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Development and characterization of a natural lightweight composite solution for aircraft structural applications

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Abstract

Sandwich-based structures play a major role in several transport applications due to their high stiffness and strength-to-weight ratios. Some properties of cork agglomerates suggest that this natural material may represent an excellent candidate when implemented as the core of sandwich components such as the ones typically adopted in aircraft interiors. However, one major drawback still resides in their higher density values in comparison to other lightweight benchmark materials. In order to address this issue, a perforated structural concept is herein presented for the cork agglomerate core as part of a weight minimization strategy. The aim of this investigation consists in assessing the influence of several core design variables, including the cells' geometry, perforation ratio and pattern, with regard to the impact on the components' overall mechanical stiffness and damping performance. The design process was supported by numerical simulations carried out with the ABAQUS® FEM tool and validated via experimental testing characterization. Results showed that distinct optimized cellular topologies can be derived with improved properties tailored for the functional requirements of specific components, thus confirming the validity of such cork-based composites in aircraft structural applications.

Keywords

Cork agglomerate; cellular morphology; topology optimization; strain energy; loss factor

1. Introduction

The increasing adoption of advanced composite materials in aeronautical structures as an alternative to the more conventional metal alloys has opened up a new range of possibilities for the design of more efficient aircraft. The Bombardier CSeries, Boeing 787 and Airbus A350 are good examples of how extensively composite materials are now being used in aircraft components [1]. Carbon-fiber-reinforced polymers (CFRPs) are on the cutting edge of such class of materials as a result of some of their exceptional properties, including low weight, high specific strength, great corrosion resistance, durability and improved fatigue properties. However, the brittle type behaviour (low resilience) and poor damping characteristics can sometimes limit their applications under certain operational scenarios, especially when impact loads caused by foreign objects are expected during service. Additionally, the high energy consumption required during the manufacturing process of such thermoset based composites has recently raised some concerns from an environmental point of view. Hence, international regulatory agencies have been urging aeronautical manufacturers to achieve ambitious goals regarding the utilization of new and alternative materials with improved recyclability and sustainability features. As an example, the European Commission (through the ACARE's Flightpath 2050 report) has clearly set the introduction of recyclable materials in commercial aircraft over the next 30 years as one of the main priorities to minimize the carbon footprint and reduce the dependency on crude oil based products [2]. In this sense, an interesting approach consists in resorting to novel composite solutions integrating organic materials, namely for