The special features of the combined operation of the energy conversion system and electric propulsion integral with the nuclear power propulsion system (the theses)

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Solving new problems in the study, the development and the use of space calls for essential upgrading of the level of power and propulsion support of the spacecraft. It cannot be attained when using traditional means of the power supply on the basis of solar arrays and cruise engines propelled by chemical fuel. Therefore, the reversion of nuclear power to space at a new technological level is the necessary condition for solving urgent tasks in adjacent and far space and progress of astronautics in XXI century.

The most efficiency of using nuclear power in space in logistics operations can be achieved with an application of the so-called nuclear power propulsion systems (NPPS). In the NPPS the thermal energy, generated by the nuclear reactor, is converted to electricity, that can be used both for powering high-efficient electric propulsion (EP) on the segment of SC transfer flight to final orbit, and for powering the payload in working orbits [1, 2].

For the NPPS at the electric power level as much as hundreds of kilowatts … megawatts the energy conversion systems (ECS), running on the closed gas-turbine Brayton cycle with heat regeneration [1, 3] are considered. In this power range the gas-turbine ECS have some substantial advantages over other conversion systems (thermionic, steam turbine etc.) both in specific power-mass characteristics, and in indexes of reliability and safety. The conversion of energy, generated by alternator of the gas-turbine ECS (Fig.1) and the energy distribution between loads is implemented by equipment of the electric- power conversion and distribution system (EPCDS) [3, 4].

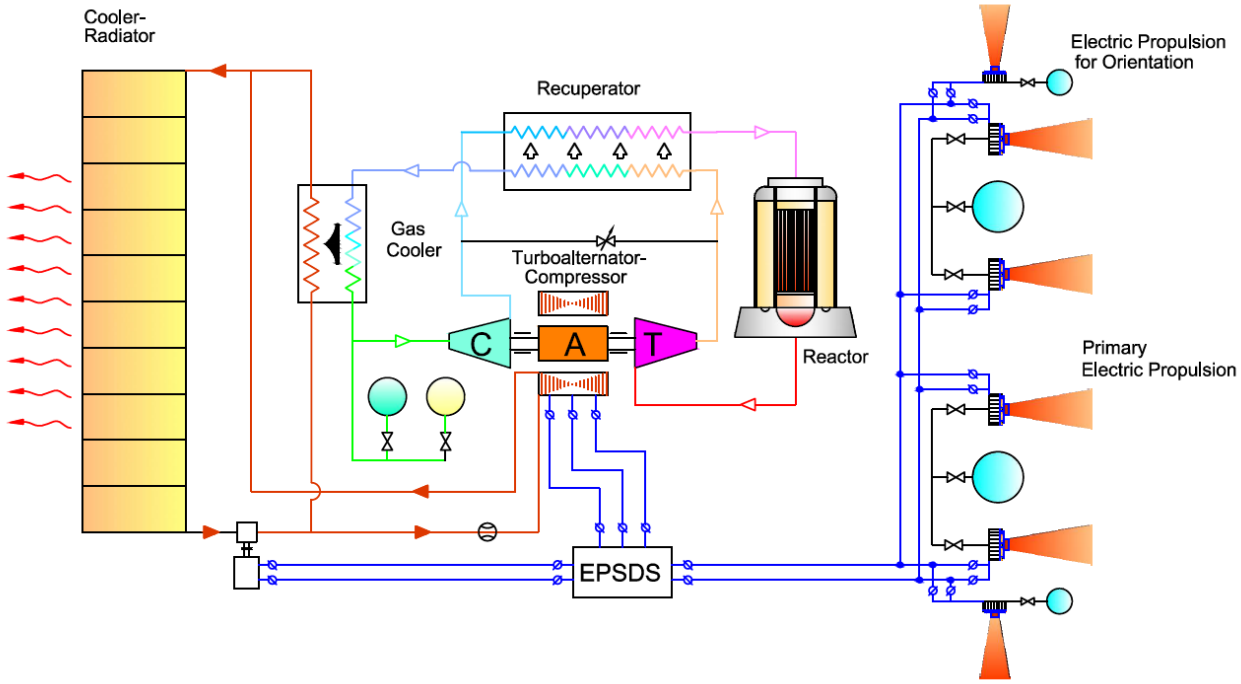

Figure 1. The scheme of the nuclear power propulsion system

In the standard conditions the NPPS can operate in the following modes, differing by electric power, generated by the ECS and the number of functioning EP:

- basic mode;
- standby mode;
- intervening modes.

The basic mode (the mode of nominal power) corresponds to the maximum electric power, generated by the ECS alternators. In this mode all primary EP and, if necessary, the electric propulsion for orientation are operating. Part of electric power is consumed by the own loads of the ECS and the reactor (the equipment of the automatic control system, the electric drives, the devices of the heat carriers feed, transducers, drives of power controls and reactor safety system and others).

In the standby mode (the mode of the minimum power) the primary EP are shutdown, and the users of electric power are the own loads of the ECS, and if necessary, the electric propulsion for orientation and SC service systems. The electric power not called for is released to the controlled dry load of the EPCDS.

In the intervening modes a part of the primary EP is operating. The intervening modes are realized on going from the standby mode to the basic mode, and the other way, as well as in definite stages of the SC transfer flight to final orbit.

Change from mode to mode is performed by an agreed alteration of the quantity of operating EP, the electric power, generated by the ECS and the reactor heat power. Having regard to the reactor sluggish response and impossibility of stepwise variation in the electric power, the algorithm of electric propulsion on/off provides for a few stages. So, by EP shutdown the following actions are effected:

- the connection of the controlled dry load of the EPCDS;
- the regulated reduction of the reactor power;
- the propellant pumping from the ECS closed loop;
- the fall in power of the connected dry load down to zero.

A separate task is the initial startup of the gas-turbine ECS loop in combination with the reactor. For realization thereof, a number of hardware, providing a sequential initial rotational of the ECS alternators in the electric motor mode, the change to electric power generation mode, acceleration up to the nominal rotational speed with going to the standby mode are envisaged. In so doing, an increase in the nuclear reactor power is controlled.

The paper deals with the subjects of the combined functioning of the gas-turbine ECS and EP integral with the NPPS in different operating modes. The logic patterns and algorithms of the change from mode to mode are described. The estimates of ECS parameters in different operating modes are given. The questions of the initial startup of the EPS loop in combination with the nuclear reactor, as well as their planned shutdown are considered separately. The hardware configuration, ensuring the combined functioning of ECS and EP, is given.

References

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