

BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 72 (76), Numărul 2, 2026
Secția
CONSTRUCȚII DE MAȘINI
DOI: 10.2478/bipcm-2026-0020

AN EXPERIMENTAL EVALUATION OF THE OPERATIONAL CAPABILITIES OF A DIAMOND-TIPPED COLD BURNISHING TOOL

BY

**COSMIN-GABRIEL GRĂDINARU*, GHEORGHE NAGÎȚ, VLADA ȚISARI,
VASILE ERMOLAI, ALEXANDRU-IONUȚ IRIMIA and
NICOLAE-RĂZVAN MITITELU**

“Gheorghe Asachi” Technical University of Iași,
Faculty of Machine Manufacturing and Industrial Management, Iași, Romania

Received: June 5, 2026

Accepted for publication: June 20, 2026

Abstract. Cold burnishing is a finishing process that improves the mechanical properties of metal components without removing material. It works by compressing and smoothing surface irregularities, inducing residual compressive stresses and increasing surface hardness, which enhances durability and surface quality. This paper focuses on slide diamond burnishing (SDB), a method that uses a diamond tool with high hardness, low friction, and good thermal conductivity to achieve superior finishes, even on difficult materials. The study investigates the tool's performance on external cylindrical surfaces using minimum quantity lubrication (MQL), while varying key parameters such as spindle speed, feed rate, and working depth. A comparison between conventional turning and diamond burnishing is made using roughness parameters Ra and Rz. Results show a significant reduction in surface roughness and the achievement of near mirror-like finishes, demonstrating that diamond burnishing is an effective and sustainable alternative to grinding and polishing.

*Corresponding author; *e-mail*: cosmin-gabriel.gradinaru@student.tuiasi.ro

© 2026 Cosmin-Gabriel Grădinaru et al.

This is an open access article licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (CC BY-NC-ND 4.0).

Keywords: Slide Diamond Burnishing (SDB), Surface Quality, Roughness Improvement.

1. Introduction

Given the increasingly demanding requirements for components produced in industrial engineering, as well as the growing competition among manufacturers, the efficient use of finishing technologies is a highly relevant topic. Cold hardening with diamond tips (diamond burnishing) stands out as a chipless surface finishing method that utilizes a fixed, highly hard deforming element pressing against the workpiece surface to improve the quality of the affected surface layer. This includes reducing roughness, the friction coefficient, and dimensional and geometric tolerances, while also increasing hardness, fatigue strength, and wear resistance (Grădinaru and Nagit, 2025; Maximov *et al.*, 2019).

Global interest in the burnishing process is continuously growing, as it is recognized as an economical and efficient method for improving surface integrity. To provide an overview, Maximov and Duncheva systematized the effects of diamond burnishing on operational behavior (fatigue, wear, corrosion) and highlighted the challenges of finite element simulations (Duncheva *et al.*, 2024), while Raza and Kumar conducted a critical analysis of burnishing tool design, emphasizing the plastic deformation mechanism of asperities and the influence of technological parameters (Raza and Kumar, 2022).

The optimization of machining parameters and their effects on the microstructure have been deeply studied, particularly on stainless steels. Varga & Markopoulos investigated the tribological aspects of diamond burnishing on X5CrNi18-10 steel, utilizing a factorial design to determine the optimal regime (55.578 m/min cutting speed, 0.050 mm/rev feed rate, 50 N force) that maximizes 3D roughness reduction (Varga and Markopoulos, 2025). On a similar material (X2CrNiMo17-12-2), Dyl *et al.* demonstrated that this process not only reduces roughness but also orients the crystalline grains in the surface layer in the direction of deformation, leading to significant hardening without generating cracks (Dyl *et al.*, 2024).

Another important aspect investigated in recent literature is the influence of the process environment, with several studies demonstrating the superiority of lubrication over dry processing. Beșliu-Băncescu and Slătineanu showed that the application of minimum quantity lubrication (MQL) during the burnishing of EN AW-2007 aluminum significantly decreases working forces, temperature, and roughness (Beșliu-Băncescu and Slătineanu, 2025). Similarly, Nagiț *et al.* confirmed, through empirical mathematical models, the beneficial effect of the lubricant on the final roughness in the vibro-burnishing of steel, also noting that the initial roughness has the greatest impact on the result (Nagiț *et al.*, 2022).

