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Effect of thermal treatment methods on magnetic hysteresis properties of Fe-Ni-Si-B based amorphous magnets

Adil P. Abdullayev[*], Nurlan M. Rafiyev[†],
Aida A. Isayeva[‡], Gunel Z. Asgarova[§]

Azerbaijan University of Architecture and Construction, Baku, Azerbaijan
Baku State University, Baku, Azerbaijan
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Abstract

Soft magnetic amorphous materials are considered a new type of magnets. Although amorphous materials have a wide scope in modern times, new areas of application can be obtained by improving their properties. In this study, as a result of heat treatment of the composition $Fe_{59}Ni_{19}Si_9B_{13}$ and $Fe_{39}Ni_{39}Si_9B_{13}$, materials with properties suitable for operation were obtained.

Keywords: *magnet, alloys, amorphous, melt spinning, thermal processing*
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1. Introduction

Amorphous metals are obtained by suddenly cooling a liquid metal from its melting temperature to its glass transition temperature in order to prevent the formation and growth of crystal centers [1-5]. Due to high corrosion resistance, high wear, high elasticity values and high stiffness values, these materials with an amorphous structure differ from their analogs with a crystalline structure. [2]. The mag-

[*]e-mail: adilabdullayev@rambler.ru; ORCID ID: 0000-0003-1128-737X.
[†]e-mail: nrafiyev@mail.ru; ORCID ID: 0000-0001-9921-0929.
[‡]e-mail: isayeva_aida86@mail.ru; ORCID ID: 0000-0002-0842-7733.
[§]e-mail: gunelesger85@gmail.com; ORCID ID: 0000-0002-0475-6062.

netic properties of these materials are particularly important. Thus, amorphous metals with favorable magnetic properties have a wide range of practical applications [3-4].

2. Materials and Methods of the Research

In this research work, improvement of magnetic hysteresis properties was carried out by thermal processing of 1-$Fe_{59}Ni_{19}Si_9B_{13}$ and 2- $Fe_{39}Ni_{39}Si_9B_{13}$ alloys in two compositions, obtained in amorphous state by cooling at high speed. For this, the samples were kept for 40 minutes in 3 different temperature conditions. The purpose of the heat treatment was to relieve the bending stresses generated during the casting process and to achieve bidirectional adjustment processes.

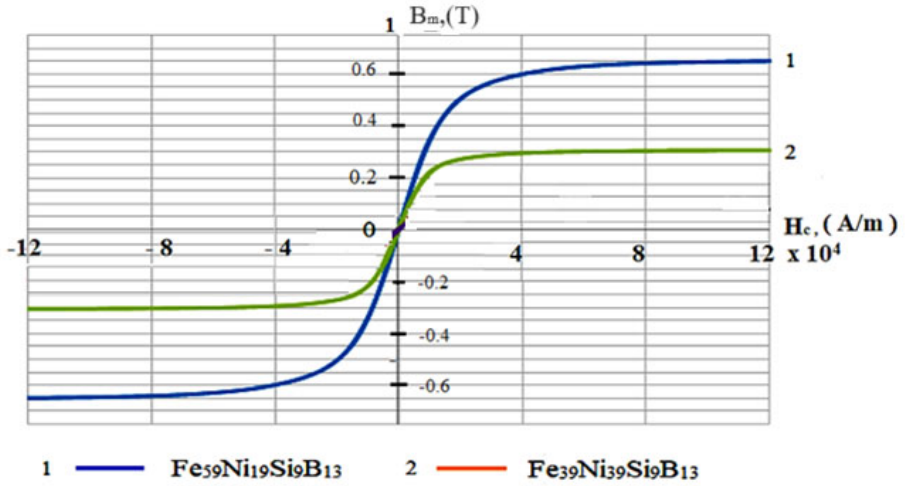

Fig. 1. Hysteresis loop of unprocessed alloys 1 and 2

In Figure shows the hysteresis curves of the samples before treatment. As can be seen, sample 1 initially has a higher saturation magnetic flux density than sample 2, and receives a value of 0.3 T, 0.65 T, respectively. In sample 1, an increase in the rectangularity of the hysteresis loop and the maximum magnetic induction B_m was determined as a result of processing at a temperature of 513K for 40 minutes. As a result of thermal treatment, a sharp increase in the coercive force is observed by holding at a temperature of 683K for 40 minutes, an increase in the value of saturation magnetic induction and residual magnetization was detected. In sample 2, it is observed that the rectangularity of the hysteresis loop changes less as a result of

processing at 513K temperature for 40 minutes, the increase of the maximum magnetic induction B_m was determined.

