Fe-Mn-Zn (Iron-Manganese-Zinc)

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The previous review of this ternary system by [1991Bha] presented from the work of [1974Bud] three isothermal sections at 1000, 720, and 625 °C for alloys containing Mn up to 30 at.%. Recently, Reumont et al. [1995Reu] determined an isothermal section for this system at 450 °C.

Binary Systems

The Fe-Mn phase diagram [1993Oka] contains no intermediate phases. It depicts a wide range of mutual solid solubility between fcc Fe and γMn. At 450 °C, the stable solid solutions are: bcc Fe based α has a range of 0-3 at.% Mn, the fcc solid solution γ has a range of 25.5-52 at.% Mn, and (αMn) is stable between 69.5-100 at.% Mn. The Fe-Zn phase diagram (Fig. 1 under the Fe-Zn system on page 544) exhibits a γ loop, extensive solubility of Zn in bcc Fe (α), and four intermediate phases: Γ, Γ_1, δ, and ζ. For crystal structure data of the Fe-Zn compounds, see Table 1 under Fe-Zn. The Mn-Zn phase diagram [1990Oka] depicts a number of intermediate phases. Due to disagreements between various reports and the lack of confirmatory work, many parts of the diagram are tentative and qualitative [1990Oka]. At the temperature of interest here (450 °C), the stable phases are (αMn), (βMn), the three modifications of the hexagonal ε phase (ε, ε_1, and ε_2), the hexagonal $MnZn_9$ phase (denoted δ by [1990Oka]), and the liquid. The low temperature modification of $MnZn_9$ (denoted δ_1 by [1990Oka]) is isostructural with δ ($FeZn_{10}$) [1995Reu] and forms peritectoidally at 424 °C [1990Oka]. The monoclinic $MnZn_{13}$ phase, which is isostructural with ζ ($FeZn_{13}$), forms peritectically at 428 °C [1990Oka].

Ternary Isothermal Section

[1995Reu] used two different methods to determine the phase diagram. Fe and Fe-Mn samples galvanized in pure liquid Zn or Mn-added liquid Zn, were given a diffusion anneal at 450 °C for a few days. In the second method, zinc was deposited on Fe-Mn alloys from a vapor phase, which resulted in the formation of Zn poorer layers. The phases in the layers were characterized by optical microscopy, energy dispersive x-ray analysis coupled to the scanning electron microscope (SEM-EDS) and x-ray diffraction. Based on the results, [1995Reu] constructed an isothermal section at 450 °C. This is redrawn in Fig. 1 to agree with the accepted binary data. An enlarged view of the Zn rich region is

