iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VII **Month of publication:** July 2017

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, July 2017- Available at www.ijraset.com

Recognition of Jiles-Atherton Parameters in Co-Based Alloy

Shailendra Singh Khinchi[1]
[1]Department of Applied PhysicsIET , Devi Ahilya University Khandwa Road, Indore- 452017

Abstract: Parameters needed to describe the hysteretic behavior by means of Jiles Atherton model using experimental DC hysteresis loops for $Co_{67}Fe_4Mo_{1.5}Si_{16.5}B_{11}$ alloys, by means of a MATLAB routine based on inverse Jiles approach are determined. Results show that computed Jiles-Atherton parameters and magnetic properties well describe the experimentally observed hysteretic behavior of the studied alloys. Annealing: i) affects Jiles parameters and magnetic properties, ii) does not affect appreciably the interaction between magnetic domains of the material and iii) computed hysteresis loops are in good agreement with the measured ones.

I. INTRODUCTION AND THEORY

Understanding and predicting the properties of a ferro-magnetic material still remains a challenge [1]. It would be useful to be able to describe hysteresis mathematically in order to model magnetic properties of ferromagnetic materials. A few models are in use at present; these include Preisach model [1], is widely used in the magnetic recor-ding industry for describing the magnetization behavior of recording tapes. Stoner-Wohlfath [1] model of rotational hysteresis applies to single domain particles and has been used for modeling the properties of hard magnets. Jiles-Atherton model (JA model) describes hysteresis [2] based on domain wall motion, is the principal cause of hysteresis in multidomain materials. Rapidly quenched amorphous and devitrified nano-crystalline soft ferromagnetic mate-rials being multi-domain systems, JA model can be effecti-vely used to describe hysteresis in these materials. In JA model the magnetization curves are described in terms of anhysteretic ($\boldsymbol{M_{an}}$), reversible and irreversible magnetiza-tion contributions arising from domain wall motion, allows to describe the hysteresis loop using JA parameters [2]:

$$\frac{dM}{dH} = \frac{1}{(1+c)}\frac{(M_{an}-M)}{\delta.k/\mu_0-\alpha(M_{an}-M)}+\frac{c}{(1+c)}\frac{dM_{an}}{dH} \qquad \textbf{(1)}$$

$$M_{an} = M_s\left[\coth\left(\frac{H+\alpha M}{a}\right)-\frac{H+\alpha M}{a}\right] \qquad \textbf{(2)}$$

where: ***k*** – irreversible wall motion parameter, ***c***–reversible wall motion parameter, ***a***–shaping coefficient, $\boldsymbol{\alpha}$ **-** parameter represents the coupling between domains, $\boldsymbol{M_s}$ – saturation magnetization. Advantages of the JA model are that it is comparatively simple, not purely mathematical but has firm physical basis described earlier. Lack of link between the modeled and the measured parameters remains the constraint on the model, contributing to the observed deviation in the modeled and measured hysteresis loops which can be minimized by suitable optimization proce-dure [3]. In the present work a program written in MATLAB utilizing inverse Jiles approach [3 and references there in] was used to calculate the JA parameters and the magnetic properties of $Co_{67}Fe_4Mo_{1.5}Si_{16.5}B_{11}$ alloys using measured hysteresis loops. The inverse Jiles program allows one to determine the JA parameters, which are related to the experimentally obtained parameters from the hysteresis loops, which can be used to compute hysteresis loops and to get magnetic properties of the material.

II. EXPERIMENTAL DETAILS

Amorphous $Co_{67}Fe_4Mo_{1.5}Si_{16.5}B_{11}$ alloys were supplied by Vacuumschmelze (Germany). Specimens having thickness of 20 and 45 μm and width ~ 1 mm in the as-cast state (samples A and B) and after annealing in flowing Argon at 375 ^{0}C / 1h in presence of transverse field of 3.2 kA/m (samples A1 and B1) were studied. DC hysteresis loops were measured using a computer controlled dc loop tracer.

