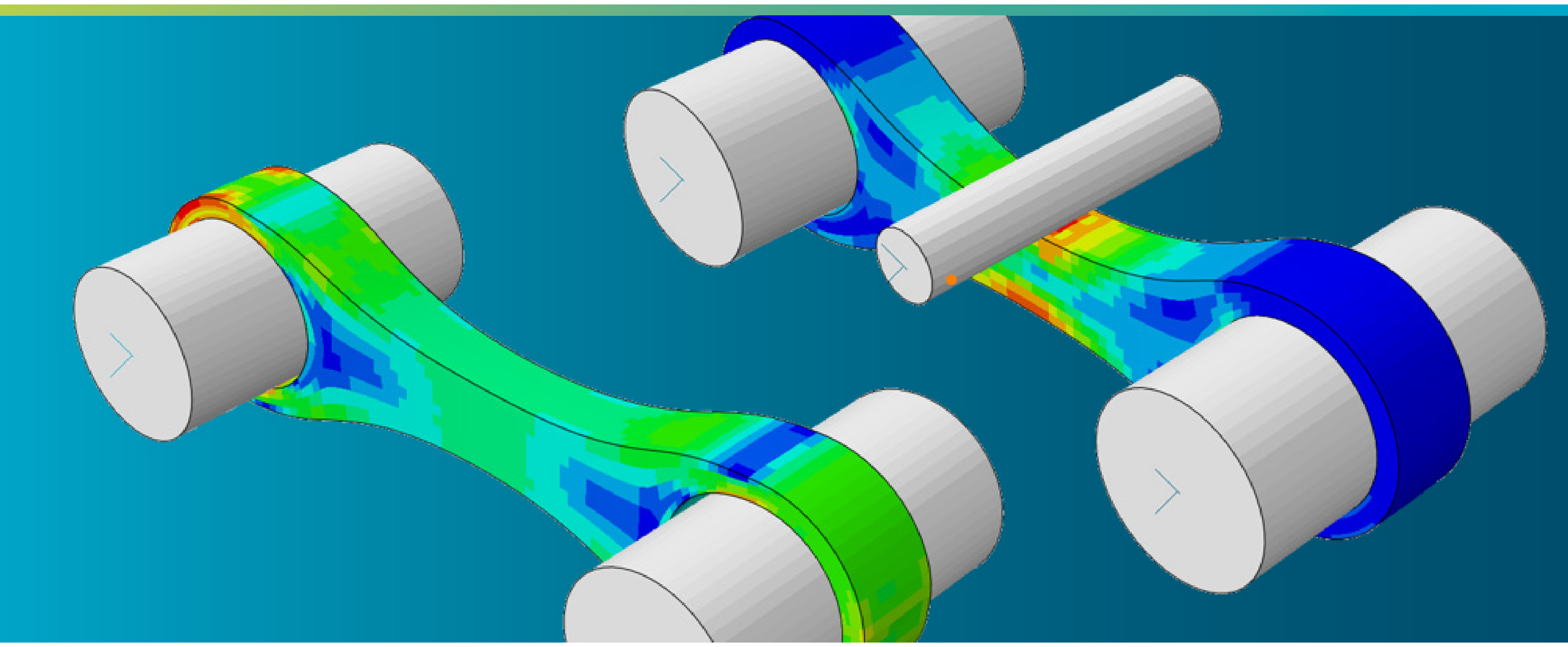
Case study

Advanced simulation captures part performance for fibre reinforced thermoplastics

Comparing the results of isotropic material data to anisotropic material data



Digimat for long fibre reinforced materials

Product engineers and designers face the ongoing challenge of optimising both design and material selection to deliver parts for high-performing applications. Virtual, computer-aided modelling is a critical tool to help predict part performance, streamline design, expedite prototyping and improve manufacturing efficiencies. However, it is complex and requires advanced data to more accurately predict how a material will realistically perform in an end-use application.

Avient Corporation, a premier provider of specialised and sustainable material solutions and services, has invested in testing equipment, personnel, and software to help its customers gain insight into its unique material solutions and how they perform. To enhance its ability to more accurately predict part performance, Avient worked with Hexagon's Digimat platform.

Avient and Hexagon used Digimat to develop anisotropic long fibre material data for a molded connector rod. The aim was to look at two responses – tensile and flexural performance – and compare the results of isotropic modelling, anisotropic modelling and physical sample tests.

