Hybrid OOA Prepreg/LCM Process for Integrated Structures

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The Clean Sky Project

Clean Sky is one of the largest research projects ever launched in Europe; it involves over 500 partners related to aerospace industry (EADS, AIRBUS, Eurocopter, Dassault and many others). The objective is to develop breakthrough technologies to significantly increase the environmental performance of airplanes and air transport. The project is divided in six technology domains, including Eco-Design, which focuses on green design, production and optimal use of materials. The Composite Materials and Adaptive Structures Lab at ETH Zürich is participating to the Eco-Design ITD within the Swiss Cluster led by RUAG AG.

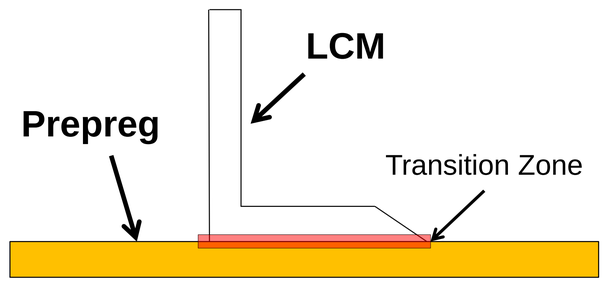
Swiss Cluster Partners:

Hybrid Processing

Traditional prepreg processing is used for high-end applications, since it can provide excellent mechanical characteristics of the component. Moreover, the material behavior can be tuned by adding tougheners and flame retardants. Typical disadvantages of those materials are the high production costs and quite laborious manufacturing of complex shape .

Liquid Composite Molding (LCM) processes give higher freedom in the components' design, but usually lower mechanical properties of materials.

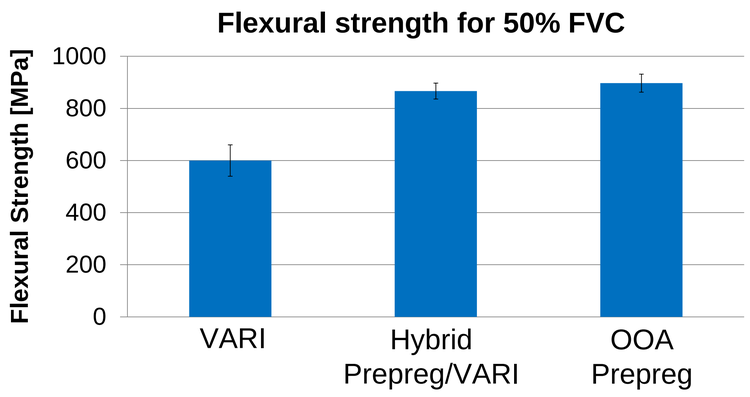
Hybrid prepreg/LCM processing can overcome the limitations of the pure processes by combining their advantages.

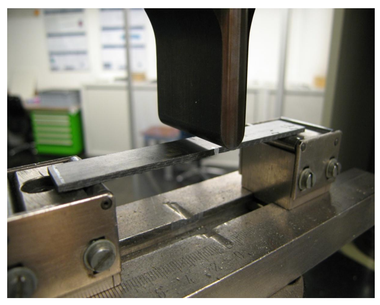


They allow the manufacturing of highly integrated structures, like carbon fiber fuselage structures. In our research, we use prepreg plies of new generation of out-of-autoclave (OOA) materials. This results in additional benefits in terms of costs and energy consumption, compared to traditional manufacturing processes.

