ANTIFERROMAGNETISM OF IRON-MANGANESE ALLOYS

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The temperature dependence of the susceptibility of iron-manganese alloys, containing 13—43.9% Mn, was studied; these alloys have fcc structure. It was found that the alloys are antiferromagnetic. Extrapolation to zero Mn content of the dependence of the antiferromagnetic transition point on the amount of manganese indicates that pure γ-iron is antiferromagnetic with a Curie point at low temperatures.

KONDORSKII and the present author have investigated the magnetic properties of austenitic chrome-nickel steel and have suggested that fcc iron (the γ-phase) is antiferromagnetic.[1] This suggestion was confirmed by an analysis of the anomalous properties of iron-nickel (Invar) alloys.[2,3] However, there was still no direct proof that γ-iron is antiferromagnetic. Neutron diffraction studies of γ-iron at high temperatures[4] did not confirm antiferromagnetism. The present paper describes an attempt to determine the magnetic properties of γ-iron by extrapolating the properties of iron-manganese alloys to 0% Mn. Iron-manganese alloys were selected because of all the alloying elements, manganese is the one which extends the region of appearance of the γ-phase most widely.

1. EXPERIMENTAL TECHNIQUE AND SAMPLES

The temperature dependence of the suceptibility was measured on several samples of iron-manganese alloys. The measurements above room temperature were carried out using the method proposed by Brandt.[5] In Brandt's method a measurement is made of the force exerted on a sample in a nonuniform magnetic field. This force is deduced from the angle of torsion of a helical spring from which the sample is suspended.

Below room temperature the photoelectric fluxmeter method[6] was employed.

Iron-manganese alloys, containing up to 30% Mn (by weight), consist of several phases in their equilibrium state.[7] At room temperature the γ-phase may coexist with the ferromagnetic α-phase (bcc) and the nonferromagnetic ϵ-phase (hcp). To avoid formation of the α- and ϵ-phases, $\approx 0.5\%$ carbon was added to alloys containing 13—24% Mn. X-ray diffraction analysis carried out on powders, prepared from the alloy samples, showed that only the γ-phase was present.

2. RESULTS

The temperature dependence of the susceptibility indicated that the iron-manganese alloys are antiferromagnetic in the region where the γ-phase exists. The results of measurements are given

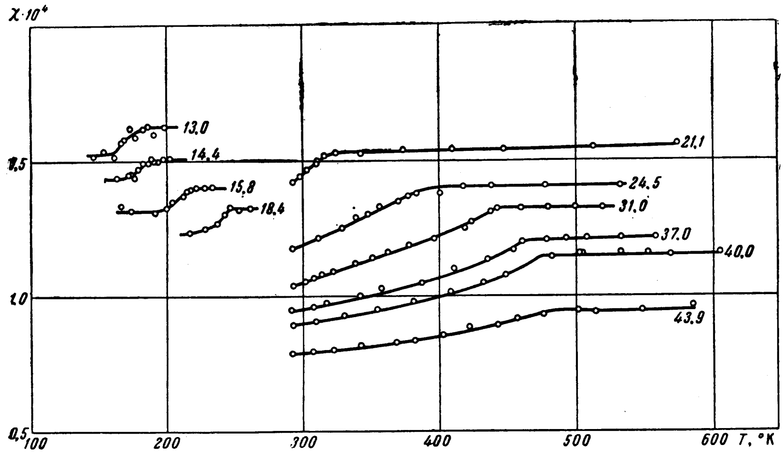

FIG. 1. The temperature dependence of the susceptibility (χ) of iron-manganese alloys. The numbers by the curves denote the manganese content in weight per cent.

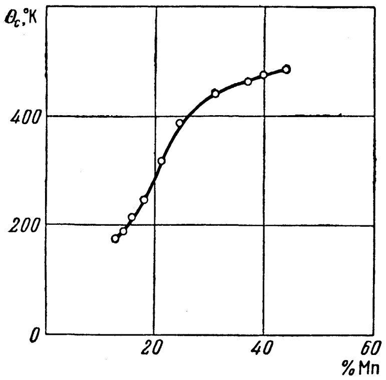

FIG. 2. The dependence of Θ_c on the amount of Mn (wt. %) in Fe-Mn alloys.

in Fig. 1. Kinks in the curves of Fig. 1 correspond to the antiferromagnetic transition points Θ_c.

Figure 2 gives the dependence of Θ_c on the concentration of manganese. The general form of this curve shows that the antiferromagnetic transition point corresponding to 0% Mn lies above 0°K. This, however, cannot be taken as a conclusive proof of antiferromagnetism of γ-iron because extrapolation is carried out over a large temperature interval.

Some magnetic properties of iron-manganese alloys are worth noting. First, the temperature dependences of the susceptibility (Fig. 1) above the antiferromagnetic transition points are horizontal straight lines. This means that in the region where these alloys should be paramagnetic they do not obey the Curie-Weiss law. Second, the susceptibility does not change greatly on passage through the antiferromagnetic transition temperature. It is possible that on reduction of the manganese concentration to zero, the susceptibility "jump" near the antiferromagnetic transition may also tend to zero. Thus extrapolation of the curve shown in Fig. 2 cannot be used to check whether γ-iron is antiferromagnetic.

These features of magnetic properties suggest that iron-manganese alloys have complex magnetic structure. They may possess antiferromagnetic ordering of magnetic moments even at temperatures above the observed antiferromagnetic transition.

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[1] E. I. Kondorskii and V. L. Sedov, JETP **35**, 1579 (1958), Soviet Phys. JETP **8**, 1104 (1959).

[2] E. I. Kondorskii, JETP **37**, 1819 (1959), Soviet Phys. JETP **10**, 1284 (1960).

[3] E. I. Kondorskii and V. L. Sedov, JETP **38**, 773 (1960), Soviet Phys. JETP **11**, 561 (1960).

[4] M. K. Wilkinson and C. G. Shull, Phys. Rev. **103**, 516 (1956).

[5] N. B. Brandt, PTÉ No. 4, 153 (1959).

[6] E. I. Kondorskii and V. L. Sedov, JETP **35**, 845 (1958), Soviet Phys. JETP **8**, 586 (1959).

[7] V. G. Kuznetsov and N. N. Evseeva, ZhPKh (J. of Appl. Chem.) **12**, 406 (1939); A. H. Sully, Manganese, London 1955.

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19