

## Friction and wear of AAR Class D wheel steel sliding against high-strength rail steel at temperatures up to 700 °C

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### KEYWORDS

*Friction; Wear; Experiments in Tribology; AAR Class D Steel*

### INTRODUCTION

When trains follow curved paths, the sliding of the flange of the wheels against the rail's gauge corner acts as a safety measure to ensure non-derailment. The elevated temperatures generated by this contact tend to promote greater adhesion at the interface, while the formation of oxide films opposes this tendency. At room temperature, oxidation is confined to the contacting asperities, however, when the nominal temperature of the contact is significantly increased, generalized oxidation becomes highly important and may even dominate the wear behaviour [1]. In this work, pin-on-disc wear tests were carried out with AAR Class D wheel steel (341-415 HBW) sliding against high-strength rail steel (Nippon Steel, 370 HBW) at room and elevated temperatures. This study aims to expand the database of friction and wear for these materials under these extreme conditions, as well as to elucidate the role of the temperature (oxidation, thermal softening, phase transformations) in the observed wear mechanisms.

### METHODOLOGY

Pins with truncated conical heads and discs were machined from a rail and a cast AAR Class D wheel, respectively. Tests were carried out at three different temperatures (20 °C, 400 °C, and 700 °C), with three replicas for each temperature. The surfaces of the specimens were prepared with SiC sandpaper, #320 for discs, and #1200 for pins. Before each test, samples were ultrasonically cleaned for 10 minutes. Tests lasted 15 minutes, with a sliding speed of 0.1 m/s and a normal load of 24.6 N (initial contact pressure of 7.83 MPa).

### RESULTS AND CONCLUSIONS

At 20 °C, the COF stabilizes at  $0.60 \pm 0.02$ , indicating significant adhesion at the interface (Fig. 1a). The lowest COFs are seen at 400 °C, averaging at  $0.41 \pm 0.02$ . This is attributed to the presence of an oxide layer in the wear track, mitigating asperity adhesion and subsequent friction. The tests conducted at 700 °C exhibit intermediate COFs of  $0.51 \pm 0.02$ . The highest wear rates of pins are observed at room temperature (Fig. 1b). For the discs, wear rates are the lowest and even negative (gain of mass). This, along with scanned profiles of the wear tracks (Fig. 1c), suggests material transfer and plastic deformation. At 400 °C, the lowest wear rates are observed for pins, while an

increase is observed for discs, indicating that the oxide layer at the interface might be affecting material transfer from the pins to the discs. At 700 °C, thermal softening of the AAR Class D steel [2], along with the chipping of the oxide layer in the vicinities of the wear track might be contributing to the highest wear rates and largest wear tracks observed in the discs. Differences in the thickness of the pre-sliding oxide layer at 400 °C and 700 °C might have also played a role. The results suggest that the application of these steels in the studied tribosystem is limited to temperatures up to 400 °C, where friction and wear remain reasonably low. A transition in the wear regime appears somewhere between 400 °C and 700 °C.

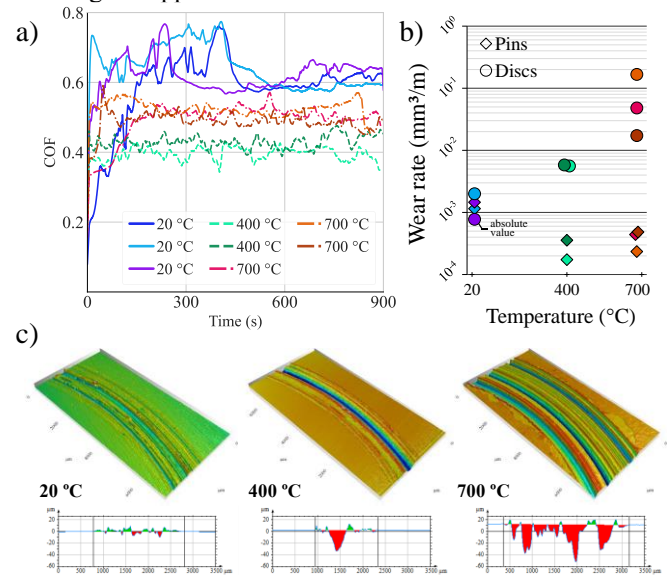


Figure 1 – (a) Coefficient of friction over time and (b) wear rate of pins and discs. (c) Regions of wear track profiles after pin-on-disc testing.

### ACKNOWLEDGMENTS

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### REFERENCES

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