Sovitec reduced parts costs by 20% in glass bead based production

Sovitec is a Belgium-based world leader in the production of glass beads for surface finishes, road markings, coatings and engineered plastics. The company was interested in replacing an existing glass fiber reinforcement technology by a solution based on glass beads. Moreover, they wanted the new solution to provide equal or improved material performance while reducing the overall cost of material production. After examining several options, they decided to use the Digimat simulation software suite to model the micro and macro materials of their respective glass products to come up with an optimal solution.

Over the last 20 years virtual material characterization for material engineers (via simulation software tools like Digimat-MF and Digimat-FE) now make it possible to explore - at relatively low cost compared to physical testing - virtually any combination of materials. Virtual compounding can therefore be simulated to identify the best material candidates from such advanced materials. Indeed, multiscale simulations allow users today to perform in-depth studies of both complex and real-world microstructures and thereby permits engineers to deeply understand their material's behavior to help identify their driving performance parameters. Hence, modern simulation software tools allow engineers to go beyond virtual characterization to do true optimization of behavior. This provides design and manufacturing opportunities never before accessible and thus leads to the ability to create innovative new products and processes.

Advanced materials such as plastics, composites, hard metals, rubber and nano-composites are being continuously challenged to yield improved performance or more integrated multi-functionality in industries like aerospace & defense, automotive, medical, electronics and oil & gas. Such materials are usually engineered as multi-phase materials and they manifest a huge challenge for material engineers despite the extremely high level of possibility and complexity offered by such materials when compared to their beneficial properties. Unfortunately, they typically show non-conventional behavior (non-linearity, anisotropy, process dependency) which can become very expensive to characterize and control in a manufacturing process. Hence, the need to predictively model their performance before committing to expensive tooling.

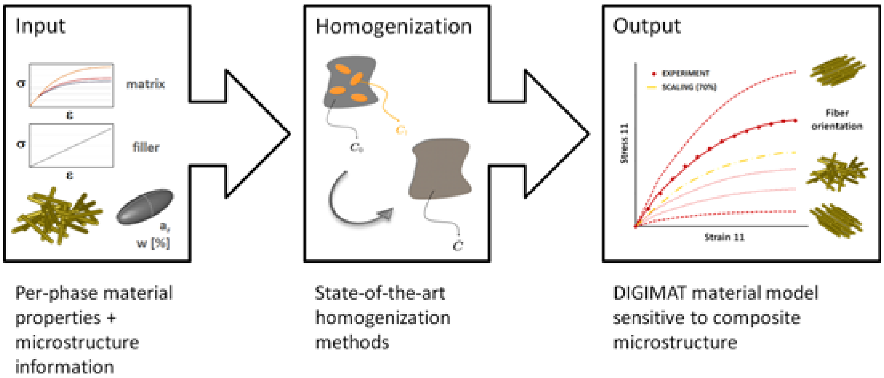

Figure 1 : Homogenization workflow in simulation software (Digimat)

Effective simulation of multi-phase materials resides in micromechanics

Micromechanics is the science of describing a material across several true scales. Materials can be described as a combination of several phases organized following a given microstructure. As a result, material behavior can be directly modeled as a function of the underlying microstructure. Material Engineering requires two complementary technologies:

- Mean-field homogenization
- Finite element-based homogenization

Coupling both homogenization technologies allows for the prediction of macroscopic material responses based on the description of a material's microscopic behavior (see Figure 1).

Mean field homogenization (in this case with Digimat-MF) uses an analytical approach to compute a material's response (see Figure 2). Hence, computer simulation is a highly efficient solution to performing material screening or predicting the effect of microstructure on a non-linear material's behavior. This simulation approach is typically applied to characterizing the behavior of short fiber reinforced plastics for a wide range of orientation states from fully aligned to completely randomly aligned fibers.

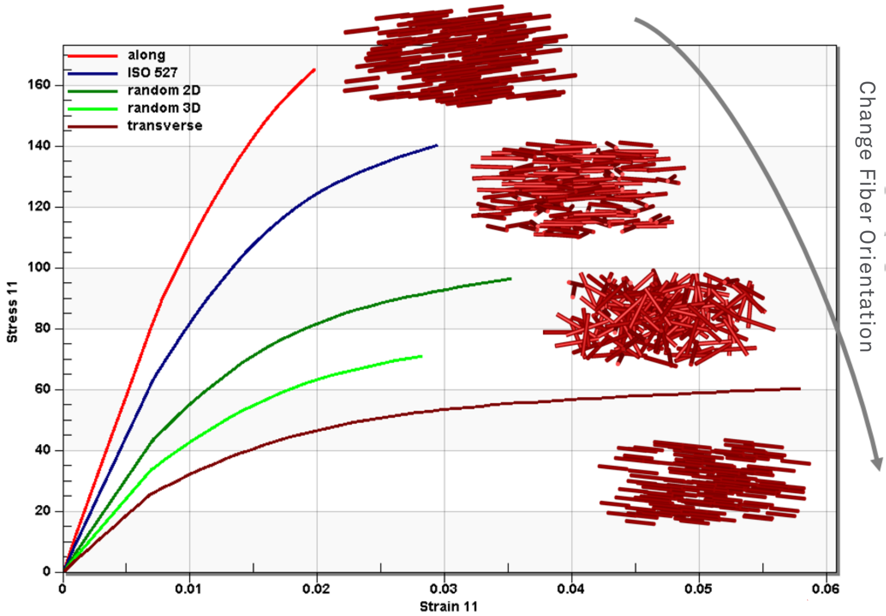

Figure 2 : Influence of fiber orientation on SFRP non-linear behavior obtained by mean-field homogenization

Another requirement in the simulation of advanced materials is an end-to-end simulation tool for multi-phase material simulation (such as Digimat-FE). Based on material inputs and a microstructure definition, a finite element model can be built and run in Digimat-FE. The results of the finite element analysis simulation can then be post-processed in the form of probabilistic distribution functions that give detailed insight into the Representative Volume Element (RVE). Mean homogenized values can then be computed and used in subsequent FE analysis at a macroscale structural part level for instance (Figure 3).

