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VARIABLE INERTIA FLUIDIC RING ACTUATOR ON ATTITUDE CONTROL AND RESIDUAL FUEL MANAGEMENT SYSTEMS

Abstract

Based on the new achievements of lunar exploration and manned space project, carrying out the manned deep-space exploration is an inevitable choice of Chinese space technology. As we know, the manned deep-space exploration vehicle can be a large complex system, which contains luxury control devices like momentum exchange devices, jet propulsion subsystem and other supportive devices. Since a manned deep-space exploration will last for long period and meet uncountable orbital and attitude maneuver requirements, none of these actuators can be reduced or repealed. However the fuel in tanks of the propulsion subsystem can slosh violently during those maneuver processes and will last for a long time even the maneuver itself has stopped. After summarizing many past studies about those large, complex space vehicles, it is shown that one of the most serious risks for them is the fluid sloshing problem. Therefore an effective fuel management strategy is necessary for all large liquid-filled systems.

For the Chinese manned deep-space exploration, this fuel management problem can be solved easily by a novel attitude control actuator-the Variable Inertia Fluidic Ring Actuator (VIFRA). VIFRA is designed as a kind of momentum exchange device. Different from the traditional momentum exchange devices, it uses fuel actually as the working medium instead of solid rotors. Pumps are mounted in VIFRA to infuse fuel from the tanks into the pipes of VIFRA and drive the flow rate varying. VIFRA changes its angular momentum via the variation of the flow rate, which provides the control torques to the vehicle and manages the fuel at the same time. Furthermore the inertia variation function of VIFRA provides an alternative of using less or more working fuel in proper process, which makes the utilization of fuel more flexible and avoids the saturation problem effectively.

In this paper the design of VIFRA is given firstly. Secondly the equivalent mechanic model of the fluidic flow is gained via integrating the velocity on every cross-section. Due to the viscous of fuel, the integration of flow is gained separately from the outside and the inside of the laminar zone. Thirdly, taken the variation of inertia into consideration, the dynamic model of VIFRA is deduced. Finally, three VIFRAs are employed to achieve a large range angular maneuver process. A comparison between VIFRAs and traditional devices is conducted via numerical simulation. Simulation results verify that the utilization of VIFRA is a proper choice for manned deep-space explorations.