

Russian and Japanese Aerospace Literature

During 1994 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Spacecraft Propulsion from Russia and Spacecraft/Satellite Design from Japan.

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Russian Aerospace Literature This month: *Spacecraft Propulsion*

A93-31172 Numerical investigation of the characteristics of an annular nozzle unit (Chislennoe issledovanie kharakteristik kol'tseвого соплового блока). A. S. TRUSHKOV and L. A. TRUSHKOVA, *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1992, pp. 83–85. 2 Refs.

The characteristics of an annular nozzle on the side surface of a solid-propellant rocket engine are investigated by using numerical modeling of the gasdynamic processes. The mathematical model used is based on a system of Euler equations approximated by a large-particle difference method. The flow coefficient and thrust losses due to an incomplete reversal of flow in the nozzle are determined as a function of the structure geometry.

A93-18424 A high-precision flight control algorithm for a ballistic flight vehicle (Algoritm vysokotochnogo upravleniia poletom ballisticheskogo LA). I. U. L. MAIBORODA, *25th Studies on the mechanics of space flight in the light of K.E. Tsiolkovsky's ideas; Lectures Devoted to K.E. Tsiolkovsky's Ideas*, Kaluga, Russia, Sept. 11–14, 1990, Transactions (A93-18420 05-12). Moscow, AN SSSR, Institut Istorii Estestvoznaniia i Tekhniki, 1991, pp. 30–36. 7 Refs.

A high-precision flight control algorithm for the guidance of ballistic flight vehicles is proposed which is based on the principle of invariance with respect to perturbations. The algorithm proposed here belongs to a class of combined control algorithms based on the predicted miss and perturbations. The use of a control circuit employing perturbation information and characterized by only a slight delay of the control action makes it possible to achieve high accuracy in guiding with relatively low computational effort.

A92-53854 Estimated optimum control of a spacecraft by the rocket engine thrust vector at the extraatmospheric section of the reentry of an artificial earth satellite (Priblizhenno-optimal'noe upravlenie KA vektorom tiagi dvigatel'noi ustanovki na vneatmosfernom uchastke spuska s orbity ISZ). N. L. SOKOLOV, A. P. SOKOLOV, and T. I. SMIRNOVA, *Kosmicheskie issledovaniia* (ISSN 0023-4206), Vol. 30, No. 2, Mar.–Apr. 1992, pp. 180–193. 10 Refs.

The paper investigates optimal, minimum-fuel control of a spacecraft by the rocket engine thrust vector on the extraatmospheric section of the reentry of a satellite. The control design, which provides for firing of the engine twice, is shown to be highly efficient. A high-speed algorithm is developed for calculating the estimated optimum reentry trajectories to the prescribed area of the earth surface.

A92-46515 Energy conversion efficiency of radiation into a mechanical impulse in a laser thruster (Effektivnost' preobrazovaniia energii izlucheniia v mekhanicheskii impul's v reaktivnom lazernom dvizhitele). R. A. LIUKONEN and A. M. TROFIMENKO, *Pis'ma v Zhurnal Tekhnicheskoi Fiziki* (ISSN 0320-0116), Vol. 18, No. 7, April 12, 1992, pp. 76–80. 7 Refs.

Experimental studies have been conducted which demonstrate the feasibility of varying the reactive thrust force in a wide range during the laser acceleration of bodies in the atmosphere and in vacuum. Specific recoil impulses up to 70 dyn s/l have been realized on a flat target. A laser thruster model using CO₂ lasers was employed in the experiments.

A93-18306 Rocket and space technology—The ideas of K.E. Tsiolkovsky and modern development; Lectures Devoted to K.E. Tsiolkovsky's Ideas, 25th, Kaluga, Russia, Sept. 11–14, 1990, Transactions (Russian book). *25th Raketnaia i kosmicheskaiia tekhnika—Ideii K.E. Tsiolkovskogo i sovremennoe razvitiie; Chteniia, Posviashchennye Ideiam K.E. Tsiolkovskogo*, Kaluga, Russia, Sept. 11–14, 1990, Trudy E. K. MOSHKIN, V. V. BALASHOV, V. P. KAZNEVSKII, and I. A., MERKULOV, EDS. AN SSSR, Institut Istorii Estestvoznaniia i Tekhniki, 1991, 128 pp.

