NANOTECHNOLOGIES IN MICRO- AND MACROMETALLURGICAL PROCESSES

Description
A new technological method of improving quality of metals and alloys with the help of nanopowder inoculators (NPI) was elaborated. The essence of the process is active targeted influence on liquid metals and alloys at the crystallization stage. For this a special additive compound such as nanodispersed powder of infusible compounds (inoculators) is added to the melt. It results in formation of heterogeneous system in the form of suspension with particles of 0.05-0.1 µ in size regularly distributed in the melt, well damped and serving as crystallization centers.

Technical appraisal and economic benefits
A key novelty of the solution suggested is applying nano-dispersed high-melting compounds which were not used before for similar aims.

The competitive ability of the articles produced from the modified metals and alloys is in applying a small amount (less than 0.05 % by weight) and cheap ceramic nanopowders in comparison with alloying elements (vanadium, molybdenum and others) used presently. Usage of the method of modification allows an important saving of alloying elements being in a very short supply. The efficiency of NPI influence on the characteristics of the cast metal surpasses, for example, that of earth metals by 1.5 – 2 fold at really lower cost and weight of a consumable material.

Usage of NPI in macrometallurgical processes (production of ingots, castings and blanks)

<table>
<thead>
<tr>
<th>NPI influence on the quality of steel</th>
<th>NPI influence on the quality of cast iron</th>
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<tbody>
<tr>
<td><img src="_image_" alt="Structure of steel 30XГСJ" /> cast samples.</td>
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<tr>
<td><img src="image" alt="Morphology of graphite inclusions into grey iron cast saples." /></td>
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<td>a - without NPI; b – with NPI.</td>
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<td>Strength enhanced by 30 –35 %, plasticity by 1.5 – 2 fold.</td>
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Enhance of lasting quality by 10-13 %; yield limit by 20-30 %, specific elongation by 1.5 – 1.7 fold (after quenching).

Morphology of graphite inclusions into grey iron cast saples.

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<th>Influence on the quality of a continuously casting from steel Ст. 8ГС2</th>
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<td><img src="image" alt="Structure in axial zone of cross-section of ingot." /></td>
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<tr>
<td><img src="image" alt="No more rough widmanstatten structure of ferrite what improved mechanic characteristics of ingot steel: yield limit (σт) by 10 %; extension strength (σв) by 5.5 %; specific elongation (δ) by 14%; contraction ratio (ψ) by 19.8 %." /></td>
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<td>Chemical inhomogeneity and porosity of the ingot are reduced.</td>
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Structure of steel 30XГСJ cast samples. a - without NPI; b – with NPI.

Morphology of graphite inclusions into grey iron cast saples.

a – without NPI; b – with NPI.

Strength enhanced by 30 –35 %, plasticity by 1.5 – 2 fold.

Structure in axial zone of cross-section of ingot.

a - without NPI, b – with NPI.
NPI usage in micrometallurgical processes
(laser treatment of metals, plasma deposition)

NPI influence on the structure of welds in laser welding of metals
Titanium alloys BT5

The quality of the joint is improved (morphology and structure of the weld). Its mechanical characteristics (rupture strength, yield point, specific elongation) are enhanced.

Macrostructure and morphology of a weld.

a – without NPI; b – with NPI.

Application areas
Foundry, metallurgy of ferrous and non-ferrous metals. Production of castings from stainless steel with a high yield limit and resistance to corrosion; castings from cast iron with preset structure and high performance characteristics; continuously castings from steels and aluminum alloys with equiaxial structure and high capacity to complex deforming, etc.

Development stage
Research works were carried out to determine optimal physicochemical parameters and essential requirements to nanopowder inoculators (NPI), methods of their preparation and introduction to the alloy. The industrial development of the technology of NPI modification was done at the P.I. Baranov engine-building production enterprise in Omsk (turbine blades from nickel alloy for gas-pumping turbines); at the Novosibirsk chemical concentrates plant (casts from grey iron). The turbine blades modified by NPI were successfully tested at the Kirov Plant (Saint-Petersburg) and others.

Several foreign organizations showed their interest to this technology.

Patent situation
RF patent (2009).

Commercial offers
Joint research of NPI applications, service in execution of the technology, investment agreement for joint commercialization, license agreement.

Estimated cost
To be negotiated.

Contacts
Scientific Secretary PhD Melamed Boris Mikhailovich
Khristianovich Institute of Theoretical and Applied Mechanics
Siberian Branch of the Russian Academy of Sciences
Institutskaya str. 4/1, Novosibirsk, 630090,
Tel: (383) 330–42–79, fax: (383) 330–72–68
E-mail: sci_itam@itam.nsc.ru
http://www.itam.nsc.ru

Co-developer: Institute of Solid State Chemistry and Mechanochemistry, Siberian Branch of the Russian Academy of Sciences