REVUE ALGERIENNE DES SCIENCES
Section -A-
- Sciences de la Nature et de la Vie
- Sciences techniques
ISSN : 2661-7064
http://univ-eltarf.dz/fr/

Impact of Burnishing on Sk, Svk, Spk and Wear Behavior of Cr–Mo Steel.

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Received: 2025-05-18 **Accepted: 2026-01-25** **Published: 2026-06-23**

Abstract:

This work focuses on investigating the influence of burnishing parameters, such as load and number of passes, on core roughness depth (Sk), reduced valley depth (Svk), and core height. reduced peak (Spk) of chrome-molybdenum steel. The tribological tests were carried out under lubrication. By examining the 3D morphology of the wear grooves for the lowest loads and number of passes, we observed wider and deeper grooves compared to those observed for other values. Analysis of Sk values , Svk and Spk shows that increasing the load and the number of passes during burnishing tends to reduce Sk, while increasing Svk and Spk. The burnishing-treated samples show improved wear characteristics compared to the untreated sample, with a notable reduction in Sk, Svk, and Spk values. The worn surfaces of chrome-molybdenum steel were analyzed by scanning electron microscopy in order to highlight the wear mechanisms under the experimental conditions studied. We observed the presence of grooves parallel to the sliding direction, produced by abrasive and adhesive wear, caused by delamination of the contact surface due to hard debris resulting from wear and plastic deformation of the asperities of the surface. These observations are in good agreement with the 3D profiles and the values of Sk, Svk and Spk.

Keywords:

Chrome molybdenum steel, Burnishing, Friction, Lubrication, Core Roughness Depth,Reduced Valley Depth, Reduced Peak Height.

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Introduction

Burnishing is a post-machining process that relies on the plastic deformation of the part on a submicron scale. This operation modifies the surface of the component by compressing it with a highly polished and hardened ball or roller structure. As a result, surface ridges are smoothed out, producing a mirror-like finish, without removing any material from the surface [1] [2]. The burnishing process can be categorized according to different parameters, such as the shape of the deforming element, the type of interaction with the surface, and the type of surface [3].

Recent research has highlighted significant advances in this area. For example, the study by Klocke et al.[4] demonstrated that vibration-assisted burnishing can increase surface hardness and reduce roughness, providing significant benefits for critical mechanical components. Another study, conducted by Zhang and colleagues [5], focused on optimizing burnishing parameters for high-performance alloys, showing substantial improvements in the life of processed parts.

The industrial approach to wear and tear has evolved considerably over the last century. In the past, engineers mainly focused on making functional equipment. Today, users are increasingly demanding when it comes to product durability. The difficulties that engineers face in predicting wear and choosing the appropriate material pairs arise mainly from the fact that friction and wear are not intrinsic properties of materials, and that the demands of the tribological system are generally complex, involving factors such as pressure and vibration [186]. The friction behavior of a pair of solid materials is influenced by several parameters linked to the mechanical characteristics of the material [7].

Tribological testing methods are generally categorized based on the type of contact and relative motions between interacting surfaces. For example, the ASTM G99 standard proposes three types of contacts (point, linear, surface) obtained by various configurations of spheres, cylinders and planes, with alternating or continuous movements [8]. A tribological system is therefore defined by the tribometric parameters, which include the operational conditions, the microstructural characteristics of the materials, as well as the interaction parameters linked to contact and the lubrication mode [9].

The classical laws of friction, established by Coulomb, state that the friction force is proportional to the normal force [10]. He also distinguished between static and dynamic friction. Oden and Martins [11] reported advances in the understanding of these laws, resulting from the in-depth study of the phenomenon since its beginnings. A recent study by Wang et al. [12] showed that roller burnishing on aluminum alloys can reduce the surface roughness by more than 60%, leading to a significant decrease in the coefficient of friction under

lubrication. According to Liu et al. [13], burnishing of titanium alloys showed an increase in surface hardness up to 35% due to work hardening and formation of compressive layers. In a study by Smith et al. [14], it was observed that high-pressure burnishing induces a more homogeneous microstructure and improves wear resistance by 40% in stainless steels.

