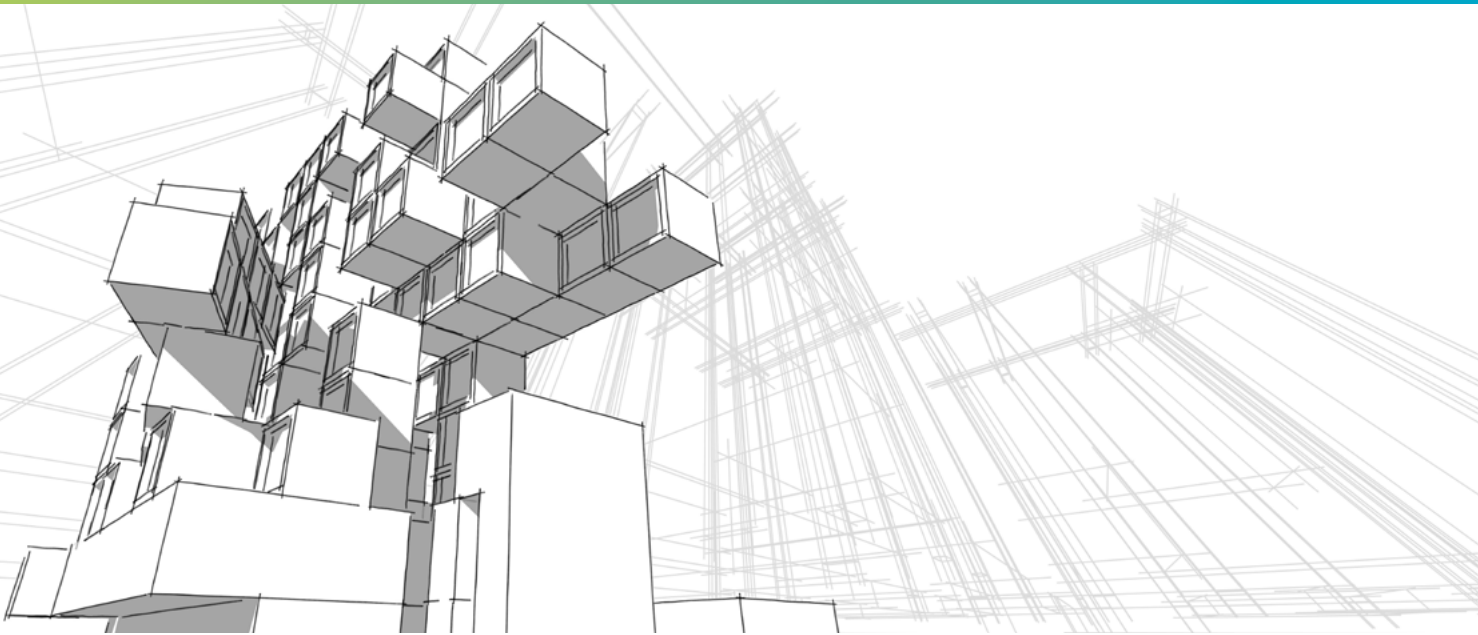# Accurate prediction of part performance in response to static loads for short fiber reinforced composites
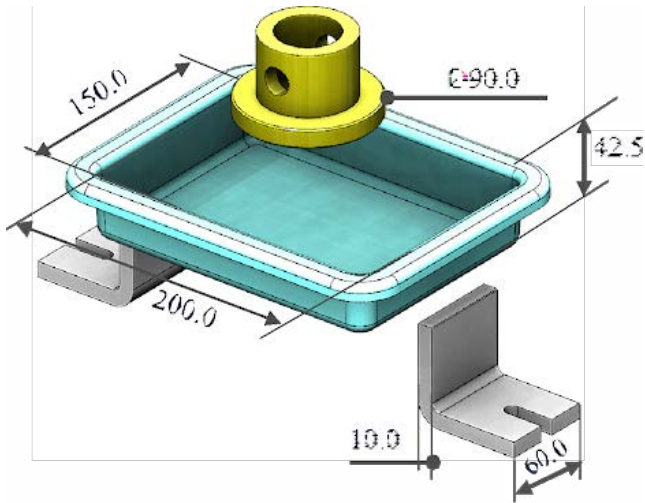
SABIC uses Digimat for high-fidelity anisotropic simulation, considering manufacturing effects and non-linear material behavior

The material data team demonstrated significant increase in the accuracy of the stiffness and strength prediction through anisotropic simulation using the Digimat tool.

