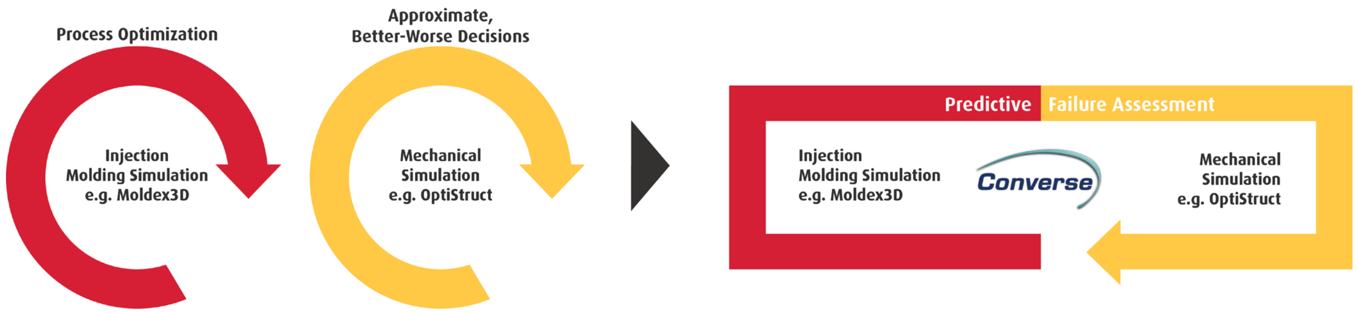
One Source Solution for Short -Fiber Reinforced Materials in FEA

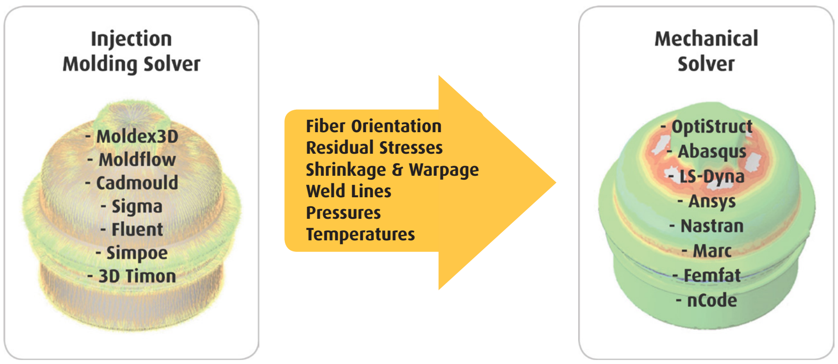


With use of today's technology, FE simulation of the injection molding process is state of the art. Several unique solvers are available for this purpose. These solvers are able to provide the data required for subsequent structural analysis (e.g. pressures, temperatures, local fiber orientation, etc.). However, an appropriate coupling between the injection molding simulation and the mechanical simulation is required.

Due to the large quantity of data that is processed in a regular FE analysis, it is obvious that such a coupling process can only be realized with an appropriate software tool. There are several requirements the coupling tool must fulfill in order to be applicable in a real-world simulation environment. The requirements include the following capabilities:

- Map between different mesh types and topologies
- Import results from regular injection molding solver result files
- Export required data for mechanical analysis in solver-specific format
- Provide all required material cards (e.g. for anisotropic analyses)

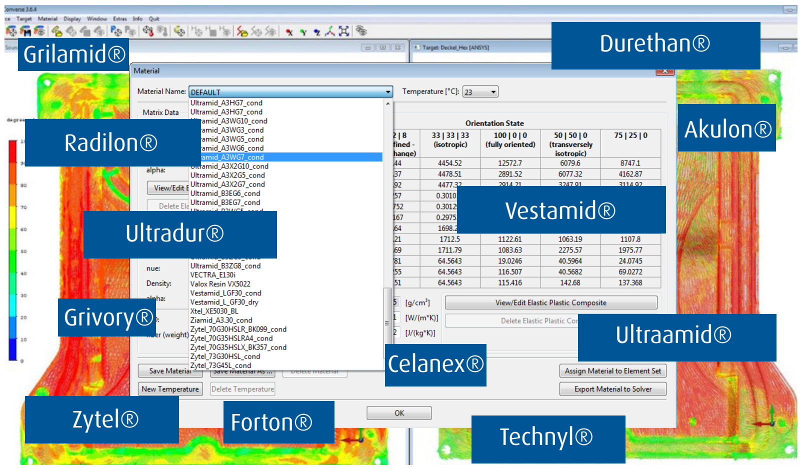
The injection molding process causes a local anisotropic material behavior within the part caused by the flow processes in the mold. The orientation varies both in different locations throughout the part and across the wall thickness. With this information, additional stiffness and strength assessments can be conducted.



