UDC 629.7+531.3+532.6

V. V. GORBUNTSOV, A. N. ZAVOLOKA, N. F. SVIRIDENKO

INCREASE IN TARGET-ORIENTED EFFICIENCY OF SPACE MEDIUM-SIZED ROCKET: ADVANCED LINES FOR UPDATING

Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and State Space Agency of Ukraine,15, Leshko-Popel Str., 49005, Dnepr, Ukraine; e-mail: office.itm@nas.gov.ua

Advanced lines for updating the space medium-sized carrier rockets (SMSCR) are offered increasing their target-oriented efficiency in an extended operational range. To attain this, untapped internal reserves are considered based on the active control of current state of the SMSCR elastodeforming body and a hydrodynamic situation in its fuel tanks with the use of SMSCR-born equipment. The terminal control of the angular motion of the first stage of the SMSCR can also be employed taking into account limitations of the control parameters of the flight. The energetically optimal algorithm for launching and servicing the discrete payload by the space stage of the SMSCR is realized using the algebraic methods of the discrete-event simulation.

Keywords: *space rocket, space stage, monitoring current state, elastodeforming body, terminal control, fuel feed system, free gas inclusions, pressurization system, turbulent vortex rings, discrete-event simulation.*

1. *Medvedchikov D.* Space Activities Insurance. Novosti Cosmonavtiki. 1994. No 24. P. 41 – 44. *(in Russian)*
2. Safety of Critical Infrastructures: Mathematical and Engineering Models for Analyzing and Supporting: edited by *V. S. Kharchenko*. Kharkov: Zhukovsky NASU "KhAI", 2011. 244 p. *(in Russian)*
3. *Dineev V. G., Zherdev Yu. V., Kireev V. A. et al.* Lines of development of control systems for space ascent facilities. Kosmonavtika i Raketostroenie. 1999. No 13. P. 129 – 132. *(in Russian)*
4. *Serdyuk V. K.* Designing Facilities of Spacecraft Ascent: textbook. Mocsow: Mashinostroenie, 2009. 504 p. *(in Russian)*
5. Development of Spacecraft Systems: edited by *P. Fortescue, H. Suayerd, D. Starck.* M.: Alpina Publisher, 2015. 765 p. *(in Russian)*
6. *Izenberg Ya.* Ye., *Zlatkin Yu. M., Kalnoguz A. N. et al.* Attack angle control and slipping first stages of launch vehicle. Kosmichna Nauka i Tekhnologia. 2002. Vol. 8, No 1. P. 61 – 79. *(in Russian)*
7. Call of the Time. Rockets and Spacecraft Made by Yuzhnoye Design Bureau: 2 books. Edited by *S. N. Konyukhov*. Dniepropetrovsk: ART-PRESS, 2004. Vol. 1. From Cold War to Technical Cooperation. 768 p. *(in Russian)*
8. *Mogilevtsev A.* A., *Fartushnyi S. K., Tishchenko Yu. S.* Possible lines of works on deacrease in volumes of control sample tests for commercial space programs. Kosmicheskaya Tekhnika. Raketnoe Vooruzhenie. 2007. Issue 2. P. 90 – 100. *(in Russian)*
9. *Feodosiev V. I.* Ten Lectures on Strength of Materials. M.: Fizmatlit, 2002. 320 p. (in Russian)
10. Technique and Device of Control of Disturbed Motion of Elastodeforming Launch Vehicle about Center of Mass: patent 102987 Ukraine: Int. Cl. B 64 C 13/00 / *V. V. Gorbuntsov, O. M. Zavoloka, M. F. Svyrydenko.* No U201209134; filed 25.07.2012; published 27.08.2013, Bulletin No 16. *(in Russian)*
11. *Gorbuntsov V. V., Zavoloka A. N., Sviridenko N. F.* Matematicheskaya model of launch vehicle elastodeforming in the flight. 2013. No 4. P. 59 – 70. *(in Russian)*
12. *Zavoloka A. N.* Problems and new lines for improving power efficiency of launch vehicles. Tekhnicheskaya Mekhanika. 2008. No 2. P. 34 – 42. *(in Russian)*
13. *Pylypenko O. V., Zavoloka A. N., Nikolaev A. D., Sviridenko N. F. et al.* Continuity of gas-saturated propellant components at in-flight vibrations of liquid rocket. Tekhnicheskaya Mekhanika. 2009. No 4. P. 3 – 16. *(in Russian)*
14. *Mitikov Yu. A., Antonov V. A., Voloshin M. L., Logvinenko A. I.* Ways for improving reliability and safety of operation of rocket complexes. Aviatsionno-Kosmicheskaya Tekhnika i Tekhnologia. 2012. No 3 (90). P. 30 – 36. *(in Russian)*
15. *Budnik V. S., Daniev Yu. F., Sviridenko N. F.* General power approach to organization of heat-mass exchange processes in free gas volume of fuel tanks of liquid rockets. Tekhnicheskaya Mekhanika. 1998. Issue 7. P. 98 – 106. *(in Russian)*
16. *Mitikov Yu. A. Sviridenko N. F.* Studies of high-temperature gas for pressurization of propellant tanks of new-generation propulsion plants: problems and ways of their resolution. Tekhnicheskaya Mekhanika. 2013. No 1. P. 68 – 77. (in Russian)
17. AC 291984, SSSR, Int. Cl. F02K9/42. Technique and Device for Pressurization of Tanks / *Sviridenko N. F., Moseyko V. A., Mitikov Yu. A. et al.* No 200200: filed 04.05.1988; published 01.04.1989. *(in Russian)*
18. *Zhovtonog V. M., Logvinenko A. I., Solod S. D.* Modern pressurization systems for upper stages of cryogenic rockets. Kosmicheskaya Tekhnika. Raketnoe Vooruzhenie. 2007. Issue 2. P. 37 – 42. *(in Russian)*
19. Technique and Device for Providing Stable Engine Running Liquid Gas-Saturated Propellant Component Rockets: patent 104841 Ukraine, Int. Cl. F 02 K 9/42 / *V. V. Gorbuntsov, O. M. Zavoloka, M. F. Svyrydenko.* No U201209694; filed 10. 08. 2012; published 11.03.2014, Bulletin No 6. *(in Russian)*

