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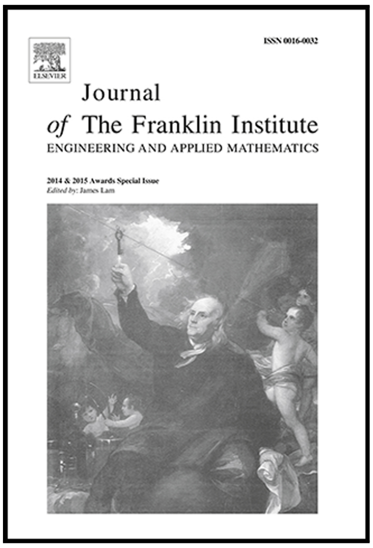

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Tracking-Protection-Recovery Switching Control for Aero-engines

Chao Chen, Jun Zhao, and Yan-Feng Sui

Abstract—**This paper presents a novel tracking-protection-recovery switching strategy to solve the thrust tracking and safety protection multi-objective control problem for the aero-engines. The proposed switching control strategy overcomes the contradiction between the tracking performance and the safety requirement. The design procedure is with larger degree of freedom and less conservatism. The proposed switching controller can be designed in three steps. For the tracking stage, the tracking controller is designed only according to the rapidity requirement for the thrust tracking with less consideration of safety. For the protection stage, the protection controller is activated to limit the protected output in the safety region. Because of the properly designed protection controller, it is unnecessary to switch on the protection controller before the protected output reaches the safety boundary. That reduces conservatism and makes the tracking performance improved. For the recovery stage, the recovery controller, as well as the properly designed resetting law, is utilized to guarantee finite number of switches and the resulting asymptotic tracking. Because of the properly designed switch-off condition for the protection controller, the thrust tracking performance gets improved. The protected output is also successfully limited. Finally, a case study for a two-spool turbofan engine is performed to verify the effectiveness of the proposed scheme. It is also indicated that the proposed tracking-protection-recovery switching strategy can improve both safety performance and the tracking transient performance.**

Key words—**Aero-engine, tracking-protection-recovery switching control, safety protection control, thrust tracking control, reset, finite number of switches**

I. INTRODUCTION

Since engines are one of the most essential components of aircraft, research on engine control has attracted much attention in recent years [1]-[3]. Modeling and control of the aero-engine has become a more and more important research field. Advanced control methods have been applied to the aero-engine control, such as adaptive control [4], distributed control [5], fuzzy control [6], gain scheduling control [7], linear parameter-varying (LPV) control [8], model predictive control (MPC) [9], sliding mode control (SMC) [10], and so on. The strong couplings among flight dynamics, aerodynamics, propulsion and control [1]-[3] result in various engine safety boundaries during the working process of the aero-craft. Safety boundaries usually include the combustion stabilization boundary, the combustor wall temperature limitation, the inlet channel un-start boundary, and so on. Disastrous accidents may happen once the system trajectory exceeds any one of the safety boundaries. Therefore, protection measures must be taken. On the other hand, to pursue desirable flight performance, the aero-engines are usually required to work close to the safety boundaries. For example, in work [23] and [24] controllers are designed to pursue performance such as fast response, handling quality and robust stability. The traditional safety protection measures usually sacrifice the rapidity performance to guarantee safety. One of the effective strategies to deal with the contradiction between the rapidity performance and safety requirements is to apply the switching control scheme [11]-[12] to the multi-objective control problem.

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