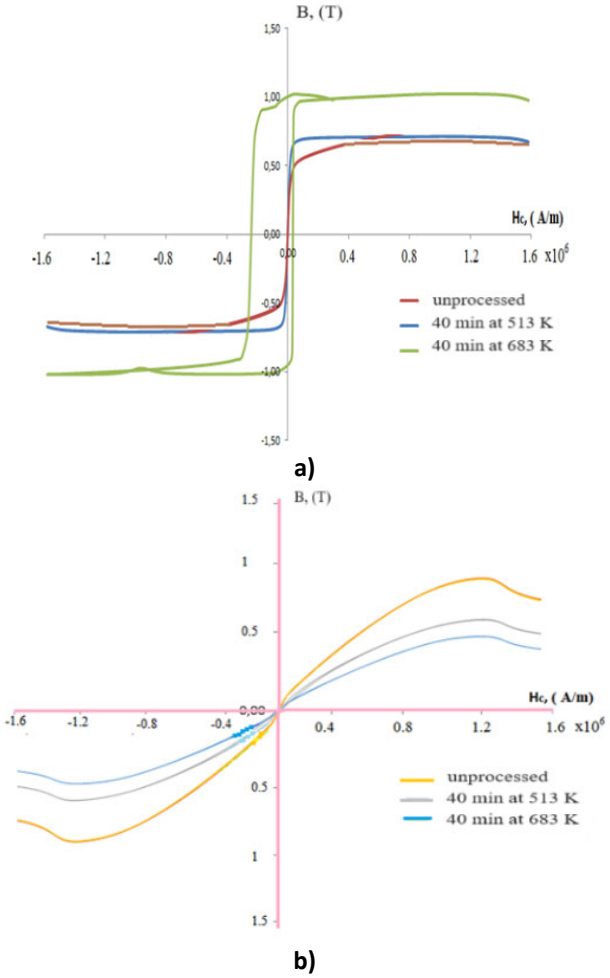

Fig. 2. Changes of the hysteresis loop as a result of alloy processing. a – 1 sample and b – 2 sample

3. Result

As a result of thermal treatment, no increase in the coercive force was observed, and a small increase in the value of saturation magnetic induction and residual magnetization was detected by keeping it at 683K temperature for 40 minutes (Figure 2).

The parameters of the hysteresis loop and the value of the specific electrical resistance of the two-component amorphous alloy indicate that these materials are suitable for use in the magnetic materials industry.

Table 1. Hysteresis loop parameters of samples after processing

Alloys	**T, °K**	**B_m, T**		**B_r, T**		**H_c, A/m**	**ρ, mk Ω *cm**
		-	+	-	+		
1 – $Fe_{59}Ni_{19}Si_9B_{13}$	Unprocessed	0.65	0.65	0.0042	0.0059	76.4	130
	513	0.80	0.80	0.0034	0.0027	95.4	
	683	1.02	1.02	0.2355	0.5387	1180	
2 – $Fe_{39}Ni_{39}Si_9B_{13}$	Unprocessed	0.35	0.35	0.0040	0.0045	52	122
	513	0.56	0.56	0.0012	0.0041	23	
	683	0.75	0.75	0.010	0.025	102	

References:

[1] Başer, T.A. 2013. “Kompozit Metalik Camlara Genel Bir Bakış” Mühendis ve Makina, cilt 54, sayı 640, s. 36-44.

[2] Herzer. G / Modern soft magnets: Amorphous and nanocrystalline materials // Acta Materialia, - 2013 –p. 718–734.

[3] Rafiyev, N.M., Ahmadov V.I., Isayeva A.A. Prospects to use amorphous Fe–Ni–Si–B ribbons in contactor cores // Ukr. J. Phys – 2023, 68, No. 3, p.201-203

[4] Abdullayev, A. P., Ahmadov, V. I. and Isayeva, A. A. Magnetic penetration investigation on the bands made of amorphous magnetically soft $(CoFe)_{75}Si_{10}B_{15}$ alloys under the thermal processing // International Journal of Modern Physics B –Sinqapur:,2021.v. 35, № 3. 2150045

[5] Panakhov T.M., Isaeva A.A., Rafiev N.M., Guseinov A.G. Magnetic thermocouples made of Co–Fe and Ni–Fe permalloys. J. Tech. Phys. 2019, v.89 (7), p. 987 -990

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