Furthermore, Zaleski and Skoczylas highlighted that the addition of surfactant solutions to the machining fluids further increases the microhardness and fatigue strength of titanium alloy parts (Zaleski and Skoczylas, 2019).

For quality prediction and control, advanced modeling techniques and Artificial Intelligence are becoming indispensable. Felhő and Varga validated the use of CAD modeling and 2D finite element method (FEM) simulations to accurately approximate theoretical roughness based on the surface topography left by prior turning operations (Felhő and Varga, 2022). Advancing to a higher level of optimization, Le et al. integrated artificial neural networks (BRFFNN) and genetic algorithms (NSGA-G) to predict and optimize diamond burnishing under MQL cooling with vortex tubes, achieving a 40.7% reduction in roughness and a 7.6% increase in hardness (Le *et al.*, 2023).

The present paper experimentally evaluates the performance of a diamond cold burnishing tool (Fig. 1) on external cylindrical surfaces under minimum quantity lubrication (MQL) conditions. The study analyzes, in a preliminary stage, the influence of varying the spindle speed, feed rate, and depth of working on surface quality. The central objective is to compare conventional turning with diamond burnishing, based on the roughness parameters R_a and R_z , to validate this process as a sustainable alternative—capable of generating mirror-like surface superior to classic grinding and polishing operations, in which some authors obtained $R_a = 0.38\text{--}0.95\text{ }\mu\text{m}$ and $R_z = 1.77\text{--}4.52\text{ }\mu\text{m}$ (Tien *et al.*, 2021) or $R_a = 0.333\text{--}1.000\text{ }\mu\text{m}$ (Rekha *et al.*, 2022).

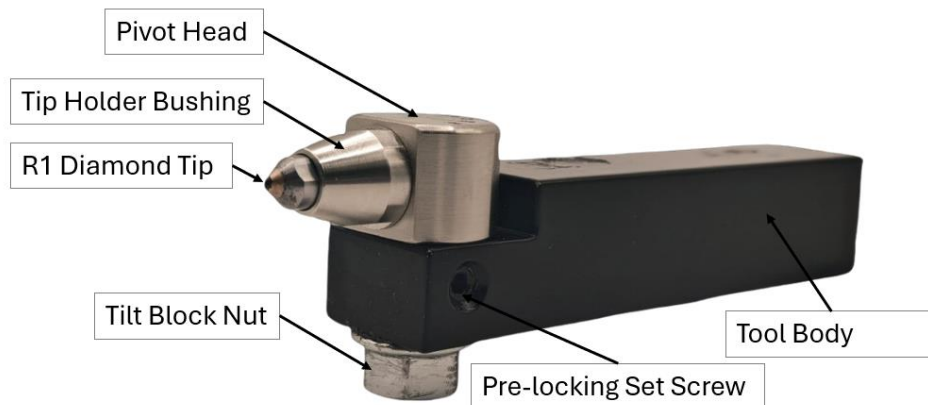


Fig. 1 – SDB burnishing tool.

2. Research Methodology

To carry out the research topic presented in this paper, a systematic methodology was implemented. The experimental procedure consisted of several distinct steps, as follows:



The first one consists of defining the research objective, namely evaluating the capabilities of a diamond-tipped burnishing tool in finishing external cylindrical surfaces. The workpiece is made of E355 material (a specific steel for tubes, widely used, exhibiting superior mechanical properties), in the form a pipe with an external diameter of 41.5 mm after turning (the machining parameters for the final pass are $V_c = 66.41$ m/min, $f = 0.096$ mm/rev, and $a_p = 0.4$ mm). The surface roughness obtained after turning is $5.39 \mu\text{m}$ for the R_a parameter and $28 \mu\text{m}$ for R_z (values obtained from the arithmetic mean of three measurements taken along different zones). The chemical and mechanical properties can be observed in Table 1, according to the EN 10297-1:2006 standard.

