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WEAR OF GLASS WITH SOFT MATERIALS

BY

BOGDAN CHIRIAC*, **ELENA ADELINA CHIRIAC, GEORGE ACHITEI and DUMITRU OLARU**

“Gheorghe Asachi” Technical University of Iaşi,
Faculty of Mechanical Engineering, Iaşi, Romania

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Abstract. The present study investigates the wear of glass surfaces when subjected to contact with textile materials, particularly those used for cleaning glasses, such as microfiber cleaning cloths. The research focuses on the behavior of the materials under conditions of small applied loads and high contact pressures, which are representative of real-world usage scenarios. To simulate these conditions, a series of experiments were conducted using a UMT, employing the classical pin-on-disk method. The experiments were designed to evaluate the wear performance over varying operating times while maintaining constant speed and load parameters. This approach ensures consistency and reliability in the data collection process. Throughout the tests, the friction coefficients were recorded to analyze the interaction dynamics between the glass and the textile materials. This study has implications for improving the design and selection of cleaning materials for delicate surfaces such as optical lenses, smartphone screens, and other glass components.

Keywords: glass abrasion, friction soft materials, abrasion of cloth, roughness glass, wear behaviour.

*Corresponding author; *e-mail*: bogdan.chiriac@academic.tuiasi.ro

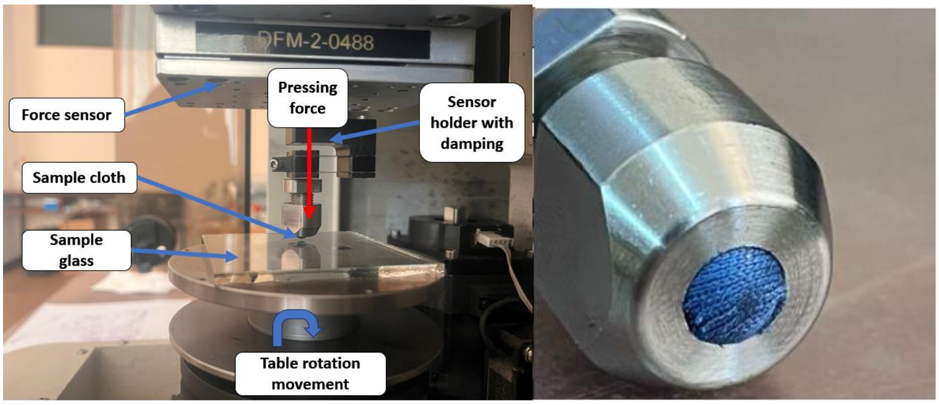
1. Introduction

The wear function plays an important role in friction processes, regardless of the materials involved, significantly influencing long-term performance. In friction phenomena, bond breakage occurs at the most vulnerable points within the system, manifesting as fracture, ductile deformation, material removal, or sliding/lubrication at fluid interfaces (Jeyaprakash and Yang, 2020). These outcomes depend on the materials' properties and the surrounding environment. More than that, the friction with an elastic material can also have important effect on the friction behaviors (Naoki *et al.*, 2022). Over time, noticeable changes in surface states are expected, often accompanied by material transfer between surfaces. This transfer creates new interaction dynamics distinct from those of the original surfaces.

Commercial glass with a very smooth surface is characterized by very low roughness values, which are usually in the order of microns. This rather low roughness can be due either to its original state after the forming process or to the precise use of delicate polishing techniques. For flat glass or glazing glass, roughness values have been quantified as being between 0.014 and 0.03 µm (Pal *et al.*, 2016).

2. Experimental procedure

For the wear tests, the microfiber cloth was used, clamped in the special pin-ball holder, to increase the pressure. As illustrated in Fig. 1a, we have the glass sample, the support with damping for constant absorption of the applied load, the steel ball wrapped with the cloth (see Fig. 1b) and the rotary table (Srivastava and Wahne, 2007).



a) b)

Fig. 1 – Tribosystem designed for glass wear with a cloth, (a) – general view, (b) – detail with the ball wrapped in the cloth.