III.RESULTS AND DISCUSSIONS

Figure 1 shows the measured hysteresis loops of the studied samples. Perusal of figure 1 shows differences in the measured loops of various samples, reflected in their JA parameters and magnetic properties. Inverse Jiles approach

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue VIII, July 2017- Available at www.ijraset.com

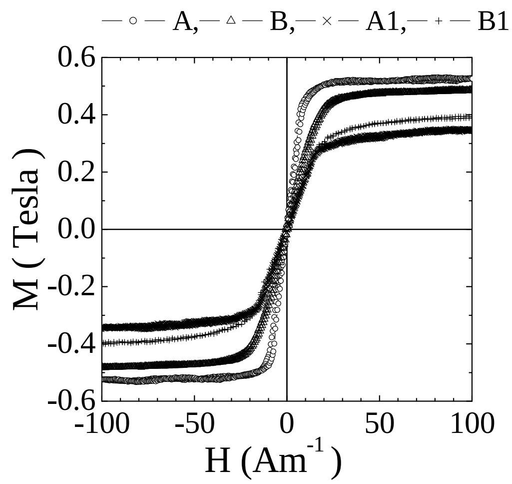


Fig. 1: Measured hysteresis loops of the studied samples.

[3 and references their in] based program written in MATLAB was used to calculate the JA parameters, the magnetic properties of the studied samples using M-H data of the measured hysteresis loops shown in figure 1. Computed parameters from inverse Jiles approach are depicted in table 1, where $\boldsymbol{B_r}$ - remanance, $\boldsymbol{B_s}$ – saturation induction, $\boldsymbol{H_c}$ – coercive field, $\boldsymbol{\mu_r}$ – relative permeability and $\boldsymbol{\mu_i}$ – initial permeability. Perusal of table 1 shows that various measured hysteresis curves (shown in fig. 1) gives different JA parameters as well as changes in magnetic properties. Table 1 also shows the variation of $\boldsymbol{k}$ with performed annealing treatment. Comparison of the values of $\boldsymbol{k}$ for as-cast and annealed samples suggests that there is a decrement in the hindrance, being offered by pinning sites to the domain wall motion in field annealed samples as compared to as-cast samples. It should be noted that thermal annealing relieves the quenched-in stresses thereby reducing the strength of pinning sites. As $\boldsymbol{k \approx H_c}$, confirms

Table 1: JA parameters and magnetic parameters obtained from inverse Jiles approach based MATLAB program.

Parameter Name	Sample A1	Sample B1	Sample A	Sample B
JA Parameters				
c	9.17	0.21	0.52	0.29
k (A/m)	0.27	0.57	0.65	1.23
M_s (A/m)	2.84e5	3.34e5	4.22e05	3.92e5
α	7.3e-6	1.91e-5	7.12e-6	1.53e-5
a (A/m)	8.51	11.44	4.02	8.82
Magnetic parameters				
B_r (T)	6.7e-4	4.6e-3	1.01e-2	1.8e-2
B_s (T)	0.35	0.42	0.53	0.49
H_c ((A/m)	0.27	0.57	0.65	1.23
μ_r	2000.3	6501.2	12326.4	11727.9
μ_i (H/m)	2245.1	1124.9	4237.8	2604.8

the soft magnetic nature of the studied samples. Values of $\boldsymbol{\alpha}$ **,** suggests that the interaction between magnetic domains within material almost remains un-affected by the trans-verse field annealing treatment. Figure 2 shows a representative comparison between modeled and measured hysteresis loops of sample B. Perusal of figure 2 shows good agreement between modeled and measured hysteresis loops. In order to have idea about saturation magnetization of the material, the model loop was computed taking higher magnetic field values ≈ 500 A/m (as compared with the applied field ≈ 140 A/m for measured once). The computed loop shows the value of $\boldsymbol{B_s}$ = 0.49 Tesla which is quite close to the $\boldsymbol{B_s}$ values reported by the manufacturer [4].

In conclusion, inverse Jiles approach utilizing a program written in MATLAB was used to calculate the Jiles-Atherton parameters and the magnetic properties of $Co_{67}Fe_4Mo_{1.5}Si_{16.5}B_{11}$ alloys using measured hysteresis loops. Annealing influences hysteresis loops, their Jiles parameters and magnetic properties. Annealing changes the Jiles parameters and is reflected in the soft magnetic behavior whereas interaction between magnetic domains within material almost remains un-affected. Computed hysteresis loops are in good agreement with measured ones.

