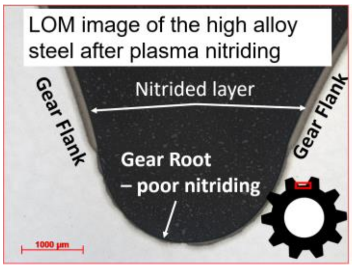
INDUSTRIAL PILOT PROJECT

XPS-study of passivating films and their effect on plasma nitriding

THE INDUSTRIAL CHALLENGE

The plasma nitriding hardening method is extremely important for improving service life of gears. However, the heat treatment subcontractor Bodycote faces challenge when working on plasma nitrided gears manufactured from advanced high-alloy steel grades. The core problem is that unwanted surface passivation seems to inhibit efficient nitriding in the gear root and lead to lack of nitriding depth. It is therefore important to understand what causes this surface passivation that leads to a lack of nitriding depth.



WHY USING A LARGE SCALE FACILITY

To measure the surface chemistry of the passive layers to a deeper depth than ordinary XPS, the higher energy of incoming X-rays of synchrotron based Hard X-ray Photoelectron Spectroscopy (HAXPES) results in an increased inelastic mean free path and increased escape depth. The ability to tune the probing depth combined with excellent chemical sensitivity of XPS allow to perform composition and chemical analysis of the surface and sub-surface layers of material.

HOW THE WORK WAS DONE

Samples of ~4x4x10 mm were cut from vacuum heat-treated gear flanks and gear roots from two different materials, AISI steel H13 and the Ovako Hybrid Steel. After vacuum treatment the flanks were ground, while the roots were left untreated. In addition, samples of similar size were cut and ground and left to age in room temperature up to six months prior to measurements. The measurements were performed at the P22 beamline of Petra III in Hamburg during a 40 hour slot.

THE RESULTS AND EXPECTED IMPACT

The results showed that aluminium oxide (Al2O3) was present in high concentrations in the gear roots of both H13 and Ovako Hybrid Steel. In the case of Hybrid Steel this was not unexpected since it contains a couple of wt% aluminium. For the H13 alloy it was more surprising since it contains only ~0.02 wt%. Aluminium evidently diffuses to the surface during the vacuum hardening performed after gear hobbing and forms an oxide. The room temperature experiments showed that aluminium diffuses to the surface of the H13 alloy, however the amounts are much lower (Figure).

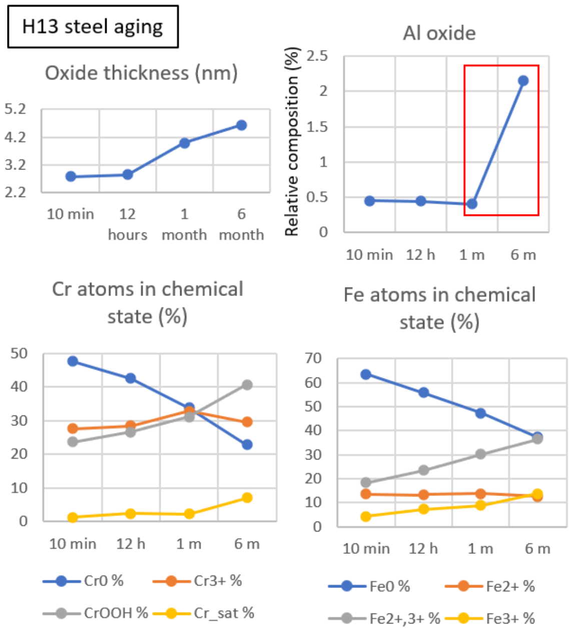


Figure. Results of HAXPES illustrating diffusion of Al in H13 steel after 1 month ageing in air.

It has previously not been known what causes the passivation in gear roots, but following the HAXPES experiment it is clear that Al2O3 is present in high concentrations. Since Al2O3 is a very dense oxide, known to pacify surfaces, it is likely that it plays a large role for the resulting passive films at the gear roots. Now it is possible to start working on solutions to circumvent this passivation.

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