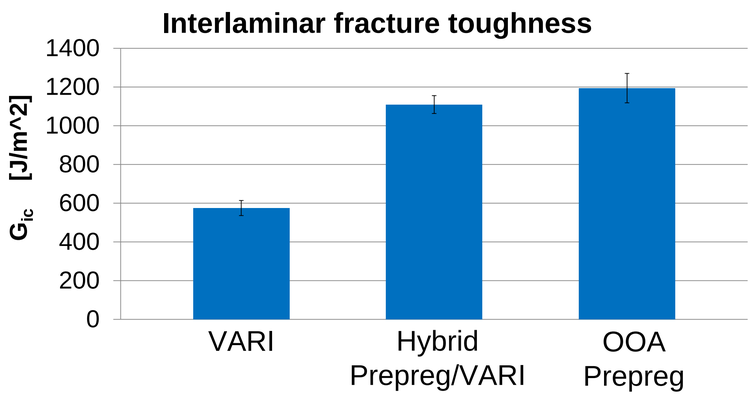
Mechanical Performance of Hybrid Laminates

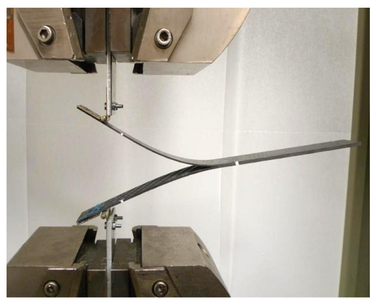
The mechanical properties of laminates produced by hybrid OOA prepreg/VARI processes have been compared to the mechanical properties of laminates produced by pure VARI and pure OOA prepreg processes. Samples of carbon fiber laminates were tested in a three point bending configuration to determine the flexural strength and the flexural Young's Modulus, as well as the interlaminar shear strength.





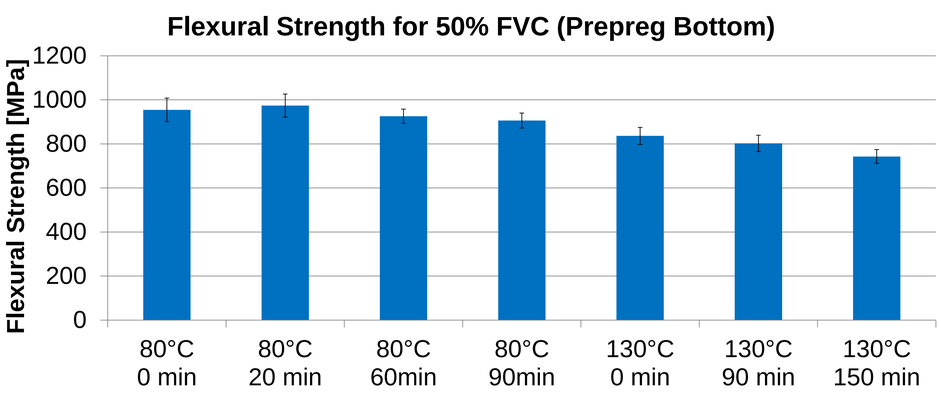
Delamination tests were performed to investigate the properties of the transition zone. Generally the results show that the performances of hybrid laminates fall within the limits set by pure processes and are typically closer to prepreg values. The interface between prepreg and VARI resins does not weaken the laminate.





Process Robustness Analysis

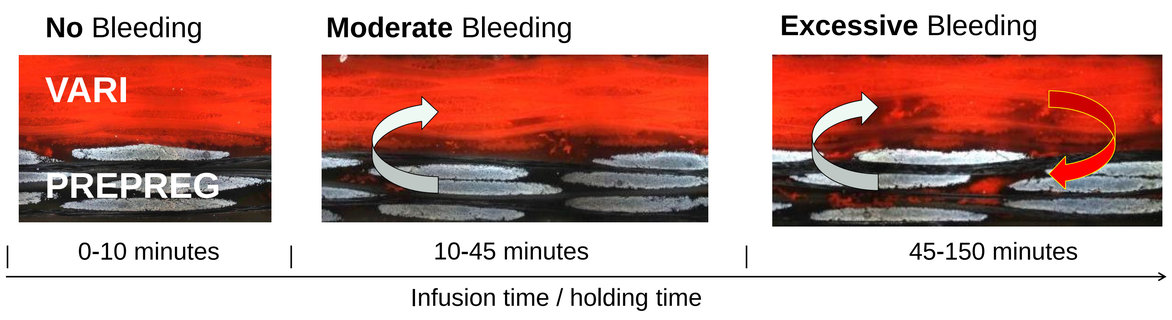
The robustness of the hybrid process has been investigated by changing the process parameters infusion temperature and holding time in the production of carbon fiber plates. Those two parameters strongly affect the flow of the prepreg resin into the dry fabric prior to the infusion. This process is called bleeding of the prepreg resin and is responsible for the mixing of the two resins in the laminate.



