Tribological behaviour of sintered steel vacuum impregnated with graphite: influence of dimensional and morphological evolution of pores

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This work addresses the dimensional and morphological evolution of sintered steel pores impregnated with graphite during incremental load tribological tests. To conduct the study, sintered steels were impregnated with graphite using acetone as the carrier fluid. Then, the scuffing resistance and wear rates of the specimens were determined using linear reciprocating tests and the wear tracks characterized by SEM, image analysis, micro-Raman spectroscopy and Vickers microhardness. Results show that while porosity is beneficial to the scuffing resistance it is detrimental to the wear rates. A model for the sealing of pores during the scuffing resistance tests is proposed.

Keywords: solid lubrication, pores, image analysis, graphite, powder metallurgy

1. Introduction

The development of self-lubricating composites produced by powder metallurgy (PM) potentially provides long-term solid lubrication due to the self-healing of the lubricating tribolayer [1]. However, in addition to a reduction in strength and, as a consequence, in load-bearing capacity, the presence of porosity might influence the wear mechanisms acting on the surfaces of sintered parts in several ways, in particular, generating and trapping wear debris as well as serving as reservoirs for solid lubricants. On the other hand, there is a strong metallurgical interaction between the different constituents in conventional PM processes, making their understanding very complicated and closely related to the lubricating phase [2].
In this work, the vacuum impregnation technique was used to fill the pores of sintered steel with graphite to avoid these interactions, thus allowing studying the relationship between the lubricating phase, the shape and size of pores and the tribological behaviour of the composites to further the understanding of the solid lubrication phenomenon in sintered composites.

2. Methods

To study the evolution of the size and shape of the lubricant reservoirs (pores), the vacuum impregnation technique was used in sintered steels samples (Astaloy CRL + 0.6 wt.% C, sintered at 1100 °C for 1 hour). Three different compaction pressures (200, 400 and 600 MPa) were used producing varying porosities associated with a hard metallic matrix (Hardness 3000-3200 MPa). The impregnation cycles were carried out in an airtight container containing a dispersion of graphite (0.83 μm) in acetone. Eight cycles of impregnation and evaporation of the carrier fluid were performed in each sample in order to achieve complete filling of the pores.
Constant and incremental load reciprocating ball on flat tests were performed and SEM-EDS images of the wear scars were analysed using a tailor-made Python v3.0 script.

3. Results

Figure 1 synthesizes the results obtained through tribological testing, SEM, and image analysis.

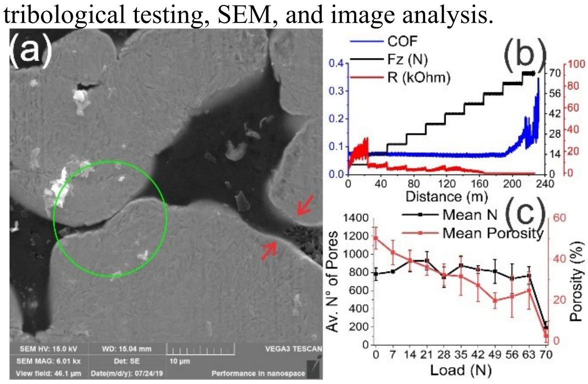

Figure 1: (a): Impregnated pore being sealed by the tribological process, (b): Evolution of COF as a function of load and distance, and (c): Evolution of the number of pores and porosity as a function of load.

4. Discussion

The repeated sliding of the counter-body is continuously sealing the impregnated pores during the tribological tests; this sealing of the lubricant reservoirs progressively reduces the ability of the composite to replenish the lubricating tribolayer. When the number of open reservoirs reaches a critical value, the lubricity regime stops, which increases adhesion, sealing the remaining reservoirs and drastically increasing the friction coefficient. A model of this sealing process is proposed.

5. References

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