This work highlights the critical importance of influence of burnishing parameters, such as applied load and number of passes, on critical characteristics such as core roughness (SK) depth, reduced valley depth (SVK) and reduced peak height (SPK) of chrome molybdenum steel. Tribological tests are carried out with lubrication, highlighting the significant impact of these parameters.

I. MATERIALS AND METHODS

II.1 Nuance de matériaux étudiés

The material used for this experimental study is low-alloy Chrome-Molybdenum steel. Due to its good tensile strength and light weight, this steel is widely used in various applications, such as airplane engine mounts, aerospace, the oil and gas industry, as well as in the manufacturing of racing cars and bicycles. It schemical composition is detailed in Table 1.

Table.1. Schemical composition.

Element	C	Mn	Si	P	Mo	Cr	Cu
%	0,33	0.55	0,39	0,017	0,188	0,912	0,045

II.2. Burnishing operation

The burnishing operation was carried out on a universal lathe model 1A616 with a power of 4.6 kW, where two bearings (P1 and P2) were treated with four (04) passes each under a pressure of 8.5Kgf and 20Kgf respectively. The process was performed under abundant lubrication using an SAE20 oil emulsion with a rotation speed N=560 rpm and a feed f=0.054mm/rev. This process acts by plastic deformation of surface layers of the surface under the tool action called a burnisher [15]. The tool driven by a longitudinal feed "f" exerts with a ball a pressure "Py" on the surface crests, which generates a plastic deformation of the material which fills the hollows as the process progresses (Figure 1).



Fig.1. Burnishing operation

II.3 Tribological Study

The parameters to be determined for a friction coefficient measurement are therefore the applied load, the measurement time, the material of the ball, the speed and the rotation path. Table (2) illustrates the values of the measurement parameters chosen for this study on the five samples Figure 02.

Table. 2. Tribological test parameters used.

Parameters	Conditions
Ball	100C6 Steel
Applied loads	8 N
Speed	5 cm/s
Temperature	Ambient Temperature (25^0)
Humidity	50%

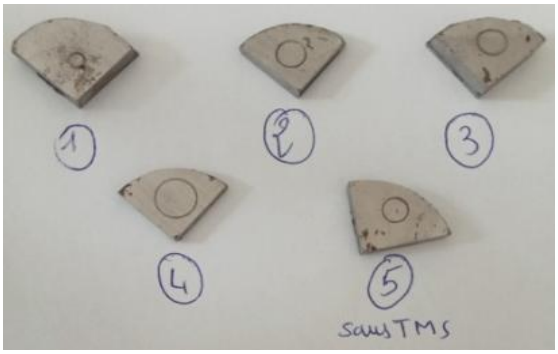
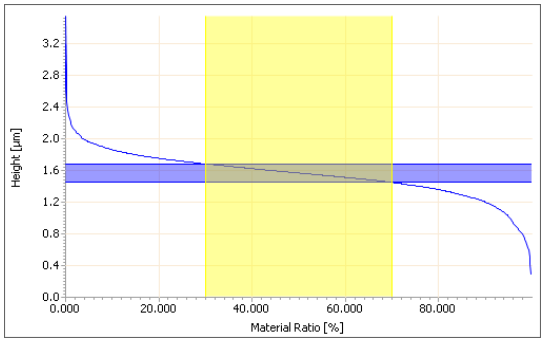


Fig.2. Samples studied.

