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Magnetic Measurements of Woodceramics

S. Sakka[a], D. Seino[a], K. Kasai[b], T. Okabe[c] and K. Saito[c]

[a] Hachinohe Institute of Technology,
Myo 88-1, Hachinohe, Japan

[b] Aomori Polytechnic College,
Iizume Kituneno 171-2, Goshogawara, Japan

[c] Industrial Research Institute of Aomori Prefecture,
Fukuromachi 80, Hirosaki, Japan

Magnetic measurements were performed on Woodceramics from room temperature up to 850 °C. The magnetization curves of Woodceramics showed a local maximum and a local minimum for the magnetic field. It was suggested that the usual diamagnetism and the very small ferromagnetism are coexisting. The ferromagnetic components of them vanished at 780 °C, that is the same Curie temperature of pure iron. We detected iron in the woodceramics by chemical analysis.

1. Introduction

All matters respond, more or less, to an external magnetic field. This response appears as the magnetization of matter. From the relation of magnetization to an external magnetic field, the matter is classified as ferromagnetic substance, paramagnetic substance or diamagnetic substance. In ferromagnetic substance, the magnetization is great and the characteristic hysteresis loop is observed in the magnetization curve. The magnetization of paramagnetic substance is proportional and that of diamagnetic substance is inversely proportional to an external magnetic field. These magnetizations are very small.

Woodceramic is a carbon material that is produced by impregnating phenol resin into wood and then baking it in an evacuated furnace. So the magnetism of Woodceramic is essentially diamagnetism. However, only a very small quantity of mineral is contained in the natural wood material of woodceramics. It is considered that one of these, as iron or iron oxide, has an effect on the magnetization of woodceramics. As in fiberboard, processed wood material may contain magnetic impurities.

We have found curious magnetization curves for woodceramics through magnetic measurements and report as follows.

2. Samples and Experimental procedures

The samples of woodceramics were prepared from medium density fiberboard (MDF) and natural beech by impregnating them with phenol resin using an ultrasonic wave technique and baking them in an evacuated furnace. The ratio

of impregnated resin to woodceramics was 68.9 %. For magnetic measurement three kinds of samples were prepared as follows.

Type I : This samples were prepared by baking in an evacuated furnace at 400 ℃, 500 °C, 600 ℃, 700 ℃, 800 ℃, 900 ℃ and 1000 ℃ respectively. And the sample sintered at 2000 °C was prepared using a high frequency induction furnace.

Type II : This sample was prepared by impregnating with phenol resin within iron chloride (0.01 mol per phenol resin 1 ℓ) and baking in an evacuated furnace at 700 °C.

Type III : The sample of this type was prepared from natural beech by baking in an evacuated furnace at 700 °C for comparison with MDF.

Magnetic measurements were made by using a vibrating sample (Foner-type) magnetometer, from room temperature up to 850 °C. The maximum sensitivity of this magnetometer is 10^{-4} emu. The magnetization curves and the temperature variation of the magnetization were obtained. Also, chemical analysis of iron was made using an atomic adsorption spectrophotometer.

3. Experimental Results

Figure 1 shows examples of the magnetization curves of Type I samples at room temperature. The magnetization curves of woodceramics with sintering temperature at 700 °C (b) showed a typical feature that the local maximum and

