Accurate prediction of part performance in response to static loads for short fiber reinforced composites

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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. 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-modulus 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 (0°). In the second approach, material curves are established from specimens cut from an injection molded plaque in three directions (0°, 45° & 90°) 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.

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

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

<table>
<thead>
<tr>
<th>Modeling Approach</th>
<th>Peak Force (N)</th>
<th>% Difference from Experiment</th>
<th>Displacement at Peak Force (N)</th>
<th>% Difference from Experiment</th>
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<tbody>
<tr>
<td>Experiment</td>
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<td>Anisotropic</td>
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<td>8.31</td>
<td>4%</td>
</tr>
</tbody>
</table>

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

Figure 4: Predictions using Digimat and comparing with other approaches
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Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

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