Surface modification of chromium-silicon martensitic steel by forming hard borides

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Surface modification of chromium-silicon martensitic steel by forming hard borides

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Abstract

In this study, an alternative surface hardening method called as "CRTD-Bor" (Cathodic Reduction and Thermal Diffusion based Boriding) was introduced for the heavy-duty applications of medium carbon, chromium-silicon martensitic steel, also known commercially Silchrome 1. The influences of process parameters (e.g. electrolyte temperatures and both electrolysis and phase homogenization durations) on the chemistry, thickness and hardness of boride structures were investigated to yield a modified surface within the industrially desired compositions, namely single Fe_2B or the layer containing max. 10 % of FeB in vol. Furthermore, adhesion as well as thermal oxidation behaviors of borided substrates were examined. Cross sectional SEM investigations revealed that it was possible to grow 35 µm or 45 µm thick boride layers within the preferred compositions after 40 min and 55 min of CRTD-bor, respectively. Thin film XRD analyses confirmed single Fe_2B formation with minor Cr_2B peaks. The hardness of boride layers varied in the range of 1400±200 HV. The grown boride layers exhibited the ideal adhesions to the steel matrix with either perfect HF1 or acceptable HF3 qualities according to their constitutions. CRTD-Bor boriding process improved the oxidation resistance of the steel at 650 °C remarkably by forming thin ~7µm thick protective layer composing of mixed iron-, chromium - oxides and borates as well as boron oxide (B_2O_3) which was firstly identified in the hexagonal crystalline structure after oxidizing borided steel samples at 450 °C and 650 °C.

Key words: CRTD-Bor, Boriding, Thermal oxidation, Silchrome, Cr-Si martensitic steel