Multifunctional Layers for Safer Aircraft Composites Structures

M. Chapartegui, A. Iriarte, C. Elizetxea

Tecnalia, Mikeletegi 2 E-20009, San Sebastian, Spain
maialen.chapartegui@tecnalia.com

The objective of the present work is to develop an electrical-thermal conductive material to be used as a heating layer in aircraft ice protection systems. For this purpose, a nanocomposite layer consisting of a polymeric matrix doped with carbon nanotubes (CNT) is developed, which afterwards will be incorporated in the manufacturing process of composite parts. Two alternatives are studied, incorporating different concentrations of multi-walled carbon nanotubes (MWCNT) into epoxy and benzoxazine resins: benzoxazine/MWCNT nanocomposites and epoxy/MWCNT-buckypaper nanocomposites.

The materials used for the manufacturing of benzoxazine/MWCNT nanocomposites are Araldite MT35600 benzoxazine resin from Huntsman and Graphistrength C100 multi-walled carbon nanotubes from Arkema. The manufacturing process consists of two main steps: in the first step, MWCNTs are dispersed in benzoxazine resin by means of extrusion with a co-rotating twin-screw extruder; in a second step, the benzoxazine/MWCNT blend is hot-pressed and cured to obtain the nanocomposite film. The MWCNT content of this nanocomposite is 10 wt.%.

For the development of epoxy/MWCNT-buckypaper nanocomposites, first a MWCNT buckypaper is manufactured by filtering a nanotube suspension. Graphistrength U100 multi-walled carbon nanotubes from Arkema are used and a 245 mm diameter and 150 μm thickness buckypaper is obtained. In a second step the buckypaper is infiltrated with epoxy resin in autoclave, using the MTM44-1 epoxy resin film from Advanced Composites Group. A nanocomposite film 40 wt.% MWCNT is obtained.

Electrical conductivity and electrothermal heating tests are carried out to evaluate the efficiency of the manufactured nanocomposites as a heating layer. The electrical conductivity is measured using the Van der Pauw four probe method [1-2]. The results reveal that the electrical conductivity of the benzoxazine/MWCNT nanocomposites is in the range of 0.13 to 0.57 S/cm, whereas the electrical conductivity of the epoxy/MWCNT-buckypaper nanocomposites is in the range of 5.2 to 23 S/cm. Therefore, the electrical conductivity of the epoxy/MWCNT-buckypaper nanocomposites is at least one order of magnitude higher than that of the benzoxazine/MWCNT nanocomposites.

Electrothermal heating tests are performed at room temperature and at -25 ºC. The temperature is measured in four points of the specimen using K type thermocouples. In addition, during room temperature tests, an infrared camera is used to capture the distribution of temperatures. The test is performed as follows: an electric current is applied to the specimen, so the temperature starts increasing. When a temperature increase of 35 ºC is reached, the current is switched off. As can be seen in Figure 1, similar heating rates are observed at -25ºC and at room temperature. The photographs obtained with the infrared camera and the graphs obtained with the thermocouples reveal that the heat distribution is significantly better for epoxy/MWCNT-buckypaper nanocomposites.

Acknowledgements

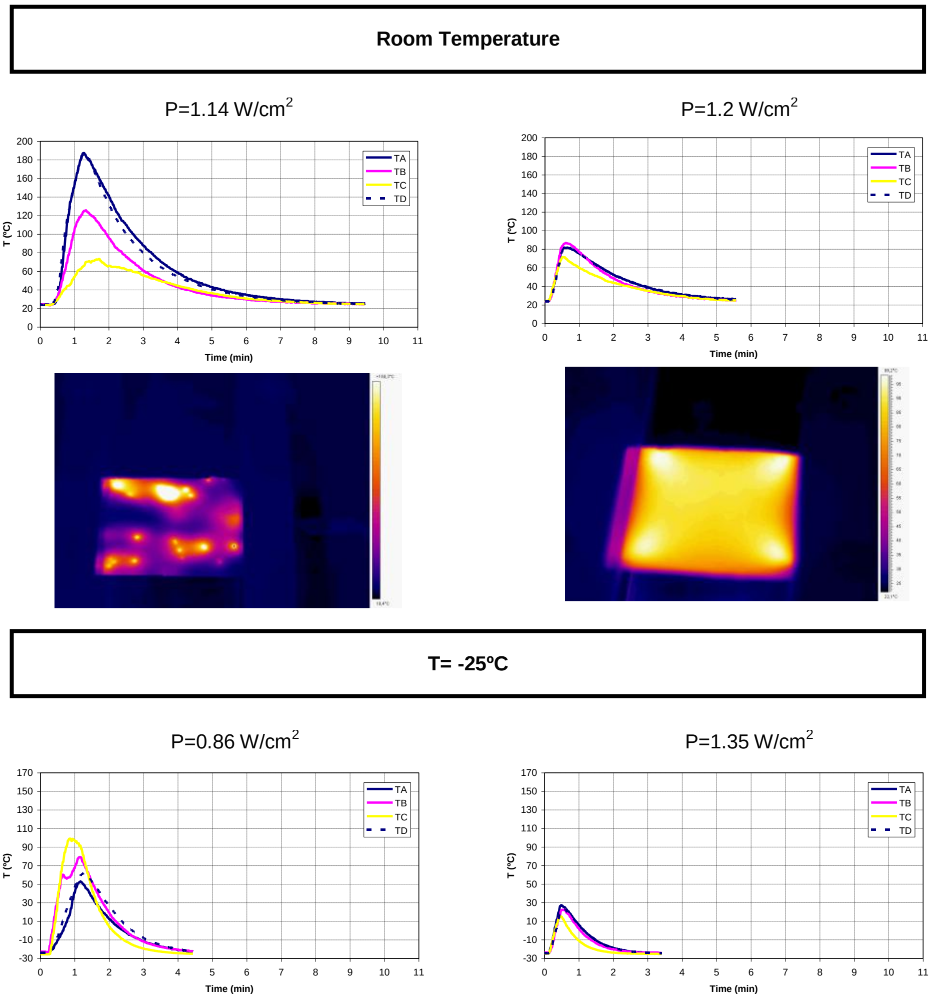
This work has been carried out within the European Project ACP7-GA-2008-21367, “Multifunctional Layers for Safer Aircraft Composites Structures-LAYSA”.

References

[1] Rosca, I.D, Hoa S.V, Carbon, **47** (2009) 1958-1968.

[2] Weiss J.D, Kaplar R.J, Kambour K.E, Solid-State Electron, **52** (2008) 91-98.

Figures



a) **b)**

Figure 1. Results of electrothermal heating tests: a) benzoxazine/MWCNT nanocomposites, b) epoxy/MWCNT-buckypaper nanocomposites.