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EXPERIMENT DESIGN OF A PAYLOAD FOR A SUB-ORBITAL ROCKET TO STUDY SPACECRAFT REPAIR AFTER SPACE DEBRIS IMPACTS

Abstract

The research described proposes the investigation into the cold-welding phenomenon for use in spacecraft shield repair following a hypervelocity impact due to space debris. The onboard test rig, custom patch design and the actuation methods described can be tested and qualified, at TRL 4, onboard a sub-orbital flight sounding rocket. Similar metallic materials will fuse or weld when they come into contact and undergo relative displacements under certain conditions. The inability of the surface contacts to re-oxide after abrasive contact is inhibited in the space environment, as a consequence atomic diffusion of the metal occurs and causes fusion. It has been demonstrated that, even under terrestrial conditions, the action of a low fretting load can nearly double the adhesion force under cyclic loading. In Space, cold welding was first analysed in the '80s as an adverse reaction, causing failures of mechanisms. In situations after hypervelocity impacts due to Micrometeoroids and Orbital Debris (MMOD) on a spacecraft or indeed fatigue failures, shield perforation or breaches may occur. In-situ repair from inside the vehicle is preferable due to the pressure differences. One potential solution is the use of "self-healing" properties of materials such as thiol-ene-trialkyl borane, nevertheless, these techniques present some limitations. Evaluating a paradigm shift in cold-welding adhesion, this project aims at developing a test apparatus to apply a custom Indium patch and investigate its adhesion properties during re-entry under a range of mechanical application conditions. For evaluation purposes, four different types of chambers can be tested and monitored using pressure sensors. The recovery of the payload will allow the metallurgical analysis of the cold-welded joint. After the phase of ground development and validation phase using a vacuum chamber the core of the activity is the design and testing of the experimental setup to be integrated into the payload of the sounding rocket. The testing rig will be able to simulate the hull breach in terms of crack and opening, and capable of applying the repair and monitoring its performance during re-entry after the sub-orbital flight. The Aerospace, Mechanical and Electronic Department at I.T. Carlow, Ireland, and the Department of Aviation at MCAST, Malta, are collaborating on the second phase of the research project presented.