SABIC is a global leader in diversified chemicals headquartered in Riyadh, Saudi Arabia. It manufactures on a global scale in the Americas, Europe, Middle East and Asia Pacific, making distinctly different kinds of products: chemicals, commodity and high performance plastics, agri-nutrients and metals. SABIC's Specialties business produces highly differentiated products which include specialty engineering thermoplastic resins and compounds, composites, thermosets & additives, and additive manufacturing solutions. Offering a distinct set of multi-function physical properties to serve a wide range of industries, the branded portfolio includes ULTEM™ resins, LNP™ compounds, NORYL™ resins, LEXAN™ copolymers and EXTEM™ resins.

SABIC's Global Application Technology Centers leverage their product engineers and material processing expertise to support customers with specific requests for design, application development and testing to help bring their innovative products to market sooner.

Challenge

The materials data team uses cutting edge material characterization labs, predictive engineering capabilities and part level testing to validate material data which can be used for designing applications.

The lack of validated data can create an increased risk of sub-optimal part performance. Through the use of validated data and advanced simulation tools, it is possible to achieve a significant increase in the accuracy of the performance prediction.

For this case, the team worked on providing high-fidelity properties of a certain anisotropic material used in healthcare applications - LEXAN™ copolymer with 30 percent high-modu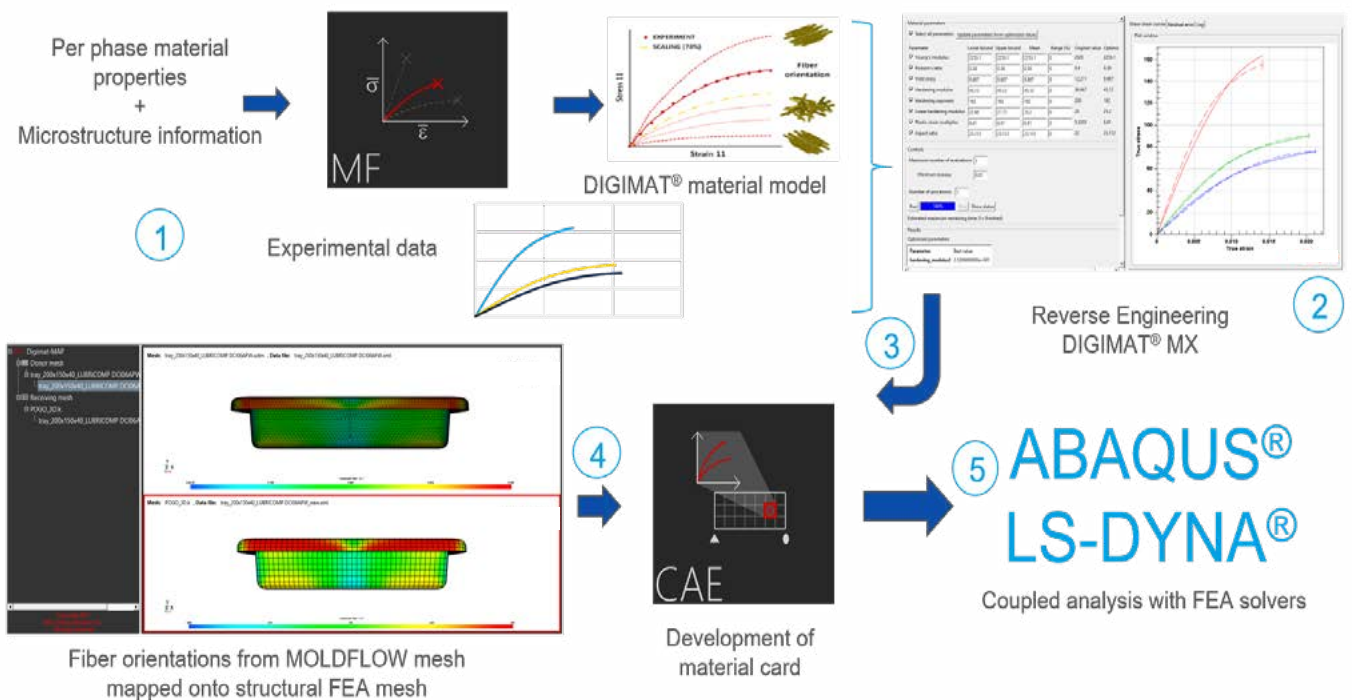lus carbon fiber and silicone. This is important since even though the usage of fiber-reinforced materials is common in healthcare, usage of detailed anisotropic data is not common in the industry.