The papers presented in this volume focus on recent theoretical and experimental research related to rocket and space technology. Topics discussed include the problem of earthquake prediction by space methods, mathematical support of geophysical experiments conducted at the Mir orbital complex, local stationary orbits of artificial earth satellites, and terminal guidance of a gliding flight vehicle on the basis of the angle of roll at the final stage of descent. Attention is also given to a new method for determining the number of flight vehicle prototypes subject to full-scale testing, optimal damping of the vibrations of the elastically attached fragments of large-scale space structures, and generation of artificial gravity in two-mass systems without balancing. (For individual items see A93-18307 to A93-18324)

A93-16773 Prediction of the life of pressed ceramic composite discharge chambers of stationary electric propulsion thrusters using a combination of nondestructive evaluation techniques (Prognozirovanie resursa keramicheskikh press-kompozitsionnykh razriadnykh kamer statsionarnykh elektroreaktivnykh dvigatelei sredstvami kompleksnykh nerazrushaiushchikh ispytani). I. A. I. BUL'BUK, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), No. 4, July–Aug. 1992, pp. 521–527. 18 Refs.

The problem of the nondestructive testing of pressed nitride composites for the high-temperature dielectric chambers of stationary plasma thrusters is treated by using an approach that represents a further theoretical development of the method proposed by Bulbik and Bychkov (1990). The method involves combining thermal loading with the application of a pulsed electric field. It is shown that, by selecting restrictions on the length of pulsed loading, it is possible to reduce the effect of the transient absorption current on the results of nondestructive test interpretation.

A92-40614 The current status of electrostatic engines and various electrostatic devices (Osobennosti sovremennogo etapa razvitiia elektrostaticheskikh dvigatelei i razlichnykh elektrostaticheskikh ustanovok). L. A. LATYSHEV, N. A. MASLENNIKOV, and N. N. SEMASHKO, *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 4, 1991, pp. 72–75. 4 Refs.

Current trends in the design and development of electrostatic engines and various electrostatic devices and systems, including those used in space research, nuclear fusion, thin-film production, and other fields, are briefly reviewed. Particular attention is given to the increasing reliance on the existing standard modules when developing new equipment, which greatly reduces the development, fabrication, and maintenance costs and improves reliability. Consideration is also given to the selection of the optimal type and size of electrostatic equipment and the selection of the proper quality criterion in the development of electrostatic rocket engines.

A93-16755 Optimal soft landing of a spacecraft from the circular orbit of an artificial moon satellite at a specified point on the lunar surface (Optimal'naia miagkaia posadka kosmicheskogo apparata s krugovoi orbity iskusstvennogo sputnika luny v zadannuiu tochku ee poverkhnosti). K. G. GRIGOR'EV, E. V. ZAPLETINA, and M. P. ZAPLETIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 30, No. 4, July-Aug. 1992, pp. 483-494. 21 Refs.

Three types of problems concerning the optimal soft landing of a spacecraft with a high-thrust rocket engine from a circular moon satellite orbit at a specified point on the lunar surface are investigated numerically using the maximum principle. In particular, consideration is given to minimum-time landing, landing with minimum mass consumption, and landing with a minimum functional representing a trade-off between the time and mass requirements. The optimal trajectories are calculated for a wide range of initial orbit heights, angular distances of the landing point, thrust-to-weight ratios of the spacecraft, specific thrusts, and tradeoff ratios.

A92-42731 A three-parameter turbulence model—A numerical study of a boundary layer in a film-cooled nozzle (Trehparametricheskaiia model' turbulentnosti—Chislennoe issledovanie pogranichnogo sloia v sople s zavesnym okhlazhdeniem). V. I. KOVALEV, V. G. LUSHCHIK, V. I. SIZOV, and A. E. IAKUBENKO, *Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 1, Jan.-Feb. 1992, pp. 48-57. 14 Refs.

The three-parameter differential turbulence model developed by Lushchik et al. (1978) is used to calculate the boundary layer in the nozzle of a liquid-propellant rocket engine. The model is implemented in a computer program which makes it possible to calculate the wall boundary layer in a nozzle of a given geometry with different wall cooling schemes and to determine both the integral and local characteristics of the boundary layer over a wide range of the governing parameters. Calculations are presented for a boundary layer in a film-cooled liquid-propellant rocket engine nozzle.

A92-16814 Diffuser efficiency estimation parameters (Parametry otsenki effektivnosti diffuzorov). B. S. VINOGRADOV and I. V. BABCHENKO, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1990, pp. 50-56. 6 Refs.

