Rare Earth Elements (Ree), Which Are of Great Importance for Modern Technology Due to the Presence of Unique Optical and Magnetic Properties in Their Compounds

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ABSTRACT

The development of information communication technologies, high-tech instrumentation, the need to create environmentally friendly technologies, alternative energy sources at the present stage have provided increasing demand for rare earth metals (REM), which today are the main components in the creation of new materials. The purpose of the article is to identify physical laws and mechanisms of modification of products from black and non-ferrous casting with oxide particles in nano- and ultra-dispersed state and the development of new composite materials on this basis materials that have a set of required operational properties.

Keywords: xenotime, ion absorption clays, loparite, phosphorites, apatites, secondary monazite, eudialyte, mineral resource base, earth metals, development, internal needs

The growth rate of REM consumption in the near future is forecasted to the level of 10–15% per year, and in some areas of industry even higher, ahead of traditional materials in this indicator. REMs include lanthanides (together with lanthanum) and yttrium, which divided into two groups: cerium and yttrium. REMs are quite widespread in the earth's crust, but are rarely found in concentrations suitable for their extraction. Main industrial sources REM are: bastnäsite ($CeCO_3F$, 75% REM); monazite ($CePO_4$, 65% REM). They account for ~70% of all REM reserves. There are ~ 70 REM minerals in nature: oxides, fluorides, silicates, phosphates, carbonates and their mixtures - complex deposits (monazite, bastnäsite, apatite, xenotime, loparite, etc.). The largest part of the world REM reserves are located in China and the USA (bastnasite), bastnasite deposits of Vietnam and Afghanistan are also known. Monazite deposits are concentrated in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, USA. Monazite is commonly found along the banks of rivers, lakes and seas and is a mixture of cerium salts, lanthanum, yttrium, phosphoric acid, etc. Significant reserves of monazite are found in the Brazilian and Caroline (USA) deposits [1].

The rest of the REM resources are concentrated in the deposits of xenotime, ion absorption clays, loparite, phosphorites, apatites, secondary monazite, eudialyte, etc. Russia has created and has a reliable mineral resource base rare earth metal, prepared for development. The reserves of most rare metals in deposits are sufficient in terms of volume to full provision of existing and prospective internal needs of Russia.

The development and production of rare metals at enterprises located on the territory of Russia are of strategic importance, eliminating the dependence of enterprises of the military-industrial complex and process of modernization of high technology industries from imports from abroad. This determines the leading role of the state in the development of

rare earth deposits at all stages of production, both in the economic sphere - public-private partnership, and in the legal sphere - by creating legal mechanisms for the protection of domestic enterprises. Foreign experience shows that a fundamental change in the situation in the rare metal industry is possible
only with the active participation of the state.

A large team of specialists with many years of experience in scientific research and practical work in the relevant fields was involved in writing the book. Most of the material presented in the book is the result of experimental work carried out on the basis of scientific and industrial organizations [2] .

One of the main tasks of materials science and foundry production is the creation of certain effects on a liquid crystallizing alloy, which will ensure its volumetric crystallization with obtaining a dense and fine-grained structure in a solid alloy condition, as well as obtaining a number of special properties. A universal, relatively cheap, technologically flexible and highly efficient method for controlling the structure of a crystallizing alloy - this is a modification. There is practically no production of modifiers in Russia, as a result of which Russian metallurgical and machine-building enterprises either use imported samples from SCHAFER GmbH (Germany), Cesana SPA (Italy), Elkem AS (Norway), FOUNDRY ECOCER (Italy), the cost of which is from 1,600,000 to 3,000,000 rubles. per ton, or do not use modifiers at all. Import modifiers are issued as compressed granules and in the form of powders.

Granular Modifier evenly distributed over the volume of the melt, but it is ineffective, since the granules do not decompose well when they enter the melt and
relatively large amount of modifier does not interact with metal. The use of additives in the form of nanodispersed and ultradispersed powders is more effective due to the greater active surface area, but there is a problem with uniform distribution of the powder over the volume of the melt and its digestibility, since a significant part of it is slagged. As a result, the use of any additional devices is required. The relatively low cost of ultrafine powders of refractory metal oxides and a small amount of additives (up to 0.4% by weight of the modified metal) make their use more economical than conventional modification and save expensive alloying metals.

