doi:10.1017/S143192762201087X
Microsc. Microanal. 28 (Suppl 1), 2022

The Galling Mechanism and Behaviour of Tristelle 5183

Samuel Rogers[1*], D. Stewart[2], D. Dye[1]

[1.] Imperial College London, Department of Materials, London, UK.
[2.] Rolls-Royce plc., Derby, UK.
* Corresponding author: samuel.rogers13@imperial.ac.uk

Hardfacing alloys have been used for many years in components where surface degradation is of concern, particularly when coupled with extreme environments; be it high wear, high temperature, corrosive or erosive environments, or a combination of these. Of particular interest is the use of hardfacings in valve seatings within the pressurised water reactor (PWR) environment. This is a high temperature and highly corrosive environment in which wear and galling (severe adhesive wear) are of critical concern. The galling of components may result in gross surface degradation and component seizure, and is characterised by the plastic deformation and adhesion of contacting asperities[1]. This is of concern since valve degradation may result in safety risks or reactor downtime, both of which being extremely costly to the operator. Galling has been found to occur most readily in systems which have limited movement perpendicular to the sliding direction such as in valves [2].

A bespoke rig was manufactured by Rolls-Royce plc. to closely resemble an in-service valve, whilst Tristelle 5183 was the material tested. Surface analysis was performed using white light interferometry, whilst subsurface analysis was performed using SEM, EBSD and SEM-EDX.

Tristelle 5183 is a Fe-based hardfacing alloys with a primarily austenitic matrix (although some ferrite is also present) and niobium and chromium carbides. It was found that once an adhesion junction formed, extensive shear at the adhesion boundary on one test surface occurred, resulting in the formation of a tribologically affected zone (TAZ), Figure 1. Whilst this high level of shear may result in a small amount of adhesive transfer, as in Figure 1, this is not always the case, as seen in Figure 2. The formation of this galling peak resulted from an adhesion event and the formation of a TAZ followed by the activation of an internal shear plane within the same test surface, as outlined in Figure 3. This is evidenced by the flow lines shown in Figure 2.

The ductility of Tristelle is limited by the incorporation of carbides into the microstructure, which may fracture upon the application of sufficient shear, resulting in stringer-like formations, and in the case of niobium carbides, result in void formation, coalescence, and internal fracture, leading to adhesive transfer occurring, Figure 4 [3].

