Effect of high-pressure hydrogen on the tribological behaviour of a 304L stainless steel contact subjected to fretting sliding

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Abstract

Hydrogen is increasingly regarded as a key solution for achieving carbon neutrality, offering promise in energy storage, transport and application across sectors like automotive, aerospace and heavy industry. This widespread industrial adoption requires the development of robust materials capable of enduring high-pressure hydrogen environments. Metals like stainless steel are commonly used in pipelines, storage tanks, and reactors for hydrogen infrastructure. However, the presence of hydrogen leads to a degradation of the mechanical properties of materials subjected plastic deformations like endured during fretting sliding. Despite this interest in the H2 industry, there has been limited research conducted in the field of tribology to investigate the wear and friction of materials and surface treatments for friction components exposed to gaseous H2 environments, such as valves and compression pistons. In this study, a dedicated fretting wear test operating in a pressurized vessel has been developed at CDM laboratory . The contact consists in a sphere/plane homogeneous 304L stainless steel interface. Different hydrogen pressures from 3 bar up to 250 bar have been tested, and the results compared to reference tests conducted in ambient air (1bar). The findings reveal that, under equivalent fretting loading conditions, the coefficient of friction increased in the presence of hydrogen compared to air. At the same time wear degradation are more severe in H2g. When the hydrogen pressure reaches a threshold value (i.e. above 10 bar), typical "ball bearing like wear debris" are formed reducing the coefficient of friction but still decaying the wear rate due to an easier wear debris ejection process. In addition to establish the fretting wear rates of the 304L/304L interface as a function of the H2g pressure, careful surface scar analyses involving SEM, EDX, micro raman and SIMS investigations are performed to better interpret the ongoing wear scenario and the dynamics of the surface damages.

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