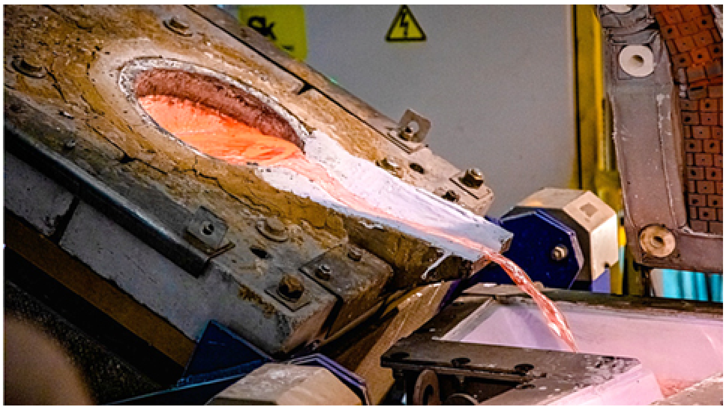
Superalloy for Aviation



It has been a joint project of SibFU specialists and their colleagues from MISIS University of Science and Technology. SibFU scientists were responsible for the technology construction and its theoretical description, while MISIS researchers performed phase analysis of ingots and studied the mechanical characteristics of products. The results were published in Metallurgical and Materials Transactions B.

Aluminium ranks first in terms of production and consumption among all non-ferrous metals. However, aluminium products cannot be obtained by traditional casting methods, when alloys are poured into moulds. It is necessary to come up with new, effective and inexpensive ways, and one of these was the technology of casting into an electromagnetic crystallizer (EMC) (Elmacast™). This technology makes it possible to obtain ingots from an experimental high-strength aluminium-zinc and aluminium-magnesium alloys, which can be used for the aircraft industry and will greatly simplify and reduce the cost of producing ingots.

> *"The use of aluminium means the need to significantly improve the strength properties of products made from aluminium alloys. This is crucial for aircraft, construction and additive manufacturing technologies. Al-Zn-Mg-Cu-based alloys additionally alloyed with nickel, cobalt, and iron additives have suitable characteristics,"* said **Eduard Vinter**, co-author of the research, the researcher at the Polytechnic School, SibFU.

According to the experts, products made of these alloys cannot be obtained by traditional casting methods. One is forced to use powder metallurgy methods, which, though providing unique product characteristics, mean high cost, high safety requirements, complexities of the processing chain organization, and low productivity.

The technology of EMC casting, studied by the scientists together with experts of the Research and Production Centre of Magnetic Hydrodynamics (Krasnoyarsk), provides cooling rates of the cast billet comparable to the speeds of powder metallurgy technologies. This makes it possible to obtain cast products from complex multicomponent aluminium alloys. At the same time, compared with the powder metallurgy methods, the new technology is characterized by a simplified equipment layout, it is cheaper and much more productive.

According to the researchers, EMC casting involves electromagnetism, heat and mass transfer, metal phase transition (crystallization), and the dynamics of the interphase boundary of a levitating melt with an open air medium. The combination of these factors significantly complicates the theoretical description of the process and requires methods and tools of multidisciplinary numerical analysis.

> *"One of the most challenging tasks in the development of this technology and the formulation of its theoretical principles was to establish and quantify these relations. Understanding how electromagnetic, thermal, and hydrodynamic fields coexist with each other, as well as how microstructures are formed inside ingots, allowed us to stabilize semi-levitation casting and create a full-fledged high-tech industrial complex that meets the modern requirements*

of the production sector for high alloys with enhanced physical and mechanical properties," noted **Maksim Khatsayuk**, professor of the Electrical Engineering Department, Polytechnic School, SibFU.

As a result, the scientists determined a set of technological parameters for casting billets from experimental Al-Zn-Mg-Cu alloys. Such billets have a fine-dispersed microstructure with an extremely crushed grain of no more than 5-15 microns. At the same time, the particles of iron-containing phases have a very small size, and this opens up wide opportunities for further processing of billets. For example, thin-walled profiles or ultrathin wire can be obtained from them.

The billets underwent thermal and mechanical treatment. The scientists found that the deformation results in a structure characteristic of composite materials — microparticles of alloying elements evenly distribute in aluminium. This structure provides excellent physical and mechanical characteristics which are unattainable for batch-produced alloys obtained by the traditional methods.

The research was funded by a grant from the Russian Science Foundation (Project No. 22-19-00128 Evolution of the structure of high-strength aluminium alloys of the Al-Zn-Mg (Ni, Fe, Ca) system obtained by technology of electromagnetic casting).

SibFU Press Office, 24 august 2023