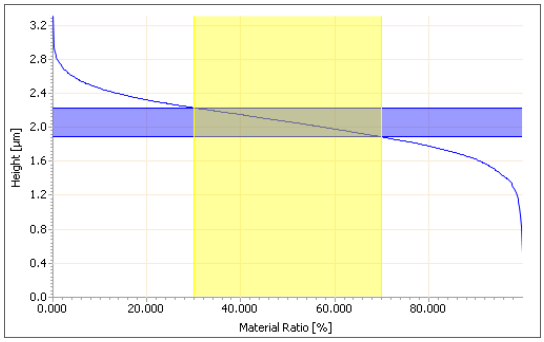
II.4 Core roughness depth (Sk), Reduced valley depth (Svk) and Reduced peak height (Spk)

The parameter Sk represents the roughness depth in the main contact area, where the main friction occurs. A higher value of Sk indicates a rougher surface Ei, which can lead to increased frictional resistance and wear. Wear grooves on a

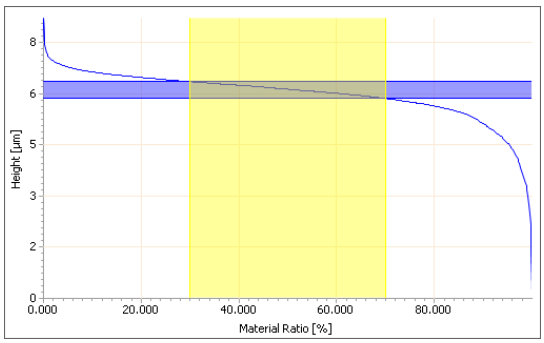
surface with a high Sk can be more pronounced and wide due to the increased interaction between the surface asperities and the contacting element. Svk represents the depth of the valleys present in the surface profile, below the main contact surface. This parameter is important for the surface's ability to retain lubricants. A high value of Svk can indicate a greater ability to retain lubricants, thus reducing friction and wear. However, deep valleys can also act as traps for wear debris, influencing the morphology of the wear grooves by promoting the formation of debris and deep grooves. Spk measures the height of the peaks above the main contact surface. High Spk values indicate the presence of many prominent peaks on the surface. These peaks may be subject to rapid initial wear, leading to the formation of early wear grooves. A surface with a high Spk may have finer and more concentrated grooves, as the peaks wear more quickly and are leveled. Significant reduction in SK and SVK of burnished surfaces compared to the initial surface. This phenomenon can be attributed to the pressure exerted pushing the peaks into the valleys, leading to a smoothing of the surface. This action contributes to the reduction of peaks, thus inducing a reduction in debris (Figure 3).



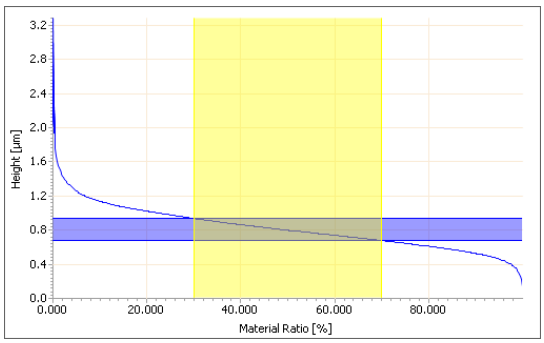
E1



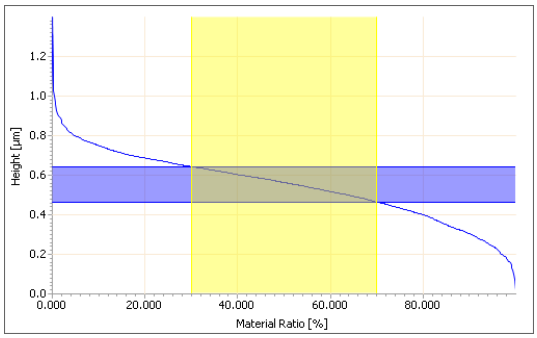
E2



E3



E4



Ei

Fig.3. Functional parameters "Sk" and Abbott-Firestone curve for surfaces

Table 03 shows the values of SK, SVK and SPK. These parameters are calculated from the Abbott curve obtained by integrating the height distribution over the entire surface.

