Spacecraft orientation and stabilization.

Space technology is intended for the exploration and use of outer space and extraterrestrial objects in order to solve scientific, technical, socio-economic and defense problems. The creation of space technology, which is a separate branch of industry, is a whole complex of technical tasks to be solved, necessary for the successful functioning of rockets of any purpose. One of the main tasks is the orientation and stabilization of the spacecraft in space.

Space flights are performed at an altitude of at least 100 km, and it occurs practically in the absence of aerodynamic forces, since the ambient pressure already at an altitude of 100 km is about 10-2 N / m2, and the air density is about 10-6 kg / m3. Therefore, under conditions of space flight (vacuum, weightlessness, long flight duration), the damping and restoring moments are negligible, and any disturbance acting on the apparatus causes its rotation until a torque opposite in direction is applied to it. In this regard, to compensate for even negligible perturbing moments, appropriate control moments must be applied to the apparatus.

The disturbing moments that violate the angular position of the vehicle in space are the moments from rotating masses inside the vehicle (up to 10 N • m), aerodynamic and gravitational moments (up to 10-3 N • m), moments from the forces of pressure of sunlight, moments from the interaction of current-carrying circuits of onboard systems with an external magnetic field, etc.

The motion of a spacecraft can be represented as a combination of two motions - the translational motion of its center of mass and its rotational motion relative to its own center of mass:

a) movement with the engines turned off (orbital movement that takes up the main flight time);

b) movement with the engines running (launching into orbit, landing, trajectory correction and other minor operations).

During the orbital motion of a spacecraft, its dependence on angular rotations around the center of mass is determined only by its orientation of angular positions relative to celestial bodies, magnetic and gravitational field lines, the location of antennas, solar batteries, mutual orientation when spacecraft approach each other, etc.

The angular control of the spacecraft in the free flight section with giving it a certain position relative to the given positions is called orientation. Orientation systems can provide uniaxial or full (triaxial) orientation. In orientation, angular motion around the center of mass does not affect the trajectory of the center of mass.

When the spacecraft moves different from the orbital motion, when the main propulsion system is operating, it is necessary to keep the direction of the aircraft axes unchanged, which is not possible without controlling its angular position, since the direction of the engine thrust or aerodynamic forces depends on this, i.e. forces determining the trajectory of the center of mass. Controlling the angular position of the vehicle around the center of mass in flight segments with significant acceleration (when the engines are running, braking, etc.) is called angular stabilization.

During stabilization, the control of the angular position is auxiliary, necessary to control the motion of the vehicle's center of mass (to maintain the proper direction of the thrust vector or lift). Angular stabilization systems operate at relatively large perturbing moments, therefore, to create control moments during stabilization, more powerful control devices are used than in attitude control systems.

Orientation and stabilization systems, due to the proximity of their tasks, are sometimes combined either as a whole or in separate units. Thus, when two spacecraft approach each other from a long distance, the engines are repeatedly and briefly switched on with long breaks between them, and the entire approach process consists of alternating modes of orientation and stabilization.

According to the method of forming the control moments, the unified orientation and stabilization system is divided into active, passive and combined.

Active systems, to create control torques, require energy consumption from onboard renewable sources, and onboard reserves of the aircraft:

- gas nozzles or low-thrust micro-rocket engines that generate large control forces. To create thrust, the energy of compressed gas, combustion of liquid or solid fuel, electrical energy can be used;

- gyroscopes using inertial flywheels and gyroscopes, the operation of which is provided by electric motors.

Passive systems are characterized by a complete absence of energy and mass consumption and an unlimited service life:

- the gravitational system uses the gravitational field of the Earth, it is most effective for orbital heights of 200 km. up to 2000 km.;

- the aerodynamic system is used in the presence of the atmosphere, in low orbits for the Earth from 200 km to 400 km;

- the electromagnetic system, using permanent magnets on board the aircraft, reaches a certain position relative to the lines of force of the Earth's magnetic field.

Combined systems contain elements of both systems. The most widespread are active systems. Passive and combined systems are used much less frequently than active systems.