UDC 629.78.533.6.013:621.45

T. A. KOVALENKO [1], N. P. SYROTKINA[1], Yu. D. SHEPTUN[2]

ON THE ADAPTATION OF BIFUNCTIONAL SYSTEMS OF LIQUID-PROPELLANT ROCKET THRUST VECTOR CONTROL TO MODERN METHODS AND SYSTEMS OF SPACE ROCKET STAGE FLIGHT CONTROL

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

[2]*Oles Honchar Dnipro National University*
72 Gagarin Ave., Dnipro 49010, Ukraine; e-mail: udsheptun@rambler.ru

The aim of this paper is to demonstrate that bifunctional rocket trust vector control systems can easily be adapted to modern flight control systems of space rocket stages with mass asymmetry that changes during the flight. A bifunctional thrust vector control system based on separate counteraction to random and deterministic disturbing factors is considered. It is shown that its adaptation to modern rocket stage control systems significantly widens the range of actuator control efforts at low power consumption for control without affecting high dynamic qualities and the accuracy of control systems, increases the reliability and performance characteristics of actuators, and reduces the power consumption for space rocket flight control.

Keywords: *gas-dynamic and mechanical thrust vector control systems; power consumption reduction; reliability improvement; control range.*

1 *Igdalov I. M., Kuchma L. D., Polyakov N. D., Sheptun Yu. D.* Dynamic Designing of Rockets. Problems in the Dynamics of Rockets and their Space Stages (*in Russian*). Dnepropetrovsk, 2010. 254 pp.

2 Control of a rocket stage with mass asymmetry (*in Russian*). Proceedings of the International Scientific Conference “Space Technologies: the Present and the Future” (May 19-21, Dnepropetrovsk, Ukraine). Dnepropetrovsk, 2015. 4 pp.

3 Method for liquid-propellant rocket engine thrust vector control and a liquid-propellant rocket engine for its implementation (*in Ukrainian*): Patent 103528 Ukraine: IPC F02K 9/00. No. 2011 14384; filed Dec. 12, 2011; published Oct. 25, 2013, Bul. No. 20. 11 pp.

4 Method for liquid-propellant rocket engine thrust vector control and a liquid-propellant rocket engine for its implementation (*in Ukrainian*) : Patent 105214 Ukraine: IPC F02K 9/56, F02K 9/82. No. 2011 12467 ; filed Oct. 24, .2011; published Apr. 25, 2014, Bul. No. 8. 10 pp.

5 Thrust vector control method for a liquid-propellant rocket engine with a turbopump assembly to feed the propellant components into the combustion chamber and a liquid-propellant rocket engine that uses it (*in Ukrainian*): Patent 107270 Ukraine: IPC F02K 9/00. No, 2013 06211 ; filed May 20,.2013 ; published Dec. 10, 2014, Bul. No. 23. 11 pp.

6 Method for liquid-propellant rocket engine thrust vector control and a liquid-propellant rocket engine that uses it (*in Ukrainian*) Patent 108677 Ukraine: IPC F02K 9/00. No. 2011 14384 ; filed July 8, 2013 ; published May 25, 2015, Bul. No. 10. 9 pp.

7 *Kovalenko T. A., Syrotkina N. P., Kovalenko N. D.* Bifunctional thrust vector control system of a launch vehicle space stage engine (*in Russian*). Tekhnicheskaya Mekhanika. 2015. No. 1. Pp. 42–54

8 *Kovalenko T. A, Kovalenko G. N., Syrotkina N. P.* Thrust vector control of a launch vehicle space stage liquid-propellant rocket engine in the occurrence of mass asymmetry (*in Russian*). Tekhnicheskaya Mekhanika. 2016. No. 1. Pp. 51–59.

9 *Degtyarev A.V.* Sixty Years in Rocket Production and Cosmonautics (*in Russian*). Dnepropetrovsk, 2014. 540 pp.

10 Launch vehicle stage control method (*in Ukrainian*): Patent 114354 Ukraine: IPC F02 K 9/00. No. 2015 07716; filed Aug. 3, 2015 ; published May 25, 2017, Bul. No. 10. 5 pp.