The currently used parameters for estimating the pressure characteristics and efficiency of diffusers are examined with reference to data in the literature. Formulas relating the pressure recovery and drag coefficients are proposed, as are expressions for calculating the drag of supersonic diffusers from the known drag coefficients of the components.

A92-12811 Optimal launch of a spacecraft from the lunar surface into circular lunar orbit (Optimal'noe vyvedenie kosmicheskogo apparata s poverkhnosti luny na krugovuiu orbitu ee sputnika). K. G. GRIGOR'EV, M. P. ZAPLETIN, and D. A. SILAEV, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 29, Sept.-Oct. 1991, pp. 695-704. 10 Refs.

The paper presents results of a numerical solution for the optimal injection of a spacecraft from the lunar surface into a circular lunar orbit. The functions that are controlled are the direction and magnitude of the rocket thrust; the spacecraft is equipped with a high thrust engine. The functional that is minimized represents a tradeoff between the orbital injection time and the mass expenditure. The problem is solved using the maximum principle. Optimal trajectories are calculated in a wide range of orbit altitudes, thrust-to-weight ratios, and net specific thrusts.

A92-12205 Numerical modeling of unstable combustion in solid-propellant rocket engines (Chislennoe modelirovanie neustoiichivogo goreniia v raketnykh dvigatelakh na tverdom toplive). S. A. EKIMTSOV and N. A. KULACHKOVA, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0869-1339), July-Aug. 1991, pp. 40-44. 4 Refs.

Unstable combustion in solid-propellant rocket engines is investigated by using a phenomenological combustion model based on the hypothesis about the existence of a delay in the response of the combustion process to changing conditions. The differential equations describing flow in the combustion chamber are approximated by using the first-order arbitrary Lagrangian-Eulerian method with artificial viscosity. The artificial viscosity makes it possible to result steep pressure fronts without oscillations before and after the discontinuity.

A90-45036 A study of the kinetics and mechanism of chemical reactions in flames of mixed composition based on AP and polybutadiene rubber (Issledovanie kinetiki i mekhanizma khimicheskikh reaktssii v plameni smesevogo sostava na osnove PKhA i polibutadienovogo kauchuka). O. P. KOROBENICHEV, A. A. CHERNOV, I. D. EMEL'IANOV, N. E. ERMOLIN, and T. V. TROFIMICHEVA, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 26, May-June 1990, pp. 46-55. 31 Refs.

In earlier studies (Ermolin and Korobinichev, 1981, 1982, and 1986), an approach to the study of the combustion chemistry of condensed systems was developed which combines experimental investigation of the chemical structure of the flames by mass spectrometry with theoretical modeling of the flame structure based on the solution of flow equations for a reacting multicomponent gas with allowance for multistage kinetic mechanisms. Here, this approach is applied to the investigation of the combustion chemistry of solid fuel mixtures based on ammonium perchlorate and polybutadiene rubber. A summary of the chemical reactions of the principal flame components is presented, and some rate constants are estimated.

A91-41160 Stabilization of the operation of a liquid-propellant rocket engine (Stabilizatsiia raboty zhidkostnogo raketnogo dvigatel'ia). F. D. BAIRAMOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 1, 1991, pp. 37-42. 5 Refs.

The problem of the stabilization of the steady-state operation of a two-component liquid-propellant rocket engine with a turbopump unit is solved using the Liapunov function method. The asymptotic stability of the engine is achieved by controlling the pressure in the oxidizer and fuel tanks.

A91-40106 Propagation of weak perturbations during the combustion of compressible porous fuels (O rasprostraneni slabykh vozmushchenii pri goreni szhimaemykh poristyykh topliv). N. N. SMIRNOV and S. I. SAFARGULOVA, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 27, Mar.-Apr. 1991, pp. 26-34. 14 Refs.

The properties of a system of equations describing the unsteady propagation of a convective flame front in a porous compressible solid fuel are investigated using a two-velocity model which allows for the difference between pressures in the gas and stresses in the condensed phase. The type of the system of equation is determined as a function of the difference of the velocities and pressures in the phases. It is shown that a continuous transition to known solutions occurs in particular limiting cases.

A91-39086 Dispersion during the unsteady combustion of solid fuels (Dispergirovani pri nestatsionarnom goreni tverdykh topliv). L. K. GUSACHENKO, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 27, Jan.-Feb. 1991, pp. 63-66. 8 Refs.