Table.3. Evolution of the friction coefficient with lubrication after burnishing.

	(P) kgf	(i)	SK	SVK	SPK
E1	8.5	2	0.57	0.49	**0.32**
E2	20	2	0.84	0.42	**0.3**
E3	8.5	4	0.62	0.17	**0.28**
E4	20	4	0.41	0.19	**0.15**
Ei	-	-	**1.21**	**1.72**	**0.44**

It appears that the lubrication friction tests revealed significant differences between the burnished and untreated surfaces. The results indicate an increase in SPK for the burnished surfaces compared to the initial surface. This improvement can be explained by a pressure-related phenomenon, where the peaks of the burnished surface are pushed into the valleys, resulting in a smoothing of the surface. In addition, it is mentioned that a change in topography is noticeable. Specifically, the wear groove on the burnished surface is described as being shallower and narrower than that on the untreated surface, which has prominent peaks. This observation suggests that the burnished surface offers increased wear resistance, resulting in a less pronounced wear groove.

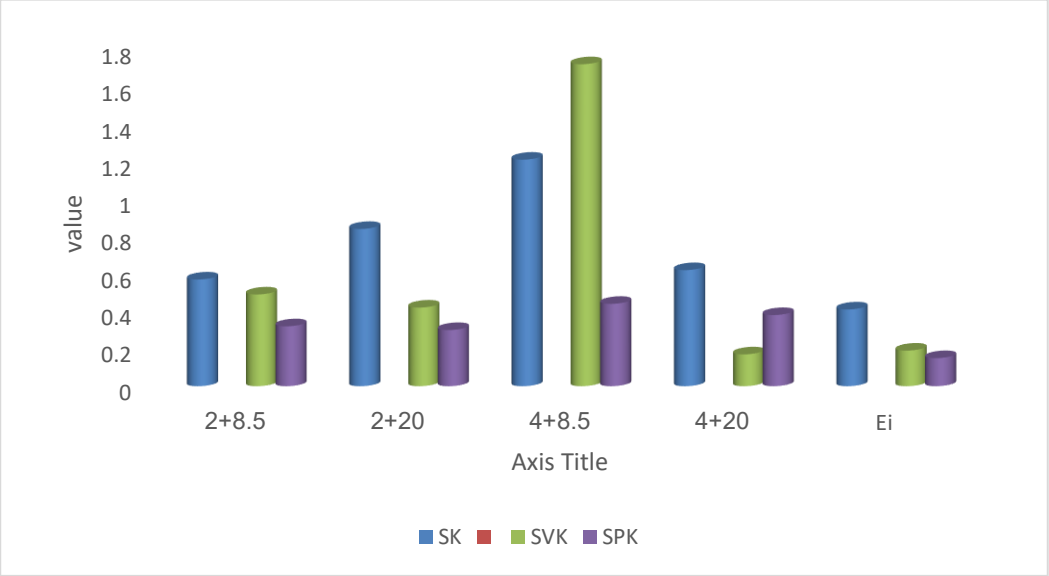


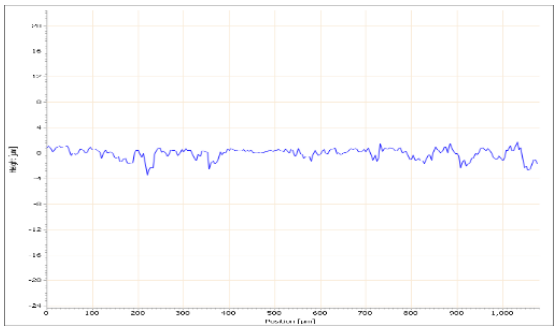
Fig.4. histogram Comparative of SK, SVK and SPK values for the different states

