«Pipe» Experiment

SMALL-SIZED AND MINIATURE HEAT PIPES FOR COOLING SYSTEMS AND THERMAL STABILIZATION OF SPACE INSTRUMENTATION AND HARDWARE

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Maintenance of normal thermal modes of space instrumentation and hardware is an important and difficult technological problem.

Problems of effective heat removal and maintenance of normal thermal modes of space vehicles have been solved by the following main methods: improvement of the extant heat engineering units, e. g. heat pipes. However, in terms of the thermal-physical aspect the conditions of heat pipes functioning in space are different essentially from those on Earth.

The IPMS NASU has designed heat pipes with high-performance metal-fibre capillary structures. Some of these pipes have been operating without failures since 1975 for thermal stabilization of orientation instruments mounted on space vehicles. In spite of the fact that these pipes have been used in space for a long time, an influence of microgravity on their parameters has not been studied.

On the other hand, the gravitation influence on thermo-physical processes occurring inside a heat pipe, leads to essential changes in the value of the pipe thermal resistance after long-time operation.

The anticipated results of heat pipes investigations under the space conditions would make a significant contribution to their theory. Results will be undoubtedly useful for design of cooling and thermal stabilization systems of space objects, satellite instrumentation, high-altitude aircraft, and rocket engineering as well as for development of high-performance heat-transfer units in the future.

«Indentor» Experiment

NEW METHOD AND INSTRUMENT FOR DEFINITION OF MECHANICAL PROPERTIES OF MATERIALS IN SPACE BY LOCAL LOADING WITH AN INDENTOR

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Exposure to space radiation, vacuum, and low temperatures, of materials and various instruments located on the external side of space vehicles (SV) results in the change of their structure and mechanical properties. Witness-specimens are currently used for control of the mechanical properties of materials. These specimens should be mounted on the SV shell, exposed to raw space and should be taken off before landing for further study on the ground. It is a very complicated and expensive operation, which does not provide any concrete control of the mechanical properties during the SV mission.

There is a necessity to analyse the mechanical properties and structure of materials on other celestial bodies, for example, on other planets during SV missions to them. However, right now it is only possible by specimens selection and their delivery to Earth for investigations.

The method of hardness and microhardness measurement has been widely used for many years for estimation of the mechanical properties of materials, both in research laboratories, and in industry. This method is the simplest, while being a highly sensitive one, and it does not require the production of any complicated specimens. Hardness measurement is performed without destruction of specimens, or damage of their surface; requires minimum expenses for microsections preparation and responds accurately enough to the finest changes of metals and alloys structure.

There exist many hardness measurement methods. However, the most convenient and versatile method is the Vickers hardness measurement, due to the application of a diamond pyramid and a new generation of devices for determination of micro- and nanohardness. Applying the loads from 1 mg to 500 g makes it possible to measure hardness both of the most brittle metals and of the microscopic bodies.

The capabilities of determination of the mechanical characteristics by the traditional methods are rather limited for nonplastic materials because of their brittle fracture at stress values close to the yield point or even lower. On the other hand, even with plastic materials, the traditional methods of determination of the mechanical characteristics require great expenses for sample preparation and a great number of samples that is unacceptable in some cases.

In tensile mechanical testing the specimens are used only once, whereas in microhardness measurement the number of measurements on one section is unlimited.

At local application of a rigid indentor even brittle nonplastic materials can be greatly deformed without macroscopic destruction. Over the last few years the method of local loading (MLL) of materials by a rigid indentor has been developed from a method of estimation of mechanical characteristics into a method of determination of the whole set of mechanical characteristics (yield limit, strength, plasticity, Young's modulus, cold brittleness temperature). Development of a procedure for determination of mechanical characteristics by the MLL method is especially important for brittle ceramic materials, for coatings and other surface layers. Only MLL allows determination of the yield limit of these materials, as well as comparison of the plasticity of materials, which demonstrate complete brittleness at mechanical tests by tension, compression and bending.

Considerable capabilities for determination of mechanical characteristics are provided by the method of hardness measurement by indentation depth, in which the dependence of the indentor load on the indentation depth is recorded. The hardness in depth Hh depending on the load is calculated from the loading diagrams. The diagrams of loading are also used for determination of Young's modulus and other characteristics. Thus, hardness and other mechanical characteristics will be determined for surface layers of materials (at different distances from a surface), which are damaged to the greatest extent by space radiation.

It is essential that application of this method eliminates the need for the indentation size measurement by the optical methods. This has opened a possibility to measure hardness at extremely small loads (nanohardness).

The purpose of the experiment is development of the new procedure of determination of the mechanical characteristics of materials during the ISS flight by periodic local loading of material models, exposed to outer space, with a rigid indentor, while recording the stress-strain curve.

The set objectives are as follows:

1. Determination of mechanical characteristics of surface layers of materials (at different distances from a surface), which are the most sensitive to outer space factors.
2. Study of mechanical characteristics of materials produced in space under the conditions of microgravity, namely monocrystals, composites, welded joints, and coatings etc.
3. Study of mechanical characteristics of non-plastic and brittle materials.
4. Measurement of hardness at extremely small loads (nanohardness) The indentation results will be presented as the indentation curves; numerical files; calculated values of the non-restored hardness in indentation depth and of restored hardness in an impression diagonal; modulus of elasticity (Young's modulus); plasticity characteristics; values of a material yield point.

Objects of research will be test specimens of different materials, including materials obtained under the flight conditions. The test specimens should have a cylindrical shape with the diameter up to 15 mm and the width up to 5 mm.

The following equipment will be used:

1. Device for the micromechanical tests of materials by a method of continuous impression of the indentor (60 cm × 45 cm × 45 cm size, up to 10 kg weight, energy consumption of up to 100 W during several minutes of the experiment).
2. High-resolution optical microscope connected to a computer to transfer images.