The combustion of dibasic fuels under conditions of fluctuating pressure may be accompanied by the ejection of disperse particles from the burning surface. This phenomenon is examined assuming a dispersion mechanism whereby the separation occurs when the hydrodynamic effect of the outflowing gases exceeds the strength of the bonds retaining the k-phase fragment. The critical pressure drop corresponding to the onset of dispersion is estimated.

A91-39082 Mechanism of the effect of lead catalysts on solid propellant combustion (Mekhanizm deistviia svintsovykh katalizatorov na gorenie porokhov). S. I. IAKOVLEV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 27, Jan.-Feb. 1991, pp. 32-36. 35 Refs.

An analysis is made of the mechanisms of the effect of lead catalysts producing an anomalous pressure dependence of the combustion rate of ballistite solid propellants. A model is proposed which is based on changes in the intensity of the catalysis of the simultaneously occurring reactions $\text{NO}_2 + \text{RCHO}$ and $\text{NO} + \text{C}$ with increasing pressure. The model provides an adequate description of the experimentally determined changes in the intensity of sooting on the combustion surface.

A91-39081 Analysis of solid propellant reignition after depressurization from the standpoint of the pulsed-cell combustion mechanism (Analiz povtornogo vosplameniia porokha posle spada davleniia s pozitsii ochagovo-pul'siruiushchego mekhanizma goreniia). V. N. MARSHAKOV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 27, Jan.-Feb. 1991, pp. 12-18. 15 Refs.

Solid propellant combustion regimes following depressurization, such as continuous combustion, temporal extinction (with reignition), and complete extinction, are examined in the context of the pulsed-cell combustion of nitroglycerin propellants. It is shown that the probabilistic nature of each combustion regime, large differences between thermal conditions in different areas of the combustion surface, a large scatter in reignition delay times, and other factors suggest the inhomogeneous nature of combustion under conditions of rapid pressure decay and can be explained in terms of the cell mechanism of combustion.

A91-29889 Stage separation from a rocket vehicle using pyrotechnic mechanisms (K voprosu otdeleniia ob'ektov ot nositeli rakety s pomoshch'iu pirotekhnicheskikh mekhanizmov). I. U. V. DROBINSKII, V. G. KHVOSTOV, and V. I. SHTOGRIN, *Physics of the upper atmosphere* (A91-29876 11-46). Moscow, Gidrometeoizdat, 1990, pp. 85-92.

A theoretical analysis of stage separation from a rocket vehicle using pyrotechnic mechanisms is presented. Analytical relationships between the separation parameters and the parameters governing the expansion of the combustion products of the explosive used in the separation mechanisms are examined. Optimal conditions for the conversion of the internal energy of the combustion products into useful work are obtained.

A89-52889 An investigation of the maximum capabilities of interorbital space tugs with controllable electrorocket engines and the choice of rational modes of their operation in flight (Issledovanie predel'nykh vozmozhnostei mezhorbital'nykh buksirov s reguliruemymi elektro-raketnymi dvigateliami i vybor ratsional'nykh rezhimov ikh funktsionirovaniia v polete). G. A. KULAKOV, S. V. PILIUTO, and V. F. SAFRANOVICH, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, July-Aug. 1989, pp. 514-519. 6 Refs.

The paper identifies the existence of special (characteristic) points on the family of dependences of the mass of the body pulled by an interorbital tug with electrorocket engines on the initial mass of the tug and the time of electrorocket-engine operation for given values of the propulsion-system power, the separated mass, and the characteristic velocity of the tug. Expressions for the characteristic points are obtained, making it possible to determine lower bounds on the specific impulse of the electrorocket engine.

A91-21961 Effect of pressure fluctuations on the local natural pulsations of the solid fuel combustion rate (Deistvie kolebaniy davlennia na sobstvennyye lokal'nye pul'satsii skorosti goreniia tverdogo topliva). L. K. GUSACHENKO, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 26, July-Aug. 1990, pp. 27-32. 12 Refs.

The effect of pressure fluctuations on the local pulsations of the solid fuel combustion rate is investigated experimentally and analytically using a solid fuel with a highly combustible matrix and an inert additive as an example. By using two simple models, it is shown how the chaotic local pulsations of the solid fuel combustion rate resulting from pressure fluctuations may become coherent. The mechanisms of the chaos-order transition are examined.

A91-19909 Effect of short-term creep on the stability of rocket fuel tanks (Vliianie kratkovremennoi polzuchesti na ustoiichivost' toplivnykh bakov raket). V. K. BELOV, *Problemy Prochnosti* (ISSN 0556-171X), Oct. 1990, pp. 65-68. 7 Refs.

