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Infrared thermography to an aluminium foam sandwich structure subjected to low velocity impact tests

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Abstract

This work is the straightforward continuation of previous ones in which vibro-acoustic characteristics of AFS panels were investigated both numerically and experimentally. Herein, the use of infrared thermography (IRT) is exploited to investigate impact damaging of an aluminium foam sandwich panel by monitoring its surface, opposite to the impact, during a low velocity impact test, which is performed with a modified Charpy pendulum. Thermal images, acquired in time sequence during the impact by the infrared camera, are post-processed to get information useful for understanding absorption capabilities and impact damaging mechanisms of this kind of structure.

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Keywords: Impact; sandwich structures; metal foam; infrared thermography

1. Introduction

Sandwich structures are increasingly used in an a more and more wide number of application fields such as transport industry, civil infrastructures, chemical equipment; this because of their high strength-to-weight ratio, easy formability, and other properties that make them preferable to conventional engineering materials.

Aluminum foam sandwiches (AFS) [1,4], obtained by combining metal face sheets with a lightweight metal foam core, have peculiar properties (low specific weight, efficient capacity of energy dissipation, high impact strength, acoustic and thermal insulation, high damping), that make them interesting for a number of practical applications, such as the realization of lightweight structures with high mechanical strength and good capacity of energy dissipation under impact. In fact, sandwich structures have so far shown good capabilities in absorbing energy in response to collision and crash events, which are very important for high speed terrestrial and marine

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vehicles. Then, it is necessary to acquire a better knowledge concerning the impact behavior of structural parts, built up resorting to sandwich technologies.

Core deformation and failure are decisive factors for the energy absorption capabilities of sandwich structures. After the impacting object has fractured the skin, it may penetrate into the core and damage it. With aluminum honeycomb cores, damage consists of crushing or “buckling” of cell walls in a region surrounding the impact point, while, in foam cores, damage looks more like a crack for low-energy impacts [5].

The attention of this work is focused on the use of infrared thermography (IRT) to investigate impact damaging of metal sandwich structures. It has been already demonstrated the usefulness of an infrared camera to monitoring the impact event of structures made of composite material [6,7]. The intention, now, is to apply infrared thermography also to AFS, attempting to gain more information on the role played by metal foam as energy absorber.

2. Experimental investigations

The Aluminium Foam Sandwich (AFS) panel under investigation has been manufactured by the Austrian company Mepura Metallpulver GmbH with the commercial name Alulight. As depicted in Fig. 1, the AFS panel consists of a three-layer composite: two external face sheets made of aluminium alloy and an internal core layer made of foamable aluminium alloy sheet (containing TiH2 as a blowing agent) .

The total thickness of AFS panel is 10mm: the foam thickness is 8mm, each of the two external layers is 1mm thick and the average cell size of the foam bubbles is about 2 mm.

Fig. 1. Aluminium foam sandwich panel.

Impact tests are carried out at different energies (from 3.6 J up to 39 J) with a modified Charpy pendulum available at the Laboratory of the Department of Industrial Engineering of the University of Naples Federico II. The pendulum consists of a hammer, which has hemispherical nose 12.7 mm in diameter and a specimen lodge with a window 12.5 cm x 7.5 cm to allow for the contact with the hammer from one side and optical view (by the infrared camera) from the other one. Therefore, the infrared camera views the surface opposite to impact and acquires thermal images in time sequence at frame rate fr = 960 Hz.

The first image (t = 0) of the sequence, i.e. the specimen surface at ambient temperature before impact, is subtracted to each subsequent image so as to generate a map of temperature difference ΔT:

$$\Delta T(i,j,t) = T(i,j,t) - T(i,j,0) \quad (1)$$