One Shot Sandwich Composite Structure by Liquid Resin Infusion Influence of Manufacturing Process Parameters on Low Velocity Impact

J. Gulla[1], A. Cantarel[1*], M-L. Pastor[1] , X. Gong[1]

[1] *Institut Clément Ader, Université de Toulouse, CNRS, UPS, ISAE-Supaero, Mines d'Albi, 3 rue Caroline Aigle, 31400 Toulouse FRANCE*
*Corresponding author (Arthur.Cantarel@iut-tarbes.fr)

Keywords: *Liquid Resin Infusion; sandwich composites; low-energy/low-velocity impact*

Introduction

Composite materials are taking an increasingly important role in mechanical structure, where high specific stiffness and specific strength (relative to their density) are required, especially in the aeronautical domain. In order to develop transport equipments carried by aircrafts, a sandwich composite structure was proposed, and prototypes (military equipments for helitransported mortars) were produced during one of our previous studies. These structures consist of composite skins (glass fiber/epoxy resin) on a foam core, and the first tests showed advantages in terms of overall weight or load distribution during transport. Their resistance to impact, however, strongly influenced by the manufacturing process, can be problematic. In order to improve the properties of sandwich composite structures under low-velocity and low-energy impact loadings, the present study aims at optimizing the process parameters and at controlling damage propagation in the structures using an infrared thermography method. This paper describes the results of low velocity impact on samples produced using a one-shot sandwich resin infusion we developped with several elaboration conditions.

One-shot sandwich infusion, manufacturing parameters

The principle of the manufacturing method developped for this project is shown on Figure 1.

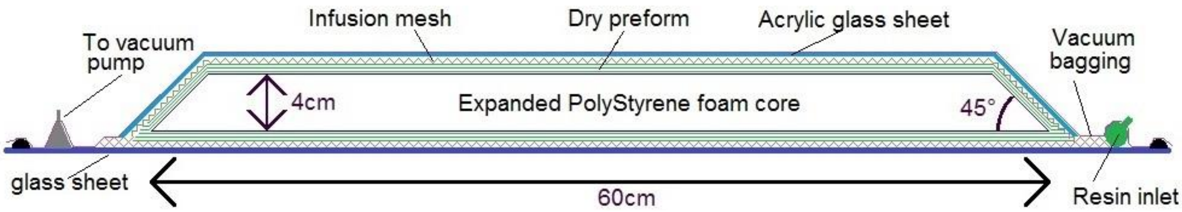

Figure 1: *One-shot sandwich resin infusion principle.*

The first step in this study was to determine which elaboration parameters are of importance in impact applications. A review of the bibliography showed that our research could be centered on the infusion temperatures [1], and on energy dissipating additives [2]. A preliminary study of the epoxy system using nanoscaled additives (Nanostrength® M52N, 7%w) showed the need of a slower hardener. Other aspects during the process had to be taken into account, such as hardener's compatibility with the foam, increased viscosity, and consequently infusion duration and exothermy risks. The selected conditions are shown in Table 1, and the different combinations have been tested.

Table 1: *Selected infusion parameters.*

Resin's temperature (°C)	*Preform's temperature (°C)*	*Hardener*	*Additives*
50	50	Standard	Nanostrength® (7%w)
40	40	Slow	
25	25		

Impact testing

A reference sample (T_{resin}=25°C, $T_{preform}$=25°C, standard hardener, no additives) was selected, to which the different parameter's variations will be compared. A panel measuring 60 x 40 cm² was divided into 3 rows and 4 columns to cut samples measuring 15 x 10 cm² and the uniformity of behavior under impact on a drop-weight tower (E_i =10 J, m=2.065 kg) in a single plate was verified. Figure 2 shows uniform indentation after impact in a plate and the disposition of the samples.

