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THERMO-MECHANICAL CHARACTERIZATION OF A CARBON MICRO-FIBRE REINFORCED POLYMER FOR ADDITIVE MANUFACTURING IN SPACE APPLICATIONS

Abstract

In the latest years 3D printing is taking hold in a wide range of industrial applications. This fast diffusion is especially due to its characteristics of flexible, rapid and cost-efficient production of objects which have a complex geometry, not obtainable with traditional techniques, or prototypes to be tested. These features have urged a rapid development of increasingly efficient materials in order to use additive manufacturing, not only for rapid prototyping, but also to build real industrial products.
It has gone from producing objects for rapid prototyping using common thermoplastic polymers up to additive manufacturing techniques which use metal alloys or some special Carbon and glass fibre reinforced composite materials.
It is well known that in the aerospace field the structure design and construction is a challenge; in particular the materials choice represents a crucial phase. The polymeric matrix composite materials technology, combined with the advantages of 3D printing, would represent an ideal industrial application in the aerospace sector in which the mass and cost reduction is often pursued. In particular this technology would be ideal for micro and nano-satellites for which miniaturization often requires near-net-shape process techniques and the mass reduction is desirable, in order to reduce the launch cost which represents the greater expense.
In order to verify that an innovative material, such as a composite material for 3D printing, is suitable for challenging space applications, it must be tested to verify that it meets the space stringent requirements. Furthermore, an experimental investigation to know its thermo-mechanical behaviour in detail is mandatory in order to determine its physical and engineering properties. The aim of this paper is to provide a complete thermo-mechanical characterization of a carbon micro-fibre reinforced polymer, created and produced with rapid prototyping selective laser sintering. It is a powder of mixed Polyamide resin and Carbon polyacrylonitrile micro-fibres and, as the most of composite materials, it has an anisotropic behaviour both from the mechanical and from the thermal point of view. Several tests will be performed on various different samples in order to verify the outgassing requirements compliance and to determine the principal mechanical and thermal properties. This complete material characterization shows the real properties of such material, widely used in automotive field, which appears particularly attractive for aerospace applications. It also allows detailed mathematical models developing, for example for Finite Element analysis, in order to provide fundamental tools for thermo-mechanical designers.