In Fig. 1b the cloth attached to the special support with a steel ball is shown, where the wear area of the cloth can be noted. The tests were carried out in dry conditions at a speed of 60 rpm, with a pressing force of 3N. The tests lasted 1h and 2h (Cetkin *et al*., 2022).

The behavior of the friction and wear depends on the properties of materials in the contact. The test on this tribological system was made at ambient temperature and most likely the temperature was changed due to the analysis of the microfiber cloth (see Fig. 1b) (Rahaman *et al*., 2013). The interest of the tests is to observe over time the behavior of the glass when worn in contact with the microfiber cloth at high pressures.

3. Experimental results obtained on the microfiber cloth.

In Fig. 2 the variation of the friction force with respect to time is presented, the red color represents the test with a duration of 1h and the blue one the test with a duration of 2h. In both cases an increase in the friction force with respect to time is observed, for the test with a duration of 2h the friction force is much higher, reaching values of 1.3N.

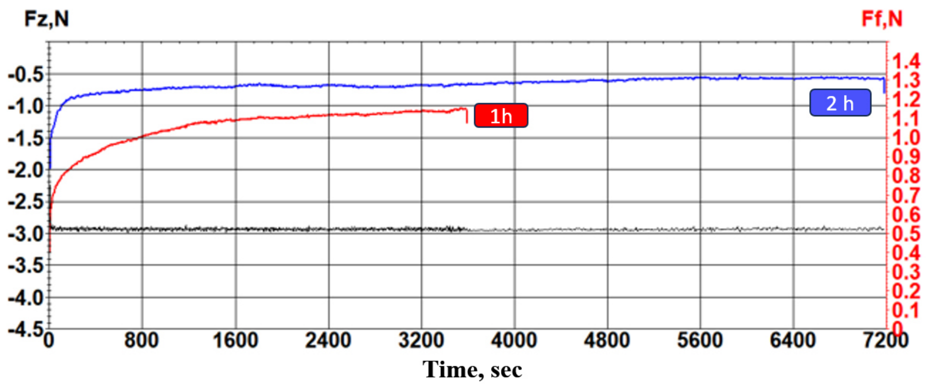


Fig. 2 − Variation of friction force with respect to time for a pressure of 3N.

The friction coefficient increases with time, so for a duration of 2h, the friction coefficient reaches a maximum value of 0.45 and for the 1h test the value is 0.4.

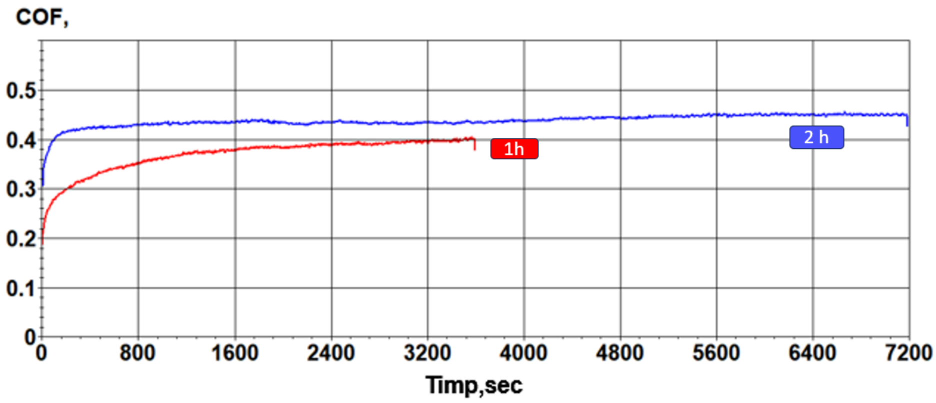


Fig. 3 − Variation of the coefficient of friction with respect to time.

