Properties using metallic amorphous ribbons from (Fe-Co-Ni)-metalloid system, obtained by melt-quenching

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Abstract.

The paper presents an original equipment designed and achieved at the polytechnic Institute of Iassy, for obtaining continuous amorphous metallic ribbons through the melt quenching method and study of some properties using to ribbons from (Fe-Co-Ni)-metalloid system.

1. Introduction.

There is a general up-to-date tendency in producing new types of materials with strictly-defined properties, in this class the ones obtained by ultrarapid solidification being included.

Producing amorphous metallic materials by ultrarapid quenching with cooling rates over 10^6 K/s leads to new technological properties and utilization means.

A new equipment for producing amorphous metallic ribbons using the melt centrifuging method is presented in this paper, obtaining the ribbons from metal-metalloid system and the study of some properties using of their.

2. The equipment for obtaining continuous amorphous metallic ribbons.

The equipment (fig.1) uses a cylinder (1) made of copper activated by a d.c. motor with variable rotation (2).

Fig.1. Scheme of the equipment for obtaining continuous amorphous metallic ribbons.

In order to achieve thickness and width as uniform as possible for the amorphous ribbons the motor rotation was stabilized using an electronic device, the cylinder being assembled in two high speed pin bearings (3). The whole assembly was both statically and dynamically stabilized so that cylinder radial vibrations were less than $1 \mu\text{m}$.

At the top of the equipment a gear rack system (4) was built, which allows four degrees of freedom (three translations and a rotation) of the crucible (5). The crucible made of quartz has an ejection capillary hole at the spherical bottom its top being connected to the argon pressure circuit.

This circuit contains: a bottle with argon, a pressure reducer, a column which dries and purifies the gas, a pressure regulating device with a pin which allows a fine adjustment of the gas flow, a gas accumulator for protection and an electromagnetic valve which commands gas admittance inside the crucible.

The melting of the amorphizable alloy inside the crucible is accomplished in argon atmosphere by induction performed with a high frequency (5MHz) generator of a 6 kW power.

On this equipment ribbons with thickness and width above 40 to 250 μm , respectively 1 to 30 mm have been obtained from the amorphizable alloys: $\text{Fe}_{80}\text{B}_{20}$; $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$; $\text{Fe}_{40}\text{Ni}_{40}\text{P}_{14}\text{B}_6$ and as part of $(\text{Fe}_{37.5}\text{Ni}_{32.5-x}\text{Cr}_5\text{Co}_x\text{B}_{15}\text{Si}_{10})$ system.

The amorphizable pre-alloys realized using the powders of high purity, the suitable proportioning, the mould pressing 100 Pa and the vacuum melting to 10^{-3} torr.

3. Study of some mechanic properties using of obtained metallic amorphous ribbons.

The investigations on microhardness change as chemical composition (fig.2) and as the time of maintaining at the soaking treatment to 250°C (fig.3), have been made. Also, the breaking strain change as heating temperature has been investigated (fig.4).

Fig.2. The microhardness change of $(\text{Fe}_{37.5}\text{Ni}_{32.5-x}\text{Cr}_5\text{Co}_x\text{B}_{15}\text{Si}_{10})$ system as increasing of Co content.

From this studies, it find that the average microhardness of $(\text{Fe}_{37.5}\text{Ni}_{32.5-x}\text{Cr}_5\text{Co}_x\text{B}_{15}\text{Si}_{10})$ system increase easily with easy

increasing of Co content as above 100 units to 15% Co, and from the studies of microhardness change with increasing of temperature of maintaining to 250°C , a increasing above 100 units to 10^4 seconds have been ascertained, after which the microhardness remain constantly.

Fig.3. The microhardness change as function of maintaining time to 250°C .

Fig.4. The breaking strain change as heating temperature.
(amorphous ribbons of $0,05 \times 1,9 \times 560$)

From fig.4, it's remark that metallic glass plasticity decrease initially as increasing of temperature, then it's maintain constantly, and in the end increasing very much. Increasing of metallic amorphous material strenght as temperature explain by aparition of structural expansion process, while a decreasing of strenght from final stage, it's take place, because the metal glasses passingt in a quasi-crystalline state by diffusion to temperatures around the crystallization temperature (for $\text{Fe}_{80}\text{B}_{20} = 448^{\circ}\text{C}$; $\text{Fe}_{40}\text{Ni}_{40}\text{P}_{14}\text{B}_6 = 400^{\circ}\text{C}$). The breating and determination of statistical breaking strain on are TESTATRON System 1283 (Wolpert-Germany) equipment-type, have been executed.

After a soaking shortly, the metallic glasses utilization is indicated; the time and heating temperature must so selected that the fragility process inake not one's appearance.

4. Study of some magnetical properties of $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ ferromagnetic amorphous ribbons as heat temperature.

In figure 5 the influence of the heating (annealing) temperature on the coercive magnetic field (H_c) is plotted. Note that H_c is unchanged till 125°C . When the annealing temperature increases beyond this value H_c grows first slightly and then more abruptly as it approaches the crystallizing temperature of the amorphous alloy $T_x = 300^{\circ}\text{C}$. This sudden growth is due to the crystals occurence which fixes the limits of the magnetic domains.

A similar case where H_c grows with the heating temperature was noted in $\text{Fe}_{5}\text{Co}_{70}\text{Si}_{15}\text{B}_{10}$ metallic glasses heated between $240\text{--}420^{\circ}\text{C}$ /5/. On the other hand, for $\text{Fe}_{80}\text{P}_{13}\text{C}_7$ amorphous alloy a decrease in the coercive magnetic fields was observed when heating untill the crystalizing temperature beyond which it increased abruptly reaching values of about 8000 A/m /6/.

Figure 6 shows the change in the values of saturating magnetization (M_s) as a function of the annealing temperature. On heating until T_x , M_s decreases continuously and over this value it increases.

Fig.5. Variation of the coercive magnetic field (H_c) with the heating temperature for $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ ferromagnetic amorphous ribbons.

Fig.6. Variation of the saturating magnetization (M_s) with heating temperature for $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ ferromagnetic amorphous ribbons.

The remanent magnetization (M_r) varies with the annealing temperature in a similar way as M_s (fig.7). The maximum value for M_r corresponds to temperatures ranging from 20 to 50°C, i.e. $M_r = 2,9 \times 10^5$ A/m for $H_a = 378$ A/m.

Fig.7. Variation of the remanent magnetization (M_r) with heating temperature for $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ ferromagnetic amorphous ribbons.

In $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ metallic glasses usual annealing for stresses relaxation doesn't prevent the increase of coercive field the reducing of which needs another method. In this purpose, magnetizing field annealing might be an idea.

The magnetization of $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ amorphous ribbons has large values, after melt quenching, without heat treatment values decrease as stresses relax which involves poor magnetic properties for these alloys.

The studies concerning the coercive magnetic field change (H_c) for $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ amorphous ribbons in the perpendicular fields, has been examined. It is find that the coercive magnetic field (H_c) depends of angle α made by detector direction a high magnetic tide with the shaft of easy magnetization of ribbon.

From fig.8, it's observe that the coercive field (H_c) increase with increasing of H_s (static magnetic field given by two Helmholtz coils) from difference of Fe-Ni crystalline materials, where the coercive field decrease with increase of H_s .

Fig.8. The curves of change of the coercive magnetic field (H_c) as function of the static magnetic field (H_s) for $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ amorphous ribbons.

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