Paper ID: 17659
oral

ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimisation (1) (6)

Author: Dr. Dong-Hyun Cho
KARI, Korea, Republic of

Prof. Hyochoong Bang
Korea Advanced Institute of Science and Technology (KAIST), Korea, Republic of
Dr. Hae-Dong Kim
Korea Aerospace Research Institute (KARI), Korea, Republic of

OPTIMAL LUNAR LANDING TRAJECTORY DESIGN FOR HYBRID ENGINE

Abstract

There are currently many researches and space projects for lunar exploration in most countries, and the many kinds of researches for the optimal lunar landing trajectory design method are introduced as the first goal of the lunar exploration mission.

These lunar landing trajectories are generally divided into two parts: de-orbit burn phase and powered descent phase. In these phases, the almost researches provided the optimal solution for the powered descent phase. In this phase, the initial conditions of lunar lander are usually fixed from Hohmann transfer orbit of the de-orbit burn phase and the final target velocity is 0m/s for landing. To find this optimal solution, two dimensional dynamics have been introduced for simplicity in many researches. Ramanan introduced the optimal lunar landing trajectory for this problem and analyzed on case-by-case basis. Shan also provided the similar optimal solution for the variable thrust level. Recently there are some other approaches to find the optimal solution for the final vertical landing condition. Hwakins used the spacecraft rotational motions for this problem, and Zhou also studied a vertical lunar landing problem by using the attitude state variable. Cho find out the optimal solution by using the control constraint. There are some researches for the guidance control. Liu studied the landing guidance control by using these optimal lunar landing trajectory. McInnes suggested another guidance strategy of vertical landing by using gravity-turn technique. There is another approach to find the optimal perilune altitude. Cho introduced the optimal perilune altitude problem by using the free initial states problem.

In these optimal lunar landing trajectories, the lunar lander frequently increased its altitude to earn the enough time to reduce the horizontal velocity. This phenomenon is depending on its thrust-mass ratio. For the enough thrust, this increasing phase does not appear. However, this huge thrust is sometimes not physically possible for the cost, mass budget, thruster technology and so on.

Therefore, in this paper, the optimal solution is suggested for the hybrid engine. The hybrid engine means that the lunar lander has the impulsive and continuous thruster. In this problem, we supposed that the lunar lander retrofired the impulsive thruster to rapidly reduce the horizontal velocity. Then the lander reduced the total velocity and altitude for the lunar landing. To solve this problem, we will apply the free initial problem for the impulsive thruster and typical approach also.