304L stainless steel breakaway oxidation:

Mechanisms and influence of pre-strain

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Abstract: To ensure good resistance to high temperature oxidation, the oxide scales formed on stainless steels should remain thin, rich in chromium and adherent to the metallic substrate. When operating in severe conditions (aggressive atmospheres or high temperatures), breakaway oxidation happens. It is characterized by the destabilization of the Cr-rich oxide scale and the quick growth of non-protective Fe-rich oxide nodules. This study focuses on the different mechanisms leading to the loss of the protectiveness of the oxide scale, the growth of the iron oxides, and the formation of internal oxidation zones. The microstructure and the composition of the oxides were characterized with conventional techniques together with Raman spectroscopy, TEM and EBSD mappings. A mechanism for the formation of the internal oxidation zone, relying on the formation of a healing oxide layer along the grain boundaries of the underlying metal, is proposed. The results also show that a tensile deformation prior to oxidation improves the durability of the steels by promoting the formation of a protective duplex oxide scale from the first stages of oxidation. When starting, breakaway oxidation remains localized while for as-received austenitic stainless steel 304L samples a protective regime is never reached at 850 °C.

Keywords: High temperature oxidation, austenitic steel, growth mechanism, breakaway oxidation, cold-work