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SPECIAL FEATURES OF ALGORITHM FOR ACTIVE CONTROL OF HYDRODYNAMIC STATUS OF TANKS OF LAUNCH VEHICLE

A rational approach to monitoring the hydrodynamic status (HDS) of the fuel tank (FT) of the launch vehicle (LV) as a basis of the active control of the fuel component (FC) gas content at the inlet of the liquid-propellant engine fuel line is grounded. The idea of a practical linear shape of the pressure oscillation mode (POM) along the FC height in the LV tanks exposed to the influence of the vibration loads from the operating engine serves as a basis for the approach. The above circumstance provides the possibility of renewing the POM with the respect of indications of the single sensor set in the immediate vicinity of the FT flexible lower bottom. A simple condition of the operational engine stability according to the free- gas inclusions (FGIs) content in the FC at the engine inlet is proposed. This is provided by prevention of the discharge of the FGIs forming in the FC during the flight along the boost path from the FT by controlling the pressure in the FT free-gas volume with changes in the gas flow supplied for the FT pressurization. Time relations for controlling the HDS pressurization gas flow are derived. The pressure control problem for one of schematics of the FT pressurization with liquid oxygen is considered; the analysis of this process demonstrated the possibility of brief controlling the pressure using standard gas pressure-reducing valves.

Keywords: *launch vehicle, fuel tank, hydrodynamic status, free gas inclusions, pressure fluctuations, active control, pressurization system, regulator of gas pressure.*

1. Rocket as an Object of Control (in Russian) / *I. M. Igdalov, L. D. Kuchma, N. V. Polyakov, Yu. D. Sheptun.* – Dniepropetrovsk : ART-PRESS, 2004. – 544 p.
2. *Gorbuntsov V. V.* Active control of disturbed motion of launch vehicle based data for monitoring status of its systems: problems and prospects (in Russian) / *V. V. Gorbuntsov, A. N. Zavoloka, N. F. Sviridenko* // Tekhnicheskaya Mekhanika. – 2012. – No 1. – P. 72 – 81.
3. Patent for Invention 102987 Ukraine, Int. Cl B64C 13/00. Technique and Apparatus for Controlling Disturbed Motion of Stressed-Strained Launch Vehicle about Center of Mass (in Ukrainian) / *Gorbuntsov V. V., Zavoloka O. M., Svyrydenko M. F.* : applicant and assignee Institute of Technical Mechanics, NASU&SSAU. – U201209134 ; filed July 25, 2012 ; published August 27, 2013, Bul. No 16.
4. *Gorbuntsov V. V.* Mathematical model of launch vehicle stressing and straining in the flight (in Russian) / *V. V. Gorbuntsov, A. N. Zavoloka, N. F. Sviridenko* // Tekhnicheskaya Mekhanika. – 2013. – No 4. – P. 59 – 70.
5. *Kolesnikov K. S.* Dynamics of Rockets (in Russian) / *K. S. Kolesnikov.* – Moscow : Mashinostroyenie, 1980. – 376 p.
6. Patent for Invention 104481 Ukraine, Int. Cl F 02 K 9/42. Technique and Apparatus for Providing Stable Operation of Launch Vehicle Engine Using Liquid Gas-Saturated Components of Fuel (in Ukrainian) / *Gorbuntsov V. V., Zavoloka O. M., Sviridenko M. F.* ; applicant and assignee Institute of Technical Mechanics, NASU&SSAU. – U201209694 ; filed August 10, 2012 ; published May 11, 2014, Bul. No 6.
7. *Gorbuntsov V. V.* Methodical approach to formation of active control of hydrodynamic status of fuel tanks of launch vehicle based on monitoring its status (in Russian) / *V. V. Gorbuntsov, A. N. Zavoloka, N. F. Sviridenko* // Tekhnicheskaya Mekhanika. – 2015. – No 2. – P. 30 – 41.
8. Continuity of gas-saturated components of fuel in the presence of in-flight vibrations of liquid launch vehicle (in Russian) / *O. V. Pylypenko, A. N. Zavoloka, A. D. Nikilaev, N. F. Sviridenko, A. N. Mashchenko, V. N. Bichay* // Tekhnicheskaya Mekhanika. – 2009. – No 4. – P. 3 – 16.
9. *Chebayevsky V. F.* Cavitation Characteristics of High-Speed Impeller Pumps (in Russian) / *V. F. Chebayevsky, V. I. Petrov.* – Moscow : Mashinostroyenie, 1973. – 192 p.
10. *Vassiliev Yu. N.* Device for degassing a liquid fuel fore of pumps of rocket engine (in Russian) / *Yu. N. Vassiliev, V. N. Tikhomirov* // Izvestia RAN. Energetika. – 2003. – No 4. – P. 51 – 57.
11. *Groys L. V.* Dissolving gas bubbles into a liquid (in Russian) / *L. V. Groys, N. Ye. Kvantaliani* // IFZh. – 1978. – Vol. 34, No 2. – P. 292 – 300.
12. *Yefremov G. I.* Studies of hydrodynamics of a bubbling layer (in Russian) / *G. I. Yefremov, I. A. Vakhrushev* // Khimia i Tekhnologia Topliv i Masel. 1969. – No 4. – P. 34 – 38.
13. Experimental investigations of vibration effects on serviceability of bubbling system (in Russian) / *V. S. Budnik, N. V. Sviridenko, B. V. Sverdlichenko, V. I. Kuznetsov* // Hydrodynamics of Engineering Systems: Transactions. – Kiev : Naukova Dumka, 1985. – P. 102 – 108.
14. Dynamic Environmental Criteria NASA, NASA-HDBK-7005 MARH 13, 2001 http : // standards. nasa. gov.
15. *Hasimoto H.* Surface failure and formation of bubbles in column of a liquid under vertical oscillation (in Russian) / *H. Hasimoto, S. Sudo* // Raketnaya Tekhnika i Kosmonavtika. – 1980. – Vol. 18, No 5. – P. 116 – 124.
16. Trajectories of bubbles and equilibrium levels in vibrating columns of a liquid (in Russian) / *J. M. Foster, J. A. Botts, R. Barbin, R. I. Vahon* // Transactions of the American Society of Mechanical Engineers. Series D. – 1968. – No 1. – P. 137 – 146.