A study is made of the effect of temperature stresses and short-term creep on the critical time parameters, axial compression, and internal pressure of reinforced cylindrical shells of AMg6-BNN material. The analysis allows for the initial anisotropy of creep due to the strain-hardening of the material. The critical values of time, temperature, and stress corresponding to the axisymmetric buckling of the shell and also to the axisymmetric-nonaxisymmetric equilibrium transition are determined. The calculation results are compared with experimental data on the stability of full-scale shells.

A90-45035 Radiative activation of AP-steam interaction (Radiatsionnaia aktivatsiia protsesssa vzaimodeistviia PKhA s vodianym parom). A. V. BASTEEV and V. V. SOLOVEI, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 26, May-June 1990, pp. 36-41. 17 Refs.

The interaction between ammonium perchlorate and steam was investigated experimentally using the weighing method to analyze the result of thermolysis and sublimation. The results obtained indicate that the presence of water vapor in the combustion zone of condensed mixture systems intensifies the mass transfer of irradiated and nonirradiated AP, used as an activator in suspension-type condensed mixture systems. The results can be used in the study of the combustion of alternative diesel fuel systems with additions of carbon dust and AP that are currently being considered for large diesel powerplants.

A90-45027 A study of the flame structure of AP-based layered systems (Issledovanie struktury plameni sloevykh sistem na osnove PKhA). O. P. KOROBENICHEV, A. G. TERESHCHENKO, V. M. SHVARTSBERG, A. A. CHERNOV, A. E. ZABOLOTNYI et al., *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 26, Mar.-Apr. 1990, pp. 53-58. 16 Refs.

The chemical and thermal structures of the combustion of a system consisting of alternating layers of finely disperse AP and polybutadiene rubber are investigated experimentally using mass spectrometric analysis. Two distinct flame zones are identified, and their characteristics are discussed; component concentration and temperature profiles are determined. The results of the study are essential for the development of a mathematical combustion model for layered systems.

A90-39520 Principal energy characteristics of an explosive linear accelerator (Osnovnye energeticheskie kharakteristiki lineinogo reaktivnogo dvigatelia). A. E. VOITENKO, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.-Apr. 1990, pp. 118-120. 5 Refs.

The energy characteristics of an explosive linear accelerator, in which a projectile is accelerated inside a tubular detonating explosive charge, are investigated analytically. Expressions are obtained for the maximum velocity of the projectile as a function of the explosive charge mass and for the efficiency of the accelerator. The parameters of an explosive linear accelerator required to accelerate a mass of 1 kg to a velocity of 8 km/s are estimated as an example.

A90-23423 Design of an optimal cooling system for positioning thrusters (Proektirovanie optimal'noi sistemy okhlazhdeniia dvigatelei upravleniia). N. N. KOVAL'NOGOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1989, pp. 83-85. 5 Refs.

An approach to the optimization of the cooling system for positioning thrusters is proposed which uses a simplex optimum search procedure implemented on a computer. The optimality criterion used here is the specific thrust pulse. The analysis is carried out for a film cooling system, which is commonly used in low-thrust liquid-propellant rocket engines. The applicability limits of the approach proposed here are defined.

A90-21900 First fundamental studies of combustion processes in the rocket engine (Pervye fundamental'nye issledovaniia protsessov goreniia v raketnom dvigatеле). IURII I. SOLOV'EV and IURII S. VORONKOV, *Akademiia Nauk SSSR, Vestnik* (ISSN 0002-3442), No. 12, 1989, pp. 92-98.

The history of the development of rocket science in the USSR is briefly reviewed. The problems discussed at the first rocket science conferences in the 1930s are mentioned, as are contributions of such scientists as Korolev, Semenov, Vavilov, Rynin, and Tikhonravov. Particular attention is given to the work of academician Glushko, the author of numerous fundamental studies in the field of combustion processes in rocket engines.

A90-19213 Kalman duality in control theory for dynamic differential-difference systems (Dvoistvennost' po Kalmanu v teorii upravleniia dinamicheskimi differentsial'no-raznostnymi sistemami). A. V. METEL'SKII, *Avtomatika i Telemekhanika* (ISSN 0005-2310), Sept. 1989, pp. 81-90. 8 Refs.

