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Short Communication

Aluminium foams as a filler for leading edges: Improvements in the mechanical behaviour under bird strike impact tests

J.A. Reglero *, M.A. Rodríguez-Pérez, E. Solórzano, J.A. de Saja

Cellular Materials Laboratory (CellMat), Condensed Matter Physics Department, Faculty of Science, University of Valladolid, 47011 Valladolid, Spain

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ABSTRACT

The use of aluminium foams as filler materials in aeronautical leading edges is investigated. Particularly, the improvement of the mechanical behaviour of the filled structure respect to the hollow one is analysed by means of standard bird strike impact tests. For this purpose, a collection of $AlSi_{10}$ foams were fabricated using the powder metallurgical route (PM), and introduced into leading edges profiles, maintaining or reducing the total weight of the composite structure (leading edge + aluminium foam) in comparison with the original one (hollow structure). Bird strike impact tests were carried out in both types of structures, comparing the global deformation and total load transferred in the tests. The results showed that the composite structure, a 13% lighter than the original one, showed four times better behaviour in terms of global deformation and an improvement of two times in the transmitted load.

1. Introduction

Aluminium foams have become attractive materials in a wide number of industrial sectors, such as the automotive, aerospatiale and aeronautical [1,2]. In the last years, numerous investigations have deal with this topic, and at the same time, a reasonable industrialization of several production routes have been achieved, thus increasing the applicability of these materials in numerous engineering applications [3,4].

Specifically, these materials are interesting in aeronautical applications due to a unique combination of properties, such as low density, great absorption energy, good thermal stability and damping capabilities [5,6]. In previous investigations in this area, metal foams have been used as core in sandwich panels for mechanical and acoustical applications [7–9], and have been employed to improve the energy absorption in hollow tubes [10,11]. However, no investigations are reported using these materials as fillers for leading edges.

The aim of this paper follows the previous idea analysing the possibility of re-designing a typical aeronautical structure: the leading edge of the wing in an airplane. The new design incorporates an $AlSi_{10}$ foam produced from the powder metallurgical route as a filler [12,13]. The mechanical behaviour of the filled structure has been compared to the empty leading edge, performing standardised bird strike impact tests. The results have showed significant improvements in the energy absorption capability, proving that the proposed concept is technically promising.

2. Materials

2.1. Leading edges

The leading edge is a functional part in the airplane's wings. It is specially designed to redirect the incoming air flux towards the bottom part of the wing, keeping the plane flying. The mechanical solicitations on this structure are critical, and it is important to take into account that the wing is usually a hollow structure only internally reinforced with ribs positioned in a perpendicular plane to the wing axis. For this reason, several mechanical tests must be performed to assure the plane stability. One of the most critical tests that the structure has to overcome is the bird strike impact test, which simulates the potential risk on an impact with birds during taking off or landing.

This investigation is focused on this type of test, trying to define a new design for the leading edge in which the metal foam could act as filler, thus improving the mechanical behaviour respect to the empty structure. The main aspects that were considered to define the new leading edge were chosen as follows:

1. To maintain the external shape.
2. To reducing the total weight of the structure.
3. To select a section in which the damage caused by an impact could be higher. For this reason the selected section was located in between two consecutive ribs.
4. To reduce the size to the laboratory scale. A scaled structure was used for this purpose.
5. To adapt the design in such a way that allows performing the impact tests.

* Corresponding author. Tel.: +34 983423572; fax: +34 983423192.
E-mail addresses: jareglero@gmail.com, reglero@fmc.uva.es (J.A. Reglero).

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