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ADAPTIVE CONTROL OF ELECTRICAL SOLAR SAIL

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Research results of optimal control and identification algorithms of the dynamic systems in extreme conditions and limited prior information are discussed. The model of electrical solar sail is chosen as an object for research. The electrical solar sail consists of a net of the thinnest electric send-offs with a diameter of 10 microns, whose general length is more than 30 000 meters and complex of electronic equipment, providing the permanent functioning of this system in space. Features of structure and function scheme of the object control system are considered.

The dynamic pressure of the solar wind varies but is on average about 2 nPa at Earth distance from the Sun. This is about 5000 times weaker than the solar radiation pressure. Due to the very large effective area and very low weight per unit length of a thin metal wire, the electric sail is still efficient however [1, 2]. A 20 km long electric sail wire weighs only a few hundred grams and fits in a small reel, but when opened in space and connected to the spacecraft's electron gun, it can produce a one square kilometer effective solar wind sail area which is capable of extracting 1-2 mN force from the solar wind. For example, by equipping a small, 200 kg, spacecraft with 100 such wires, one may produce acceleration of about 1 mm/sec^2 . After acting for one year, this acceleration would produce a significant final speed of 30 km/sec. Small payloads could be moved quite fast in space using the electric sail, a Pluto fly could occur in less than five years, for example.

The dynamical characteristics of the electrical solar sail confirm that the closed-loop system of the one section wire is unstable. To design the optimal control law which guarantees the stability of the control system we use the algorithms of parametric identification to compute coefficients of matrices A and B. These coefficients are used to compute matrix coefficients of the optimal control system solving Riccati equation [3].

The dynamical characteristics (impulse response, Bode Diagram) of the electrical solar sail confirm that the closed-loop system of the electrical solar sail is stable when the algorithms of parametric identification are used in the control system. Therefore, the controlled system is stable [4].

Modelling results of time-optimal adaptive system with a linear-square regulator in a feedback loop and parametric identification algorithm confirm that the synthesized control system of electric solar sail is steady. The comparison of efficiency of the adaptive control system of electric solar sail with the similar systems using Pontryagin's maximum principle confirms its advantage.

REFERENCES

[1] P. Janhunen, A. Sandroos. A. Simulation study wind push on a charged wire: basis of solar wind electric sail propulsion . *Ann. Geophys* , **25** 2007, 755 – 767.

[2] P. Janhunen. Electric Sail for Spacecraft Propulsion. *Journal of Propulsion and Power*, **20** No.4, 2004, 763 – 764.

[3] Al. Matvejevs, An. Matvejevs, Ģ. Vulfs. Time-optimal Adaptive Control of the Dynamic Systems Based on Parametric Identification . *Scientific Proceedings of RTU* , Riga, 2007, 121 – 130.

[4] Al. Matvejevs, An. Matvejevs, Ģ. Vulfs. Adaptive Control of the Electrical Solar Sail Based on Parametric Identification . *Scientific Proceedings of RTU* , Riga, 2008, 10 – 18.