Table 1
Chemical composition and mechanical properties of E355

Element	Percentage [%]	Me. property	Value
C	Max. 0.22	Tensile strength	490 – 630 MPa
Si	Max. 0.55	Yield strength	≥ 355 MPa
Mn	Max. 1.60	Young modulus	~ 210 GPa
P	Max. 0.030	Density	~ 7.85 g/cm ³
S	Max. 0.035	Hardness	$\sim 150 - 170$ HB

To conduct the experiments, the workpiece was clamped in the universal lathe chuck at one end and supported by a rotational center at the other, being subjected to a primary rotational motion. The tool was mounted in the tool holder,

executing the secondary feed motion, as shown in Fig. 2. The machining operations were performed using a cooling and lubricating fluid, specifically a mineral oil (ISO VG 68). Its kinematic viscosity is approximately $68 \text{ mm}^2/\text{s}$ at 40°C , with a density of 880 kg/m^3 at 15°C , ensuring efficient lubrication and a significant reduction in friction between the workpiece and the deforming element, thereby minimizing tool wear.

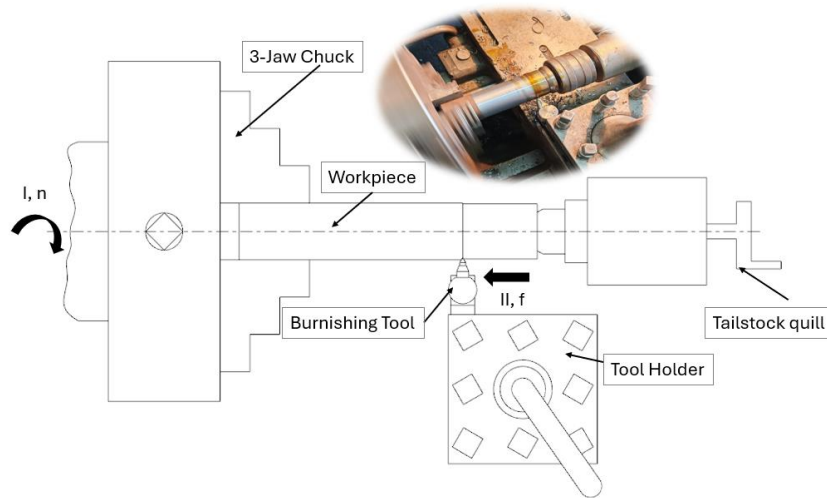


Fig. 2 – Experimental setup.

In order to evaluate the tool's behavior under variable machining conditions, the workpiece was divided into five distinct sections, with a different set of burnishing parameters applied to each. The selection of these values was grounded in an analysis of the specialized literature. The experimental strategy consisted of initiating the process with parameters capable of ensuring optimal surface quality, followed by the gradual incrementation of certain variables to enable a relevant comparative analysis. The exact values of the burnishing regime corresponding to each segment are detailed in Table 2.

Table 2
Variance of burnishing parameters for each segment

Segment No.	Burnishing speed V [m/min]	Feed f [mm/rev]	Depth t [mm]
1	52.12	0.024	0.1
2	52.12	0.024	0.15
3	52.12	0.053	0.1
4	65.16	0.053	0.15
5	65.16	0.096	0.15

Roughness data acquisition was conducted using the Surtronic S25 device, which is capable of generating and storing complex surface profiles. The testing methodology required taking three independent measurements for each individual experiment; to reduce the influence of errors, the arithmetic mean of these three measurements was considered as the reference value.

The percentage of surface roughness improvement (Δ_r) relative to the initial turned surface was calculated using Eq. (1).

$$\Delta_r = \frac{R_i - R_f}{R_i} \cdot 100 [\%] \quad (1)$$

Where R_i is the roughness (R_a/R_z) after turning and R_f after the SDB.

3. Results

An initial analysis of the profilograms obtained after turning (Fig. 3a) and after SDB (Fig. 3b) highlights that this tool successfully finishes external cylindrical surfaces under various working conditions. The graphical analysis reveals a transition from a pronounced geometric roughness to one with enhanced functional characteristics. Thus, while the turned surface (Fig. 3a) exhibits sharp irregularities with high amplitude, the SDB-finished surface (Fig. 3b) illustrates the direct effect of localized plastic deformation. The material from the asperity peaks was compressed and it moved into the valleys, attenuating the initial harshness of the profile and generating a much more uniform and stable contact surface.

