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Al-C-Cr-Fe-Mn-Mo-N-Ni-Si-V

V. Raghavan

In order to aid in the selection of the optimum temperature for intercritical heat treatment of an SA508 Grade 3 steel, [1998Lee] performed a thermodynamic calculation of the γ (austenite) - α (ferrite) phase equilibria in this 10-component system.

Thermodynamic Models and Computation

The calculations were done for a steel of composition in wt.%: 1.24 Mn, 0.88 Ni, 0.47 Mo, 0.21 Cr, 0.25 Si, 0.004 V, 0.008 Al, 0.21 C, 0.005 N, and balance Fe. Comparisons were made with an experimental alloy of the same composition, but containing in addition 0.03 Cu, 0.002 S, and 0.007 P. The solid solution phases were described as a two-sublattice model with formula $(Fe,Mn,Ni,Mo,Cr,Si,V,Al)_a(C,N,Va)_c$, where Va stands for vacancy. In the case of body-centered cubic ferrite (α), $a = 1$ and $c = 3$. For face-centered cubic austenite (γ), $a = 1$ and $c = 1$. Available assessments of Fe-based quaternary carbide and nitride systems (Fe-M-M-C and Fe-M-M-N, M standing for metal) and the corresponding subsystems were considered adequate for the reliability of the calculations. Complete descriptions were available for all important lower-order systems such as Fe-C, Fe-N, Fe-M, M-C, M-N, Fe-M-C, and Fe-M-N.

The computed equilibrium mole fractions of austenite, ferrite and various carbides and nitrides as a function of annealing temperature are shown in Fig. 1. Figure 1(b) shows in greater detail the austenite formation as well as the cementite and ξ-carbide dissolution. To produce an austenite fraction of 0.4, the calculations yield an intercritical annealing temperature of 720 °C. An independent experimental verification in the authors' group showed that this temperature is 725 °C for this steel. Despite the influence of variables such as thermal history, prior microstructure and incomplete attainment of equilibrium during the intercritical anneal, the agreement is good.

References

1998Lee: B.J. Lee, H.D. Kim, and J.H. Hong, Calculation of α/γ Equilibria in SA508 Grade 3 Steels for Intercritical Treatment, *Metall. Mater. Trans. A*, 1998, **29A**, p 1441-1447

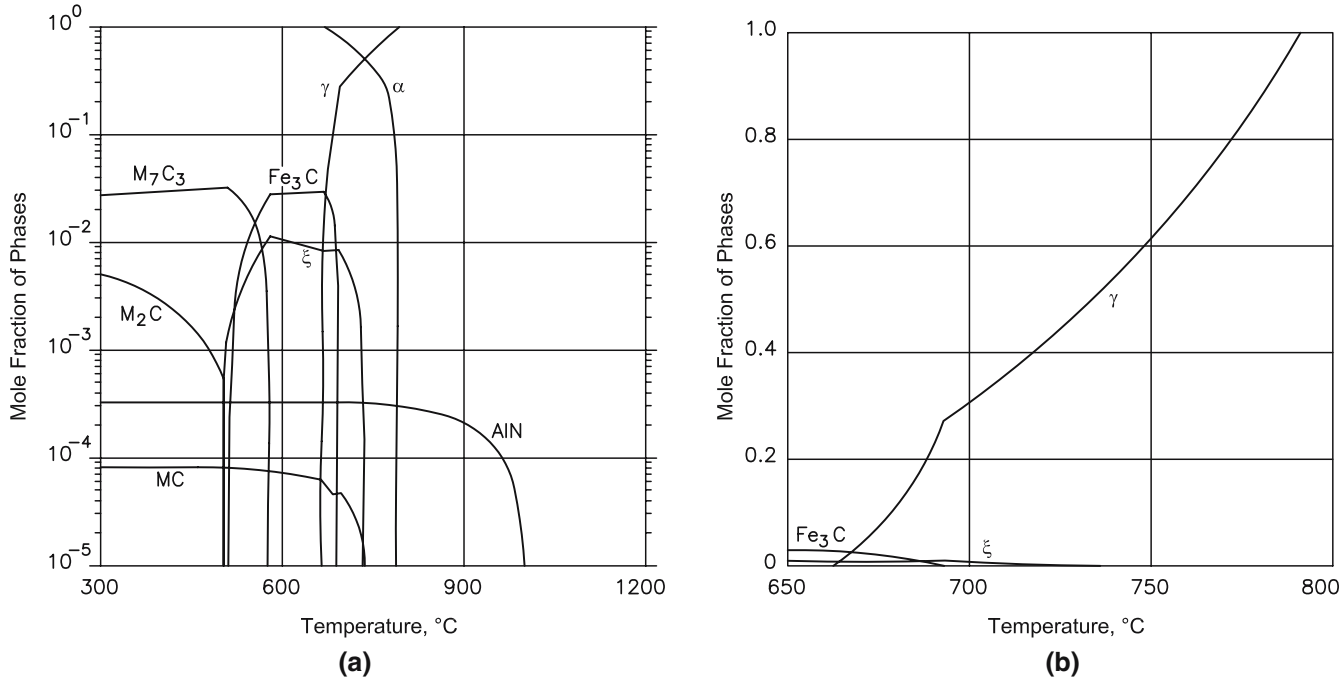

Fig. 1 (a) SA508 Grade 3 steel computed equilibrium mole fraction of phases. (b) Enlargement of the austenite (γ) region [1998Lee]