The distribution of oxide particles in the matrix depends on the amount additives to the melt, technology of melting and pouring of alloys, and dimensions particles are determined mainly by the physicochemical properties of the introduced element. The introduction of the modifying mixture leads to a shift towards higher temperatures of critical points (liquidus and solidus) and narrowing of the crystallization interval. The fluidity of the alloy and the fillability of casting molds are improved, which leads to the elimination of pores and shrinkage cavities. As a result, the density and uniformity of castings increase by 1.5–2.0 times, casting defects by 15–30%, technological and physical-mechanical characteristics (strength, ductility, impact strength, wear resistance, etc.) are improved.

The principle of operation of the developed modifiers based on nano and ultrafine powder materials:

- when it enters the metal melt, the ultrafine powder of titanium and zirconium oxides reacts with an activating additive (cryolite), which reduces the oxide to metal - a nanodispersed metal particle is formed, which has a modifying effect: it grinds the metal grain, localizes impurities in the alloy;
- in parallel, the activating additive has a refining effect on the melt, in particular, it removes non-metallic inclusions.

Thus, the developed modifiers have a number of advantages compared to all existing analogues [3]:

1. Nano- and ultrafineness. Due to the high active surface, the modifier consumption is 3–4 kg per ton of melt, which is much less than when using analogues: the consumption of briquettes and fluxes is 10–12 kg, the consumption of modifiers Aluxal 25 10–30 kg, consumption of Probat-fluss VLP 200 modifiers - 5–6 kg.
2. Multicomponent. Allows you to achieve a complex effect on the melt due to the simultaneous introduction of 4-5 components, which have a different effect: a decrease in marriage by 5–10 times, an increase in physical

and mechanical characteristics by 15–25%, and an increase in the service life of castings by 1.5–2.5 times [2].

3. The use of a modifying mixture does not require additional devices when introduced into the melt and allows casting products into various forms (sand, foundry, etc.).

4. Application for the production of equipment modifiers with low power consumption and high yield of nano- and ultrafine powders allows to reduce the cost of the final product, which makes the developed modifier available to a wide range of consumers: small and large enterprises.

5. The developed modifier has a high degree of resistance to external conditions, which reduces the requirements for transportation and storage.

The modification effect is a complex effect modifier on the melt during crystallization. The addition of modifiers to the melt at the stage of material preparation can lead to important phase transformations [4]. In the process of transformation phases during heating or cooling each fixed state of the phases corresponds to the equilibrium following from the corresponding curves; moreover, for the temperature taken, the found compositions will refer to the entire volume of the phases, and not only to the boundary contacting layers, where the phase equilibrium is established practically very fast. During a phase transformation, the formation germinal centers and their subsequent growth. However, despite accumulated experimental knowledge in the field of selection of modifiers, issues related to the study of physical processes.

The mechanisms of modification of alloys by oxide particles remain open. Questions related to the mechanisms of grain refinement and the increase in the surface area of grain boundaries, etc., also remain open.

The development of fundamental knowledge in the field of mechanisms for modifying refractory metal oxides with ultra- and nanodispersed powders will make it possible to expand the production of microalloying additives for ferrous and non-ferrous castings on an industrial scale. The expected improvement in the properties of alloys from ferrous and non-ferrous castings (limit strength, ductility, operating temperature) will be 20–30% in comparison with alloys used in foreign industry.

Developed technologies will be present within two priority areas for the development of science, technology and technology in Russian Federation [3]:

1) Industry of nanosystems. One of the main directions for the implementation of scientific research is the creation of high technologies for foundry production of structural materials using alloying and modifying components based on nanopowders of d-metal oxides, multilayer carbon nanotubes, cluster nanodiamonds, graphene. As a result of this scientific research, metal materials created using nanosized particles will be used in technological production cycle of high-strength plastic materials.

2) Energy efficiency, energy saving, nuclear power. This scientific research is aimed at creating an energy-saving technology for metallurgical casting of ferrous and non-ferrous alloys. This technology is based on the use of color modifiers castings based on nanosized oxides of d-metals in a weakly aggregated form. The main difference of the developed technology is the low yield of casting defects (3–5%), which ensures savings energy resources due to the absence of the need to remelt castings. The existing casting technology makes it possible to achieve the yield of finished metal products at the level of 70–75%, the rest is sent for remelting, which requires additional energy consumption [4].

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