17. Patent for Invention 57097 Ukraine, Int. Cl F02K 11/00. Technique and Device of Pressurization of Fuel Tank of Liquid Rocket (in Russian) / *Zhovtonog V. M.* ; applicant and assignee SE 'KB" Pivdenne" named after M. K. Yangel. – U200020664 ; filed February 8, 2000 ; published June 16, 2003, Bul. No 6.
18. *Kozlov A. A.* Systems of Feed and Control of Propulsion Systems of Liquid Rockets (in Russian) / *A. A. Kozlov, V. N. Novikov, Ye. V. Solovyev*. – Moscow : Mashinostroyenie, 1988. – 352 p.
19. *Yermilov V. A.* Gas Pressure Regulators (in Russian) / *V. A. Yermilov, Yu. V. Nesterenko, V. G. Nikolaev*. – Leningrad : Mashinostroyenie. Leningrad Branch, 1981. – 176 p.
20. *Timoshenko S. P.* Oscillation for Engineering (in Russian) / *S. P. Timoshenko*. – Moscow : Nauka, 1967. – 444 p.
21. *Gimadiev A. G.* Automatics and Control of Propulsion Systems of Rocket and Space Systems (in Russian) / *A. G. Gimadiev*. – Samara : Samara State Aerospace University named after Acad. S. P. Korolev, 2010. – 201 p.
22. *Loytsyansky L. G.* Fluid Mechanics: Textbook. – 7th Revised Edition (in Russian) / *L. G. Loytsyansky*. – Moscow : Drofa, 2003. – 840 p.
23. *Kim D. P.* Theory of Automatic Control. In 2 volumes. Vol. 1. Linear Systems (in Russian) / *D. P. Kim*. – Moscow : FIZMATLIT, 2003. – 288 p.