Design of dielectric sensing and measurement system for the monitoring of the cure process in composite materials

N Niakas and G Maistros
INASCO Hellas, 17 Tegeas St., Argyroupolis 16452, Greece

The monitoring of the cure process in composite materials production has been the subject of extensive research during the last twenty years. Additionally, significant progress has been done in the area of dielectrometry during the last decade. The basic components for a dielectric monitoring system are the sensor and measurement unit.

In this work, an optimum sensor for the composite materials cure monitoring has been developed. The most crucial requirements that a sensor must satisfy are recapitulated into two factors. The first one is the low dissipation factor of the substrate material at the corresponding temperature level and the second one is related with the background capacitance in order to fit with the resin properties during cure. Also, an embedded thermocouple could be useful because cure is very sensitive in temperature and small variations can affect the measured degree of cure in the surface of the sensor and thus, is a very good practice to measure the temperature exactly in the sensing area.

Also developed is a dedicated measurement unit, which can be described as impedance analyzer. This unit can measure in a wide range of both frequencies and resistances the complex impedance of the resin during cure on the sensor surface. In order to fulfill the aim of a continual monitoring of cure process, a complete compatibility between measurement unit and sensor response must firstly be achieved.

Against the above restrictions and the challenge of the industrial market, the design of the novel monitoring system including the sensor and the measurement unit, offer a significant accuracy and repeatability in the results. The new system has been built by integrating high-end hardware modules with the corresponding software drivers and a friendly user interface. Numerous test cases have been accomplished featuring tests on standard circuit elements, pure resin cure, cure of carbon and glass reinforced composite parts and a pilot trial for a real case in an industrial environment. The demonstrated potential of the system relies on the capability to predict in real time the material state of the curing material and therefore the development of the mechanical performance of the processed component.