Paper ID: 64620
student

IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

Author: Mr. Runsheng Hu
National University of Defense Technology, China, runwuyousheng1993@163.com

Prof. Jianjun Wu
College of Aerospace Science and Engineering, National University of Defense Technology, China, jjwu@nudt.edu.cn
Dr. Zhenyu Chen
North China Electric Power University, China, czy_ac@outlook.com
Dr. Yuqiang Cheng
College of Aerospace Science and Engineering, National University of Defense Technology, China, cheng_yuqiang@163.com
Mr. Yu Zhang
National University of Defense Technology, China, zhangyu_nudt@126.com
Mr. Honggang Liu
National University of Defense Technology, China, deanlau@yeah.net
Dr. Shuming Yang
National University of Defense Technology, China, yangshuming07@nudt.edu.cn

PROPELLANT MASS FLOW RATE CONTROL SCHEME OF A DEEP-THROTTLING ROCKET ENGINE

Abstract

To fulfill a soft landing task for recycling use or lunar descent, a deep-throttling rocket engine is inevitable. During the throttling process, the electric pump is an essential part for regulating the propellant mass flow rate. As for a throttleable rocket engine, the precision of flow regulation determines the precision of thrust regulation. A well-observed and controlled propellant mass flow rate is beneficial for a better implementation of the task. However, severe noise exists during the whole operating process for a rocket engine, including engine roar and mechanical vibration. In order to track the target thrust curve, an observer is needed to filter the external noise and give an accurate estimation on propellant mass flow rate and a controller is needed to resist the disturbance. In this paper, propellant mass flow rate target tracking is achieved through a linear model predictive controller (MPC) and estimation is conducted by an unscented Kalman filter (UKF). Numerical simulations with several reference trajectories confirm the effectiveness of the controller and observer. The steady-state errors between simulation results and references are within 1%, which demonstrated that the controller can suppress the disturbance and track the target. In throttling process simulation, the UKF performs outstandingly with strong robustness against modeling bias, initial error, and external disturbance in all different working conditions and continuous regulating phase. Consequently, the MPC combined with the UKF can fulfill the task to control the propellant mass flow rate in the electric pump outlet accurately during the whole deep-throttling process. As future developments we are aiming at extending the current control and estimation architecture in order to implement Fault Diagnosis and Fault Tolerant Control functionalities for the electric pump as well as the whole engine. This addition would prove extremely valuable towards implementation on a real rocket engine, which can be subjected to unexpected faults during remote missions.