AEC-NASA TECH BRIEF

Study Reveals Effect of Aluminum on Saturation Moment of Fe–Ni Alloys

The electronic structure of the transition elements has been under investigation for over three decades, but due to the complexity of the problem, there is still no theory that can explain the physical properties related to the valence electrons of these elements and their alloys. The current study concerns itself with the ferromagnetic saturation magnetization of an element or an alloy, which is one of its intrinsic properties and is entirely dependent on the electronic structure. Thus, the measurement of saturation magnetization is an important tool in the investigation of the electronic structure of alloys. This study, *"The Effect of Aluminum on the Saturation Moment of Fe–Ni Alloys"*, which is in the form of a doctoral dissertation by D. I. Bardos, is available on request from the Argonne National Laboratory.

It has been known that the addition of a nontransition metal solute such as aluminum to iron does not affect the moment on iron (iron-type behavior), while the addition of aluminum to nickel decreases the nickel moment by an amount proportional to the valence of aluminum (nickel-type behavior). To determine whether these different characteristics of iron and nickel are inherent properties of the atomic species or simply related to the different structural and electronic environments, saturation magnetization measurements have been made on the fcc nickel-rich and bcc iron-rich solid solutions in the iron–nickel–aluminum system. Several series of alloys were made up in which the iron-to-nickel ratio was kept constant as the aluminum concentration was increased.

The principle on which the magnetization measurements were based is that a ferromagnetic specimen experiences a vertical force when it is in a nonuniform magnetic field whose horizontal component changes in the z direction. This force is given by the following equation

$$F_z = m\sigma_{H,T}\frac{\partial H_x}{\partial z} \qquad \text{(dynes)}$$

where m is the mass in grams, $\sigma_{H,T}$ is the intensity of magnetization per gram, and $\partial H_x/\partial z$ is the field gradient in the vertical direction. The magnetization was determined by measuring this force with a semi-automatic vacuum recording balance in increasing fields at various temperatures.

The saturation magnetizations were extrapolated to the absolute zero of temperature for calculating average atomic moments.

The results show that in ternary alloys both iron and nickel atoms retain their individual characteristics and the magnitude of the magnetic moment on each atom depends strongly on the near neighbor environment.

The effect of aluminum on the saturation moment of fcc Fe–Ni alloys can be described with the aid of the following assumptions:

(1) There is no atomic magnetic moment associated with an aluminum atom.

(2) The average atomic magnetic moment associated with the iron atoms is not affected by the addition of aluminum to the alloy, but depends on the number of Ni nearest neighbors adjacent to each Fe atom.

(3) The decrease in the average atomic moment of a nickel atom is the same as that of a binary Ni–Al alloy with the same Al content.

(continued overleaf)

Notes:

1. This information should be of interest to those (1) studying the magnetic behavior of metals and alloys, and (2) doing solid state research.
2. Additional details may be found in *Journal of Applied Physics*, vol. 38, no. 3, p. 1260–1262, March 1, 1967.
3. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
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   Reference: B68-10172

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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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