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EFFECT ANALYSIS OF THRUSTER CONFIGURATION TO CONTROL ERROR AND FUEL CONSUME

Abstract

Advanced by rapid development of the astronautics, the technologies of space maneuver and on-orbit operation attract more and more attention in the new millennium. Several projects such as DART, Orbit Express, etc. were held recently by US to verify the kernel technology of this field.

Precise orbit and attitude control of the chaser spacecraft is the precondition of rapid, precise space maneuver and multiple sophisticated on-orbit operation, demanding real-time and precise 6 DOF control of the spacecraft. Control allocation is progressively becoming very important technique of spacecraft control system design.

Some simple optimization methods were introduced to solve the control allocation problem, without quantitative analysis of the effect of thruster number and relative geometry relation on allocation error and fuel consume. Inspired by the GDOP (Geometry Dilution of Precision) concept in satellite navigation, CDOP (Configuration Dilution of Precision) factor is introduced to describe the proportion relation between actuation error of thrusters and allocation error induced by relative geometry configuration of allocated thrusters. The formulation of CDOP and allocated thruster number is deduced. Similarly, FCF (Fuel Consume Factor) is introduced to describe the proportion relation between expected control and gross fuel consumption induced by the geometry relation, and the formulation of FCF and thruster number is also deduced. The simulations of corresponding conclusions are presented in the paper.

The theoretical analysis and simulation shows that CDOP is the proportional coefficient between actuation error and allocation error induced by geometry relation of thruster, and FCF is the proportional coefficient between expected control and gross fuel consumption. When allocated thruster number increases, CDOP increases and FCF decreases. The foregoing two factors could be used as the criteria of thruster configuration.