ICME for post-industrial and post-consumer recycled engineering polymers

RadiciGroup High Performance Polymers

Creating a circular economy requires a multitude of technologies to be adopted and implemented to provide a technologically and economically feasible value chain. RadiciGroup High Performance Polymers has invested in providing mechanically recycled engineering polymers to the market. As developing recycled polymers for high-end applications is a challenge in and of itself, RadiciGroup High Performance Polymers turned to Hexagon's Digimat and Marc to create an advanced predictive approach to provide customers the confidence these sustainable materials will meet their application requirements.

In the European Union's CarE-Service Project, RadiciGroup High Performance Polymers has validated three recycled products. One Post-Industrial Recycled (PIR) grade and two Post-Consumer Recycled (PCR) grades originating from airbag waste and from wheel cover waste. Based on a Life Cycle Assessment the CO_2 reduction of these materials is an astonishing 84% to 88% compared to similar virgin materials. This highlights the importance of recycled engineering materials for a reduced environmental impact.

a b

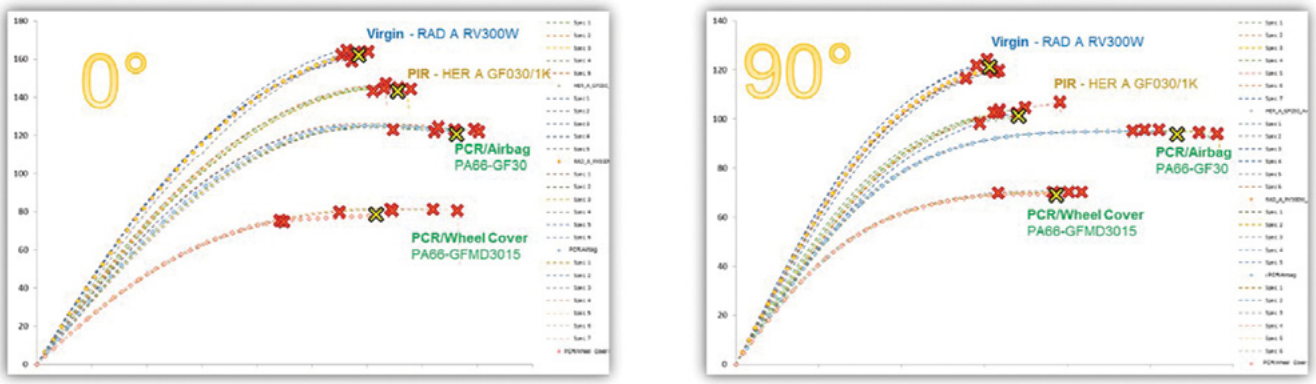

Figure 1: Tensile properties comparison. Observe the material's mechanical performance on the axial direction (a) and transverse direction (b).

Commercialising recycled engineering polymers for high-end applications not only requires a high quality product, winning over the hearts and minds about recycled materials is equally important. An advanced predictive approach will show customers these sustainable products will meet their application requirements. RadiciGroup High Performance Polymers has used Digimat and Marc to reverse-engineer high quality material cards based on the microstructure, tensile test data and micro-mechanical modelling. This material card was validated on a demonstrator part in a 4-point bending (4PB) experiment.

The tensile test data in Figure 01 is an initial indication of the challenge for material development and commercialisation of recycled polyamides 6.6. Here three recycled compounds have been compared to a virgin references, the PIR GF030/1K, the PCR PA6.6-GF30 with end-of-life airbags content, and PCR PA6.6-GFMD3015 with recovered wheel covers percentage. Variation in material performance among the three grades and a virgin material reference shows the performance dependence on the sourced materials.

Digimat, the materials modelling platform, allowed RadiciGroup High Performance Polymers to accurately model the material behaviour of the recycled grades including each specific microstructure. Additional processing steps make the microstructure a critical component in the material behaviour of recycled engineering polymers. Fibre length distributions, affected by grinding and compounding, are accurately captured in the Digimat material cards.