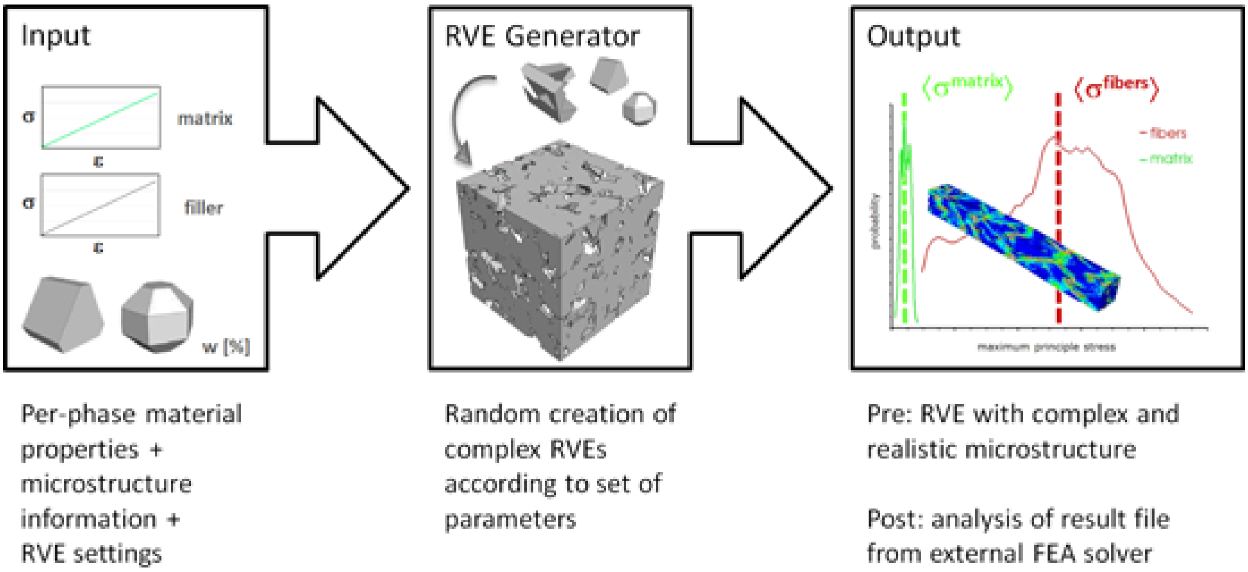

Figure 3 : Finite element-based homogenization workflow

Simulation of glass beads to replace glass fibers at Sovitec

The Digimat software simulations that Sovitec needed to carry out in this case were first calibrated based on experimental data for two different reinforcement configurations: PA6 polymer reinforced with a 30% weight fraction of glass fibers, and 30% weight fraction of glass beads. Based on these two material models, virtual material compounding was executed in Digimat-MF to find possible new mixtures. Once promising candidates were identified, multiple in-depth micro-level simulation investigations were performed with Digimat-FE (Figure 4).

The most optimized reinforcement material solution Sovitec found was a combination of 15% glass fibers and 15% glass beads. Material benefits they discovered included an identical stiffness as the full fiber solution, an isotropization of thermal properties thanks to the glass beads, as well as an improvement of failure strength due to reduced fiber stress levels. Once the new virtually engineered material was introduced to the market by Sovitec it led to important cost savings because of a 20% lower price per produced part, a 29% reduction in cycle time per part, and an improvement in machine durability.

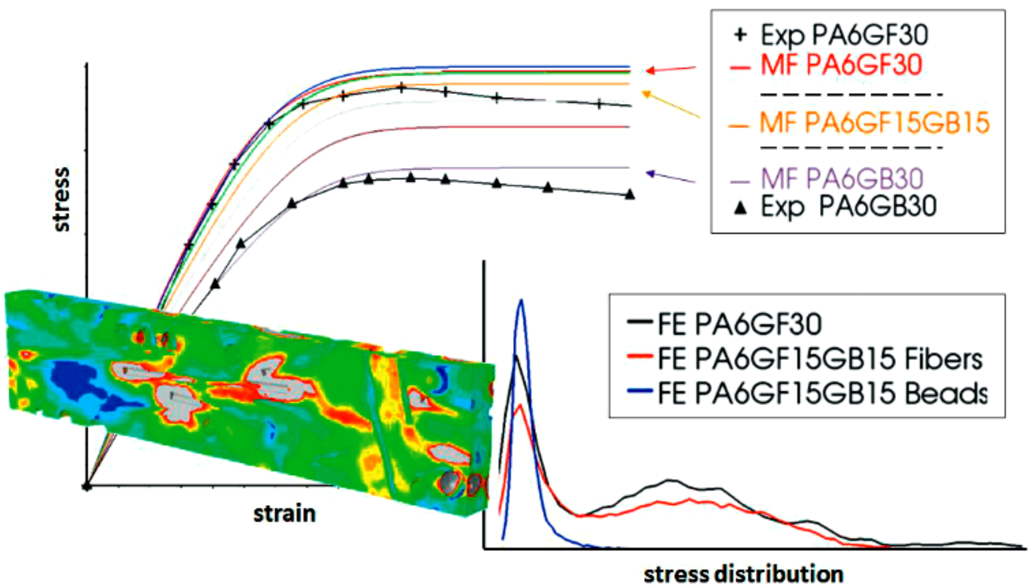

Figure 4 : In-depth investigation of new material compounding