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Structure of low cobalt Fe-Cr-Co-based alloy for permanent magnets

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Abstract: Results of an experimental research into evolution of structure and micro hardness hard magnetic alloy Fe-30Cr-8Co-0.7Ti-0.5V-0.7Si at complex two-level in isothermal conditions on the circuit deposit - torsion at various temperatures in single-phase (are given. It is revealed that deformation results in transformation of coarse-grained structure in fine-grained in all volume of the sample, however the generated structure is non-uniform on section of a sample. In an active zone of deformation near to mobile it is brisk the microcrystalline layer with the size of grains about 5 microns which thickness poorly depends on temperature is formed. In process of removal from an active zone of deformation the size of grains is increased, and micro hardness decreases.

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Hard magnetic materials with high coercivity generally have low ductility property. However a problem of reception of a combination high coercive force and appreciable plasticity arises in connection with a number of technical requirements to modern devices and gauges.

The given work is devoted to research of deformation ability and structurization deformable hard magnetic alloy Fe-30Cr-8Co-0.7Ti-0.5Si-0.5V (wt%) at deformation by its method complex loading at various temperatures (Fig.1).

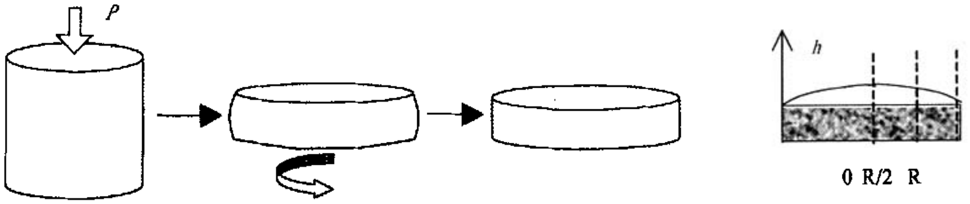

Fig. 1 The scheme of deformation of a sample at complex loading

Deformation at temperatures 700, 750, 800 , 850℃ carried out on the installation described in [1] allowing to combine various scheme of deformation: a stretching-torsion, torsion-compression simultaneously or consistently at various speeds of deformation. In work deformation carried out in isothermal conditions in two stages: as the first stage used the scheme compression and on the second torsions.

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Speed of deformation at a compression made $4\times10^{-3}c^{-1}$ at torsion $4\times10^{-2}c^{-1}$. Total logarithmic degree of deformation estimated under low (1) indicated in [2] taking into account contribution of torsion e_1 and compression e_2:

$$e = e_1 + e_2 = \ln\,(1 + (\varphi\cdot R\,/h_{iR})^2)^{1/2} + \ln(h_o/h_{iR}) \tag{1}$$

Where φ — a corner of turn a mobil anvil in radians, R—distance from an axis of rotation, h_c thickness of a sample before deformation, h_{iR}—thickness of a sample after deformation on distance R from the centre. The degree og deformation at a compression has made 1,2 and at torsion of half of radius from the centre 4.5.

Microstructure of samples studied in a raster electronic microscope JXA 6400 at accelerating voltage 10 kV and in transmission electronic microscope JEM 2000 EX at accelarating voltage 150 kV. Microhardness determined on device PMT-3 at loading of 0.2 kg. Research off-orientation boundarieies of grains carried out a method diffraction back reflected electrons (EBSD) on a raster electronic microscope JSM 840.

On Fig. 2 as an example dependence strain of flow from a degree of deformation is given at complex loading a sample of alloy 30Cr8Co at temperature 750℃.

Apparently at the initial stage loading there is the growth of strain caused by elastic deformation and then the bend connected with the beginning of plastic current is observed. Inclusion of torsion at II stage loading sharply reduces working strain approximately twice at all temperature of deformation. Rise in temperature of deformation with 750℃ up to 900℃ leads to result in a reduction strain of current with 55 MPa up to 32 MPa.

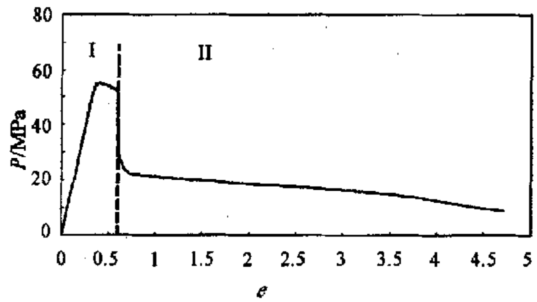

Fig. 2 The diagram of deformation of an alloy 30Cr8Co at complex loading at temperature 750℃ with a section of compression(I), torsion(II)

On Fig. 3 the panoramic picture (a) microstructures and pictures with top (b), average (c) and bottom (d) parts of sample after deformation at 750℃ is given received on section of a sample along an axis of deformation.

Apparently in a panoramic picture the structure of a sample on section is non-uniform and consists of large grains and separate grains in the size no more then 5 microns and the large grains located, as a rule, on boundaries. The greatest crushing of structure is observed in the bottom part of sample near to mobile head. In the top part of samples near to motionless head the size of grains maximal and on the average has intermediate value. In particular at temperature of deformation 750℃ in the top of sample the size of grains of the basic phase makes 100 microns, on average about 50 microns and in bottom did not exceed 5 microns.

