CARBURISATION AND METAL DUSTING OF CAST HEAT RESISTANT ALLOYS

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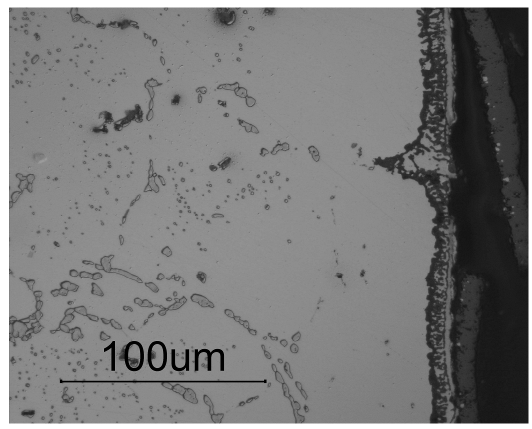
The carburisation resistance of a range of heat resisting alloys, including new grades, has been investigated. Attention was focussed on the effects of aluminium and reactive element additions on the performance of alloys containing nickel levels of 45 weight percent and higher. These materials were compared with conventional grades based on Fe-25 Cr-35Ni, Fe-30Cr-30Ni and Fe-35Cr-45Ni.

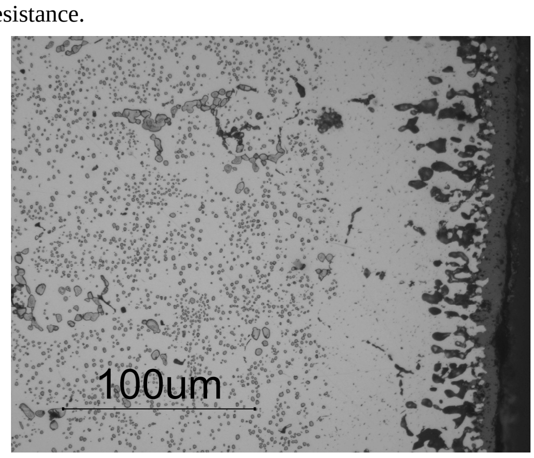
All were exposed isothermally at temperatures of 900-1100^{o}C to flowing gas mixtures of hydrogen – 5 volume percent methane. Internal precipitation of chromium-rich carbides, M_7C_3 and $M_{23}C_6$ was the main corrosion process for all alloys. Parabolic kinetics were observed, and comparison of the rate constants with those predicted from Wagner's diffusion theory was used to identify the benefits of the minority alloy additions.

The alloys were also subjected to carburising – oxidising conditions, in a gas of composition H_2-4.7CH_4-6H_2O volume percent, producing an oxygen activity high enough to react with chromium and aluminium, but not iron or nickel. To make conditions more severe, temperature cycling was employed: 45 mins at reaction temperature and 15 min at room temperature, repeated 500 times. At 1000^{o}C, all alloys grew protective spallation-resistant oxide scales. At 1100^{o}C, clear differences emerged between the alloys. Alloys containing high nickel concentrations and low levels of aluminium displayed slow parabolic weight uptake kinetics throughout the 500 cycle tests. Higher aluminium levels led to much slower weight uptake, with little or no weight change after the first 20 cycles. The 45Ni alloys showed weight gains for the first 200 cycles, but lost weight subsequently. The standard alloys generally lost weight from an early stage at 1100^{o}C.

Scaling was always accompanied by subsurface dissolution of original alloy chromium carbides, and a deeper zone of carburisation. Despite the improved oxide scaling performance on some alloys, internal carburisation still occurred to some degree. The extent of carburisation is discussed in terms of oxide scale morphologies. High aluminium levels were particularly beneficial, as shown in the Fig.

Preliminary results are presented for metal dusting at 680^{o}C in a gas mixture of CO-26%H_2 – 6%H_2O, corresponding to a_c = 2.9 and an oxygen activity sufficient to oxidise chromium, but not iron or nickel. The varying susceptibility to dusting is correlated with the oxide scale composition and morphology. High nickel, aluminium-bearing alloys provided superior resistance.





Microstructures of alloys after 500 cycles at 1100^{o}C in H_2 / CH_4 / H_2O.

Upper: standard microalloyed Fe-25Cr-35Ni; lower: high nickel, aluminium-bearing grade