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# NASA TECH BRIEF



## Process Yields Co–Fe Alloys with Superior High Temperature Magnetic Properties

**The problem:**

Alloys of cobalt and iron that have been available for use as magnetic material do not have suitable properties at high temperatures (up to 1000°C). The requirements of high permeability, low hysteresis loss, good saturation induction, and good temperature stability are important in high temperature transformers and rotating machinery and in computer memories.

**The solution:**

Prepare the cobalt–iron alloys from ultrapure cobalt and iron.

**How it's done:**

High quality cobalt and iron obtained from commercial sources are the starting materials. These metals are refined by the electron beam, float zone method in a vacuum of $10^{-6}$ torr. After three zone passes, the impurities are reduced to less than 90 parts per million. The binary alloys are then prepared by arc melting predetermined proportions of the refined metals in purified argon. The total of all impurities in each batch of alloy obtained from the melts was less than 250 parts per million.

Specimens of 5 alloys, containing 6.4, 7.0, 8.0, 9.3, and 10.0 percent of iron, respectively, were prepared for tests. These specimens consisted of 0.012-inch-thick strips which were cold rolled from 0.5-inch-thick rods. During the cold rolling, only the 9.3- and 10.0-percent-iron alloys required intermediate annealing. All specimens were given a final stress relief at 1020°C, a temperature just below the Curie point.

The magnetic properties of the 5 alloys were measured over a temperature range from 25° to 1000°C. Over this range, the maximum permeability increased with temperature for all of the specimens. At any given temperature within the test range, the specimen containing 9.3 percent iron showed the highest maximum permeability.

The 9.3-percent-iron alloy, selected for additional measurements, exhibited a saturation magnetization of approximately 19,000 gauss at 25°C and essentially no change in magnetic properties during 3 successive temperature cycles over the range from 25° to 1000°C. Over this temperature range, also, the hysteresis loss and coercive force of the alloy decreased with increasing temperature at a given induction.

**Notes:**

1. The cobalt–iron alloys containing from 7.0 to 9.3 percent iron prepared by this method have the highest Curie point of all known magnetically soft materials. Their high permeability, low hysteresis loss, good saturation induction, and square-loop characteristics recommend them for use in power transformers, rotating machinery, and square-loop devices in the temperature range from 600° to 1000°C.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10535

**Patent status:**

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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Category 03