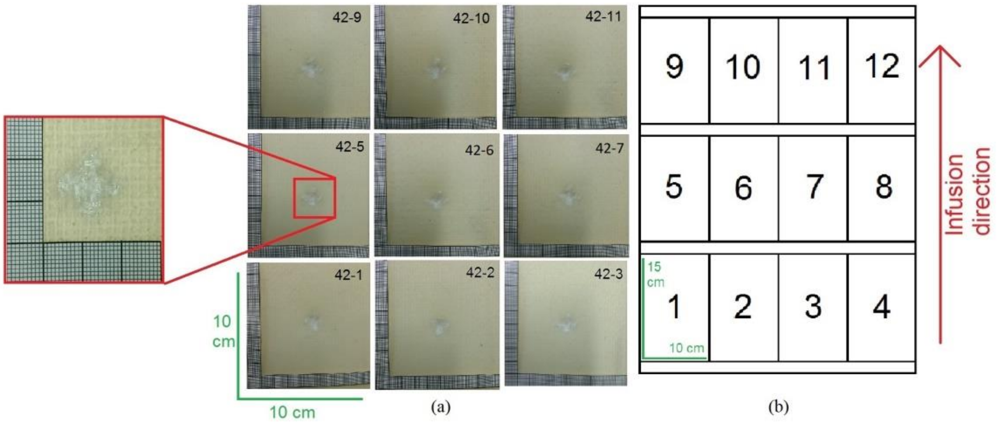

Figure 2: *Residual indentations on impacted samples (a), identification of samples (b).*

We observed that the behavior was not uniform in a plate of samples if the resin's temperature was different from the preform's temperature. The resin's temperature during the infusion quickly lowered from its initial value to reach the preform's. Three different behaviors observed on the force and energy curves can be linked to three different observable damages. Figure 3 shows the curves for impact force versus time and impact energy versus time for 3 samples taken in the same column but in 3 consecutive rows.

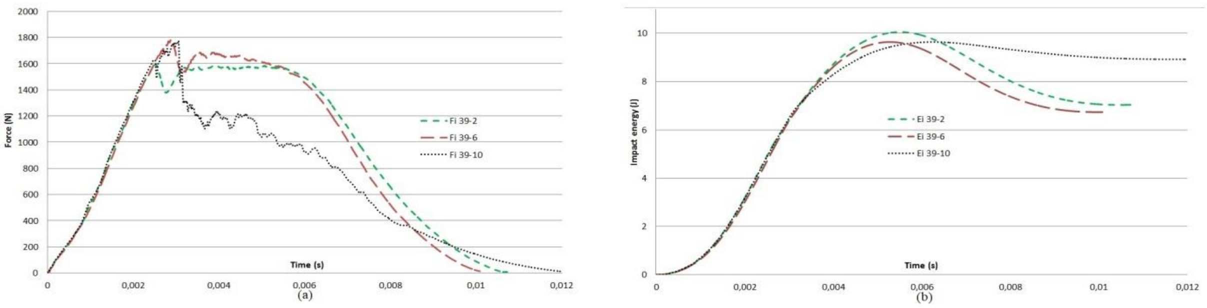

Figure 3: *Impact force vs. time (a), impact energy vs. time (b) for samples in the same column.*

Conclusion

The different behaviors observed on the force and energy curves can be linked to three different observable damages and are directly related to the manufacturing conditions, such as temperatures and infusion duration. We also observed that when using nano-additives in the resin, the resistance to impact was improved (lower absorbed energy, no skins perforation). Further investigation is pending on the temperature's influence on fiber's impregnation and void creation.

Acknoledgments

We thank Dr. Frederic Leonardi (IPREM, Pau) for his help with the Nanostrength® additives.

References

[1] Wang, P., Molimard, J., Drapier, S., Vautrin, A., & Minni, J.C. Monitoring the resin infusion manufacturing process under industrial environment using distributed sensors. *Journal of Composite Materials*, 46(6): 691-706, 2012.

[2] Boumbimba, R., Froustey, C., Viot, P., Olive, J.M., Leonardi, F., Gerard, P., & Inoubli, R. Preparation and mechanical characterisation of laminate composites made of glass fibre/epoxy resin filled with tribloc copolymers. *Composite structures*, 116: 414-422, 2014.