MAGNETOHYDRODYNAMIC (MHD) TECHNOLOGIES FOR PREPARATION AND CASTING OF ALUMINUM ALLOYS

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The main purpose is to increase the productivity of melting and casting units and the quality of aluminum alloys

The developed equipment is used as part of melting and casting units for the preparation and casting of aluminum alloys and the implementation of the following technologies:

- electromagnetic stirring of an aluminum alloy in a mixer during preparation;
- refining aluminum from non-metallic impurities and removing hydrogen;
- electromagnetic stirring of the liquid core of the ingot in the casting process;
- casting of an aluminum bar in an electromagnetic field.

The main consumers are RUSAL’s smelters, Hydro, Novelis, Sapa, Alcan, etc.
MHD STIRRING OF ALUMINUM ALLOY IN THE PROCESS OF PREPARATION

Mixing oven for the preparation of aluminum alloys

Dependence of slag formation on surface temperature

Dependence of hydrogen solubility on surface temperature

Change in metal temperature with stirring: 1 - surface of the melt, 2 – bottom of the cell
LINEAR INDUCTION MACHINE (LIM) FOR MIXING LIQUID METAL

Mixer with MHD stirrer:
1 - molten metal in the cell; 2 - MHD stirrer

LIM’s mode of operation for stirring liquid metal:
1 - magnetic circuit; 2 - conductor with current; 3 - melting
The main functional purpose of the MHD stirrer is to solve the following problems:
— ensuring uniformity of temperature and chemical composition throughout the cell;
- acceleration of the dissolution of the solid charge in the melt;
- dissolution of heavy metal components of the melt.

The use of MHD stirrers in the process of alloy preparation in a mixer allows:
— increase the productivity of furnaces with a capacity of 5 to 120 tons up to 25%;
— reduce gas consumption by up to 15%;
- to reduce the formation of slag up to 25%;
- to reduce the cost of loading operations, hand tools and manual labor up to 50%;
- to ensure high reliability of the system, due to the absence of contact with metal, moving parts, as well as the absence of water cooling of the inductor.
- to automate the melt preparation process.
TECHNOLOGIES OF MHD REFINING OF ALUMINUM ALLOYS BEFORE CASTING

Hydrogen content in aluminum depending on temperature

Aluminium oxidation rate versus temperature

Removal of solid non-metallic inclusions by means of electromagnetic forces

Removal of gas inclusions from molten aluminum
SECONDARY REFINING INSTALLATION

It is used for complex out-of-furnace cleaning of aluminum casting and wrought alloys from solid and gaseous inclusions. In addition, the installation can perform alloying and modification of alloys during casting.

The rotation of the metal is created by special MHD rotators, the refining mixture is fed into the inlet channel through a gas inlet made in the form of a special tube equipped with graphite discs. As a result, a complex magnetohydrodynamic environment is created in the zone of interaction of the melt with the reagents, which, by analogy with systems with rotors with nozzles, creates favorable conditions for maximum processing of the melt and its purification.
CASTING OF BARS FROM HIGH-ALLOY ALUMINUM ALLOYS IN THE ELECTROMAGNETIC FIELD

The main purpose is the production of aluminum wire with a fine structure from special aluminum alloys for aerospace industry and mechanical engineering, including additive technologies.
PROBLEM OF PRODUCING HIGH-ALLOY ALLOYS

Alloying components
Mn, Cr, Fe, Ni, Ti, Zr, Si, etc.

They allow obtaining the necessary combination of physical and mechanical properties (tensile strength, elongation, etc.) and special characteristics (heat resistance, electrical resistance, weldability, etc.)

They have low solubility in solid aluminum, thus forming primary intermetallics, which are in ingots in the form of rough, unevenly distributed inclusions.

$v_{\text{cooling}} \sim 10 \text{ K/s}$

$v_{\text{cooling}} \sim 100 \text{ K/s}$

$v_{\text{cooling}} \sim 10^4 \text{ K/s}$
TECHNOLOGY FOR PRODUCING BARS IN AN ELECTROMAGNETIC FIELD

Continuous casting plant with electromagnetic mold:
1 - mixer oven; 2, 3 - gutter with metal; 4 - foundry equipment; 5 - electromagnetic crystallizer; 6 - cooling; 7 - power source, 8 - pulling stand; 9 - continuous bar

Electromagnetic crystallizer
1 - liquid metal; 2 - foundry equipment; 3 - inductor; 4 - cooler; 5 - ingot
Foundry plant for obtaining bar stock

Continuous coil of rod with 9 mm diameter

Wire diameter 1 - 0.25 mm
OTHER MHD DEVICES FOR CASTING PRODUCTION

Dosing of liquid metal
1 - melt; 2 - inductor

Stirring the liquid core of the crystallizing ingot
1 - inductor; 2 - crystallizer; 3 melt

Mixing metal in the transport bucket металла в транспортном ковше
1 – Ladle; 2 - inductor; 3 melt; 4 - slag