Sliding Wear Assessment of Various Alloys for Pumping Applications: A Comparative Study

Pumping applications require wear resistant components to ensure long operating life spans. Sliding wear is a key mechanism of damage for rotary machinery, particularly in the oil and gas sector. Components in this context frequently experience failure due to material loss and changes in geometry, so processes such as nitriding and heat treatments are applied. This improves tribological properties, however adds time and expense to the manufacturing stage.

The present study focusses on examining the tribological properties of various potential alloys for pumping applications to judge their suitability in this sliding wear context. The performance of these potential alloys were compared to the results of the current heat treated and nitrided pumping materials. Nitronic 60, AISI 420, 15-5PH, AISI 4340, grey cast iron, nitrided M39T, and leaded bronze were analysed in pin-on-disc sliding wear tests. This involved sliding two samples, a pin and a disc, together while under load to create wear scars on the surface of the disc.

The resultant mass and volume losses from the scar were measured to allow material combinations to be ranked. Through examination of the wear scar, the mechanisms of deformation were able to be discerned, allowing for the wear behaviour to be established. To give further context, these were accompanied by metallurgical techniques such as hardness measurements, energy dispersion spectroscopy, glow discharge optical emission spectroscopy, and profilometry.

The untreated materials did not surpass the performance of the nitrided and heat treated materials. It was found that the sliding wear results broadly divide the material combinations into three groups from best to worst: those with cast iron pins, those with Nitronic 60 pins, and self-mated/bronze disc combinations. This behaviour is attributed to the favourable graphite and oxidative lubrication properties inherent to cast irons, whereas the other combinations have no such microstructural features.

Further work involves the external conditions of the pumping environment. While much data has been gathered for alloys in the dry sliding conditions, little has been done to account for the marine environment in which these machines operate. The current study addresses this by conducting sliding wear tests while submerged in salt water, allowing for the corrosive properties of the pumping media to be accounted for. The materials tested in this study were two of the best performing widely-available materials from the dry testing regime: AISI 4340 alloy steel and 15-5PH stainless steel.

The pin-on-disc tests will vary in their applied corrosive media. The first regime involves testing with water only, before then using salt water, before then using salt water with the samples cathodically protected. This allows for the contribution of corrosion to be isolated, allowing for a greater understanding of the synergy between wear and corrosion to be established.

Through this combination of dry and wet testing, a larger context of the wear properties of these alloys can be generated, extending the current knowledge of wear materials for pumping applications.