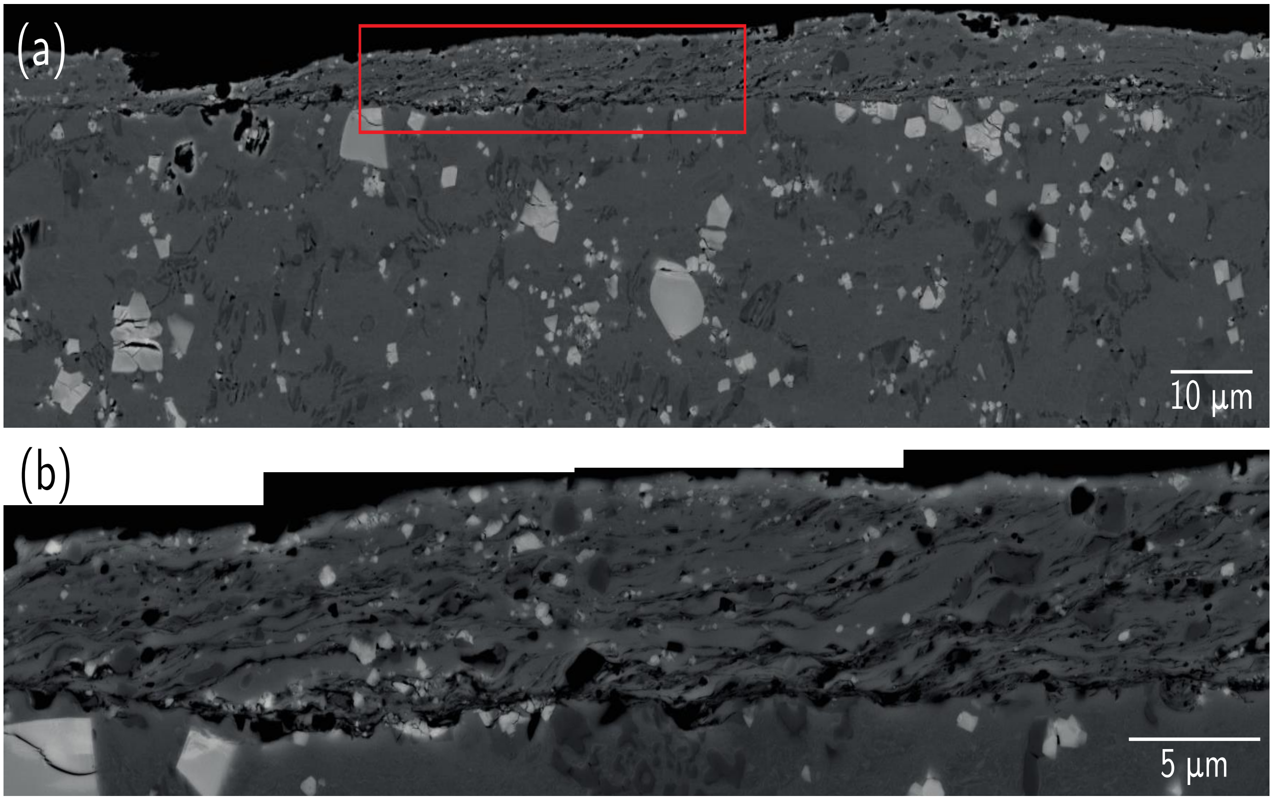

Figure 1. A cross-section of a small galling peak of Tristelle 5183 made entirely of the TAZ.

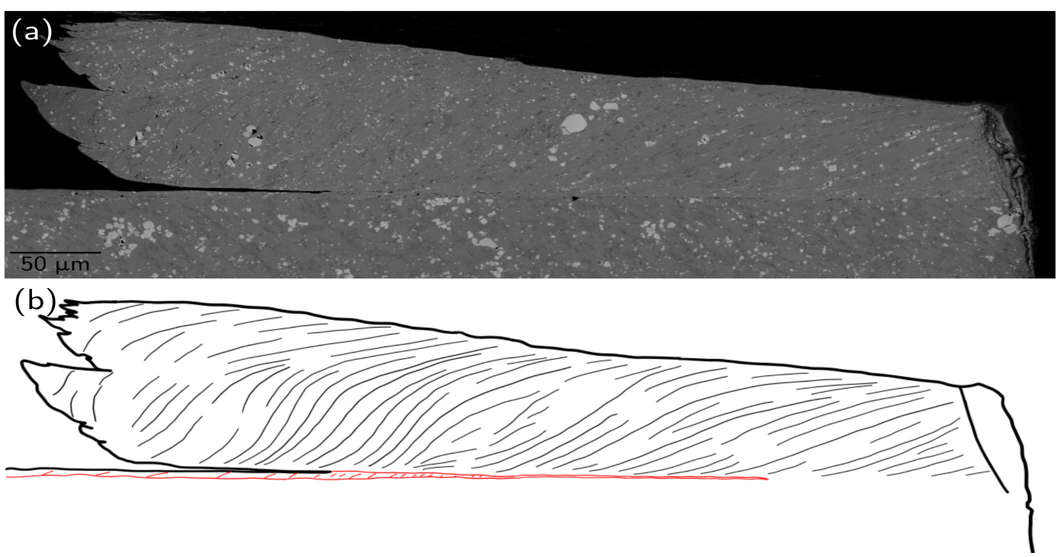

Figure 2. A cross-section of a severed galling peak of Tristelle 5183 (a) viewed in BSE imaging mode and (b) with flow lines shown in black, and the TAZ shown in red.

https://doi.org/10.1017/S143192762201087X Published online by Cambridge University Press