The principal concepts of Kalman's mathematical control theory are extended to systems of differential-difference equations. The reachability criterion and duality relations are obtained, and the characteristics of a canonical implementation are discussed. An example involving the combustion chamber of a liquid-propellant rocket engine is examined.

A90-14581 Modeling of a liquid-propellant rocket engine (Modelirovanie zhidkostnogo raketnogo dvigatelia). A. P. TISHIN and L. P. GUROVA, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 3, 1989, pp. 87, 88.

A general-purpose algorithm and a program are proposed for calculating the static characteristics of liquid-propellant rocket engines of arbitrary pneumatic-hydraulic configuration. The algorithm is based on a general method for calculating the parameters of hydraulic circuits. To develop a general-purpose model, the engine is divided into standard elements, such as the principal engine components. Each element is described by one or several equations. When the elements are combined into a whole, their mathematical models form a system of nonlinear equations describing the operation of the engine (i.e., an engine model).

A89-48062 A qualitative study of the characteristics of the heliocentric motion of a spacecraft with a low piecewise-constant thrust (Kachestvennoe issledovanie osobennostei geliotsentricheskogo dvizheniia KA s maloi kusochno-postoiannoii tiagoi). V. V. IVASHKIN, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 27, May-June 1989, pp. 357-367. 11 Refs.

The transfer characteristics of a spacecraft from satellite orbit to the orbit of a small planet are studied. A low-thrust electrojet propulsion unit is used in the heliocentric-motion segment. Control regimes using constant thrust and constant jet acceleration in two boundary regions separated by passive flight are discussed. The optimal geocentric energy of the spacecraft at the end of acceleration at the earth is determined.

A89-34138 Electrochemical rocket powerplants in spacecraft control systems (Elektrokhimicheskie raketnye dvigatel'nye ustanovki v sistemakh upravleniia KA). IU. P. RYLOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1988, pp. 50-54. 7 Refs.

The physical processes occurring in the electrochemical rocket powerplants of spacecraft control systems consisting of low-thrust (0.01-10 N) engines are examined. Some specific design features of these engines that are associated with their applications in flight control, orientation, and stabilization systems are discussed, and methods for calculating such engines are presented. (V.L.) Source of Abstract/Subfile: AIAA/TIS

A89-34118 A method for the analysis of the erosive combustion of blended solid fuels in the boundary layer approximation (Metodika rascheta erozionnogo goreniia smesevykh tverdykh topliv v priblizhenii pogrannichnogo sloia). V. K. BULGAKOV, A. M. LIPANOV, and A. SH. KAMALETDINOV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 24, Nov.-Dec. 1988, pp. 26-33. 12 Refs.

A method for calculating the erosive combustion of blended solid fuels is proposed which is based on the Herman model. Calculations are carried out assuming that the thermophysical characteristics of the gas phase remain constant and that the gas phase flow is a weakly expanding flow allowing the plane boundary layer approximation. The governing equation is solved numerically using the fourth-order Runge-Kutta method, with convergence achieved after 3-5 iterations.

A89-34117 Turbulent model of the combustion of blended solid fuels (Turbulentnaia model' goreniia STT). V. IA. ZYRIANOV, V. M. BOLVANENKO, O. G. GLOTOV, and IU. M. GURENKO, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 24, Nov.-Dec. 1988, pp. 17-26. 20 Refs.

An empirical turbulent model is developed which provides a qualitatively satisfactory description of the available experimental data on the dependence of the combustion rate of blended solid fuels on their composition and ambient conditions. It is shown that, with proper selection of the kinetic constants and physical parameter values, the model can be used for calculating the combustion rate for fuels with a wide range of oxidizer particle sizes over a certain range of ambient conditions. The model also predicts the possibility of designing fuels with anomalous dependences of the combustion rate on the oxidizer particle size and pressure.

A88-43610 A mathematical model of the internal cooling of control thrusters for continuous operation (Matematicheskai model' vnutrennego okhlazhdeniia dvigatelei upravleniia dlia nepreryvnogo rezhima raboty). N. N. KOVAL'NOGOV, V. L. ROMANOVSKII, and V. K. SHCHUKIN, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 1, 1988, pp. 40-44.

A mathematical model for the internal cooling of control thrusters is proposed which uses a system of differential equations for a compressible chemically nonreacting boundary layer. The numerical integration of the equations yields the boundary conditions of heat transfer as well as the local and integral characteristics of the boundary layer. Calculations of internal cooling are presented for different schemes of gas screen formation.