E.A. Vasilyeva, A.N.Lihachev
Baltic State Technical University BSTU «VOENMEH» named after D.F. Ustinov,
Russia, Sankt – Petersburg

DEVELOPMENT DESIGN PRINCIPLES OF LARGE PRECISION SPACE REFLECTOR ANTENNAS, CONTAINING ACTUATORS OF SMART MATERIALS

In satellite communications, space observatories and satellites - repeaters are used reflector antennas. Such antennas are now in operation in the frequency range of 4 - 6 GHz and 11 - 14 GHz. Begin to master a range of 20 - 30 GHz. There are plans to increase the carrier frequency up to 60 GHz. The increase in carrier frequency requires a large precision reflector antennas that have to meet stringent requirements on the stability of the shape and size of working surfaces ("mirror"). For example, the deviation of the accuracy of the working surface of the antenna mirrors for communications satellites on the value of 2 mm leads to a reduction of the gain by about 10%. In the best modern antennas designed for the range of 10 - 12 GHz, the total deviation does not exceed 0.5 mm. For space radio telescope operating in the millimeter and sub millimeter wavelength range, is the deviation of the working surface of the mirror not more than 2 microns.

A significant effect on the stability of the shape and size of mirrors of large antennas and radio telescopes has an impact space factors (heat fluxes, vibration, gravity and aerodynamic forces, etc.). Due to the considerable unwanted strain arising in the process impact of external and internal factors, it is necessary to solve the problem of monitoring and managing strains of the mirror during flight exploitation. Creating space structures with controlled mirror will solve the problem.

A particular class of space structures with controlled mirror is intelligent structures. The term "intellectual structure" in this report is understood structure, monitoring and active management of working surfaces is based on the use of actuators and sensors of the smart materials are embedded in the structure of the material of construction.

For today the development of design principles and the creation of large intellectual space structures is a primary concern for the development of space grow back. When establishing such structures important role is given full-scale tests, which are determined by the basic criteria of reliability and functional fitness structures. Creating conditions a similar outer space (for full-scale ground tests) need expensive installation. Therefore, is an alternative to mathematical experiment to determine the functional fitness and reliability of structures. For the mathematical modeling of large space structures are frequently used numerical methods such as finite element method.

Analysis of open source print show boundedness of suggested methods design and creation of large precision space structures containing actuators of smart materials. The main disadvantage of these methods is to differentiate the process of designing and creating smart structures, i.e. the process of creating the project design, decision making on the application of actuators, their type (functional and structural properties), the size, number, position, are isolated from each other. Therefore in this scientific research sought to develop a unified design principles of structures and actuators, and to create on its basis of a single complex of programs (integrated into the software system finite - element calculation ANSYS), which will allow determine the appearance of intellectual structure and select the type of actuators, to determine the optimal position the number and size of the actuators in the structure of structures for managing the stability of the shape and size high precision work surfaces in response to external forcing.

Development of design principles are now in the early stages, so the object of scientific research is a multilayer thin circular plate of composite material. The main tool of mathematical modeling structures selected finite element method, which has proven itself as a reliable tool for

engineering calculations. Design principles in the general form can be represented as the following stages:

1. determination of the primary appearance of the intellectual structure (in this case, it is assumed that it is a thin circular plate of composite material);
2. analysis of changes in the stress and strain under the action of design loads;
3. first refinement of the design appearance of the intellectual structures;
4. determination prior position, number and power actuators;
5. second refinement of the design appearance of the intellectual structures;
6. select the type of actuators and refinement of their structural organization, functional properties, position and size.

Let us give a few comments on each stage. The first stage is based on the creation of appearance of structures. It is assumed that the initial appearance of large space structures (not containing the actuators) is defined on the basis of one of the already developed engineering methods (subject to design tasks and mass and size capabilities missile - launchers). At this stage of scientific research as an object of scientific research is a multilayer thin circular plate of composite material. At this stage of scientific research as an object of investigation, the circular plate, so the first step is simplified. In the second phase a finite - element model of the structure to which are applied design loads. The third step is based on the analysis the obtained data on the impact of design loads to change the stress and strain intellectual structures and decision-making to change the appearance of intellectual structures. For analysis and decision-making is created program that is integrated into complex finite - element calculation of ANSYS.

At the next stage to determine the approximate region of position actuators, as well as their number and power for compensation unwanted strain. Therefore in this scientific research is proposed to replace a set of actuators concentrated forces and moments (let's call them "countervailing force factors"), applied to the nodes of finite - element model of the design. This simplification will allow a first approximation to determine the optimal position of the actuator and its power. The situation of the actuator corresponds to the position countervailing force and / or moment, and his power is correlated with the value of the power factor.

The position, numbers and value of power factor countervailing is determined by solution optimization task that can be formulated as follows: to determine the optimal position, the numbers countervailing and the value of power factors for unwanted strain intellectual structures prior to permissible level, arising from impact external and / or internal factors, provided minimize the objective function. As the objective function is selected the work of external forces. Currently, to solve the optimization problem, program is being developed which will the integration into the software system finite - element analysis ANSYS.

The fourth stage of the offered technique needs to refine the project constructions on the base analysis of the change of stress and strain analysis of the design and solving the optimization problem. At this stage, for example, may to decide on amendments composition structure, change or add of stiffeners, etc. In this stage, a program of analysis and decision making, integrated into the ANSYS.

After a stage of "refinements appearance of intelligent structure" must replace "countervailing power factors" in the real actuators and refine the structure and functional properties, as well as the position and size of the area occupied by them for managing unwanted strain construction. For this stage it is planned to create a program selecting the type actuator, refine their position and size.

The report is expected to present the results of the first four phases of the developed design principles of intelligent structures on the example of circular multilayered composite plates. Design loads are heat fluxes which cause unwanted strain of the plate. As a result of the first four stages of the technique refined the structure of the plate material (number of layers and their orientation), the terms of fastening plates and determined the optimal position and the value of countervailing forces and moments.