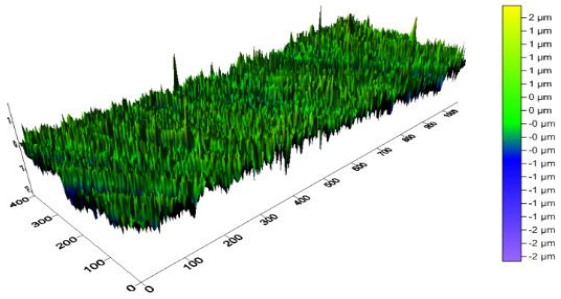
II.5 Characterization of wear by 2D and 3D profilometer

The results of the 3D surface analysis (Figure 5) confirm the wear character of the traces obtained on the Chrome-Molybdenum steel, subjected to different loads and numbers of passes during the mechanical treatment by burnishing. Examining the 3D morphology of the wear grooves for the lowest number of passes and load, we find a wider and deeper groove compared to those obtained for other values (Figure .4.). Similarly, the morphology of the wear groove for the lowest number of passes and burnishing load reveals a smaller width and depth compared to the others. Referring to the wear rate values summarized in Table III.2 below, we can observe that the highest wear rate is observed in E4 and Ei, indicating a more pronounced wear, suggesting abrasive wear. On the other hand, the lowest wear rate is obtained at E1, suggesting a better wear resistance. In this case, the wear debris (third body) plays the role of solid lubricant, where the film formed on the surface is compact, adherent and prevents the direct contact of the two rubbing bodies, thus reducing the friction coefficient and, consequently, the wear rate. These observations are confirmed by the 2D surface profiles.

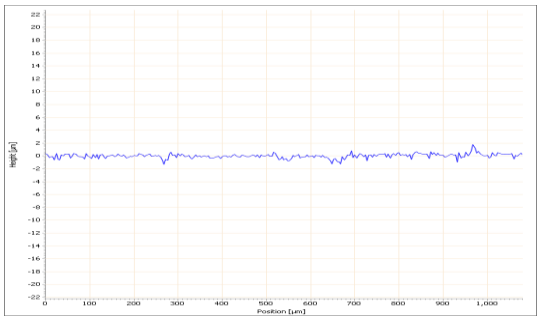
A significant improvement in the topography was achieved, marked by a noticeable reduction in peaks. A change in the topography was made, highlighting

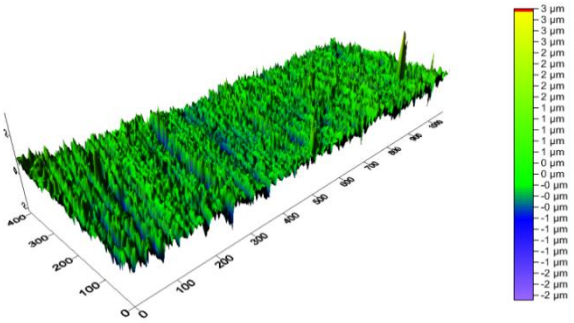
that the wear groove on the burnished surface is now less deep and less wide than the groove on the untreated surface, which initially had prominent peaks.