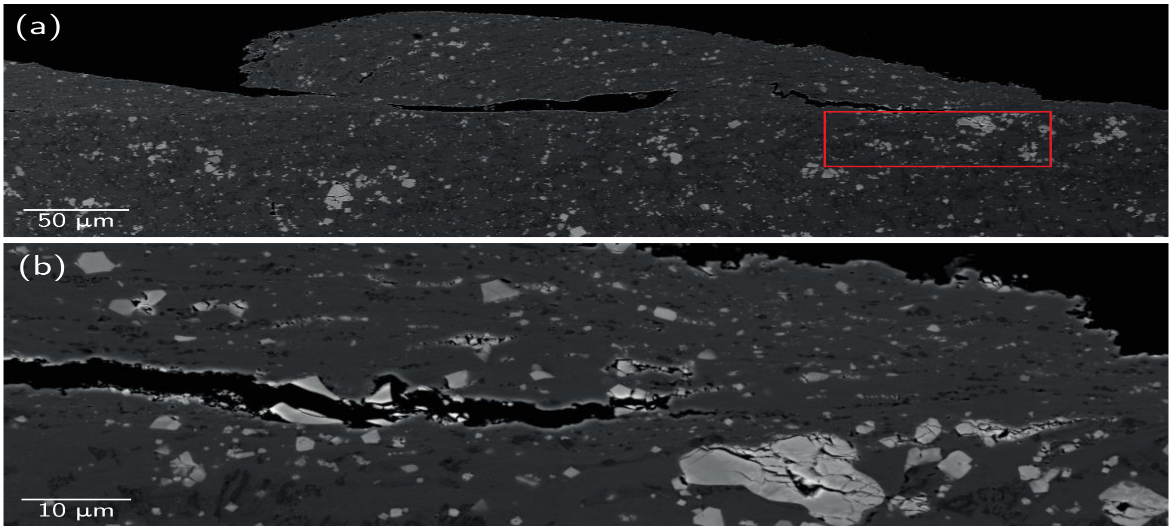

Figure 3. A cross-section of a galling peak of Tristelle 5183, viewing the TAZ and crack tip between the adhered galling peak and original surface material. Niobium carbides can be seen to have fractured and when sheared further have the appearance of a stringer.

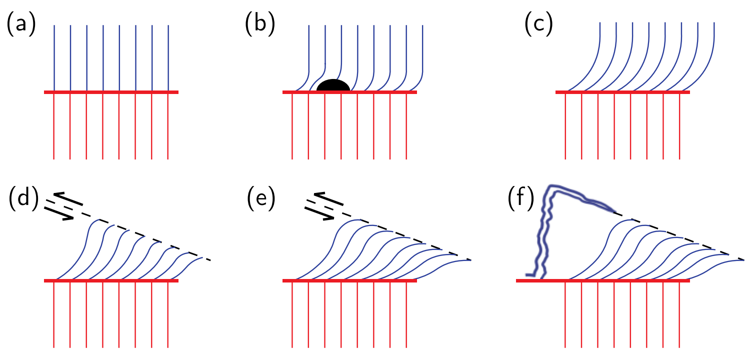

Figure 4. The galling mechanism experienced by self-mated Tristelle 5183 at elevated temperature. (a) An adhesion junction is formed between the two tribosurfaces. (b) Sub-surface shear occurs in only a single tribosurface, and intermittently, as a result of low shear strength regions along the adhesion junction. A shear `shadow' is found shown in black, along with the change in shear direction around it. For simplicity it is not shown elsewhere. (c) Shearing continues, resulting in a very heavily sheared region immediately below the adhesion boundary. (d) An internal shear plane is activated. (e) Shear at the adhesion boundary and internal shear boundary continue until (f) fracture occurs, resulting in adhesive transfer.

References:

[1] I. Hutchings and P. Shipway. Tribology. Second Edition. Oxford: Butterworth-Heinemann; 2017.
[2] Committee of Stainless Steel Producers. Review of the wear and galling characteristics of stainless steels. A Designers' Handbook Series. Washington: Committee of Stainless Steel Producers; 1978.
[3] The authors acknowledge funding from Rolls-Royce plc.