The wear mark on the glass for the first 1h test with the cloth is represented on a width of approximately 2.3mm, as can be seen in Fig. 4.

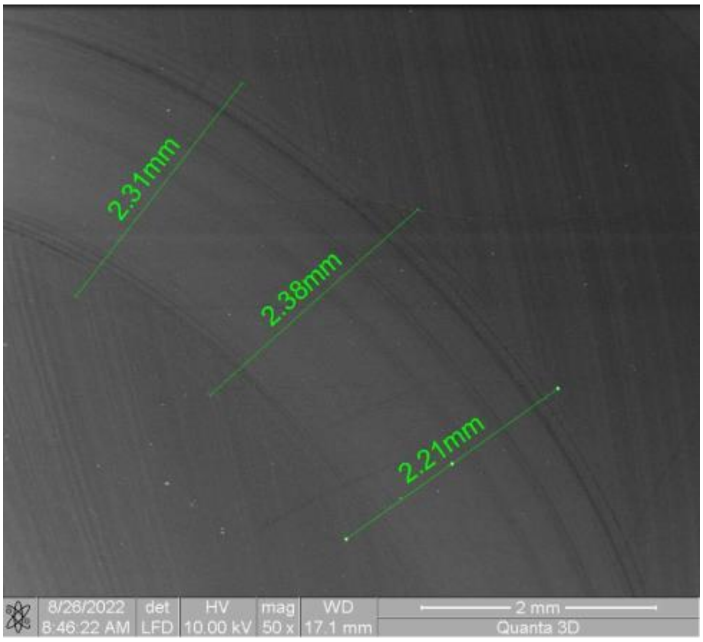


Fig. 4 − Trace of wear on the glass for the 1h test with a cloth. 50x

Deposits resulting from the test are distributed throughout the test area. In the central area, where the pressure is very high, deposits of up to 12.57 µm are observed (see Fig. 5).

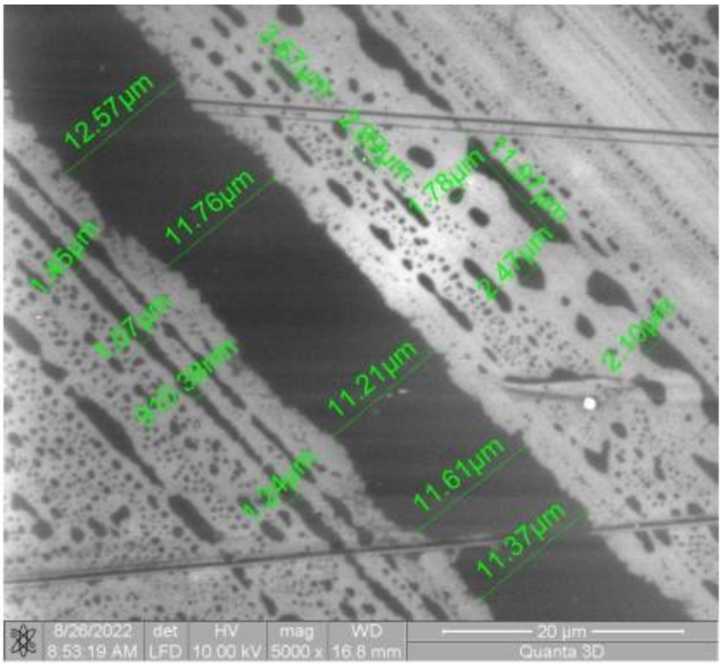


Fig. 5 − Cloth deposits on the glass surface. Duration 1h. 5000x

In Fig. 6, the microfiber cloth can be seen under a microscope, in image a) the cloth measured at a resolution of 33x can be seen, and in image b) it is magnified at a resolution of 500x and you can see how the microfibers are detached and have a melted appearance, as shown in the areas marked in red.

a) 33x b) 500x

Fig. 6 − Microfiber cloth under the microscope.

