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Combining Nitrocarburisation and Dry Lubrication for Improving Component Lifetime

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Abstract : Nitrocarburisation is a surface hardening technique often applied to improve the wear resistance of steel surfaces. It is considered to be a promising solution in comparison with other processes such as flame spraying, owing to the formation of a diffusion layer which provides mechanical integrity, as well as its cost-effectiveness. To improve other tribological properties of the surface such as the coefficient of friction (COF), dry lubricants are utilized. Currently, the lifetime of steel components in many applications using either of these techniques individually are faced with the limitations of the two: high COF for nitrocarburized surfaces and low wear resistance of dry lubricant coatings. To this end, the current study involves the creation of a hybrid surface using the impregnation of a dry lubricant on to a nitrocarburized surface. The mechanical strength and hardness of Gerster SA's nitrocarburized surfaces accompanied by the impregnation of the porous outermost layer with a solid lubricant will create a hybrid surface possessing both outstanding wear resistance and a low friction coefficient and with high adherence to the substrate. Gerster SA has the state-of-the-art technology for the surface hardening of various steels. Through their expertise in the field, the nitrocarburizing process parameters (atmosphere, temperature, dwelling time) were optimized to obtain samples that have a distinct porous structure (in terms of size, shape, and density) as observed by metallographic and microscopic analyses. The porosity thus obtained is suitable for the impregnation of a dry lubricant. A commercially available dry lubricant with a thermoplastic matrix was employed for the impregnation process, which was optimized to obtain a void-free interface with the surface of the nitrocarburized layer (henceforth called hybrid surface). In parallel, metallic samples without nitrocarburisation were also impregnated with the same dry lubricant as a reference (henceforth called reference surface). The reference and the nitrocarburized surfaces, with and without the dry lubricant were tested for their tribological behavior by sliding against a quenched steel ball using a nanotribometer. Without any lubricant, the nitrocarburized surface showed a wear rate 5x lower than the reference metal. In the presence of a thin film of dry lubricant (< 2 micrometers) and under the application of high loads (500 mN or ~800 MPa), while the COF for the reference surface increased from ~0.1 to > 0.3 within 120 m, the hybrid surface retained a COF < 0.2 for over 400m of sliding. In addition, while the steel ball sliding against the reference surface showed heavy wear, the corresponding ball sliding against the hybrid surface showed very limited wear. Observations of the sliding tracks in the hybrid surface using Electron Microscopy show the presence of the nitrocarburized nodules as well as the lubricant, whereas no traces of the lubricant were found in the sliding track on the reference surface. In this manner, the clear advantage of combining nitrocarburisation with the impregnation of a dry lubricant towards forming a hybrid surface has been demonstrated.

Keywords : dry lubrication, hybrid surfaces, improved wear resistance, nitrocarburisation, steels
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