Challenge

An isotropic modelling approach employs a single material response and assumes this singular response at every location within a potential part. The resulting tensile test data shown in Figure 1 gives an indication of the variation in material response that can be observed as a function of the fibre orientations. In reality, the material response can fall anywhere between the curves shown in Figure 1. This observed variability in the material response highlights the need for an advanced predictive approach for material modelling that incorporates anisotropic data. This more accurate advanced prediction is achieved through an Integrated Computational Materials Engineering (ICME) approach to give customers the confidence that Avient products will meet their application requirements.

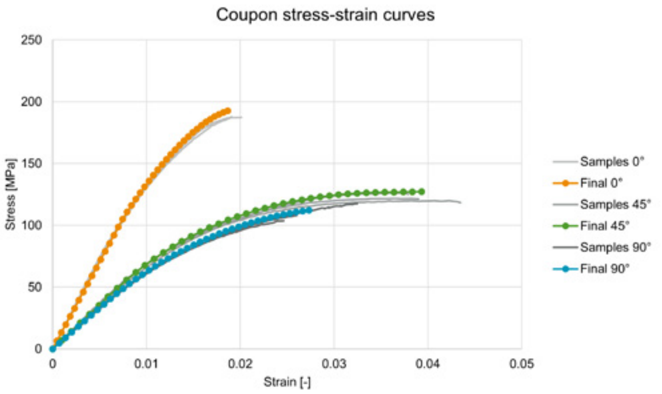


Figure 1: Tensile test data as a function of the fibre orientation 0° (orange), 45° (green), 90° (blue)

Solution

Avient leveraged Digimat to reverse-engineer material data based on the microstructure, tensile test data, and micro-mechanical modelling. Long fibre reinforced materials have an added degree of modelling complexity due to the need to capture the effects of bundling, fibre entanglement and weld lines. The Digimat material cards accurately capture all three of the above phenomena. Once the calibration procedure was complete, Avient applied this Digimat material model to various structural models. All commonly-used finite element analysis (FEA) codes utilise Digimat material models via the workflow outlined in Figure 2.

"By using mold filling simulation and Digimat to evaluate several options, we can account for manufacturing variation when performing long fibre structural analysis. This greatly improves solution resolution and provides a guide for optimising the plastic component and mold tooling design," said Brad Davison, the North America Director of Technology for Specialty Engineered Materials at Avient.

Results & benefits

Avient has applied the Digimat material model to two different load cases, a flexural test and a tensile test. Figure 3 shows the flexural test results with a convincing advantage in terms of stiffness correlation for the Digimat anisotropic modelling approach over the conventional isotropic modelling approach.

In Figure 4, the failure location between the isotropic modelling approach and the Digimat anisotropic modelling approach is identical.

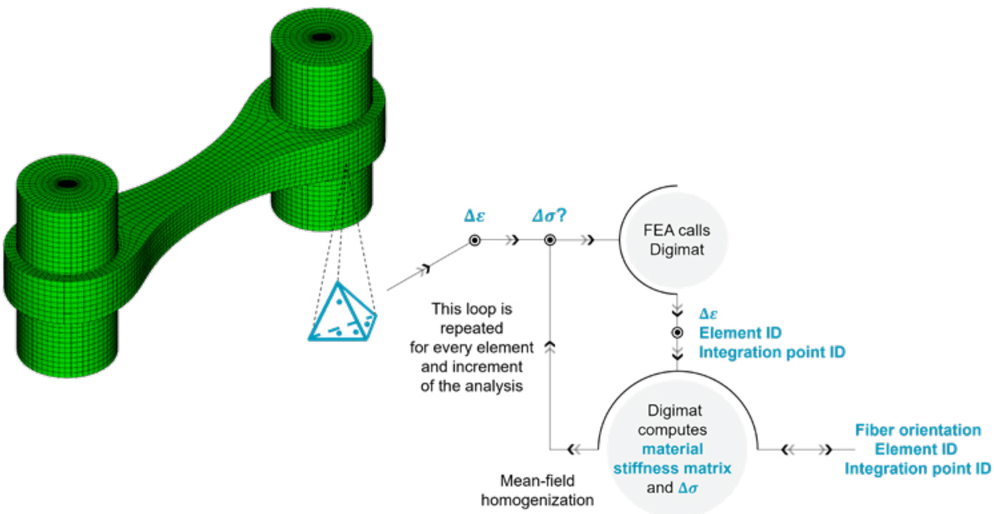


Figure 2: Digimat material model workflow when coupled with an FEA solver

Figure 5 shows the tensile test results with, again, a convincing advantage for the Digimat anisotropic modelling approach against the isotropic modelling approach. Through further investigation of the advanced material modelling results, an opportunity to improve the test model was identified and implemented. The initial tensile test model did not capture a number of elements through unintended movements of the testing assembly, so the FEA model was adjusted to capture the entirety of the test setup. The results of the Digimat anisotropic modelling approach shown in Figure 5 demonstrate a far improved stiffness accuracy compared to previous results.