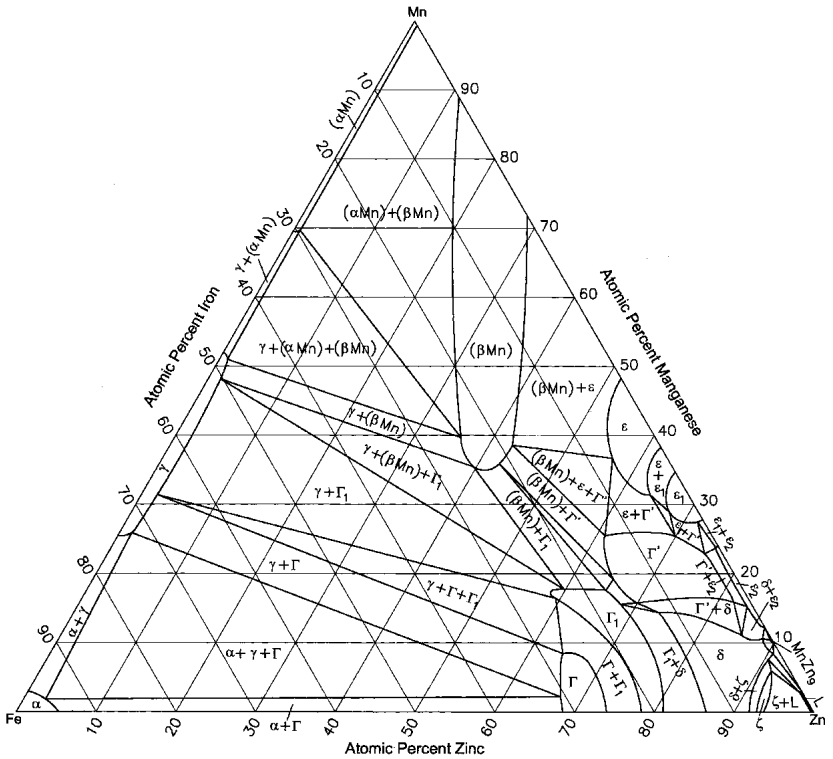

Fig. 1 Fe-Mn-Zn isothermal section at 450 °C [1995Reu]

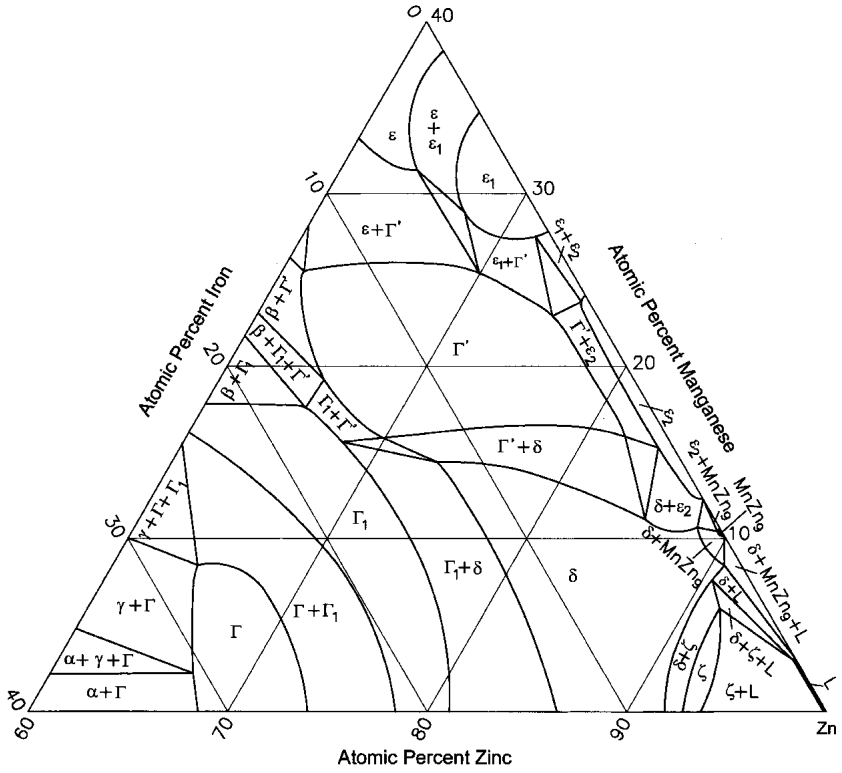

Fig. 2 Fe-Mn-Zn isothermal section at 450 °C for Zn rich alloys [1995Reu]

shown in Fig. 2. Mn replaces 75% of the Fe atoms in the ζ ($FeZn_{13}$) phase and probably forms a continuous solid solution below 428 °C, where ζ ($MnZn_{13}$) becomes stable. Mn substitutes over 90% of Fe in the δ ($FeZn_{10}$) phase [1993Reu]. The solubility of Mn in Γ and Γ_1 is appreciable. In βMn, more than half of Mn is replaced by approximately equal amounts of Fe and Zn. A ternary phase Γ′ (denoted Γ by [1995Reu]) has a significant homogeneity range. It is isostructural with the Fe-Zn phase Γ, but is not continuous with it at 450 °C.

References

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