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A new set-up for the investigation of electrical and tribological properties of wire/ring sliding contacts

Context & Objective:

Many industrial systems require the transmission of electrical current from a static part to a rotating one. This is achieved by a sliding contact within a slip-ring device. In order to study the electrical and tribological behaviour of a gold alloy plating used in a slip ring system, a tribometer has been adapted. The use of this experimental device allows to simplify contact geometries offering the possibility to instrument the contact, to control test conditions, to facilitate post-analysis, and to study the influence of various parameters such as speed, normal force, lubrication, etc.

Wire/Ring contacts:

The tribological system in a slip ring is composed of:

- AuAgCu wire ($\varnothing 0,4 \text{ mm}$)
- AuCuX-plated ring ($\varnothing 40 \text{ mm}$) with V-groove
- Ester synthetic lubricant

2 contact zones represented by a simplified cylinder/cylinder geometry

↳ Allow to transmit an electric current in a reliable and durable manner over time

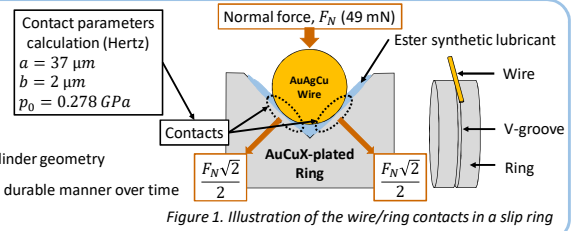


Figure 1. Illustration of the wire/ring contacts in a slip ring

Experimental set-up:

Initial configuration (Ball-on-disc)

The ball is fixed and applies a normal force on the rotating disc

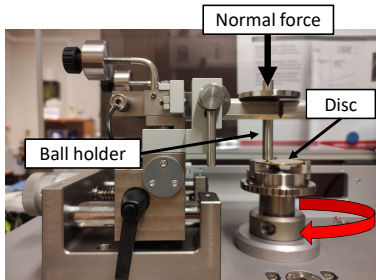


Figure 2. Picture of the TRB3 tribometer from Anton Paar in the ball-on-disc configuration

Adapted configuration

In order to mimic one of the two wire/ring contacts:

- a disc with a special roughness following the same gold-plating protocol represents one face of the V-groove
- the ball is replaced by a curved wire (same as in a real device) mounted in a special holder

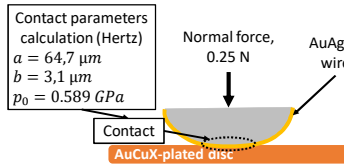


Figure 3. Illustration of the wire-on-disc configuration

Electrical contact resistance measurement

- 1 Connection to the wire
- 2 Sliding brush against the side of the disc

Two connections on each element to ensure electrical resistance measurement of the contact by the 4-probes method

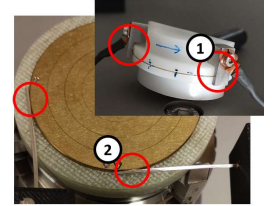


Figure 4. Illustration of the electrical connections

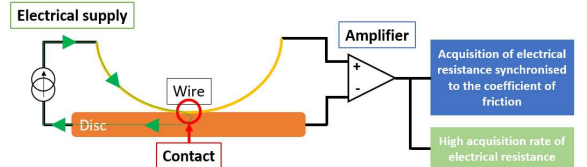


Figure 5. Electrical diagram of the 4-probes method

Tribometer results and surface observations:

Test conditions	
Linear speed (m/s)	1 (477 RPM)
Load (N)	0,25
Current intensity (mA)	250
Acquisition rate (Hz)	76 (1 point/36°)
Distance (m)	4000

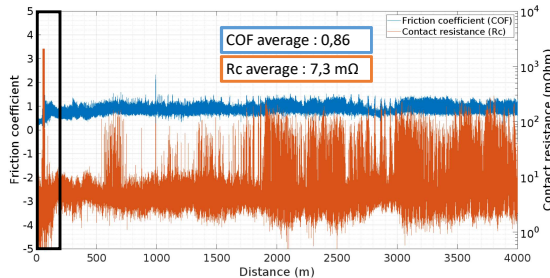


Figure 6. Friction coefficient and contact resistance as a function of distance

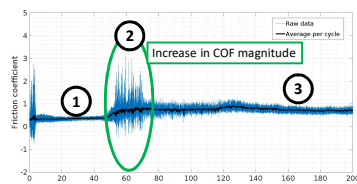


Figure 7. Zoom in on the friction coefficient

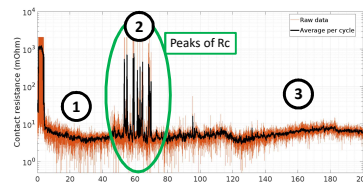


Figure 8. Zoom in on the contact resistance

Increase in COF magnitude correlated with peaks of Rc between 50 and 70 meters:

- An event takes place at the contact interface
- Previous short tests show that this event can be linked to a switch from a majority wear of the wire to a majority wear of the disc

Hypothesis on the event:

- 1 Wear of the wire and formation of debris
- 2 Debris spread and break up leading to a work-hardening of the wire surface
- 3 Wear of the disc and formation of debris

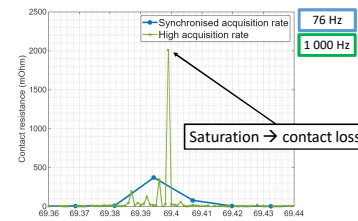


Figure 9. Comparison between the two acquisition rates of the contact resistance – Blue: with the tribometer (76 Hz); Green: with the high acquisition rate device (1 000 Hz)

Observation of the surfaces

- SEM: Highlighting chemical and topographical contrast
- EDX: Quantifying the chemical presence in the wear track
- Profilometer: Quantifying surface roughness and obtaining a 3D visual of the wear track

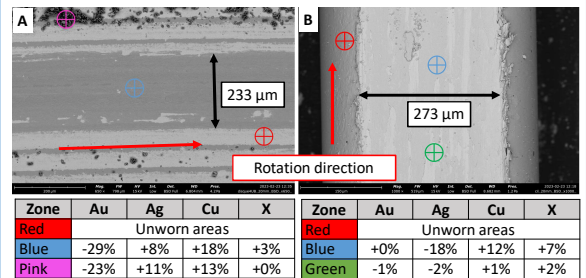


Figure 10. Observation of the wear tracks with a SEM + EDX measurement compared to unworn areas (%wt) – A. on the disc, x650 ; B. on the wire, x1000

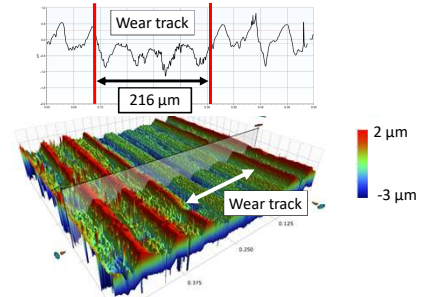


Figure 11. Observation of the wear track on the disc with a profilometer – x27.5 (Size: 0.5x0.5 mm)

Conclusion:

This modified device allows to follow the evolution of the friction coefficient and the contact resistance during the test. Thanks to data processing and surface analyses, the characterisation of the tribological system allows to understand the degradation mechanisms in the case of a simplified contact, and in extension, in the real slip ring contact.

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