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APPLICATION OF PARALLEL MECHANISMS FOR DIRECTING AND ORIENTING OF SPACECRAFTS ONBOARD EQUIPMENT

Abstract

For the modern spacecrafts information systems to function properly, it is necessary to ensure precise control of the positioning of their onboard equipment (telescopes, antennas, reflectors, etc.) using the mechanisms with precision accuracy and high reliability. This paper presents the solution of the problem at hand based on multi-DOF mechanisms with parallel kinematics (MPK), made according to the hexapod or tripod scheme. Among the promising projects that use MPK it is possible to highlight the Millimetron space observatory, the James Webb telescope and some of the others. To solve the tasks of positioning these or similar mechanical objects, mechanisms that allow precise directing and orienting in micrometers and microradians, respectively, are required. In addition, the task of directing of a large-sized structure relative to a space platform comparable in mass must be performed in special dynamic modes due to the large moments of inertia of the telescope, the low natural vibration frequencies of its design, as well as strict requirements for the accuracy of directing. At the same time, the operating conditions in outer space impose significant restrictions on the element base used, making it difficult to implement direct feedback, which stands in the way of successful achievement of the goal of precision control. To solve these problems, it is suggested in this paper to use a control system based on feedback sensors of angular positions of actuator motors with positioning error corrections. The analysis of the sources of the errors revealed that the geometric errors of the parts of the mechanism, as well as their thermal expansion, have the greatest influence on the positioning errors. It is proposed to compensate for geometric errors by pre-calibrating both individual parts (linear actuators) and the entire mechanism as a whole. To compensate for thermal deformations, an adjustment is introduced depending on the temperature fields of the structural elements of the mechanism. To ensure the least dynamic disturbance of the MPK on the control object and the carrier platform of the spacecraft, an algorithm for forming and reproducing the trajectory of motion has been developed, which allows limiting the speeds, accelerations, jerks and other derivatives of linear and angular coordinates. The results of numerical simulation of the working space of a mechanism with parallel kinematics of the hexapod type are presented in case of a proper operation of all linear drives, as well as in cases of failure of one or more drives. It is shown that even if the actuators fail, the MPK can continue to perform the target function in a limited mode with a decrease in accuracy and / or working space. To improve the reliability of the MPK, the recommendations are given for adjusting the mechanism control laws in case of actuator failures. To improve the reliability

of the electronic modules when operating under ionizing radiation, as well as to ensure the possibility of upgrading the algorithms of mechanisms with parallel kinematics, a method for updating the software via the main information channel of data exchange of the Russian standard GOST R 52070-2003 type is proposed. The promising direction of scientific research in the field of space-used MPKs is the developing of construction, methods and operating with the aim of vibration isolation of the onboard equipment.