EFFECT OF NATURE OF THE COMMINUTION MEDIUM ON THE MAGNETIC PROPERTIES OF SmCo$_5$ ALLOY POWDERS

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It has already been established that the magnetic properties of powders of the intermetallic compound SmCo$_5$ are determined by their conditions of preparation: the weight ratio of the alloy to the milling elements and comminution time and environment [1-4]. The last-named factor needs further investigation because comminution is a complex physicochemical process capable of being controlled in a manner which will enable the magnetic properties of SmCo$_5$ alloy powders and permanent magnets to be improved.

A decrease in the particle size of a material, which is accompanied by an increase in its active surface, initiates various mechanochemical reactions [5]. The medium in which comminution is performed can also experience changes. Water under these conditions can dissociate into oxygen and hydrogen [6], and organic substances into gases, with the formation of new chemical compounds [7]. The actual presence of a fine powder in any medium increases its reactivity because the particles of the powder can act as catalysts [8]. As a result, the surfaces of the particles of powders comminuted in different media are in different states, which can be expected to be reflected in the physicochemical properties of the powders.

The object of the work described below was to study the dependence of the magnetic properties (coercive force $J_{Hc}$ and specific residual magnetization intensity $a_r$) of powders of the hard magnetic alloy SmCo$_5$ on the viscosity $\eta$ of various media and time of comminution $\tau$ in them.

An SmCo$_5$ alloy produced in a vacuum arc furnace was comminuted in an N-10 ball mill at an alloy-to-ball weight ratio of 1:16 in various media (air, Freon, toluene, and water), the comminution time being varied from 30 min to 20 h. The magnetic properties of the powders were measured in a vibration magnetometer. A 50-mg powder batch was mixed with molten paraffin wax in a capsule, which was then placed in an orienting constant magnetic field of 240 kA/m. Magnetic characteristics were measured in a slowly changing magnetic field of 2400 kA/m. An MIM-8 optical microscope was employed for determining the particle sizes of the powders, after the latter had been mixed with epoxy resin and the specimens had set. The presence of microstresses was ascertained by the physical broadening of diffraction lines. Diffraction photographs were taken, using iron radiation, in a DRON-3 apparatus.

The experimental results obtained showed that the decrease in particle size in comminution in all the media was a linear function of the logarithm of time (Fig. 1). The plots in the figure have different slopes, and are arranged in order of increasing viscosity of the media, $\eta = 0.000181, 0.37, 0.568$, and 1.005 mPa·sec for air, Freon, toluene, and water, respectively.

The higher the viscosity of the medium, the longer was the time necessary to obtain particles of a given size. This difference disappeared at comminution times of more than 15-20 h, which was a consequence of the asymptotic character of the dependence of milling rate on the viscosity of the medium and comminution time (Fig. 2). Under these conditions, the larger the mean particle size the higher was the particle milling rate and the more marked was the dependence of the mean particle size on the viscosity of the medium. With decreasing mean particle size the rate of comminution fell and approached some constant value which was no longer dependent on the viscosity of the medium (portions of the curves in Fig. 2 for particles of size less than 2 $\mu$m).

A study of the variation of the magnetic characteristics of the powders with time of milling in the different media revealed that in the particle size range 1-10 $\mu$m the coercive...
force steadily grew proportionally to the logarithm of time in comminution in Freon and toluene, while comminution in air and in water was characterized by a deviation from proportionality in the range of longer times. It is reasonable to assume that the deviation was due to a growing influence of particle agglomeration, since air has a low density, while water does not wet SmCo₅ [4]. The corresponding curves of specific residual magnetization intensity vs comminution time have maxima (Fig. 3b), which strongly depend on milling time, but are virtually unaffected by the nature of the medium.

The curves of magnetic properties plotted against particle size (Fig. 4) are similar in character to those of the magnetic properties of the powders vs time of comminution in the various media because particle size is related by a monotonic function to milling duration. Comparing the data depicted in Figs. 3 and 4, it is possible to determine optimum milling conditions for the magnet manufacture process. Clearly, the best magnetic properties