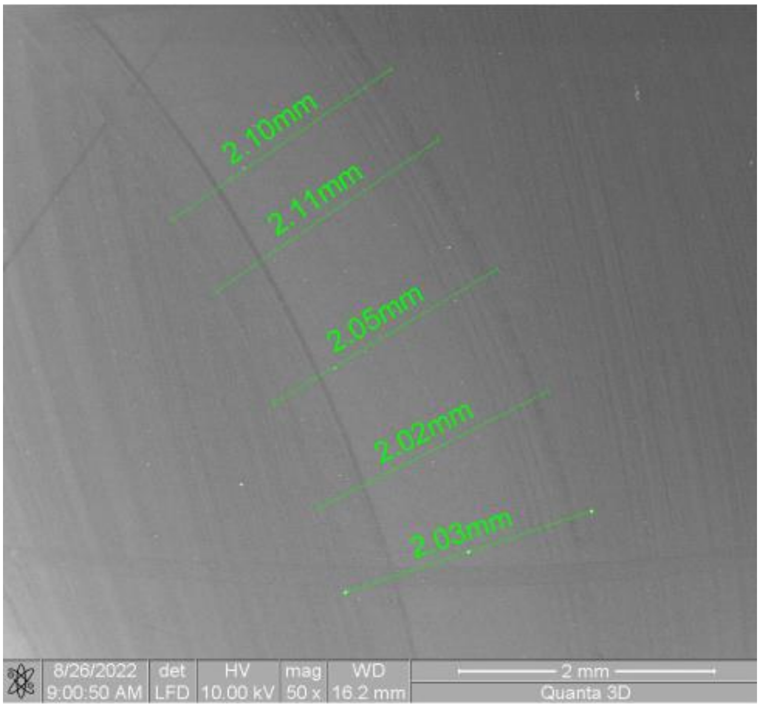


Fig. 7 − Trace of wear on the glass for the 2h test with a cloth. 50x

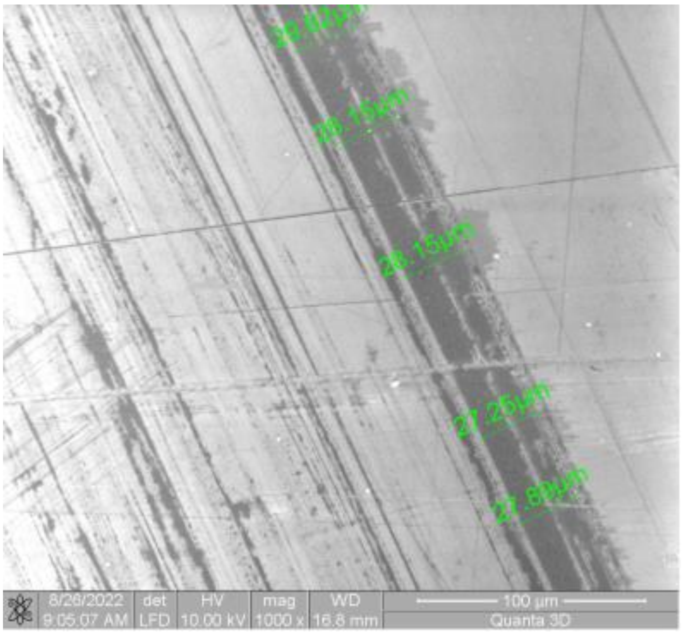
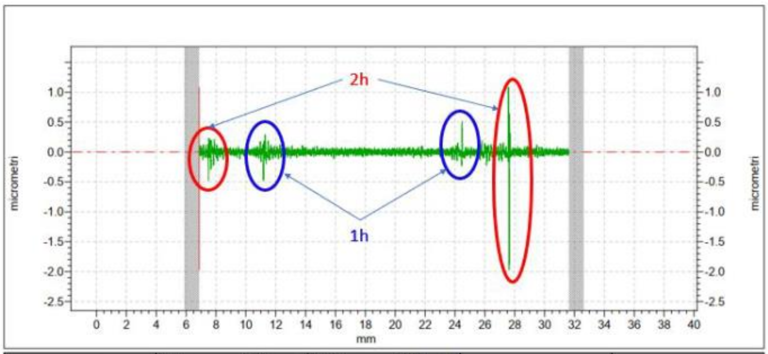