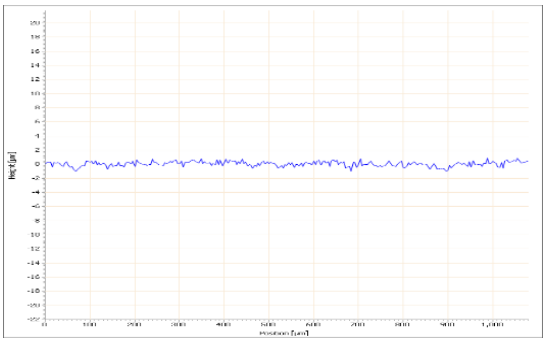


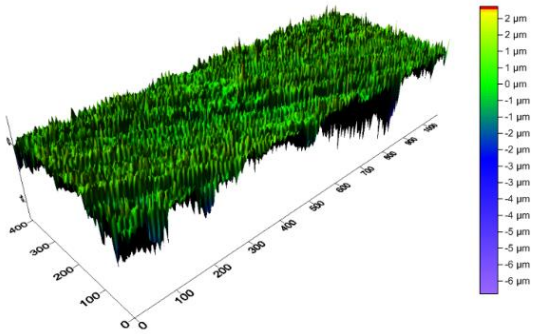
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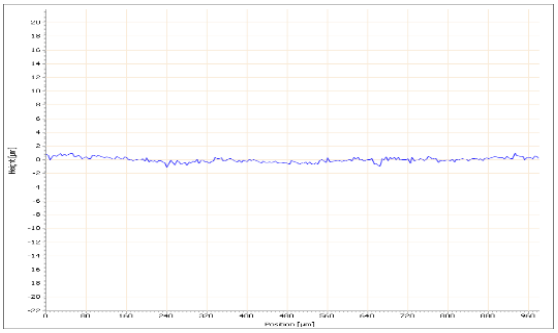