Validating the generated material cards on a demonstrator part (Figure 02-a) in a 4PB test (Figure 02-b) shows a good correlation in failure and in stiffness. The demonstrator part resembles features from typical structural components with ribs and corners causing real-world stress concentrations. Figure 03 indicate an accurate prediction for all three recycled engineering grades.

With a convincing validation, RadiciGroup High Performance Polymers used the PCR grade and the predictive approach in a misuse test for an adjustable desk actuator housing. Comparing the PCR grade with a similar virgin material in a full predictive approach shows the strength of the recycled engineering polymer. In Figure 04 an overview of the predictive approach is

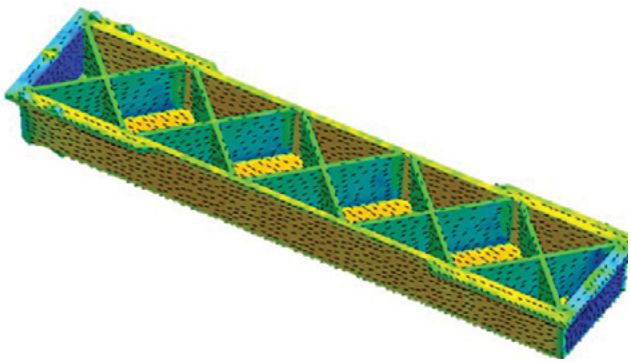

Figure 2-a: Injection-molded demonstrator ribbed beam. The little black arrows indicate the fiber orientation.

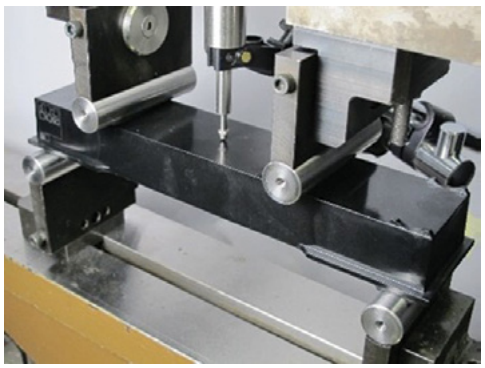

Figure 2-b: Four points bending test set-up (4PB).

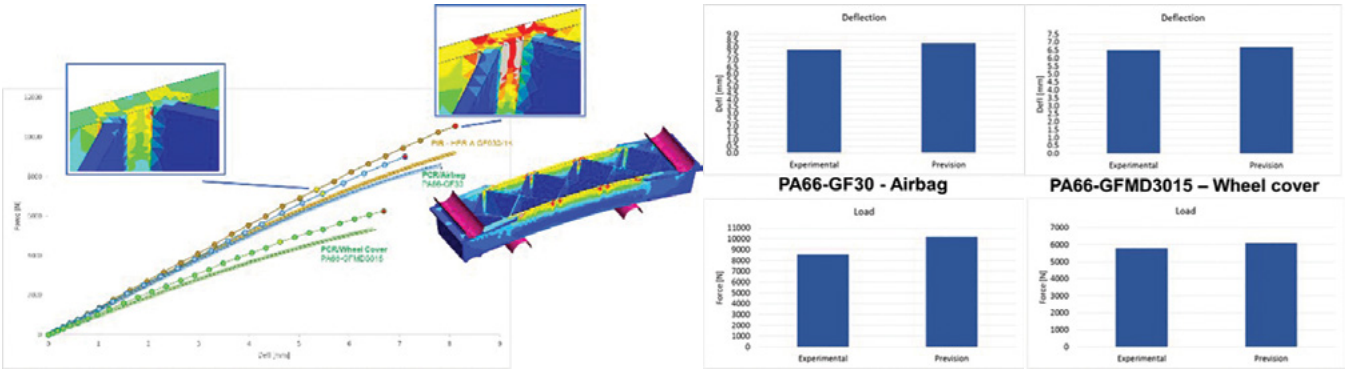

Figure 3: Comparison between experimental test and simulation result performed by Digimat. Flexural test (a) ultimate points (b)

depicted. Combining the adjustable desk actuator model with the fibre orientation distribution in Digimat yield two FEA models that are analysed in MSC Marc. The misuse test for the actuator housing applies a maximum electric motor torque of 6Nm on the housing. The predictive approach shows the PCR grade is able to handle that level of misuse.