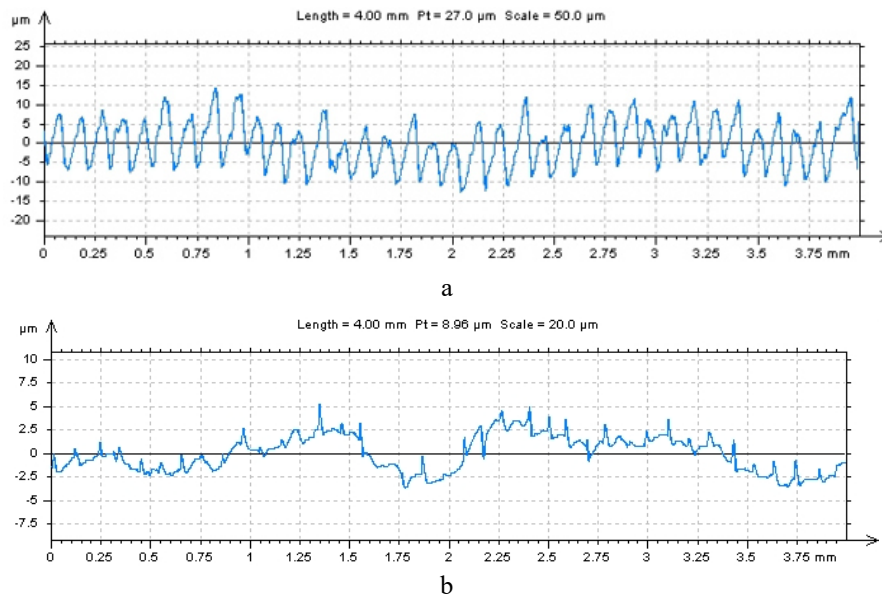


Fig. 3 – Surface roughness profile: (a) after turning; (b) after SDB.

Consequently, after the roughness measurements, the results can be observed in Table 3, alongside the percentage of improvement (Δ_r) achieved after SDB, for each of the two analyzed parameters (R_a and R_z).

Table 3
The results of the research

Exp. No.	R_a [μm]	Δ_r [μm]	R_z [μm]	Δ_r [μm]
1	0.541	89.956	3.350	88.035
2	0.794	85.269	4.296	84.654
3	0.871	83.828	5.923	78.845
4	0.900	83.296	5.640	79.857
5	1.156	78.540	6.386	77.190

Furthermore, the illustration of the improvement percentages can be observed in Fig. 4.

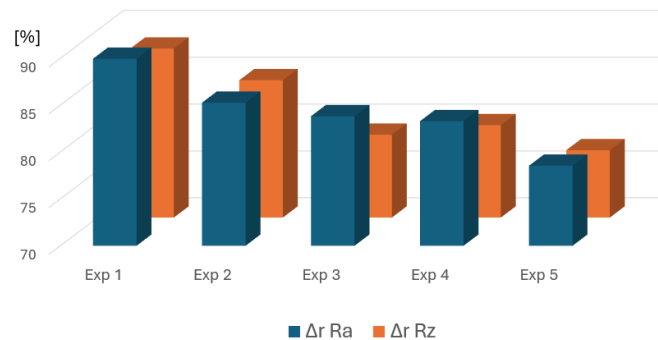


Fig. 4 – Percentage of roughness improvement for each experiment.

The analysis of the experimental data reveals a significant influence of the machining parameters on the quality of the surface processed by SDB. The best results, reflected by the minimum roughness values ($R_a = 0.541 \mu\text{m}$ and $R_z = 3.350 \mu\text{m}$), were obtained in Experiment 1, utilizing a burnishing speed of 52.12 m/min, a minimum feed rate of 0.024 mm/rev, and a working depth of 0.1 mm. In this case, the highest percentage of surface improvement compared to the initial state was also recorded, exceeding 88% for both analyzed parameters.