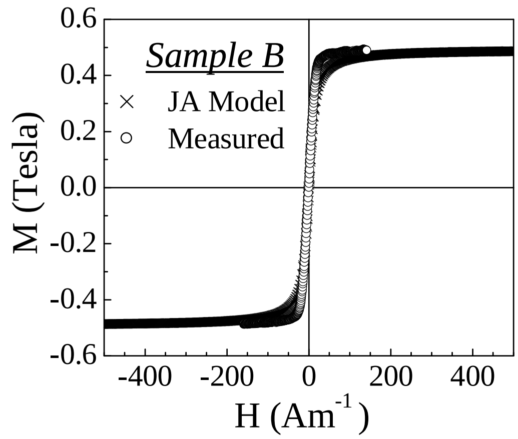
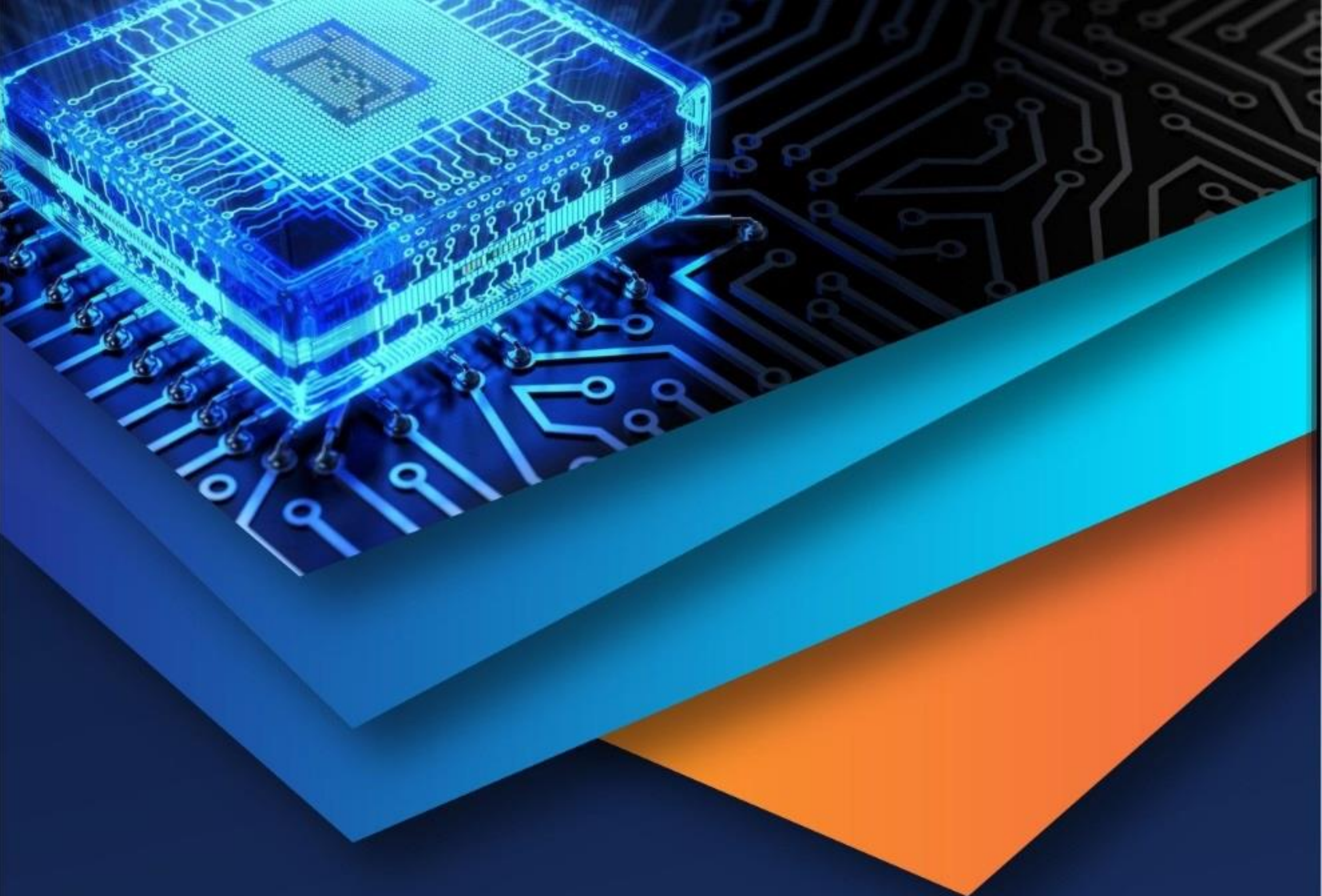


Fig.2: Comparison between model and measured loop.

REFERENCES

[1] G. Bertotti, Hysteresis in Magnetism, (Academic, London, 1998), p 3; F. Preisach, Z. Phys. 94 (1935 277; E. C. Stoner, E.P. Wohlfarth, Phil. Trans. Royal. Soc.A240 (1948) 59
[2] D. C. Jiles and D. L. Atherton, J. Magn. Magn. Mater. 61 (1986)
[3] J. Izydorczyk, J. Magn. Magn. Mater. 302 (2006) 517
[4] Amorphous Metals Vitrovac, Vacuumschmelze Catalogue, Edition 07/89, Germany



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY