MAGNETIZATION OF THIN CAST AMORPHOUS MICROWIRE IN ZERO MAGNETIC FIELD

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Abstract

The effect of the residual quenching stresses on the magnetization distribution in thin cast amorphous microwire in zero magnetic field is studied. The cast amorphous microwire has total magnetization in zero magnetic field.

Keywords: Cast amorphous glass-covered microwire, magnetostriction, magnetization.

1. Introduction

Interest in cast amorphous glass-covered microwire has greatly increased the last few years.

The simplest variant of a domain structure in cast amorphous glass-covered microwire with negative magnetostriction can be the one presented in [1]. When radius of the metallic core microwire $r_c$ is smaller than domain wall then we have non-domains structure [2-5]. The aim of this work is to present new data on the magnetic properties for a given thin cast amorphous glass-covered microwire.

2. Theoretical analysis

The goal of the present paper is to solve the well-known Brawn equation [2,3]

$$0''(\rho) + 1/\rho \ 0'(\rho) + (\eta/f(\rho) - 1/\rho^2) \sin \{2\theta(\rho)/\rho \} = 0,$$

(1)

$0 < \theta(\rho) < \pi/2$ is the angle with the cylinder axis and the magnetization vector, $\rho = r/r_c$ is the relative radial coordinate cylinder, $\rho^* \leq \rho < 1$, $(\rho^*)^2 = A[K(r_c^2)]$, $\rho^* < 0.1$ is the relative radius, when the magnetization is homogenous and $\theta(\rho) = 0$ [4,5], $A$ is the exchange constant, $K$ is the magnetostriction energy.

Parameter $\eta = 1$, when the magnetostriction is negative, and $\eta = -1$, when the magnetostriction is positive [5].

According to [6] we obtain

$$1/f(\rho) = 1/(\rho^*)^2 \left\{ \frac{\sigma_{m-z}}{\sigma_z} \right\},$$

(2)

$\sigma_m$ is $\sigma_\rho \ (\sigma_\phi)$.

Let us consider the following model for the stress formation in cast amorphous glass-covered microwire [1,7]. The electrochemical interaction means that the outer surface of the strand adheres strongly to the glass shell. In the inner part of the core, there may be
thermoplastic relaxation, we use the following model: the core out to radius $b \sim \rho^*$ is subject to considerable thermoplastic relaxation. While from $b$ to the radius of the microwire core $\rho_c$ it freezes earlier and only elastic internal stresses persist. This model gives the following [1,7]

$$
\sigma_\rho = P(1 - b^2/\rho^2) + \sigma^*
$$

$$
\sigma_\varphi = P(1 + b^2/\rho^2) + \sigma^*
$$

$$
\sigma_z = v(\sigma_\rho + \sigma_\varphi) \sim P + \sigma^*
$$

(3)

where $v$ is Poisson’s coefficient (in elastic-plastic displacements case $v \sim 0.3\div0.5$), and $\sigma^* < P$.

The parameter $P$ has been defined in [8] and as regards order of magnitude is determined by the product of the difference in thermal-expansion coefficients between the glass and the metal on the one hand, the temperature difference between the onset of freezing in the composite and the temperature of the end of relaxation on the other hand together with Young’s modulus for the metal.

The asymptotic behavior of $\eta/f(\rho)$ is

$$
\eta/f(\rho) = (\eta a^2 + 1)/\rho^2 = \{\eta/(\rho^*)^2\} \{b^2/\rho^2\},
$$

(4)

The asymptotic term of (1) has the form when the magnetostriction is negative:

$$
\theta''(\rho) + 1/\rho \ \theta'(\rho) = 0.
$$

(5)

The exact linear solution of (5) can be written as:

$$
\theta(\rho/\rho^*) = C \ \ln |\rho/\rho^*| ,
$$

(6)

$$
C = \pi/2 \ln |1/\rho^*|.
$$

The asymptotic term of (1) has the form when the magnetostriction is positive:

$$
\theta''(\rho) + 1/\rho \ \theta'(\rho) - a^2/\rho^2 \sin \{2\theta(\rho)\} = 0.
$$

(7)

The exact solution of (7) can be written as:

$$
tg \{\theta/2\} = (1/\rho)^a.
$$

(8)

The cast amorphous microwire with the negative magnetostriction has remnant magnetization:

$$
M/M_0 \sim (0.1 - 0.2).
$$

The cast amorphous microwire with the positive magnetostriction has remnant magnetization:

$$
M/M_0 \sim (0.4 - 1).
$$

We can find resonance frequency: 1. The cast amorphous microwire with the negative magnetostriction $\Omega/2\pi \sim (1 - 2)$ GHz; 2. The cast amorphous microwire with the positive magnetostriction $\Omega/2\pi \sim (7 - 17)$ GHz.
Conclusions

1. The cast amorphous microwire has total magnetization in zero magnetic field.
2. The cast amorphous microwire can be used for elements of memory.

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References