As the operational parameters—particularly the feed rate—were increased, a gradual degradation of the surface quality was observed. For example, in Experiments 3 and 4, where the feed rate was doubled to 0.053 mm/rev, the R_a roughness values increased to approximately 0.87 - 0.90 μm , and the improvement percentage dropped below 84%. This trend suggests that a

higher feed rate reduces the contact time and the plastic deformation force per unit area, thereby limiting the tool's capacity to completely flatten the asperities left by the previous machining operation.

The most pronounced decrease in process efficiency was observed in Experiment 5, where the maximum speed (65.16 m/min), the maximum feed rate (0.096 mm/rev), and a depth of 0.15 mm were applied simultaneously. Under these conditions, the highest final roughness ($R_a = 1.156 \mu\text{m}$) and the lowest improvement percentage ($\Delta_r = 78.54\%$ for R_a) were recorded. Therefore, to maximize the smoothing effect and achieve a surface with superior tribological characteristics, it is recommended to use moderate values for speed and depth, together with a low feed rate.

4. Conclusions

Following the analysis of the experimental results, it can be concluded that the tested slide diamond burnishing tool demonstrates the capability to successfully process external cylindrical surfaces. The method has proven to be a reliable and efficient solution for significantly improving the surface condition of E355 steel workpieces, successfully eliminating the microgeometric defects left by the prior turning operation. The fact that roughness improvement percentages of over 88% (up to $R_a = 0.541 \mu\text{m}$ and $R_z = 3.350 \mu\text{m}$) were recorded confirms the potential of this technology to substitute classic finishing operations, such as grinding, yielding benefits regarding the final product quality.

Furthermore, the systematic testing of the tool under various kinematic conditions highlighted the critical importance of optimally selecting the processing parameters. It was demonstrated that the maximum performance of the burnishing process is achieved by utilizing low feed rate values (0.024 mm/rev), correlated with moderate speeds and depths. An aggressive increase in these parameters, particularly the feed rate, leads to a limitation of the plastic deformation effect and a decrease in the roughness improvement rate. This dependency underlines the necessity of precisely calibrating the burnishing regime for each individual application.

The paper validates the tool's performance and attests to the viability of the SDB process as a finishing method. It provides a technological alternative capable not only of ensuring minimum roughness but also of imparting superior tribological and mechanical characteristics to the machined surface, which are essential for extending the service life of mechanical components subjected to stress and wear. In the future, research will focus on precisely determining how the processing regime influences the quality of the surface layer (roughness, hardness, wear, and corrosion resistance). To this end, factorial experimental designs will be implemented, including the application of the Taguchi method, to identify the optimal combination of technological parameters.

