ADVANCED TECHNOLOGIES FOR MITIGATING HAZARDOUS PROPELLANTS AND GASES IN TERMINAL LIQUID STAGE OF NEAR EARTH ORBIT MISSION: ENHANCING PLANETARY DEFENSE

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Terminal stage

Terminal stage in Launch vehicle poses several challenges: space debris, residual propellant and high-pressure gases.

Space debris is due to spent terminal rocket stage, explosion or fragmentation of damaged space objects.

Space debris

The increasing space debris leads the risk of collisions with operational satellites, space craft, and even crewed missions.

This space debris can damage or destroy the services such as communication, navigation, weather monitoring on Near Earth Orbit (NEO). Also, the re-entry of space debris to earth's atmosphere cause damage on the ground.

Advanced Technologies

This paper explores the technical approach by using artificial intelligence and machine learning techniques for mitigating the spent terminal stage by controlled venting of hazardous propellants and gases with passivation and disposal systems, minimizing the risk of uncontrolled de-orbiting and controlled re-entry. Also spent terminal rocket stage can use as a orbital platform for short term scientific experiments using three axis control.

Passivation system:

Prevents the uncontrolled propellant release, explosion, fire hazards, contamination of the environment and damage to nearby spacecraft or space assets. A reliable passivation system (Figure- I) in the terminal liquid stage can effectively mitigate these risks, ensuring a safe and successful conclusion.

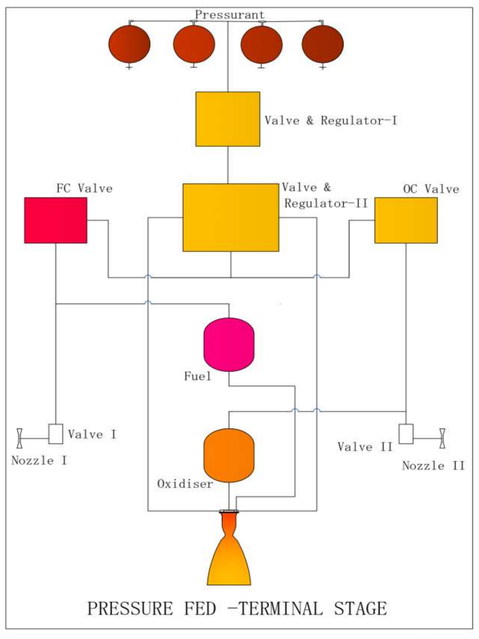

Figure-I

Disposal system:

A critical safety feature designed to safely dispose of residual propellant after passivation, preventing ignition or explosion. This is achieved through a cold gas-based control system (Figure- I) utilizes the gas bottles isolated from the propellant tank circuit after the main mission via valve operation.

The leftover pressurant gas is utilized for the cold gas-based control system and the leftover propellant is dispensing through the engine.

The efficient disposal of the residual propellant and gases from the terminal liquid stage (Figure- II) is accomplished through sequential operation of engine valves controlled by the onboard computer.

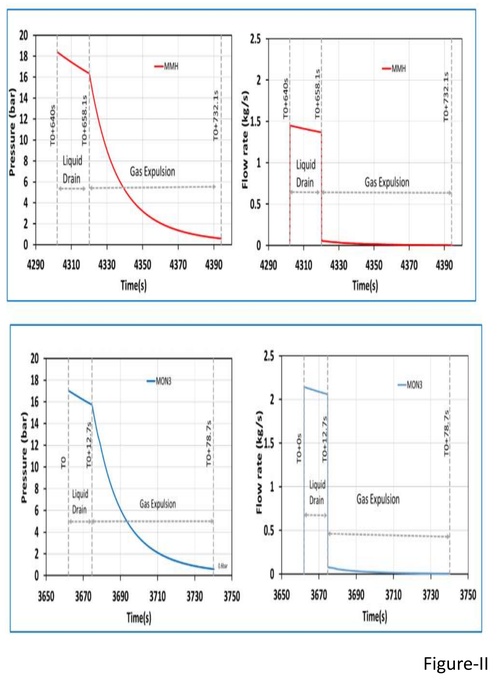

Figure-II

Artificial Intelligence (AI) based system:

It is integral to hazard mitigation in Near-Earth Orbit (NEO) operations, especially in managing the risks associated with hazardous propellants, gases, and other potential threats. AI based system play a vital role in managing these risks.

Artificial Intelligence (AI) based system:

AI can optimize propellant usage to minimize waste and reduce the risk of residual propellant hazards at the end of the mission.

Creating an interface system between mechanical systems and Artificial Intelligence (AI) for hazardous mitigation in Near-Earth Orbit (NEO) is complex but essential for modern space operations.

Key components include Sensor Network & Data Acquisition, AI-Driven Data Processing & Analysis, Control Interface for Mechanical Systems, Feedback Loop & System Adaptation, Human-Machine Interface (HMI) and Safety & Security Protocols

AI can also optimize propellant usage to minimize waste and reduce the risk of residual propellant hazards at the end of the mission. For predictive maintenance, it is proposed to use Long Short -Term Memory (LSTM) neural network methodology.

With the use of Isolation Forest Algorithm, any potential threats in real time can be detected. AI system enables continuous monitoring the health of propulsion systems and related components, providing real-time alerts, if abnormal behavior is detected.

Orbital Platform:

The terminal stage as a platform on which the scientific experiments can be mounted and tested after separation of all satellites.

The left out pressurant in the pressure vessel after the main mission is used as the working medium for the cold gas thrusters.

Conclusion

Advanced Technologies for mitigating hazardous propellants and gases in Terminal liquid stage of Near Earth Orbit missions include a comprehensive strategy using passivation systems, disposal systems and Artificial Intelligence (AI) based systems.

These technologies manage and reduce risks associated with liquids and gases in space exploration.

The spent terminal rocket stage can use as a orbital platform for short term scientific experiments using three axis control.

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THANK YOU