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Oxidation behavior of novel Fe-based alloys under high-temperature steam-containing atmosphere

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The introduction of high-entropy alloys has motivated the development of novel materials with more complex compositions. Concerning Fe-based alloys, this gave origin, for example, to the FeMnAlC-based high-entropy steels, which show remarkable mechanical properties. Similarly, it is possible to find high-entropy stainless steels with promising corrosion resistance. The potential for applying these new alloying concepts to develop high-temperature oxidation-resistant steels, however, is still underexplored. This study presents a nonequiatomic Fe-Cr-Ni-Co-Si alloy with and without Mo addition. The samples were synthesized in an arc-melting furnace and studied in their as-cast condition. Samples of conventional AISI 310 steel were also produced and tested in the same conditions. The starting microstructure was characterized through SEM/EDX and XRD analysis. Samples were also exposed for up to 1000 h at 900 °C in a quasi-isothermal regime, with stops at 100 and 300 h for weighing as well as the removal of one sample of each alloy after 100 h for characterization. The samples were ground, cleaned, weighed, and exposed to a synthetic air atmosphere with 5% water vapor addition. Oxidized surfaces and polished cross-sections were analyzed through SEM/EDX and XRD. Results show that the addition of a higher Co content can stop the precipitation of the sigma phase, which occurs in the conventional steel and is usually responsible for the embrittlement of high-Cr stainless steels at moderate to high temperatures. With the addition of Mo, however, the sigma phase is present even in the as-cast state. After oxidation, Si-rich Laves phase is present in the Cr-depleted zone. All alloys presented significant spinel formation after 1000 h, with the conventional stainless steel showing a lower amount of spallation. In all alloys, the spinel contained a mixture of all alloying elements. The Cr_2O_3 oxide was only identified through XRD in the novel alloys. Another indication that these alloys have a better oxidation behavior is that, after only 100 h, the conventional stainless steel already formed Fe-rich oxides, while the novel steels formed mainly Cr-rich oxides, with some Fe oxide nodules. The addition of Mo seems to have reduced the oxidation resistance and phase stability of the alloy, leading to a thicker spinel layer after 1000 h and the formation of secondary phases. The novel alloy without Mo, on the other hand, is more resistant than the conventional steel and presents a higher phase stability.