20. *Gorbuntsov V. V., Zavoloka A. N., Sviridenko N. F*. Special features of formation of an algorithm for active controlling the content of free gas inclusions at inlet of cruise engine fuel lines using data of monitoring the current state of hydrodynamic status in tanks of launch vehicle. Tekhnicheskaya Mekhanika. 2015. No 4. P. 103 – 116. *(in Russian)*
21. *Wainer G. A.* Discrete-Event Modeling and Simulation: a Practitioner's Approach. Boca Raton : CRC Press, Taylor & Francis Group, 2009. 486 p.
22. *Gorbuntsov V. V.* Theoretical and Group Approach to Solution of Combinatorial Optimization Problems. Kiev: Naukova Dumka, 1983. 192 p. *(in Russian)*
23. *Heidergott B., Olsder G. J., van der Woude J.* Max Plus at Work. Modeling and Analysis of Synchronized Systems: a Course on Max-Plus Algebra and its Applications. Princeton: Princeton University Press, 2006. 232 p.
24. *Krivulin N. K.* Methods of Idempotent Algebra for Problems of Simulation and Analysis of Complex Systems. St.-Petersburg: Publishing House of St.-Petersburg University, 2009. 256 p. *(in Russian)*
25. *Gorbuntsov V. V.* Theoretical and group method for optimization of multi-element systems. Kosmicheskaya Nauka i Tekhnika. 1988. Issue 3. P. 22 – 27 *(in Russian)*
26. *Gorbuntsov V. V.* Calculations and optimization of discrete programs of spacecraft motion control. Kosmicheskaya Nauka i Tekhnika. 1992. Issue 6. P. 33 – 40. *(in Russian)*