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EXTRACTION OF RARE-EARTH METALS FROM WASTES OF MAGNETIC ALLOYS AND WARES FROM THEM

Report 2. Wastes of alloys of the system «neodymium-iron-boron»

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The review of different technologies of neodymium extraction and other rare-earth elements from a bar and wastes of alloy on the basis of the system Nd-Fe-B and permanent magnets, made from this alloy is executed.

Keywords: NdFeB alloy, permanent magnets, scrap, grinding waste, slag, sludge, separation of iron, extraction of REM

Permanent magnets, containing rare-earth metals (samarium, neodymium, dysprosium, празеодим, terbium and other), especially alloys on the basis of the system *Nd-Fe-B*, excel other magnetic materials on the size of magnetic energy on unit of volume and on the size of coercitivity.

At processing of wastes of *NdFeB* alloy and wares from its the problem of effective extraction of neodymium is set -, for what, first of all, the problem of separation the ferrous constituent of alloy must be decided. With this purpose that ends in work [1] it is suggested to carry out melting of REM-containing sludge in carbon crucible at a temperature 1550 °C. Here metallic iron forms an alloy, and REM remain in form oxide slag, easily dissociated from a metal. The losses of REM with an alloy are insignificant. In work [2] wastes of *NdFeB* alloy alloyed with B_2O_3 in crucible from the boron, and then cooled in the flowing of argon to the room temperature. Researches showed that from fusion two phases are crystallized only: α-*Fe* and Fe_2B, and neodymium practically all remains in glass.

In most cases the task of neodymium separation and iron decides on the stage of hydrometallurgy. For dissolution of scrap of *NdFeB*-magnets in work [3] four reagents was tested: *NaOH*, *HCl*, HNO_3, H_2SO_4. It is shown that at the optimal mode of lixiviating sulphuric acid allows to extract 75.41 % neodymium.

In the method of extraction of neodymium from wastes of production of *NdFeB*-magnets [4] slag, containing a neodymium, process amidosulfate acid (NH_2SO_3H) at pH = 2-3 under anodic potential. Thus iron is deposited on a cathode, and *HF* add to amidosulfate solution, getting sediment of NdF_3, which is dried out in a furnace. Coarse Nd_2O_3 process an acrtic acid at pH = 4.7, transferring a neodymium in solution as $Nd(CH_3COO)_3$. Solution is evaporated, getting the crystals of acetate of neodymium which at treatment by hydrofluonic acid transforms in NdF_3. Trifluoride neodymium dry, getting the finished good with 3 % moistures.

Hydrochloride lixiviating, used in work [5], allowed to get the oxide of neodymium of high degree of cleanness on an output at technology of processing of

wastes of production and scrap of magnets of *NdFeB*. The separation of neodymium and dysprosium was executed by the method of liquid extraction.

On the Siberian chemical combine (Seversk, Russian Federation) there are produce *NdFeB* alloys and *DyFe* ligature on out-of-furnace fluoride technology, and magnets - by the method of powder-like technology [6]. Dignity of «wet» charts of processing of metallic wastes consists in the concentration of REM by the separation of boron, iron (complete or partial) and limiting admixtures, such as a nickel, chrome, aluminium, silicon, copper and other.

Method of melting of bar of *RFeB* magnets (where *R - Nd, Pr, Tb, Dy, Y*), on a patent [26], consists of melting in the furnace of metallic charge, not containing REM (electrolyte iron, *FeB*, cobalt, aluminium alloys or their mixture) and introductions to fusion of charge, REM-containing (*Nd-Fe* and *Dy-Fe*), and 0.1-50 % charge from the bar of rare-earth magnets and/or sludge. Melting is conducted in an inert atmosphere at a temperature 1500-1800 °C.

Electro-slag remelt for processing of wastes of production of *NdFeB*-magnets is offered in work [7]. The body of heating is a slag, containing CaF_2, $CaCl_2$, and also chlorides or REM fluorieds.

Ordinary technology of recovery of neodymium from scrap of rare-earth alloys and magnets consists in acid dissolution of wastes, liquid extraction and renewal of the got connection to the metal. For the production of Nd_2O_3 with a cleanness 99-98 % the additional extraction cleaning is needed.

Processing of wastes of production of magnetic alloys *NdFe*(*Co*)*B* and REM-*Fe* ligatures of on fluoride technology with the use of magnetic separation is considered in work [8]. Fundamental possibility of making of magnetic faction is shown as a REM-containing concentrate with extraction of REM to 60 % from remaining content in the slags of the restoration melting of fluorides of metals.

In the laboratory of «*Ames*» (USA) the simple and cheap method of extraction of neodymium from scrap by molten magnesium is offered [9]. Scrap break and fall asleep in molten magnesium at a temperature 800 °C. Here a neodymium dissolves in an alloy, and iron and boron remain in a hard kind. Alloy *Mg-Nd* use in a casting production.

Process of extraction of neodymium from *NdFeB*-magnets scrap by extraction from fusion it was studied also in work [10]. Changeable parameters at self-control of scrap at the temperature of 800 °C: time of self-control and largeness of scrap. It was set that at the increase of time of self-control to 50 minutes and to the sire of scrapa 5 mm the quantity of the extracted neodymium grew to 24.2 %.

Conclusion. Wastes of production and application of magnetic *NdFeB* alloy are valuable secondary raw material of rare-earth metals. For their extraction there are use such piru- and hydrometallurgical technologies, as high temperature fluorination, calciumthermal renewal, extraction from fusion, burning, melting, lixiviating, hydrolysis, liquid extraction, electrolysis, chemical deposite.

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