The results of the mechanical tests show that bleeding has a major effect on the final properties of the component.

The resin distribution has been investigated by adding a red dye to the infused resin. Microscopy analysis of the laminate cross section shows that for long holding time, a strong exchange of resin between the two regions take place.

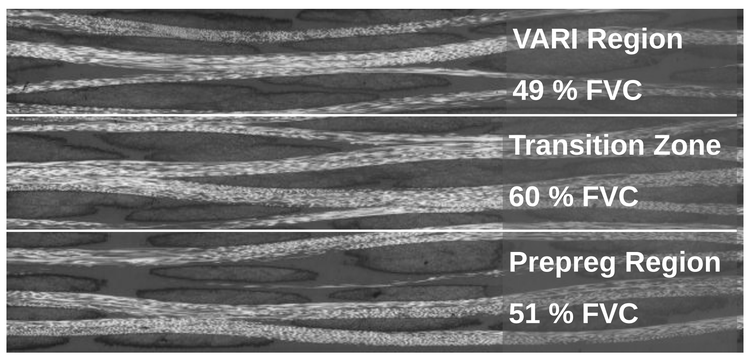
Aspects like the creation of voids and the local distribution of fibers, influencing the mechanical properties, are related to resin flow during the bleeding process, which is further investigated.



Modelling of Hybrid Processing

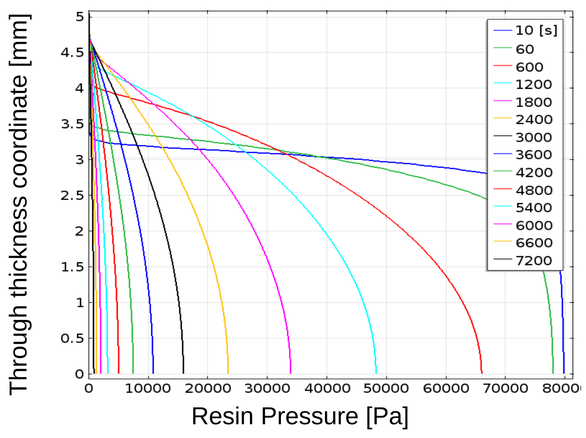
The high sensitivity of the bleeding process to the variation of the process parameters highlight the necessity for the definition of models, able to describe the resin flow in hybrid processes and to consider occurring deformations of the textile.

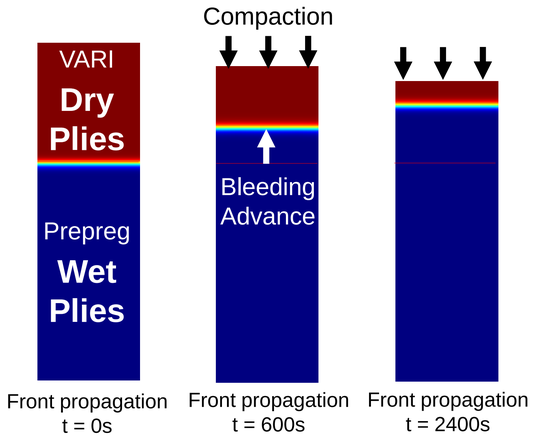
Those models should allow the prediction of the laminate properties, like the Fiber Volume Content (FVC) distribution.



Microscopy of the cross-section of a hybrid laminate with moderate bleeding. The local FVC has been estimate through image analysis.

Advanced simulation tools could be used to optimize the process parameters with regards to the final part properties. An example of the numerical simulation of the prepreg resin bleeding in a dry textile is shown below. It shows the evolution of fluid pressure distribution and the textile deformation during the bleeding process.





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