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Author: Prof. Loredana Santo
University of Rome - Tor Vergata, Italy, loredana.santo@uniroma2.it

Dr. Walter villadei
Italian Air Force , Italy, walter.villadei@aeronautica.difesa.it
Dr. Manuele Bernabei
Italian Air Force , Italy, manuele.bernabei@aeronautica.difesa.it
Dr. Valfredo Zolesi
Kayser Italia Srl, Italy, v.zolesi@kayser.it
Dr. Gabriele Mascetti
Italian Space Agency (ASI), Italy, gabriele.mascetti@asi.it

SHAPE MEMORY EPOXY FOAMS FOR AEROSPACE: EXPERIMENTATION ON ISS

Abstract

Shape memory polymers (SMPs) working is based on the ability of these materials to fix a given deformation by cooling below a certain transition temperature (which is mostly the glass transition temperature, Tg). Upon reheating to above the transition temperature the polymer chains reorganize, resulting in a macroscopic recovery of the original shape. Foaming is another way to tailor SMP properties for application requirements; foams generally have reduced mechanical stiffness and strength but enhanced compressibility. The Department of Mechanical Engineering of the University of Rome "Tor Vergata" has developed a new foaming technology which is able to produce thermoset foams starting from thermosetting powders. This method is simpler than conventional foaming methods and gives homogeneous closed-cell foams with excellent mechanical properties. It was observed that foams produced by solid-state foaming present remarkable shape memory properties. In fact, these foams, which are very rigid at room temperature, become spongy when heated above the Tg; in this state they can be packed up to the complete collapse of the pores, without generating any foam damage. Cooling below transition temperature, this compact structure remains stable with no constraining force. Heating above the transition temperature, the foam recovers its original shape. Shape memory foams can be used in aerospace for different applications: from light actuators to structural parts with reduced size during shipping. In order to study the behavior of this new class of materials in microgravity, a set of experiments was designed for the next Space Shuttle STS-134/ULF-6 in I-23/24, on July 2010. This initiative originates from the cooperation between the Italian Space Agency and the Italian Air Force within the human spaceflight field. In the proposed study, the experiments on ISS, the pre and post flight qualification activities and the development and integration process, achieved with the support of ALTEC and Telespazio, are described: the shape recovery of an epoxy block, the unfolding of a complex structure, and a simplified actuator. The experiment will be performed in space, by an autonomous device contained in the BIOKON container, composed of control and heating system, battery pack and data acquisition system, developed by Kayser Italia. Several tests, performed to support such experiments, are presented in this study: compression tests on epoxy foam samples, recovery tests with different packing levels, recovery tests of samples foamed under different technological conditions. Some considerations regarding such technology possible future development in microgravity environment will be presented as well.