Development of algorithms for controlling the orientation of a large elastic spacecraft

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One of the promising directions for space study and exploration is the design of large spacecraft (SC), equipped with a powerful power block with high thermal output and efficient engines. The desire to distance the instrumentation section from the power plant determines the length of a large spacecraft assembly of 50 meters or more. The main mass of the spacecraft of more than 15 tons is concentrated in the instrument compartment (located in the same place as the payload) and a power plant. Structurally these two massive compartments are connected by a light rod with variable section. The difficulty of controlling such a spacecraft control is determined by its considerable elasticity and complexity of the spatial configuration.

This paper considers problems of control law synthesis for the spacecraft orientation at large increments of the angular position in the non-uniform gravitational field of the Earth and in outer space. To solve these problems the Pontryagin maximum principle is used. Solutions of problems of accurate stabilization of the spacecraft with errors on the order of tens of arc minutes which take into account the elasticity of all the elements relative to the three axes are presented.

Recommendations are given for construction of actuators for stabilization system with high fuel efficiency. The basis for the synthesis of control laws are mathematical models of elastic spacecraft. These models are obtained based on a special software package, developed by the author over the past 10 years. The software allows to develop a mathematical model of the spacecraft in the form of a system of differential equations with variable parameters or transfer functions for different phases of flight, based on the information about the construction, materials and the elastic properties of separate elements of the construction.

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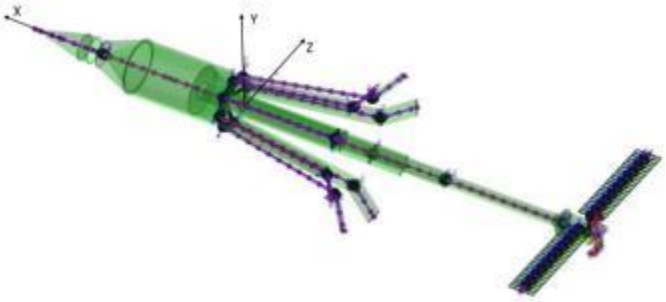

Figure 1: The investigated model of the spacecraft

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3. Panferov A.I. Nebylov A.V., Brodskiy S.A. Complex Flexible Aerospace Vehicles Simulation and Control System. Design19th IFAC Symposium on Automatic Control in Aerospace, International Federation of Automatic Control, Wursburg, 2-6 September, 2013, IFAC, Wurzburg, Germany, Wurzburg, 2013
4. Panferov A.I. Nebylov A.V., Brodskiy S.A.Synthesis of optimal distributed measurement systems for control of an elastic object. Selected, peer reviewed papers from the AEROTECH V conference, Progressive Aerospace Research 29-30th October, 2014 Kuala Lumpur, Malaysia, p. 208-213 http://www.scientific.net/AMM.629.208
5. Panferov A.I. Nebylov A.V., Brodskiy S.A. Software Package for Simulation and Control System Design for a Nonrigid Space Vehicle. Embedded Guidance, Navigation and Control in Aerospace (IFAC-EGNCA 2012), Bangalore, India

Biography

Alexander Panferov is a professor of the State University of Aerospace Instrumentation in St.-Petersburg and the Senior Researcher of the International Institute for Advanced Aerospace Technologies. He led many R&D projects in the field of aerospace instrumentation, control systems design for the aeroelastic object, micromechanical gyroscopes and systems. He is a coauthor of more than 12 patents and 100 articles in reputed journals.

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