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Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

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A SELF-SEALING CONNECTION FOR WATER AND PROPELLANT TRANSFER

Abstract

This paper presents an innovative self-sealing interface for water and propellant transfer between spacecraft. Fluid transfer between large satellites has been performed for refuelling and refurbishing purposes, and it is still a fundamental operation for ISS management. The possibility to exchange fluids between two or more autonomous vehicles is currently under investigation in the larger framework of On Orbit Servicing: the possibility to refuel and refurbish satellites will make it possible to increase their lifetime and their utilization in innovative missions and configurations. Furthermore, this technology is also a fundamental building block for the realization of fuel depots for both large and small satellites. Many different studies have been carried out on autonomous refuelling, that led to space demonstrations such as Orbital Express and Robotic Refuelling Mission; these systems require berthing interfaces and/or robotic arms to perform the fluid transfer, as well as complex preload and sealing systems to create the pressurized connection.
The proposed system is designed to overcome such limitations performing the fluid transfer while in a standard docked configuration, allowing the simplification and automation of the transfer procedure. It consists of a small androgynous interface able to create the watertight connection, with control valves and sensors to monitor the transfer. Two identical pipes with flanges are put in contact by means of external actuation, creating a preliminary connection, and the flanges are cooled with a small Peltier cell before the water transfer. The self-sealing is realized by means of the temperature gradient, freezing the fluid in the peripheral section of the connectors to reduce the leakage and creating the watertight effect while maintaining the water flow in the internal section. After the fluid transfer, the Peltier cell can be switched off to allow the ice melting and the interfaces separation.
In this paper the proposed system is introduced and its working principle is explained. In particular, a section will focus on the importance of water transfer in current and future space activities: thanks to its high density, water can be used to protect spacecraft from most of the radiation environment as well as propellant stock. The design process and the results of preliminary test on a scaled prototype are then presented, to demonstrate the technology working principle both in pressurized and vacuum environment. Last, the implementation of the proposed interface for other fluids transfer is investigated, to evaluate the adaptability of such solution for other perspective applications.