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# EFFECT OF HYDROGEN TREATMENT ON THE MICROSTRUCTURE AND MAGNETIC PROPERTIES OF THE KS37 ALLOY (BASED ON $SmCo_5$)

Hydrogen is used in processing of rare earth metal-based constant magnets because of modification of phase and structure state of the materials associated with improved properties. Hydrogenation combined with disproportionation, sorption and recombination (HDDR) is a widespread method of hydrogen treatment.

The paper reports the results of the studies of the microstructure and magnetic properties of the KS37 alloy after the hydrogen treatment by combined milling and HDDR.

The commercial KS37 alloy based on the $SmCo_5$ compound was smelted in an induction furnace and tested. The alloy was milled in hydrogen medium in a one-chamber planetary-type mill. HDDR in the KS37–$H_2$ system was tested under conventional and solid variant of the process.

The tests performed by X-ray phase analysis, scanning electron microscopy and microroentgen spectral analysis have been demonstrated that combined hydrogen treatment allows substantial enhancement of the amount of the $SmCo_5$ phase as compared to the as-cast state. This fact is an important positive result from the viewpoint of the improved properties of magnets.

The alloy was of high magnetic properties; in particular, the coercive force achieved more than 40 kOe.

Due to the performed studies of application of hydrogen treatment by combination of milling and HDDR to the $SmCo_5$ based ferromagnetic alloys, the principles of a new method of formation of anisotropic structure in the powders of this type of ferromagnetic materials have been developed. A peculiarity of the new approach allowed solution of the problem of formation of magnetic anisotropy in nanostructured ferromagnetic materials. New method of hydrogen treatment can be applied to formation of the anisotropic nanostructure in other types of magnetic materials (based on $Sm_2Co_{17}$, $Nd_2Fe_{14}B$).

**Keywords:** ferromagnetic material, milling, hydrogen, hydrogenation, disproportionation, anisotropy, nanostructure, scanning electron microscopy, microprobe analysis

**Fig. 1.** Scheme of HDDR-treatment of the KS37 alloy

**Fig. 2.** Microstructure of the as-cast KS37 alloy registered by SEM: *а–в* – the contrast in back-scattered electrons; *г*, *д* – the distribution in the characteristic radiation of Co $K_\alpha$, Sm $L_\alpha$, respectively. Magnification: ×40 (*а*), ×250 (*б*), ×3000 (*в–д*)

**Fig. 3.** The results of the test of the milled KS37 alloy after HD (I) and after DR at the temperature of 800°C (II) and 950°C (III) obtained by X-ray phase analysis (*а*: *1* – arbitrary put powder, *2* – the powder oriented in the magnetic field; ○ – $SmH_2$, ● – Co, ◊ – $Sm_2Co_{17}$, ■ – $Sm_2Co_7$, □ – $SmCo_5$) and obtained by REM (*б*, *в* – non-etched section; *г–е* – the section has been etched by 1% nital for 15 s; the areas where microroentgen structural analysis have been carried out are marked in Fig. *в*). The contrast is in back-scattered (*б*, *в*) and secondary emitted (*г–е*) electrons. The scale is marked in the figure

**Fig. 4.** Hysteresis loop of the KS37 alloy powder after milling and DR at the temperature *t*, °C: *а* – 800, *б* – 950