UDC 629.78.533.6.013:621.45

T. A. KOVALENKO

BIFUNCTIONAL SYSTEM OF THRUST-VECTOR CONTROL OF LIQUID ROCKET ENGINE WITH TURBINE GAS INJECTION INTO NOZZLE

The results of the study of a bifunctional thrust- vector control system of a liquid rocket engine based on the combined use of the mechanical (engine swinging) and gas-dynamic (the gas turbine injection into the nozzle) control systems are reported. Various options of the control system to expand the control range, to increase the system reliability and reduce the energy consumption for the flight control of the space stage of the rocket are considered. The physical models of the processes in the nozzle when injecting the gas turbine are examined. The calculated ratio for determining the characteristics of the flow disturbance are proposed.

Keywords: *space stage of rocket, stage flight control, liquid rocket engine, bifunctional system of thrust-vector control, engine swinging, disturbance of supersonic flow through nozzle.*

1. Patent for Invention 103528 Ukraine, Int. Cl. F02K 9/00. Technique of Thrust-Vector Control of Liquid Rocket Engine and Liquid Rocket Engine for this Purpose *(in Ukrainian) / Kovalenko M. D., Sheptun Yu. D., Strelnikov G. O., Kovalenko T. O., Syrotkina N. P.;* applicant and patentee ITM, NASU&NSAU. – a 2011 14384; filed 05. 12. 2011; published 25.10.2013, Bullitin No 20. – 11 p.
2. Patent for Invention 107270 Ukraine, Int. Cl. F02K 9/00. Technique of Thrust-Vector Control of Liquid Rocket Engine with Turbopump Assembly of Propellant Supply into Combustion Chamber and Liquid Rocket Engine with its Equipment *(in Ukrainian) / Kovalenko M. D., Sheptun Yu. D., Strelnikov G. O., Kovalenko T. O., Syrotkina N. P.;* applicant and patentee ITM, NASU&NSAU. – a 2013 06211; filed 20. 05.2013; published 10.12.2014, Bullitin No 23. – 11 p.
3. Patent for Invention 108677Ukraine, Int. Cl. F02K 9/00. Technique of Thrust-Vector Control of Liquid Rocket Engine and Liquid Rocket Engine with its Equipment *(in Ukrainian) / Kovalenko M. D., Sheptun Yu. D., Strelnikov G. O., Kovalenko T. O., Syrotkina N. P.;* applicant and patentee ITM, NASU&NSAU. – a 2013 08511; filed 08.07.2013; published 25.05.2015, Bullitin No 10. – 9 p.
4. Dynamic Rocket Designing. Problems in Dynamics of Rockets and their Space Stages *(in Russian) / I. M. Igdalov, L. D. Kuchma, N. V. Polyakov, Yu. D. Sheptun*; Edited by *S. N. Konyukhov*. – Dniepropetrovsk : Publishing House of Dniepropetrovsk University, 2010. – 254 p.
5. *Kovalenko T. A.* Space stages as an object of control *(in Russian) / T. A. Kovalenko, Yu. D. Sheptun* // Proceedings of the Scientific Conference on Information Technologies for Control of Complex Systems. – Dniepropetrovsk : Publishing House "Svidter A. L.", 2011. – P. 210 – 213.
6. *Kovalenko N. D.* Rocket Engine as an Actuator Device of Rocket Flight Control System *(in Russian) / N. D. Kovalenko.* – Dniepropetrovsk : ITM, NASU&NSAU, 2003. – 412 p.
7. *Sheptun Yu. D.* Control of rocket stage with mass asymmetry *(in Russian) / Yu. D. Sheptun, N. D. Kovalenko, T. A. Kovalenko* // Proceedings of the International Conference on Space Technologies : the Present and the Future, May 19-21, 2015, Dniepropetrovsk, 2015. – P. 57 – 60.
8. Sixty Years for Rocket Manufacturing and Cosmonautics *(in Russian)* / Edited by *A. V. Degtyarev.* – Dniepropetrovsk : Art-Press, 2014. – 540 p.
9. *Kovalenko T. A.* Bifunctional system of thrust-vector control for launch vehicle space stage *(in Russian) / T. A. Kovalenko, N. D. Kovalenko, N. P. Sirotkina* // Tekhnicheskaya Mekhanika. – 2015. – No 1. – P. 42 – 54.
10. *Ignatiev A. D.* On the determination of flow parameters for unsymmetrical Laval nozzles *(in Russian) / A. D. Ignatiev, S. I. Migur* // Hydrodynamics and Heat and Mass Exchange. – Kiev : Naukova Dumka, 1984. – P. 63 – 71.