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The effects of small additions of silicon on the oxidation resistance of Fe-based alloys and steels in high pressure CO_2*

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The oxidation kinetics, in high pressure CO_2, of Fe-based alloys and steels containing up to 12 %Cr can undergo a transition from protective (reducing) rates of oxidation to relatively rapid linear oxidation rates (breakaway oxidation). The effects of small additions of silicon to pure iron and Fe–Cr binary alloys, and the effects of silicon content of steels on oxidation has been studied. Additions of silicon to pure Fe decreased the protective oxidation rates, increased times to breakaway and decreased post-breakaway rates. The morphologies of the oxide scales and the distribution of silicon were examined by optical and electron optical techniques. It is proposed that the beneficial effects of silicon are due to the blocking of short circuit diffusion paths in the protective oxide scale and to the promotion of graphite nucleation in the metal. The latter process provides a 'sink' for the carbon produced by the oxidation/carburization reaction and prevents the deleterious nucleation of Fe_3C at the metal–oxide interface.

Additions of silicon to Fe–9 %Cr and Fe–12 %Cr alloys greatly reduced protective oxidation rates and increased times to breakaway by promoting the formation of thin chromium-rich sesquioxide scales rather than double layered Fe_3O_4–Fe–Cr spinel scales. With increasing silicon content the protective oxidation rates of Fe–9 %Cr steels decreased but sesquioxide scales were not formed. At high temperatures high silicon contents promoted the formation of a chromium-enriched spinel healing layer at the metal–oxide interface.

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