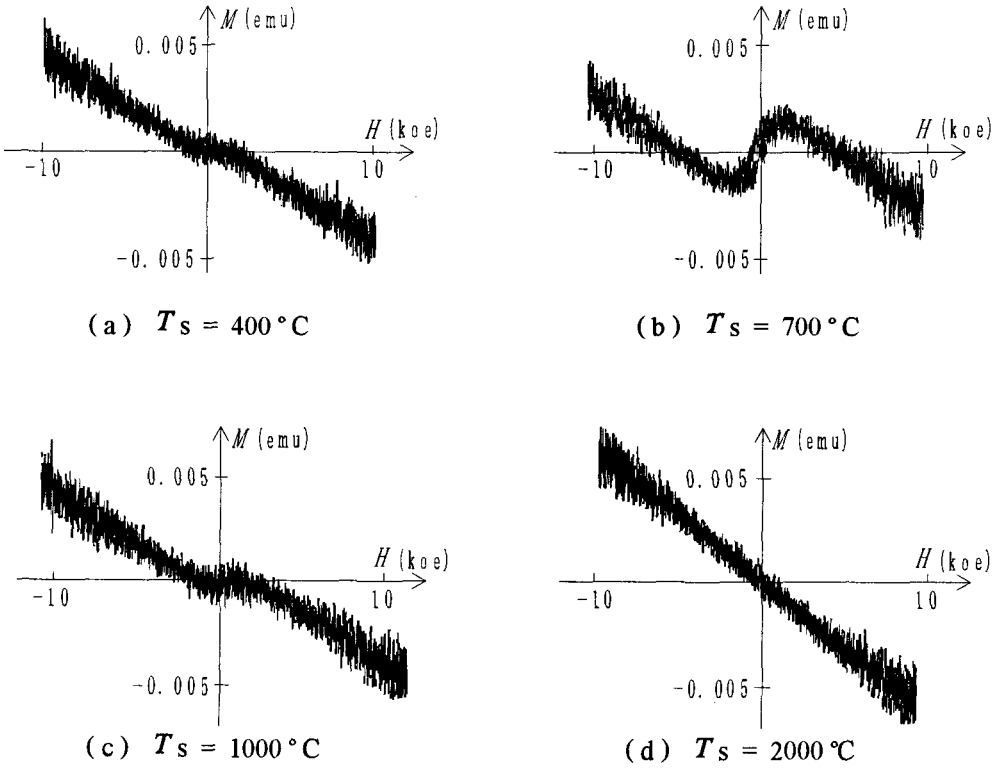


Fig. 1 Magnetization curves of woodceramics at room temperature with sintering temperature T_s

the local minimum for magnetic field and the hysteresis loop were observed. These features were observed also on the samples with sintering temperature at 500 ℃, 600 ℃ and 800 ° C. These features were observed only on the samples with sintering temperature at 400 ℃, 900 ℃ and 1000 ℃. On the samples with sintering temperature at 2000 ℃, complete diamagnetism was observed.

Temperature variations of the magnetization were taken on the samples with sintering temperature at 400 ℃, 500 ℃, 600 ℃, 700 ℃, and 800 ℃ respectively. Except for the samples with sintering temperature at 800 ° C, magnetization vanished at about 600 ℃ on the first measurement. However, after the second measurement, the magnetization decreased as the temperature rose and vanished at 780 ° C. This temperature of 780 ℃ is the same Curie temperature of pure metallic iron[1]. Figure 2 shows the magnetization curve at 805 ° C for the sample with sintering temperature at 700 ℃, that is complete diamagnetism. For the sample with sintering temperature at 800 ℃, this phenomenon near 600 ℃ was not observed.

Figure 3 shows the magnetization curves of type II sample, that is, doped iron. A greater magnetization was observed in comparison to the Type I samples, where the effect of diamagnetism was not observed. And the external magnetic field that the magnetization is saturated is larger than those of the Type I samples.

For this Type II sample, temperature variation of the magnetization was measured. At first measurement, the magnetization seemed to vanish near 600 ℃. But as the measurements were repeated near 600 ° C, the magnetization grew up to a certain value. After that the magnetization decreased as the temperature rose and vanished at about 780 ° C. This anomaly near 600 ° C was not observed after the second measurement.