REFERENCES

- Beșliu-Băncescu I., Slătineanu L., *Influence of Machining Environments on the Burnishing Performance of Aluminum Alloy EN AW-2007*, Lubricants, 13(8), 368 (2025), DOI 10.3390/lubricants13080368.
- Duncheva G., Maximov J., Anchev A., Dunchev V., Anastasov K., Argirov Y., *Effect of Roller Burnishing and Slide Roller Burnishing on Fatigue Strength of AISI 304 Steel: Comparative Analysis*, Metals, 14(6), 710 (2024), DOI 10.3390/met14060710.
- Dyl T., Rydz D., Szarek A., Stradomski G., Fik J., Opydo M., *The Influence of Slide Burnishing on the Technological Quality of X2CrNiMo17-12-2 Steel*, Materials, 17(14), 3403 (2024).
- Felhő C., Varga G., *CAD and FEM Modelling of Theoretical Roughness in Diamond Burnishing*, International Journal of Precision Engineering and Manufacturing, 23(4), 375-384 (2022), DOI 10.3390/ma17143403.
- Gradinaru C.-G., Nagîț Gh., *Study on the Application Limitations of a Cold Rolling Device for Internal Cylindrical Surfaces*, Bul. Inst. Polit Iași, Machine Constructions Section, 71, 45-57 (2025), DOI 10.2478/bipcm-2025-0004.
- Le M.-T., Le Van A., Nguyen T.-T., *Impacts of Burnishing Variables on the Quality Indicators in a Single Diamond Burnishing Operation*, Strojniški vestnik - Journal of Mechanical Engineering, 69(3-4), 155-168 (2023), DOI 10.5545/sv-jme.2022.303.
- Maximov J.T., Duncheva G.V., Anchev A.P., Ichkova M.D., *Slide Burnishing—Review and Prospects*, The International Journal of Advanced Manufacturing Technology, 104(1-4), 785-801 (2019), DOI 10.1007/s00170-019-03881-1.
- Nagîț Gh., Slătineanu L., Dodun O., Păunoiu V., Mihalache M.-A., Rîpanu M.-I., Hrițuc A., Surugiu I., *The Influence of Lubrication on the Roughness of the Vibroburnished Surface*, MATEC Web of Conferences, 368, 01002 (2022), DOI 10.1051/mateconf/202236801002.
- Raza A., Kumar S., *A Critical Review of Tool Design in Burnishing Process*, Tribology International, 174, 107717 (2022).
- Rekha R., Kumar S.V., Raj V.A., Baboo B.A., Raj P.G., Vignesh A.J., *Optimization of cylindrical grinding process parameters on austenitic stainless steel 304 using Taguchi based Grey Relational Analysis*, Mater. Tod.: Proceed., 72, 2569-2573 (2023), DOI 10.1016/j.matpr.2022.10.120.
- Tien D.H., Trung D.D., Thien N.V., Nguyen N.-T., *Multi-Objective Optimization of the Cylindrical Grinding Process of SCM440 Steel Using Preference Selection Index Method*, Journal of Machine Engineering, 21(3), 110-123 (2021), DOI: 10.36897/jme/141607.
- Varga G., Markopoulos A.P., *Tribological Aspects of Slide Friction Diamond Burnishing Process*, Materials, 18(19), 4500 (2025), DOI 10.1016/j.triboint.2022.107717.
- Zaleski K., Skoczylas A., *Effect of Slide Burnishing on the Surface Layer and Fatigue Life of Titanium Alloy Parts*, Advan. in Mater. Scien., 19(4), 35-45 (2019), DOI 10.2478/adms-2019-0018.
- ** EN 10297-1:2006, *Seamless circular steel tubes for mechanical and general engineering purposes - Technical delivery conditions - Part 1: Non-alloy and alloy steel tubes*.

EVALUAREA EXPERIMENTALĂ A PERFORMANTELOR
DE LUCRU ALE UNEI SCULE CU VÂRF DE DIAMANT DESTINATE
DURIFICĂRII SUPERFICIALE LA RECE

(Rezumat)

Netezirea suprafețelor prin deformare plastică la rece este un procedeu de finisare care îmbunătățește proprietățile mecanice ale componentelor metalice fără a implica îndepărtarea de material. Procedeu constă în comprimarea și aplatizarea neregularităților microgeometrice ale suprafeței, generând tensiuni interne reziduale de compresie și măbind duritatea superficială, aspecte care conduc la o creștere semnificativă a durabilității și a calității suprafeței. Prezenta lucrare se concentrează asupra procesului de netezire prin alunecare cu sculă diamantată, o metodă care utilizează un element activ din diamant caracterizat prin duritate extremă, coeficient de frecare redus și o bună conductivitate termică, permițând obținerea unor suprafețe de o calitate superioară, inclusiv în cazul materialelor greu prelucrabile. Studiul investighează performanțele sculei în prelucrarea suprafețelor cilindrice exterioare, utilizând sistemul de lubrifiere în cantități minime, urmărind variația parametrilor tehnologici principali: viteza de lucru, avansul și adâncimea de pătrundere. Evaluarea comparativă între operația de strunjire convențională și cea de netezire cu diamant s-a realizat pe baza analizei parametrilor de rugozitate Ra și Rz. Rezultatele experimentale indică o reducere substanțială a rugozității și obținerea unor suprafețe cu aspect de oglindă, demonstrând astfel că netezirea cu diamant reprezintă o alternativă tehnologică eficientă și sustenabilă la operațiile clasice de rectificare și lustruire.