Fig. 8 − Cloth deposits on the glass surface. Duration 2h. 1000x

Figure 9 shows the recordings made on wear marks under normal load conditions of 3 N, at a speed of 60 rpm, for a duration of I hour (areas colored in blue) and for a duration of 2 hours (areas colored in red).

Changes in the shape of the glass surface can be observed, both growths representing microfiber deposits on the glass surface and areas of wear.



			Slope	0.469	°	Rz(JIS)	0.0890	µm						
Ra	0.0335	µm	Rq	0.0775	µm	R3z	0.0799	µm						
Rsk	-8.2047		Rku	266.7994		R3y	0.1662	µm						
Rp	0.1083	µm	Rv	0.1312	µm	Rz(DIN)	0.2396	µm						
RLo	24.7517	mm	Rt	3.0503	µm	Rmr(c) (1)	49.80	%	Height (mean)	0.000	µm			
Rlq	36.53	µm	Rdq	0.76	°	RHSC (1)	792	peaks	Height (mean)	0.000	µm			
Rda	0.44	°	Rz	0.2396	µm	Rdc (1)	3.0503	µm	mr1%	0.0	%	mr2%	100.0	%
RS	15.02	µm	RSm	2306.28	µm	Rmr (1)	50.00	%	offset	0.000	µm	mr%	50.00	%
Rln	24.7500	mm	Rc	0.8046	µm	RVo (1)	0.0017	vol	offset	0.000	µm	mr%	50.00	%
						RPc (1)	437.2	pks/cm	Height (mean)	0.000	µm	bandwidth	0.00	µm

Fig. 9 − Evaluation of the wear condition of the glass surface on the profilometer for tests 1h and 2h at 5N loading and 120 rot/min.

4. Conclusions

The experimental study on glass wear by friction with various materials provided valuable information on the behavior of glass under pressure and friction conditions with variable speeds. The experiments were conducted using a microfiber cloth at different loads and operating times.

Microfiber cloth tests showed that the friction force increases over time, reaching higher values in the 2-hour tests compared to the 1-hour tests.

The friction coefficient reached a maximum of 0.45 after 2 hours of testing, indicating increased wear of the glass under high pressures. The deposits of material from the cloth on the glass were significant, especially in the central area, where the pressure was highest.

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UZURA STICLEI CU MATERIALE MOI

(Rezumat)

Prezentul studiu investighează uzura suprafețelor de sticlă atunci când sunt supuse contactului cu materiale textile, în special cele utilizate pentru curățarea ochelarilor, cum ar fi cârpele de curățat din microfibră. Cercetarea se concentrează pe comportamentul materialelor în condiții de sarcini aplicate mici și presiuni mari de contact, care sunt reprezentative pentru scenariile de utilizare din lumea reală. Pentru a simula aceste condiții, au fost efectuate o serie de experimente folosind un tribometru UMT Cetr, utilizând metoda clasică pin-on-disk. Experimentele au fost concepute pentru a evalua performanța la uzură în timpi variați de funcționare, menținând în același timp parametrii de viteză și sarcină constant. Această abordare asigură consistența și fiabilitatea procesului de colectare a datelor. Pe parcursul testelor au fost înregistrați coeficienții de frecare pentru a analiza dinamica interacțiunii dintre sticlă și materialele textile. Acest studiu are implicații pentru îmbunătățirea designului și selecției materialelor de curățare pentru suprafețele delicate, cum ar fi lentilele optice, ecranele smartphone-urilor și alte componente din sticlă.