INTEGRATED CONTROLLER FOR DIVERT THRUSTER FLIGHT PROPULSION CONTROL SYSTEMS

A.V. Sudhakara Reddy
Senior Scientist
Directorate of Control Systems Laboratory
Research Centre Imarat, DRDO
Hyderabad-500 069, India
Email : sudhakar.reddy@rcilab.in

S. Karunanidhi
Technology Director
Control Systems Laboratory
Research Centre Imarat, DRDO
Hyderabad-500 069, India

R. Padhi
Professor
Department of Aerospace Engineering
Indian Institute of Science
Bangalore-560 012, India

D.N. Reddy
Vice Chancellor (Retd)
JNTU, Hyderabad, India

Abstract

Future generation missile calls for development of fast response propulsion based control systems to achieve hit-to-kill miss distance against highly manoeuvrable targets covering high-endo to exo-atmosphere regions. Control systems based on solid propulsion are developed connecting multiple pintle nozzles and control thrust vector is generated with distribution hot gasses in pitch/yaw directions. Differential distribution of hot gasses among multiple nozzles is complex due to time varying coupled non-linear chamber pressure dynamics with propellant combustion and nozzles' flow phenomena and methods based on linear control may not ensure stability in wide operating conditions. There is need to develop "Unified Controller" based on non-linear formulation to ensure control stability in wide operating conditions of various mission applications, with advanced features for new generation missiles to counter various futuristic targets, and achieve hit-to-kill capabilities following integrated approach in order to improve the total system performance. Non-linear algorithms proposed in the recent literature do not exploit synergism between plant and actuation systems dynamics. Present paper presents novel non-linear feedback linearization technique, Dynamic Inversion, a relatively straightforward approach in Integrated Control Framework (ICF) implementing inherent time scale separation between solid motor plant and hot gas flow control valve actuation system. To ensure stability in various operating conditions and assure robust performance in the presence of parameter inaccuracies, controller is augmented with model-following neuro-adaptive design. Prototype systems: Thrust Controlled Motor (TCM) and Divert Thruster Flight Propulsion Control Systems (DTFPCS) are developed to demostrate/validate "Unified Controller" for missile control system. Closed loop control of chamber pressure is demonstrated with single pintle nozzle system and control thrust vector generation with multiple nozzle systems. Model update takes place adaptively online and unlike a typical indirect adaptive control approach, there is no need to update the individual parameters explicitly. Instead the inaccuracy in the system output dynamics is captured directly and then used in modifying the control. Based on present work, missilecontrol systems for various applications can be developed with limited controller changes and thereby minimizing number of developmental tests and cost.

Keywords: Divert Attitude Control System, Pintle Motor, Thrust Controlled Motor, Divert Thrust Flight Propulsion Control System