C-Fe-V (Carbon-Iron-Vanadium)

V. Raghavan

Data on the solubility of microalloying elements in body-centered cubic (bcc) ferrite are relatively sparse. [1987Rag] reviewed some results obtained by internal friction measurements on the solubility of V in ferrite. [1995Tay] calculated the solubility product for ferrite, using the solubility product for austenite and binary thermodynamic parameters.

Binary Systems

The Fe-C phase diagram [1992Oka] is in the form of a double diagram, corresponding to the metastable equilibrium with cementite (Fe_3C) or the stable equilibrium with graphite. The peritectic formation of the solid solution γ (austenite) based on face-centered cubic (fcc) Fe is followed by the eutectic reaction, which yields austenite and cementite (or graphite). The eutectoidal decomposition of austenite yields bcc α (ferrite) and cementite (or graphite). In the V-C system, the monocarbide VC has a homogeneity range on the C-poor side and is often denoted as VC_{1-x} or $VC_{0.75}$. Several other C-deficient modifications are known, in addition to V_2C, see [1985Car]. The monocarbide is the stable form in steels and we will denote this phase by the nominal formula VC. In the Fe-V system [1993Smi], the fcc form of Fe is restricted by a γ loop. An intermediate phase σ forms congruently from α at 1252 °C near the equiatomic composition.

Solubility of Vanadium in Ferrite

The internal friction technique has been used to measure the low solubility of C in Fe-V ferrite. The review of [1987Rag] presented the results of [1973Koy] on the phase boundary between α and (α + VC) at 800 and 700 °C. [1986Tod] obtained the following empirical relationship through a best fit of several previous results including those of [1973Koy]: $\log_{10}$[wt.% C][wt.% V] = −8300/T(K) + 4.55. Recently, [1995Tay] obtained the ferrite solubility relationships from the austenite solubility products and the activity coefficients of the solutes, Nb, Ti, and V. The solubility product for C-V equilibrium is given by: $\log_{10}$[wt.% C][wt.% V] = −12265/T(K) + 8.05 [1995Tay]. The α/(α + VC) phase boundaries at 800 and 700 °C from the results of [1995Tay] and the best-fit of [1986Tod] are compared in Fig. 1. The solubilities computed by [1995Tay] are lower than those of the best-fit of [1986Tod].

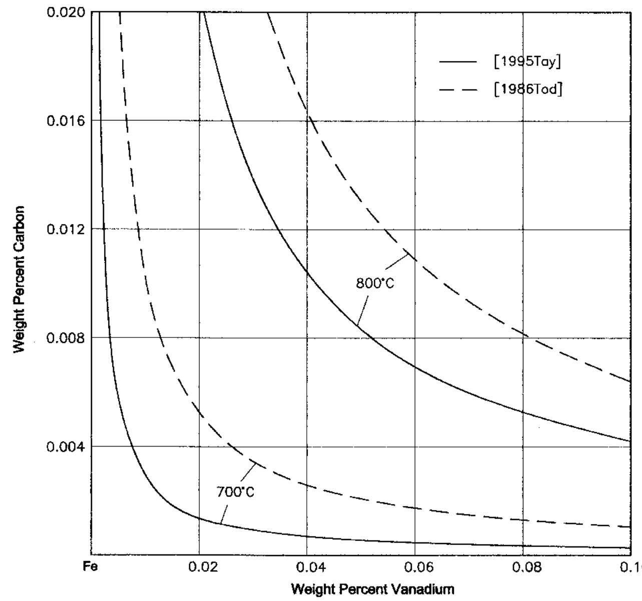

Fig. 1 C-Fe-V solubility of V in ferrite at the indicated temperatures

References

1973Koy: S. Koyama, T. Ishii, and K, Narita: "Solubility of Vanadium Carbide and Nitride in Ferritic Iron," *Nippon Kinzoku Gakkai-Shi,* 1973, *37*(2), pp. 191-96 (in Japanese).

1985Car: O.N. Carlson, A.H. Ghaneya, and J.F. Smith: "The C-V (Carbon-Vanadium) System," *Bull. Alloy Phase Diagrams,* 1985, *6*(2), pp. 115-24.

1986Tod: J.A. Todd and P. Li: "Microstructure-Mechanical Property Relationships in Isothermally Transformed Vanadium Steels," *Metall. Trans. A,* 1986, *17A*, pp. 1191-202.

1987Rag: V. Raghavan: "The C-Fe-V (Carbon-Iron-Vanadium) System," *Phase Diagrams of Ternary Iron Alloys,* ASM International, Materials Park, OH, 1987, pp. 111-25.

1992Oka: H. Okamoto: "The C-Fe (Carbon-Iron) System," *J. Phase Equilibria,* 1992, *13*(5), pp. 543-65.

1993Smi: J.F. Smith: "Fe-V (Iron-Vanadium)," *Phase Diagrams of Binary Iron Alloys,* H. Okamoto, ed., ASM International, Materials Park, OH, 1993, pp. 433-43.

1995Tay: K.A. Taylor: "Solubility Products for Titanium-, Vanadium-, and Niobium-Carbide in Ferrite," *Scripta Metall. Mater.,* 1995, *32*(1), pp.7-12.