОВЕРХНІ (Rz)

Анотація. *Якість поверхні завжди відіграє дуже важливу роль у правильному проектуванні деталей машини з властивостями, які можуть позитивно вплинути, наприклад, на термін служби, зносостійкість та корозію, жорсткість контакту, вібрацію тощо. Для традиційних процесів обробки багато дослідників показали, що необхідної якості поверхні можна досягти* *шляхом встановлення правильних комбінацій параметрів [1-4]. З цієї причини в даній дослідницькій роботі я вивчаю метод фінішної обробки, що не ріжеться, ковзаюче вигладжування, яке знижує параметри шорсткості компонента і сприяє кращій корозійної стійкості. Це пов'язано з тим, що в приповерхневому шарі утворюються залишкові напруги стиснення, які тим самим підвищують його мікротвердість. Цей процес також призводить до підвищення втомної міцності, більшої стійкості до втоми від тертя та зменшення зносу. Алмазне вигладжування – це процес холодного пластичного формування, який використовується як фінішна обробка для покращення поверхні після звичайних процедур видалення стружки. Під час шліфування циліндричних поверхонь деформуючий інструмент переміщається під дією випалювальної сили по поверхні заготовок, яка обертається із заданою швидкістю, при цьому на приповерхневому шарі відбувається пружно-пластична деформація. У статті представлено експериментальне дослідження впливу різних параметрів вигладжування на шорсткість 3D поверхні на циліндричних заготовках з низьколегованого алюмінію. Для проведення порівняльного аналізу було реалізовано вимірювання шорсткості поверхні до і після шліфування вимірювальним приладом Altisurf 520. Результати дозволяють більш точно розуміти процеси, які відбуваються під час процедури, і для промислового застосування можуть допомогти скоротити час і витрати на обробку за рахунок кращого визначення параметрів налаштування.*

Ключові слова: *3D параметри шорсткості; алмазне вигладжування; цілісність поверхні; полікристалічний алмазний інструмент.*