An advanced predictive modelling approach has proven to be crucial for introducing recycled engineering polymers in high-end applications. An extensive product development and collaborations through the entire value chain have allowed RadiciGroup High Performance Polymers to prove the suitability of their recycled engineering materials in a structural application delivering an 88% CO_2 reduction and preventing landfilling or downcycling of polymers.

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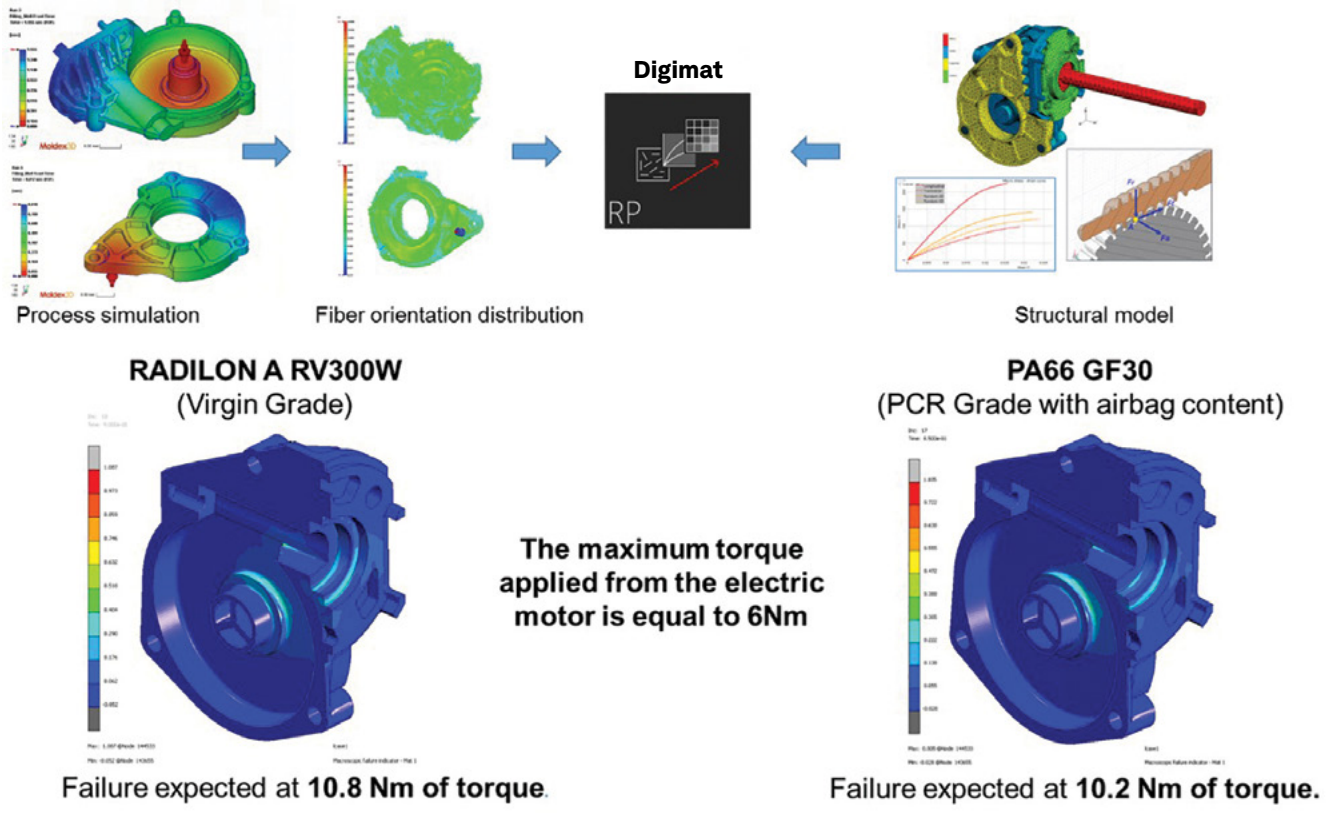

Figure 4: Application case. Desk actuator housing misuse test