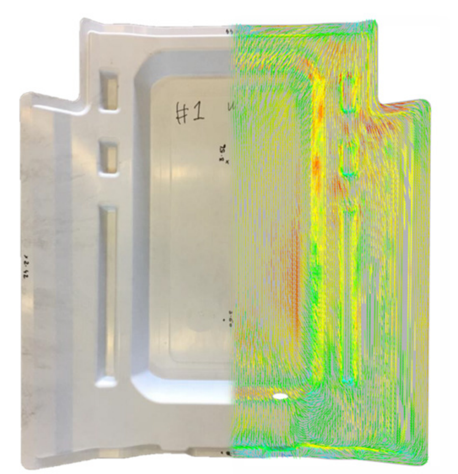
Simulating SMC part response with greater confidence using Digimat

Summary

While Sheet Molded Compound (SMC) materials have been widely used in the automotive industry for some time, recently there has been a move to apply SMCs on more structurally demanding components. Though the material has long been considered quasi-isotropic with relative success, it has become apparent in industry that due to the complex manufacturing process, optimal structural design is not possible without considering the real anisotropic nature of the material.. With growing demand from the market, now is the time to leverage advanced SMC modeling capabilities targeting crash performance.



GF-SMC inner seat part, real and digital twin

The SMC material label refers more to a process than to a grade and SMC materials share significant similarities with beam molded compound (BMC) materials. This process consists of placing one or more charges, which are cut out of raw mat rowing and piled into several layers, into a mold cavity before closing the mold and forcing the material to flow in accordance with the pattern coverage.

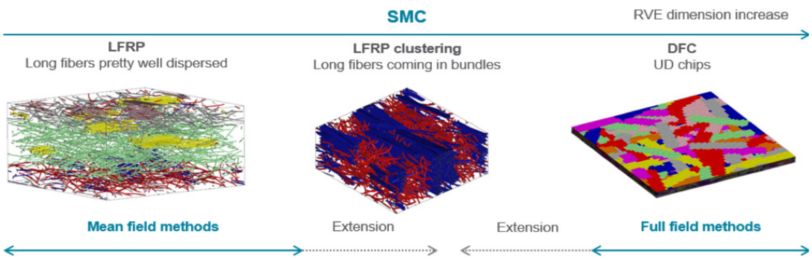


Figure: SMC grade family

> We are now ready to deploy a workflow to simulate SMC part response with a greater confidence thanks to Digimat, that achieved at demonstrator level extremely close results to test data in terms of stiffness, peak load and load drop displacement."
>
> \- *Major Automotive OEM*

Most SMC grades are composed of bundles or uni-direction (UD) scraps. From such a starting point and manufacturing process, SMC grades can range from dispersed long fiber reinforced plastics (LFRP) to discontinuous fiber chips (DFC).

Challenge

The Goal is to deploy an effective and predictive numerical solution for SMC parts facing typical automotive load cases such as crash. The primary challenges in reaching this goal include:

- Material anisotropy, thus far considered negligible by the industry, now has to be accounted for in order to shrink safety margins and reduce part weight.
- Failure initiation and damage propagation simulation appear to be significant challenges due to the complexity of the microstructure, including fiber / bundle / chips entanglement.
- When using several charge patterns and / or inserts, the material flow will meet at specific locations, resulting in weld lines. Weld lines are often the weak-links in SMC components, given no reinforcement is present in this interface region to carry load.

Solution

Anisotropy
Moldex3D can be used to predict the microstructure of SMC parts, including the complexity arising from the material flowing from the charge pattern to fill the mold as well as the presence of weld lines. Material anisotropy is then captured using Digimat technology, which relies on mean-field methods, allowing successful prediction

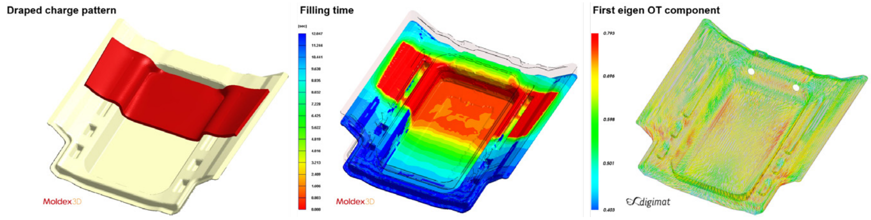


Figure : SMC process simulation and resulting anisotropy

Failure and damage
A new tunable damage law for discontinuous chopped fiber material models now relates damage propagation to the material strength. It relies on a progressive failure formulation where energy is dissipated post-failure initiation via stiffness reduction.

Weld lines
Process modeling software can also provide weld line location through a node list. Thanks to Digimat-MAP, this node list can be mapped as an element set. The strength parameters of the material card attributed to this element set receive a knock down relative to the pristine domain, accounting for the weakness of this defect.

Results

Static and crash FEA simulations can now attain an excellent level of accuracy in stiffness and can capture peak load and displacement trends for typical part load cases.

The inner seat part illustrates the proposed workflow from process simulation to structural application. The Digimat simulation achieves a much better fit with respect to test data for most load cases, including head impact (puncture) and provide a good indication of hot spot localizations.

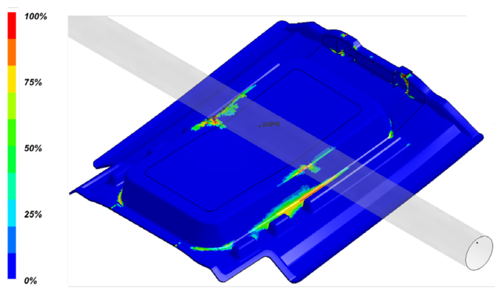


Figure : Damage variable at peak load under bending load

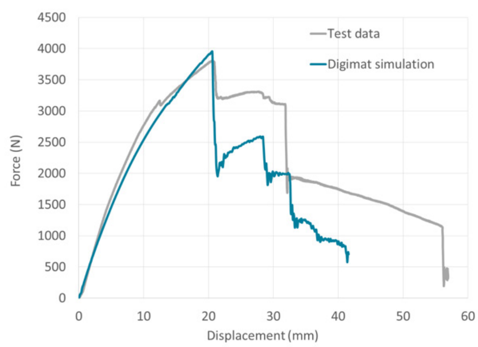


Figure : GF-SMC inner seat part results

For more information on Digimat and for additional Case Studies, please visit www.e-Xstream.com

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