PAM-FORM, the virtual verification tool for Aerospace Composite Forming processes.

By B Cartwright and D McGuckin
Pacific ESI, Sydney, Australia

The diaphragm forming and stamping of b-staged prepreg material is a cost-effective method to produce aerospace components of complex curvature. These methods have been in practice for a number of years for small aircraft wing components such as ribs.

As their competitive edge narrows, manufacturers look for increasingly complex and larger components to which they can apply these cost-effective manufacturing processes. A common dilemma facing the production engineer is that the cost to prove these novel concepts on large components increases exponentially with the size of the part, simply due to the cost of more materials and labour. These factors imply the return on the research investment carries a higher risk.

A natural progression of virtual try-out technology would be to use simulation to develop and verify the process before applying it to the large part. Such an approach reduces the risk of the process failing on the large part.

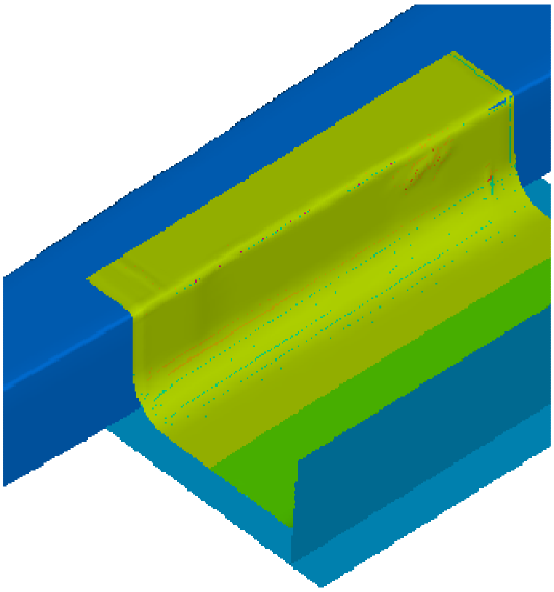
Through small scale tests to identify the types of faults that can happen in the process, e.g. wrinkles in the prepreg materials, lack of consolidation, or excessive in-plane shearing, simulation techniques were developed with the support of Pacific ESI to achieve good correlation in simulation to the physical process that caused the fault. With this fault prediction correlation accomplished, the size of the part modelled can be increased to a size that is considered far too risky to develop in a conventional, hands-on, trial-and-error approach.

Instead, process variations were tried over and over again until the virtual process produced good quality parts. At that point, the trial process could be then applied to the large item with confidence.

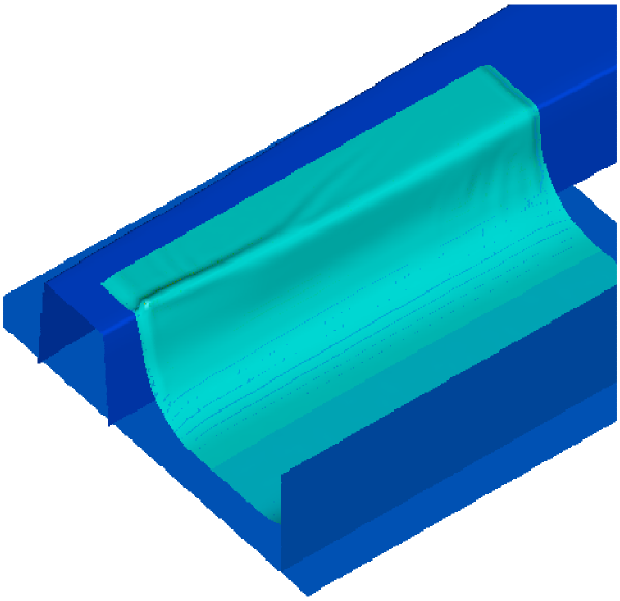
In this manner, the process simulation through PAM-FORM can facilitate the development of new parts that would be considered far too risky to be developed by experimental means.

With vacuum resin infusion becoming more commonplace in aerospace components, there is an added bonus of being able to export PAM-FORM data to PAM-RTM to enable resin infusion scenarios to be studied. In this particular application, the PAM-FORM is used to develop the process to prepare the “pre-form” of, for example, powder-bound dry multi-axial reinforcements prior to actual infusion. PAM-FORM updates the fibre-orientations throughout the forming process, and so enables the shear angles and corresponding changes in permeability to be calculated. These local permeability changes and the overall geometry of the pre-form are essential to ensuring an accurate infusion prediction in PAM-RTM.

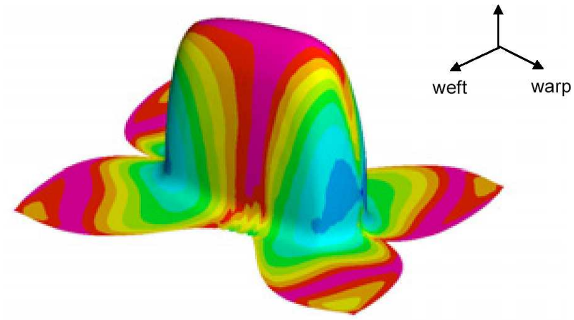
Images courtesy of collaborative research projects Pacific ESI has undertaken with CRC-ACS, and University of Auckland, NZ.



Simulation of real defects on an experimental scale is necessary to build confidence in the simulation process. Here we see wrinkles over a spar where it changes in dimension. Process changes can prevent the wrinkle from occurring. (CRC-ACS)



Experimental correlation was also achieved when the number of plies was increased – the type of wrinkle that formed was different. (CRC-ACS)



Fibre orientations in a stamped knitted fabric can be correlated to changes in permeability for infusion predictions. (M Duhovic, University of Auckland)