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SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 3 (3C)

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OPTIMAL CONTROL OF SPACECRAFT DURING THE ASCENT OF MARS ARTIFICIAL SATELLITE

Abstract

The comparative analysis of research results for different variants of orbit shaping of Mars artificial satellite shows high energy performance of schemes with preliminary braking in the atmosphere. The decision of space vehicle optimal control by classical methods showed that minimization of necessary energy cost is provided by two-parameter control by roll angle γ and attack angle α: roll angle switches from γ approximately equal to 0 to γ approximately equal to π and attack angle changes from the value of maximum aerodynamic quality α^* to the value of maximum aerodynamic drag coefficient α^{**}. Optimal trajectory calculations of space vehicle movement need a lot of time and can hardly be implemented by on-board calculation. It determines the need to elaborate methods of optimal operational space vehicles control. After the introduction of assumption about piecewise constant of series of functions and modification of equations system of space vehicle movement we will get analytical formulae for speed calculation V, trajectory angle θ for the space vehicle leaving the atmosphere and apogee altitude of transfer orbit hα depending on the current space vehicle position. The values of apogee altitude of transfer orbits hα for space vehicle moving with γ=0 and γ=π are continuously calculated when the space vehicle is moving in the atmosphere. At that hα(γ=0) height remains practically invariable and hα(γ=π) – monotonically increases, gradually reaching the given altitude of the shaped orbit hα set. In the flight phases on condition that hα(γ=π)>hα set,attack angle α gradually increases. The aerodynamic resistance of space vehicle

increases and the increase intensity of hα (γ=π) is smaller. Beginning from moment ti, this height will begin to reduce. At that roll angle swithces from 0 to π, and attack angle α gradually decreases. The intensity of altitude decrease hα (γ=π) becomes slower with decrease of attack angle. When hα (γ=π)=hα set attack angle α takes the value α^*. After the space vehicle leaving the atmosphere and reaching the orbit apogee the accelerating burn of characteristic velocity is pulsed. Application of elaborated method provides non-iterative calculations of quasioptimal trajectories with high operability level. It is showed that using the proposed scheme of spacecraft ascent to the orbit of Mars artificial satellite the necessary energy cost is reduced (approximately 2,5-3 times) compared to the use of traditional all-propulsive orbit shaping scheme.