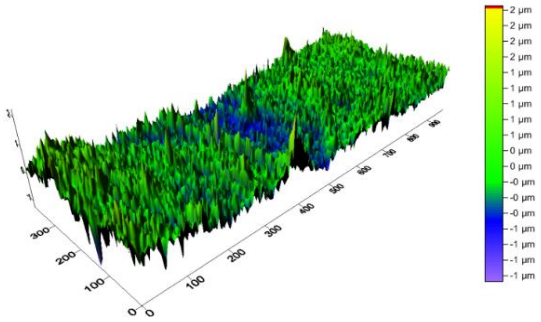
E2



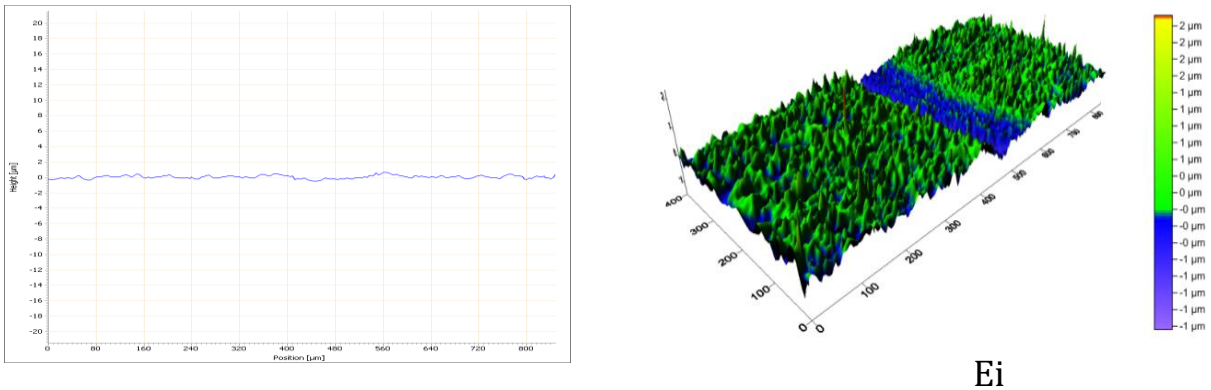


E3





E4

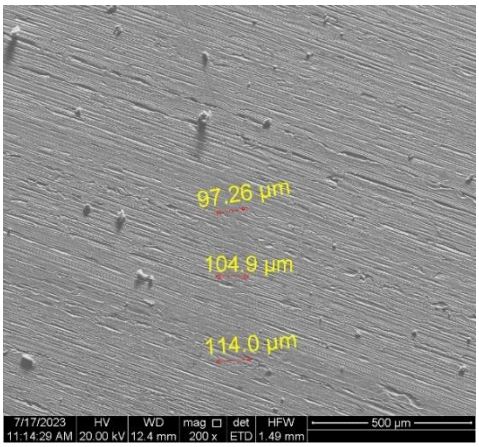


Ei

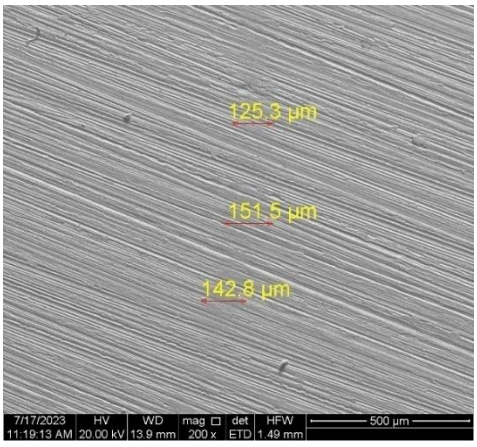
Fig. 5. 2D and 3D morphology of wear grooves for all samples.

II.6 Morphology of wear traces

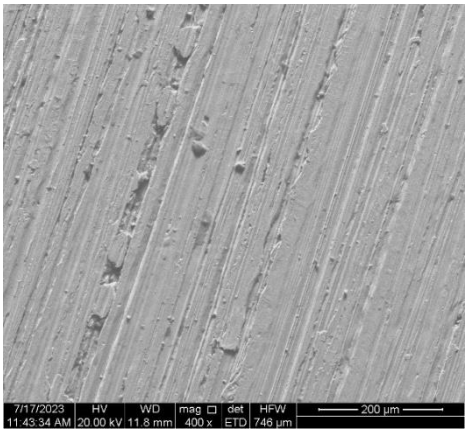
The worn surfaces of chromium-molybdenum steel were analyzed by scanning electron microscopy to highlight the wear mechanisms of the steel under the experimental conditions studied. Figure. 6 shows the wear characteristics of the chromium-molybdenum steel surfaces. For all tests, the presence of grooves parallel to the sliding direction produced by abrasive and adhesive wear caused by the delamination of the contact surface due to hard debris resulting from wear and plastic deformation of the surface asperities was observed. However, the application of a load of 10N causes the material to detach in the form of flakes at the contact surface, which accentuates the wear of the adhesive. These observations are in good agreement with the profile of the 3D results.



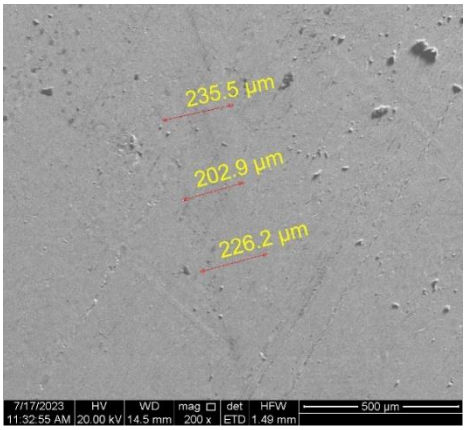
E1)



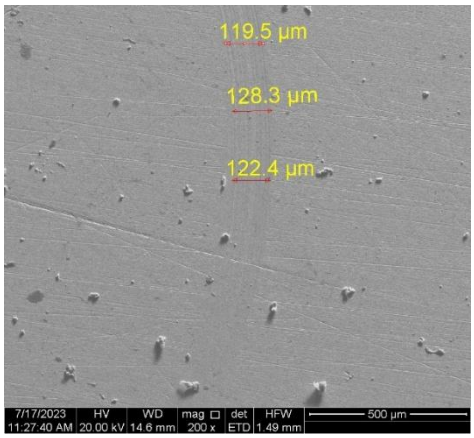
E2)



E3)



E4)



Ei)

Fig. 6. SMS steel wear mechanisms for all tests.

Conclusion

This work highlights the significant impact of burnishing parameters, such as applied load and number of passes, on the tribological properties of chromium-molybdenum steel. The results obtained demonstrate that adjusting these parameters directly influences the surface morphology, including core roughness depth (Sk), reduced valley depth (Svk), and reduced peak height (Spk). Specifically, increasing load and number of passes results in a reduction of Sk, indicating a decrease in core surface roughness.