In Figure 6, the failure locations in the tensile tests are shown for the isotropic and Digimat anisotropic modelling approaches respectively. As opposed to the isotropic approach, the Digimat anisotropic approach correctly captures the experimentally observed failure location.

In addition to providing a robust way to account for differing gate locations from the manufacturing process, Hexagon's Digimat multiscale modelling approach provides significant improvements in the accuracy of the stiffness and failure. Compared to an isotropic modelling approach, Avient obtained realistic predictions with the Digimat anisotropic modelling approach for both the tensile and flexural tests of the connector rod.

This more accurate simulation of the application increases the confidence level of success and greatly reduces development time and cost. If the simulation fails, parameters can be modified – enter a new material, modify the design, augment manufacturing, etc. – to yield the desired results. The case study shows that by utilising the 3D suite simulation and comparing to real-world testing, Avient is equipped to more accurately interpret the data to help solve its customers' toughest application challenges.

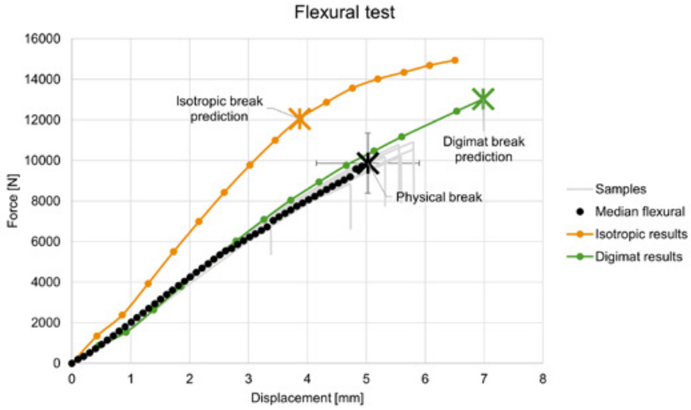


Figure 3: Flexural test results with the isotropic modelling approach (orange) and Digimat anisotropic modelling approach (green)

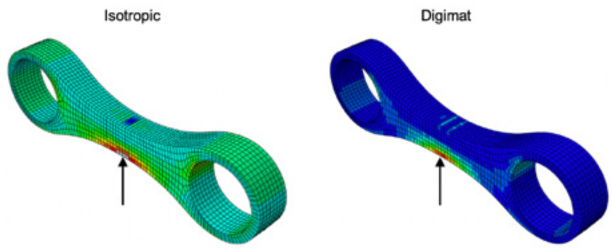


Figure 4: Failure location in the flexural test for the isotropic modelling

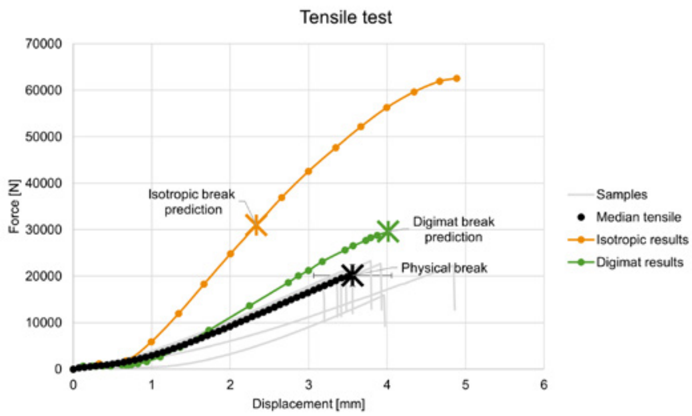


Figure 5: Tensile test results with the isotropic modelling approach (orange) and Digimat anisotropic modelling approach (green)

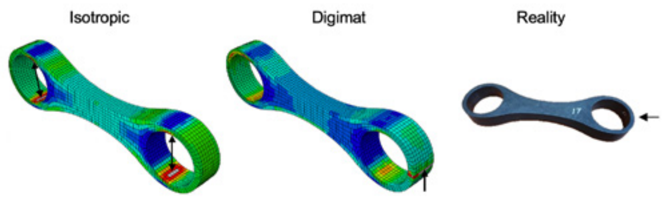


Figure 6: Failure location in the tensile test for the isotropic modelling approach (left), Digimat anisotropic modelling approach (middle) and reality (right)

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Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon's Manufacturing Intelligence division provides solutions that use data from design and engineering, production and metrology to make manufacturing smarter. For more information, visit hexagonmi.com.

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