Experimental characterization of the thermal behavior of carbon/PEEK tapes in the laser-assisted AFP process.

Violaine Le Louët[1, 2)], Steven Le Corre [2,a)], Nicolas Boyard [2)], Didier Delaunay [2)], Xavier Tardif[1)]

[1]*Institut de Recherche Technologique Jules Verne, Chemin du Chaffault, 44340 Bouguenais, France.*
[2] *Laboratoire de Thermocinétiques de Nantes, UMR CNRS 6607, Rue Christian Pauc, 44306 Nantes, France.*

[a)]steven.lecorre@univ-nantes.fr

Abstract. The AFP process, is a promising automated deposition technique for carbon fibers pre-impregnated polymer composites. It is nowadays more and more popular for the development of complex shapes in the aerospace industry. The improvement of high performances thermoplastic polymers (PAEK family) offers the possibility of enhanced and faster processes. This process has become really popular also in the scientific community, where a lot of attention was paid to different aspects: (i) efficient numerical modeling, (ii) complex laser-composite interaction, (iii) effect of the processing parameters. Surprisingly, very little question arose about the thermal behavior under the extreme conditions imposed by the laser heating. Heat transfers occurring during the heating step still require a reliable measurement, partly because the measurement of temperature directly on the process is uneasy. This study offers to step aside from such difficulties by developing a specific static instrumented bench aiming at determining what do the prepreg tape and substrate undergo during deposition in terms of temperatures and heat flux fields. As illustrated in Figure 1, composite tapes are positioned over a metallic part instrumented by thermocouples. Right in the center of this sensor, a set of three vertical thermocouples enable to form a flux sensor. Temperatures and heat fluxes can therefore be accurately measured on the back face of composite tapes. In addition, a high performance FLIR infrared camera located just over the bench records the temperature elevations of the surface illuminated by the 2kW laser. The whole device enables to reach easily the melting temperature of the PEEK (~350°C) in the range of 25ms, which is aimed at being representative of a fast industrial deposition.

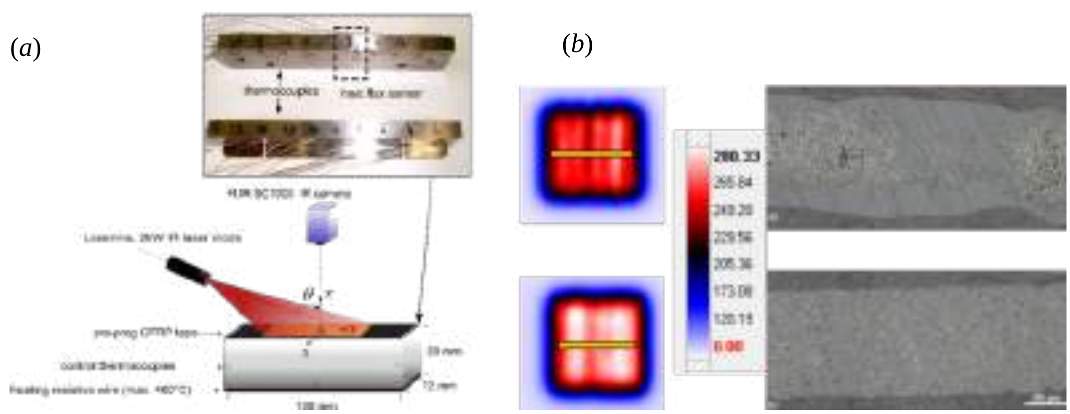

FIGURE 1: View and schematic representation of the instrumented bench (a) ; IR picture of two types of tapes after laser illumination of 25ms at 200W.

Results show several important results: (i) comparing two materials (see Fig 1b) with different microstructural organization and identical fiber fractions, results highlight the huge importance of the fiber distribution on the thermal behavior ; (ii) a surfacic heat source model is not sufficient to predict the temperature elevation so that the laser/composite interaction has to be accounted for by a volumic heat source ; (iii) the thermal contact resistance (TCR) with the metallic substrate is huge, and in the very short time range of the process, cannot be modeled by a usual TCR model, capacitive effects have to be taken into account.