In parallel, Svk and Spk values increase, suggesting an improvement in the surface's ability to resist wear and support high loads. These results are corroborated by the 3D analysis of wear grooves, which shows wider and deeper grooves for the lowest loads and number of passes, indicating more pronounced wear under these conditions. Microscopic analysis of the worn surfaces revealed

dominant wear mechanisms, such as abrasive and adhesive wear, resulting from delamination and plastic deformation of surface asperities.

These observations are in agreement with the 3D profiles and measurements of Sk, Svk, and Spk, confirming that optimal burnishing conditions improve the wear resistance of chromium-molybdenum steel. Burnishing is shown to be an effective technique to modify the surface properties of metallic materials, thereby improving their tribological performance. These results provide a deep understanding of the effects of burnishing parameters on surface topography and wear mechanisms, offering promising prospects for optimizing manufacturing processes and improving the durability of mechanical components in various industrial applications

Référence

[1] Ahmed,R; Sudhanshu,K; (2022), A critical review of tool design in burnishing process, Tribology International, 174 p.

[2] Laouar, L et all ; (2005), Influence du traitement mécanique par brunissage sur la tenue à l'usure de l'acier (RB40) produit à SIDER, Revue des sciences et technologie"synthèse" n° 14, Université Badji Mokhtar Annaba, 7 p.

[3] Mahmood,H.A et al; (1999), Improvement in the wear resistance of brass components by the ball burnishing process, J Mater Process Technol, pp.73-80.

[4] Hassan,A.M; Al-Bsharat; (1996), Improvement in some properties of non-ferrous metals by the application of the ball-burnishing process, J Mater Process Technol, pp.250-256.

[5] Hamadache, H, et all; (2006), characteristics of Rb40 steel superficial layer under ball and roller burnishing, journal of materials Technology, pp.130-136.

[6] Bourebia,M ; (2010), Influence des procédés d'usinage sur les rugosités de surface et leurs répercussions sur un contact mécanique, Mémoire de Magister, Université Badji Mokhtar, Annaba, 126 p.

[7] Gouider,M ; (2004), Tribologie des composites Carbone/Carbone : Echelles et contributions de la mécanique et de la physico-chimie, Thèse de l'Institut National des Sciences Appliquées de Lyon, 276 p.

[8] Silem,H ; (2016), Etude de l'effet de la charge normale appliquée sur le comportement tribologique des couples métalliques, Mémoire de master, Université de Msila, 65 p.

[9] Chekir,N ; (2015), Validation d'un tribomètre pion/disque vertical, Mémoire de Master. Université Mouloud Mammeri de Tizi-Ouzou, 109 p.

[10] Samuel,N; (2002), Modélisation du frottement en pied d'aube par une approche fréquentielle, PhD thesis, École Centrale de Lyon.

[11] Salman,N ; (2004), Contribution à l'étude du procédé arc-fil pour la réalisation de dépôts métalliques durs résistants à l'usure abrasive, Thèse de Doctorat, Université de Limoges, 161 p.

[12] Wang, J., et al. (2023). Reduction of Surface Roughness and Friction in AluminumAlloys by Roller Burnishing. Journal of Manufacturing Processes.

[13] Liu, X., et al. (2022). Enhancement of Surface Hardness in Titanium Alloys via Burnishing Process. Surface Engineering.

[14] Smith, R., et al. (2021). Increased Wear Resistance in Stainless Steels through High-Pressure Burnishing. Tribology International.

[15] Mounira Bourebia, SoumayaMeddah, AchouriSihem, AmelOulabbas, LatifaKahloul, AhlemTaleb, MajdiAbdelraoufMebarek, LakhdarLaouar, Study of surface topography parameters during shot peening process and their influence on the paint coating of adhesion, The International Journal of Advanced Manufacturing Technology https://doi.org/10.1007/s00170-023-11365-6 (2023).