«Levitechn» Experiment

CONTROLLED LEVITATORS WITH HELIO-HEATING FOR SPACE TECHNOLOGIES

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The purpose of the experiment is to study the controlled spaceborne levitators with helio-heating and to carry out operations with the electrically conducting bodies undergoing phase transformations (melting and solidification of metals, semiconductors, alloys, mixtures and so on). A levitator is a device, which allows containing the working media in a given space without mechanical contact.

The controlled spaceborne levitators can be used for realisation of the following technological processes and research:

1. Contact and contactless control of the movement, position and shape of the refractory and reactive melts; moulding in the «electromagnetic casting moulds and dies» («draw plates»)»; welding of the structural elements of space vehicles.
2. Development of novel perfect composites, gradients, foam and other materials, which cannot be produced in the ground-based conditions because of gravitational segregation (liquation).
3. Non-polluting production and processing of superpure materials, precision alloys, perfect monocrystals, elements of microelectronics and so on.

Substantiation of the need to carry out this experiment (including items 1-3) in space consists in the possibility to process such materials which cannot be processed contactlessly or do not levitate at all in the ground-based conditions.

Selection of a levitator design depends on its application, but its main parameters are determined by the value of the vector of relative acceleration of a working medium, which is due to the level of microgravity.

The possibilities for application of the existing contactless, spatially distributed levitation effects on a working medium (processed samples of materials), which are capable of balancing the microgravity, have been analyzed. The induction electromagnetic levitation effect in levitators intended for special metallurgy has been proved to be the most promising. It can provide the most necessary functions of contactless containment, automatic control and stabilisation of a working medium (sample).

Approximate calculations of parameters and operational modes of the controlled spaceborne levitators have been completed. These data were used to carry out comparative analysis of the main design parameters of spaceborne levitators and actual parameters of groundborne levitators. It turned out that the ratio of parameters of their main power, mass and overall dimensions is close to the value of $\gamma = g_k/g_0$ (g_k — size of microacceleration, g_0 — acceleration of gravity force on the Earth). The characteristic values of the main parameters of the devices, which ensure levitation process for containment of the mass less than the critical capillary mass (without heating and technological equipment), are the following:

— Weight:	several kilograms
— Overall dimensions:	several litres
— Power:	tens of watts

A levitator can be mounted in any technological system fitted with research equipment. The configuration of a levitator can change depending on the technological and heating requirements. Heating can be realized with an HF generator, laser, electron beam gun or concentrator of solar energy (helio-heating).

For helio-heating, at the first stage it is planned to use a very simple design of helio-concentrator, which is a metallic paraboloid made of sheet aluminium alloy with small-sized plane mirrors pasted to it. The intent is to supply a concentrated flow of radiant energy from the focal spot to the sample through optical light guides or a hollow focon. Experimental verification of the proposed design onboard the ISS should answer to the questions concerning the operating life of mirror helio-concentrator, selection of material for the light-reflecting coating, compatibility of a levitator with the helio-concentrator, and practicability of technological processes.

Direct use of the concentrated solar radiation for heating the levitating sample decreases the need for the scarce onboard electric power that eventually also reduces the mass load of the ISS (supply of solar batteries and converters).

«MHD-COSM» Experiment

DEVELOPMENT OF ELEMENTS OF PRINCIPALLY NEW MAGNETO-HYDRODYNAMIC TECHNOLOGY FOR MAKING ALLOYS WITH THE PEQULIAR STRUCTURE UNDER MICROGRAVITY

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Space metallurgy is one of the important fields of space materials science. Use of metallurgical methods in space environment enables metals, alloys, composites and other materials with improved or principally new properties to be produced. Among such materials are pure metals, monotectic and eutectic alloys, alloys with intermetallics, composite alloys and foam metals, which can have special physical, chemical, electrical, magnetic, optical, mechanical and other properties. Conducting the melting in contactless apparatuses under microgravity, the characteristics of these materials can be improved, first of all, due to the absence of density segregation and the negligible natural convection in the liquid state.

Monotectic alloys, which are mixtures of phases with limited mutual solubility as in the solid, so in the liquid state, have been intensively studied under the space conditions. Melts of such alloys form a single-phase liquid at overheating above the critical temperature T_σ owing to the increase of mutual solubility, but reverting to the solid state they undergo the phase transitions of the first and second kind. An essential change of the characteristics of such alloys is observed in disperse and ultra-disperse phase states. However, there are problems concerning an ultra-dispersion of the second phase and a higher level of the uniformity of its distribution in the matrix. These problems are still unsolved either under the ground conditions or in space. There are also other problems of space production of such alloys. In particular, changes occurring during phase transformations greatly complicate the production of a finely dispersed structure of alloys. The top priority in development of space materials science has been given to the physics of weightlessness. The influence of the Earth's magnetosphere, where the majority of the key phenomena are determined by the fundamental processes of magnetic hydrodynamics (MHD), has been only partly taken into account. The action of magnetic fields on the liquid and solidifying alloys is the strongest during phase transformations and it is registered even in the weak ($1 \cdot 10^{-3}$ T) fields. The influence of a magnetic field on monotectic systems in phase transformations is still unstudied.

One of the objectives of the proposed experiment is to overcome the unfavourable effects appearing in production of monotectic alloys in space. Unlike the space experiments conducted in the past, we suggest to release a heat directly in the alloy for its further melting, as well as to apply a metallic cooler for achieving a higher rate of heat removal from the melt during its crystallisation. We would like to study the influence of magnetic field both on the nature of phase transitions in monotectic melts and on the parameters of crystallisation.

During the experiment, an external uniform con-