«Penta-Fatigue» Experiment

INFLUENCE OF SPACE FACTORS ON FATIGUE FRACTURERESISTANCE OF STRUCTURAL MATERIALS

Pokhyl Yu. A., Yakovenko L. F., Aleksenko E. N., Lototskaya V. A.

Special Research and Development Bureau for Cryogenic Technologies of the ILTPE, NAS of Ukraine
47 Lenin Ave., Kharkiv 61164 Ukraine
Tel/fax: (380) + 572 +308551, e-mail: sktb@ilt. kharkov.ua

The long-term operation spacecraft (orbital stations, reusable space vehicles etc.) is experiencing multiple vibration loads while launches and landings, and in orbit as well (during docking/undocking with other spacecraft, while the orbit is changing, while technological experiments are conducted in space, etc.). To provide reliability and long-term durability of spacecraft, the structural materials of load-carrying parts of the body, antennae, solar cell batteries, and others units of the ISS should have not only high values of specific strength, but also high fatigue fracture resistance. The characteristics of fatigue fracture resistance of materials are the most sensitive to the influence of such outer space environment factors (SEF) as gas environment, some types of radiation, micrometeorite erosion. These factors mainly affect the material surface and sub-surface layers since the process of fatigue fracture is initiated in many cases from the surface. Experimental data obtained by simulation of several SEF in the ground-based laboratory show that the vacuum influence on fatigue fracture resistance is positive on the whole. While the low temperature impact can be different, depending on temperature values and on the type of structural material, the radiation impact on structural materials is mainly unfavorable.

To provide the long life and reliability of spacecraft structural components, it is necessary to solve the urgent task of a complete and integrated monitoring of SEF influence on fatigue fracture resistance of space structural materials. Nowadays this task is solved mainly by simulation of some SEF in the ground-based laboratories. The results obtained are extrapolated to the limit of the actual SEF parameters that does not guarantee their complete reliability.

A radical way for solving this problem, in the authors' opinion, is to install a special test module onboard the ISS for fatigue testing of structural and model materials under the real space conditions within the low- and high-cycle areas of fatigue curves.

To study the SEF influence on fatigue resistance of metals and polymeric materials, it is proposed to develop and manufacture «CYCLE-1» unit, as part of «PENTA» experimental complex for installation onboard the ISS. Such a study will be carried out in raw space for the first time. Having both applied and scientific significance, it allows evaluation of the structural materials durability under the space conditions for such important mechanical characteristic as fatigue resistance, and selection of the approved structural materials for space industry. At the same time, results of this space testing of materials in combination with the results of pre- and post-flight testing at the identical cyclic loading under the simulated conditions in the ground-based laboratory will enable determination of the adequacy of «simulated space environment factors». In case of their proximity, this will allow carrying out ground-based testing with less strict requirements to the set of simulated SEF and/or carrying out further research only in the ground-based laboratory. As regards the fundamental aspect, these results are important for establishing physical mechanisms of fatigue fracture under the conditions of integrated multi-factor space influence as well as for selection of scientifically-grounded criteria for producing new materials.