Research thin foils of a samples after deformation by a method transmission electronic microscopy has shown that the increased density of dislocations is observed at all temperatures of deformation. In an active zone of deformation near to mobile head the density of dislocations is greatest. Dislocations are built in dislocation walls forming small angle boundaries dividing initial grains on fragments. The high density of dislocations is observed not only inside grains but also near to triple joints of boundaries. Minimal contents small angle boundaries about 5% and maximal special boundaries of grains of 60%-70% was observed in annealed samples at all temperatures. Deformation has resulted in significant change of spectrum off-orientation boundaries of grains at all temperatures of deformation. The share of special boundaries of grains has sharply decreased and the share small angle boundaries has considerably grown. After complex loading at temperature 750℃ greatest contents small angle boundaries (34%-40%) is made in comparison with other temperatures of deformation. It is spoken that in structure with high density of defects on all volume.

Probably under the given conditions of deformation annihilation of defects it is complicated.

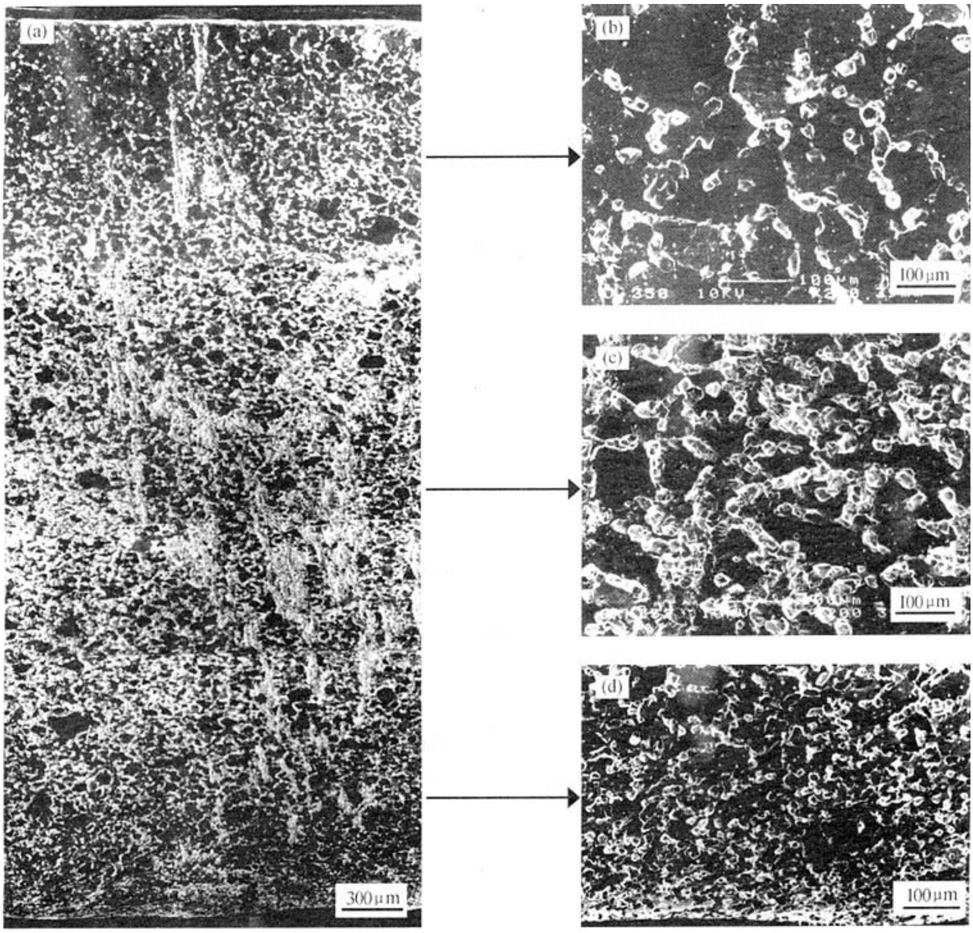

Fig. 3 A microstructure in a zone of active deformation of a sample of an alloy 30Cr8Co after deformation at temperature 750℃.

Distribution of microhardness on section of a sample is non-uniform at all temperatures of deformation. Values of microhardness are higher in the bottom part of samples. As a whole values of microhardness measured along an axis on distance R/2 and on a lateral surface of a sample about identical. It speaks that deformation proceeded homogeneously on all volume of a sample and increase of microhardness near to mobile head and as consequence greatest crushing structures in this area is connected to influence of friction on thin contact layer of a sample.

Conclusions

(1) It is shown that use of method complex loading allows to receive gradient structure with the minimal size of grains near to mobile head also constant increase of a grain on height of a sample.

(2) On data EBSD of the analysis in a zone of active deformation the share small angle boundaries raises and share of special boundaries of grains goes down.

(3) The method complex loading can be used for superficial processing a hard magnetic alloy 30Cr8Co

with the purpose of increase of mechanical properties.

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