Intelligent Control and Health Monitoring

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ABSTRACT

Typical aircraft engine control systems control fuel flow to maintain fan speed or engine pressure ratio to regulate thrust which is not directly measurable. The control logic is generally based on a variant of a Proportional-Integral scheme combined with limit logic to protect the engine from unsafe operation. This limit logic consists of a series of min select and max select blocks, each of which selects a fuel flow rate command based on various physical limits, acceleration/deceleration schedules (maximum rotor speed rate-of-change as a function of rotor speed), and the current operating state (speed governor loops). The various on-wing health monitoring systems of today, which are a collection of separate, unrelated technologies, provide a basic level of monitoring. Their capabilities are relatively limited and the information they provide is used mostly to initiate maintenance actions, not for real-time decision-making. While these traditional control and diagnostic techniques are time-tested and reliable, advanced techniques provide the promise to meet the challenging requirements of improved fuel efficiency, increased durability and life, decreased life cycle costs, and improved reliability and safety.

This lecture provides a brief description of state-of-art of engine control (system level) and inherent limitations in current architecture. Subsequently, objectives for intelligent engine control are described including simplifying control design (such as direct or model based nonlinear approaches), adapting performance to engine degradation, extending on-wing life, and improving FDIA (Fault Detection, Isolation and Accommodation). An overview of approaches to achieve these objectives is provided. For the various approaches, the technology development needs for modeling, control algorithm and hardware, and new sensors are described, with an emphasis on the latter. To keep the scope manageable, the discussion of diagnostics and prognostics technologies is limited to that required for achieving "closed-loop" control objectives. The focus of advanced control schemes is on developing algorithms that are implemented in the FADEC (Full Authority Digital Engine Control) in the form of software without requiring any additional control effectors/actuators.