

## DYNAMICS OF ELECTRICALLY CONTROLLED PROPELLANT VALVES FOR “GREEN”-PROPELLANT THRUSTERS

*Institute of Technical Mechanics  
of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine  
15 Ieshko-Popel St., Dnipro 49005, Ukraine; e-mail: knyshenko@ukr.net*

Recently, the leading space countries have paid much attention to searching for and using new types of un-toxic “green” propellants. Developments of 0.1 N to 220 N “green”-propellant thrusters have been reported, and some of them have been successfully tested in flight conditions. Liquid-propellant spacecraft thrusters are actuators of a spacecraft in-orbit motion control system. They are actuated from command signals of the spacecraft control system by applying a voltage to the electromagnet coils of the propellant valves of each of the engines that are to feed the propellant during a specified time interval to produce a required thrust impulse. A problem common to liquid-propellant thrusters irrespective of the propellant type is a thruster start-up delay with respect to the command signal and a thruster shut-down delay with respect to the electromagnet coil de-energizing. In other words, the thruster response is shifted with respect to the command signal. Because of this, the valve parameters must be chosen in such a way as to minimize the delay effect.

The goal of this work is to determine design parameters of electrically controlled propellant valves that would provide an efficient in-orbit operation of “green”-propellant thrusters with a minimum of electric energy consumption. To determine these parameters, use was made of a branch standard, the procedure of work with which was based on empirical data and verified by numerical simulation. The key factor in shortening the thruster start-up delay is to reduce the seat-to-tip valve plate travel on condition that a required propellant amount is fed to the reaction chamber. However, this extends the shut-down delay, which has a harmful effect in the short-impulse operation mode. It is shown by calculation that after the electromagnetic parameters have reached their steady-state values, the voltage can be reduced by 30 to 40 per cent of its nominal value with the valve kept in an open state, after which the valve closes with a shorter delay. In addition, this way of valve energizing reduces the total electric energy consumption for valve operation. The mathematical model of valve dynamics allows one to determine the valve operation parameters in the case of short command signals probable in flight conditions. In such a case, a valve does not open to a full extent, which results in a low specific impulse. The results of this study may be used in the development of “green”-propellant thrusters.

**Keywords:** *thruster, “green” monopropellant, electrically controlled propellant valve, valve dynamics, thruster start-up/shut-down delay, valve voltage reduction, impulse valve operation.*

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