The team decided to build a use case by conducting a set of experiments on a surgical tray made with a filled thermoplastic grade. To provide accurate performance predictions in response to impact loads, for a part made of short-fiber reinforced composites, manufacturing effects such as fiber orientations had to be considered.

Solution

There are two commonly followed classical approaches for material modeling in the industry, neither of which accounts for flow-induced anisotropy. In the first approach, a multi-point material curve is established from an injection-molded specimen in the primary fiber direction (0o). In the second approach, material curves are established from specimens cut from an injection molded plaque in three directions (0o, 45o & 90o) and subsequently, a quasi-isotropic material model is derived from employing a classical laminate theory. These approaches underestimate the peak force and energy absorption of the designed parts and can lead to under-designing the parts.

To mitigate these inaccuracies, the team decided to use Digimat, a nonlinear multi-scale material and structural modeling platform, that lets engineers perform both micro- and macro-scale analyses of composites. With Digimat, the team delivered high-fidelity anisotropic simulation by considering manufacturing effects and non-linear material behavior.

Figure 2: Workflow for developing material card for coupled FE analysis

Modeling Approach	Peak Force (N)	% Difference from Experiment	Displacement at Peak Force (N)	% Difference from Experiment
Experiment	4,426		8.0	
Isotropic 0°	9,011	104%	10.2	27%
Quasi-Isotropic	6,939	57%	11.0	37%
Anisotropic	4,228	-4%	8.31	4%

Figure 3: Better part stiffness and strength prediction (± 10%) using anisotropic modeling approach

Fig. Simulation results

Failure pattern - test
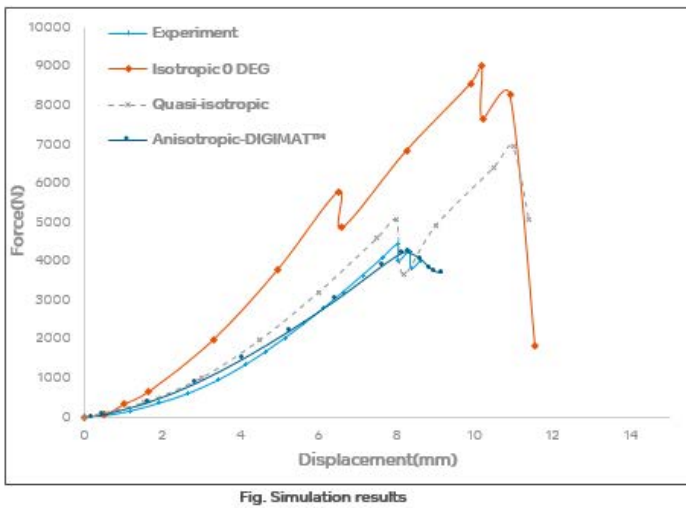
Failure pattern - simulation

Figure 4: Predictions using Digimat and comparing with other approaches

Results

The material data team demonstrated significant increase in the accuracy of the stiffness and strength prediction through anisotropic simulation using the Digimat tool. Consequently, this helps ensure greater customer confidence in the material. Accurate results from simulation were achieved using anisotropic material data, flow-induced fiber orientation and localized material properties from Digimat.

With an anisotropic modelling approach, the team could predict the peak force as well as displacement at peak force with an error margin of just four percent. In contrast, the deviation for the commonly used methods ranged from 104%-57% for peak force and 37%-27% for displacements.

The SABIC team worked collaboratively with the MSC Software team to create a validated Digimat material card.

Key highlights:

Product: Digimat

Industry: Chemical, Healthcare

Benefits: High-fidelity anisotropic simulation, considering manufacturing effects and non-linear material behavior

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