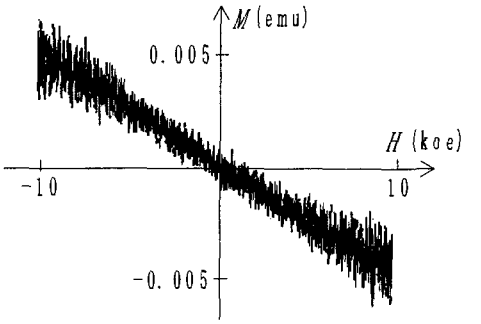


Fig. 2 Diamagnetism of woodceramics at high temperature above 800 ℃

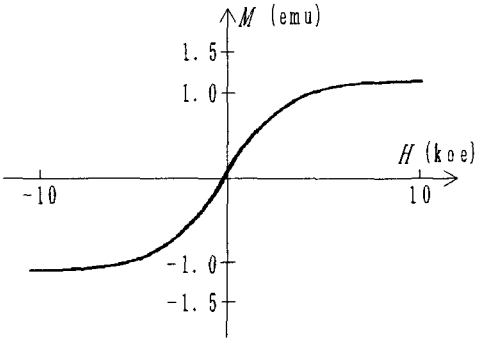
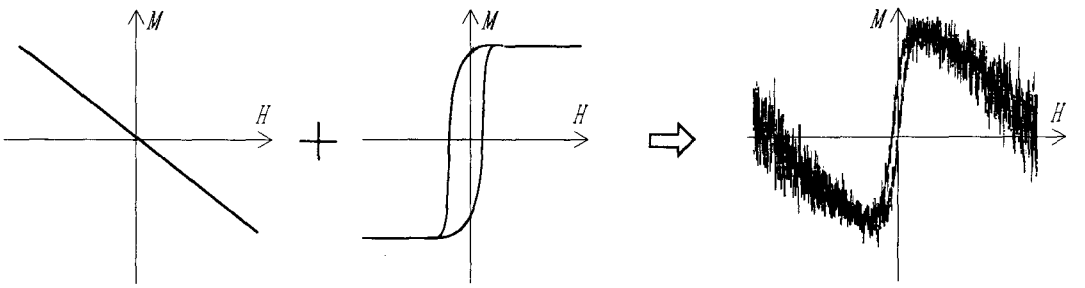


Fig. 3 Magnetization curve of woodceramics doped iron

The clear diamagnetism was shown at room temperature for samples of Type III that were made from natural beech.

Also, magnetic measurement was done at room temperature on the MDF impregnated with phenol resin and MDF itself. These levels of magnetism showed complete diamagnetism.

As the result of chemical analysis, iron was detected in all samples. Sample dependence of the iron content was as large as 0.1 - 0.2 ppm in Type I samples and 80 - 260 ppm in Type II samples. The proportional relation of the magnetizations and the iron contents was not obtained. Remarkably, the iron was detected in the sample made from



Diamagnetism Ferromagnetism Magnetization of woodceramics

Fig. 4 Coexistence of Diamagnetism and very small Ferromagnetism

natural beech, MDF impregnated with phenol resin and MDF itself. In the case of natural beech, the iron contents were about 0.4 ppm and greater than the Type I samples.

4. Discussion

The magnetization curves of woodceramics show the local maximum and the local minimum for the magnetic field. In Figure 4, this is understood as diamagnetism and the very small ferromagnetism which coexist. This idea is supported by the existence of hysteresis in the magnetization curve. This ferromagnetic component vanished at 780 °C. This temperature of 780 °C corresponds to Curie temperature of pure metallic iron. And, by chemical analysis, iron was detected from all woodceramics and MDF. Therefore it is considered that the ferromagnetic component of woodceramics is due to pure iron fine particles in woodceramics.

However, in the first measurement of the temperature variation, the magnetization showed anomaly near 600 °C. This phenomenon can not be explained by the above idea. The origin of the ferromagnetic component in the first magnetic measurement and low temperature may not be the same as that of the ferromagnetic component after the second measurement or in high temperature circumstances.

Where does this iron come from? It is considered that the iron was absorbed in the wood from the ground. Actually the iron was detected in woodceramics made by natural beech. Nevertheless, its magnetization curve did not show the ferromagnetic component. It was clearly diamagnetism. The problem is complex. It is necessary that magnetic measurements and chemical analysis be performed on many kinds of woodceramics, and that the samples doped with iron or iron oxide are prepared and measured.

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Reference

1. R. Bozorth, Ferromagnetism, D. van Nostrand, New York, 1951.