Proceedings of the Iowa Academy of Science

Volume 61 | Annual Issue Article 39

1954

# An Elastomagnetic Effect

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# An Elastomagnetic Effect

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The effect of stress upon the magnetic properties of ferromagnetic materials has been known and studied for many years. The name usually associated with this is Villari[1]. "Matteucci discovered that pulling or stretching a ferromagnetic rod changes its magnetic induction. Villari, however, with greater refinement of method found that if an iron rod is stretched when weakly magnetized its magnetic induction will be increased, whereas stretching the same rod in a strong field its magnetic induction will be decreased. This is known as the Villari reversal effect."[2]

More recently the "effect of small stresses on magnetic properties" has been studied and reviewed by Bozorth and Williams.[3] For comparison the same stress designations are used in this paper as in reference 3.

The previous papers have largely dealt with the usual B-H curves showing various curves of induction measured at various tensions. It is the object of this paper to report an entirely different and new approach to the stress magnetic phenomena. The wire sample is surrounded by a solenoid or a search coil, and as the tension is increased or decreased a voltage is induced in the coil. This is a dynamic effect, unlike the effects mentioned above, i.e. a change in tension induces the voltage in the surrounding coil.

The wire is stretched tight inside the solenoid. The solenoid is a single layer solenoid wound on a glass tube, 141.0 cm. long, 1.53 cm. in diameter, and of 6,560 turns.

The solenoid is placed in a E-W direction in a horizontal position so that in so far as possible it is across the earth's magnetic field, and except for stray fields in the laboratory the wire is not subject to any uniform magnetic field. The tension is applied to the test wire by means of copper wires at each end, so magnetically the wire is insulated.

The solenoid is used to pick up the changes in magnetic flux produced when the test wire is suddenly loaded or unloaded. These changes in flux induce voltages in the solenoid which are measured

[1]Villari, Poggendorf Ann., 126, 87, 1868.
[2]S. R. Williams, Magnetic, Phenomena, McGraw Hill. p. 118.
[3]Reviews of Modern Physics, Vol. 17 No. 1, 72-80, Jan. 1945, Bell Labs. Monograph B-1374.

on a Leeds and Northrup Type 9835-B D.C. amplifier. These induced voltages have been observed on a DuMont type 304-A scope with a long persistent screen, and they have also been recorded on a Leeds and Northrup Speedomax.

Copper wire showed no elastomagnetic effect, as was expected, so it was used to support and load the test wire inside the solenoid. The wire is kept taut by a 500 gram hanger.

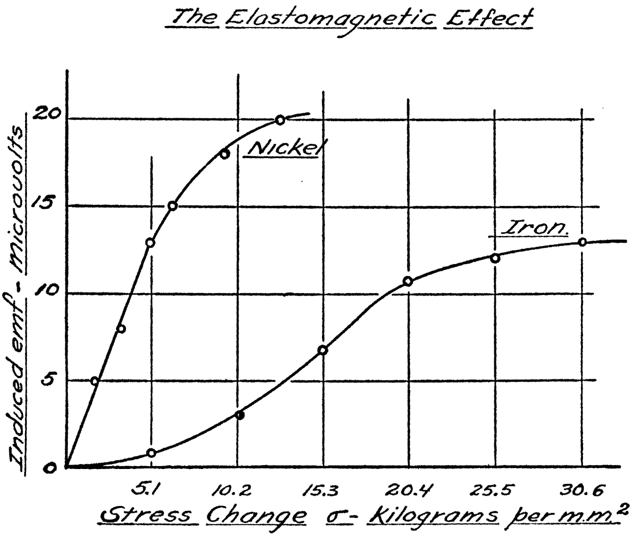


Figure 1.

Figure one shows the induced voltages produced by loading nickel and iron wire. The wires were 1.0 meter long and had radii of 0.63 mm. for the nickel and 0.50 for the iron. The wires were demagnetized as completely as possible by means of a steadily decreasing A.C. field. The data shown were taken on loading the wires. In the case of nickel the loading and unloading were approximately the same, but for iron it was found that there was an interesting reversal of sign on unloading. This is probably associated with the well known reversal of magnetostriction in iron.

The elastomagnetic effect is undoubtedly due to residual induction though neither iron or nickel could be so completely demagnetized as to exhibit no elastomagnetic voltage.

In order to establish the polarity of the induced voltage, a study was made of various amounts of residual magnetism (applied by a D.C. in the solenoid) and it was established that the sign of the induced voltage could be changed by reversing the residual induction. The study has not been completed as to the effect of the length and size of wire etc.

The explanation of the elastomagnetic effect is not difficult on the basis of the domain theory. It is assumed that the induced voltages are of the same origin as the Barkhausen voltages which are induced when a ferromagnetic material is magnetized, only in this case the flux changes are produced by stress changes. There is some indication by means of a sensitive reflecting magnetometer that the wire under stress produces a magnetic field of different pattern than it does when it is not under stress. This however, needs further investigation.

## The Effect of Current in the Wire Samples upon the Elastomagnetic Voltage

If a current through the wire sample effects the magnetic structure of the wire, it was thought that this could be revealed by means of the elastomagnetic effect. Accordingly direct currents were sent through the sample and it was discovered that the elastomagnetic voltages could actually be reversed by means of

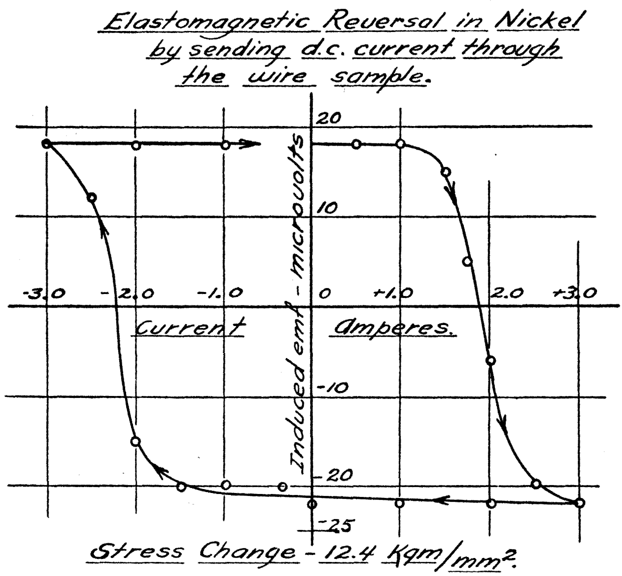


Figure 2.

direct currents in the sample. Figure two shows the reversal of the polarity and the interesting hysteresis between the voltages and the current in the sample. The data in figure two are all taken by a stress change of $\sigma = 12.4$ kilograms/mm$^2$ on nickel wire.

*Proceedings of the Iowa Academy of Science, Vol. 61 [1954], No. 1, Art. 39*



Iron wire was also investigated and it was found that the area of the hysteresis curve was considerably less, and that currents of only about a tenth of those for nickel were necessary to cause a reversal in iron.

It appears that the elastomagnetic effect has great possibilities as a new technique in trying to understand the structural changes taking place in ferromagnetic phenomena.

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