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Publication Date
1984-04-01
Presented at the 107th Iron and Steel Institute of Japan, Narashino, Japan, April 1-3, 1984

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April 1984

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TEMPERATURE AND MANGANESE CONTENT DEPENDENCES
OF TENSILE DEFORMATION IN IRON-HIGH MANGANESE BINARY ALLOYS

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INTRODUCTION

Microstructures in the Fe-Mn system depend strongly on Mn Content. The mechanical properties of these alloys have been examined by several workers [1], but many obscure points have remained and are not well understood. The purpose of this report is to identify the microstructural dependence of the tensile properties of 16 to 36 wt% Mn steels.

EXPERIMENTAL PROCEDURE

The alloys were prepared by induction-melting in a helium gas atmosphere. After homogenizing at 1150°C for 24 hs, each ingot (about 9 kg) was hot-rolled at 1200°C to a plate of 10 mm in thickness. The round bar tensile specimens with 1 in (25.4 mm) gage length and 1/4 in (6.4 mm) gage diameter were machined after solution treatment at 1000°C for 1 h in an argon atmosphere. The plate tensile specimens with 0.125 in (0.2 mm) by 0.15 in (3.8 mm) cross section and 1 in (25.4 mm) gage length were machined from cold rolled sheets annealed at 1000°C for 1 h followed by water-quenching.

RESULTS AND DISCUSSION

The microstructure of the as-quenched specimens consisted of either a mixture of austenite (\(\gamma\)) and (hcp)-martensite (\(\varepsilon\)) or single phase \(\gamma\) as shown in Fig. 1. The volume fraction of \(\varepsilon\) reaches a maximum at 17% Mn and cannot be detected above 31% Mn either by x-ray or optical microscopy.

Figure 2 shows the effect of Mn content on tensile properties. Transformations of \(\gamma\) to \(\varepsilon\) and/or \(\alpha'\) martensite were induced during deformation. The microstructural changes on deformation are plotted in Fig. 1. As the Mn content is decreased from 36% to 25%, work-hardening is increased rapidly. Despite a small change in 0.2% proof stress, both

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the 1% flow stress and tensile strength are remarkably increased. This high work-hardening is due to the intrusion of ε. Although appropriate ε formation during deformation enhances the uniform elongation as TRIP (e.g., 31 Mn), large amounts of ε deteriorate the ductility drastically.

From 20% to 16% Mn, α' is also induced by deformation. It is effective in lowering the rate of work-hardening and in increasing the ductility. In 16 Mn alloy α' generation starts from the beginning of the test (so-called stress-induced) so that the 0.2% proof stress is lowered. Also, this alloy fractures intergranularly at -196°C with associated poor ductility similar to 12 Mn steel [2].

Since martensitic transformations are not only a function of Mn content but also of temperature, tensile tests were conducted at various temperatures from -196°C to 300°C. The temperature-dependence of the 25 Mn alloy is shown in Fig. 3. An ε → γ reverse transformation occurs upon heating the alloy above 200°C, so that single phase γ deformation can be examined. Through this experiment, the plastically deformed γ was found to be stabilized against thermal γ → ε transformation.

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Sciences Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

REFERENCES

Fig. 1. Volume fraction of constituent phases as a function of Mn content. The specimens in as-quenched condition and uniformly deformed portion of fracture specimens were examined by x-ray.
Fig. 2a. Effect of Mn content on 0.2% proof stress showing 1% flow stress and tensile strength.

Fig. 2b. Effect of Mn content on 0.2% proof stress showing uniform elongation (U-EL), total elongation (T-EL) and reduction in area (φ).
This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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