The following procedure shows that incorporating a process structure interaction within the simulation scheme can lead to more realistic results when compared with traditional approaches. In particular, the consideration of a process structure interaction provides superior results for mechanical part properties. This is especially true for short-fiber-reinforced parts where the molding process induces a strong anisotropy. The coupling also opens extended possibilities for the part and mold design since process-induced loads onto the mold or the part itself can be analyzed with respect to the mold or part performance.

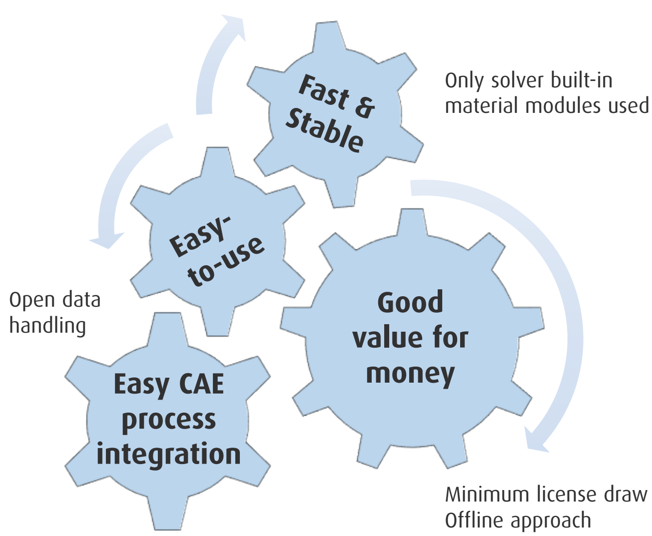
Altair's HyperWorks suite combined with the Altair Partner Alliance's (APA) extensive software offering make it easy for any company to integrate such an approach into their simulation practices. The APA provides access to injection molding software, Moldex3D by CoreTech System Co., Ltd., for creating the fiber orientation result necessary for transfer to the structural solver.

To map these results to a structural solver model such as OptiStruct, a software tool is needed that can provide the required anisotropic material properties in a ready-to-use format. CONVERSE by PART Engineering provides this function among others and is available via the APA.



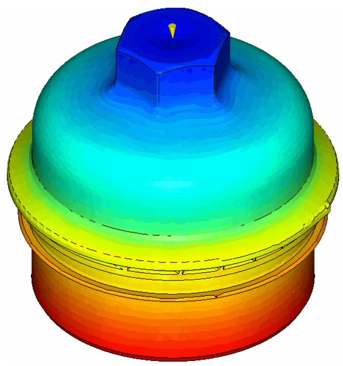
To easily integrate this advanced workflow into engineers' daily process, the software must be quick and intuitive, especially for individual work steps that do not need to be done every day. A material database that provides realistic material properties for the simulation should also be included.

A smooth integration demands a minimum amount of additional time for the development cycle. All new information is exported by CONVERSE in solver specific syntax commands. Therefore, the data is accessible, readable, able to be used for an unlimited amount of time and allows for a stable multi-processor simulation that runs as fast as possible. This process does not require CONVERSE to be running during simulation, it can be closed after all required data is exported.

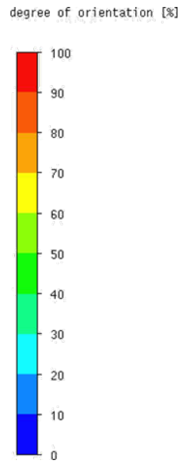


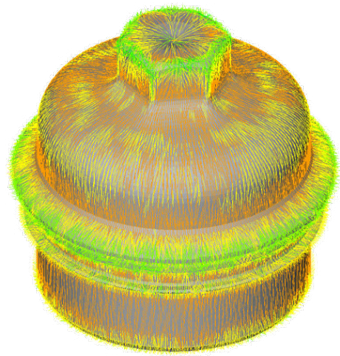
An example of a successful application of this process is shown below. The injection molding simulation results are easily mapped to the OptiStruct analysis model. Instead of an isotropic material, each element has a unique material and material orientation. The fiber-orientation is shown in the image below.

Example: Oil Filter Cover

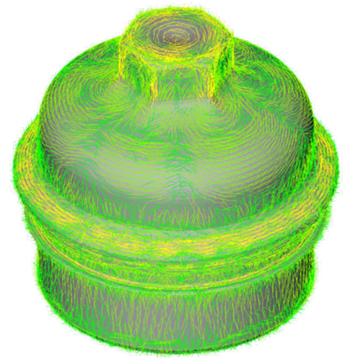


Injection Molding Animation





Shear Layer



Mid Layer

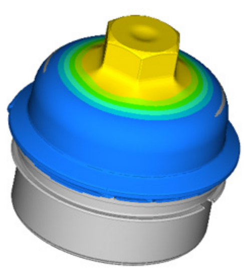
Three different analyses are performed with two models and the results are compared. One model with the isotropic material and a second model with the mapped orthotropic material distribution.

1. Linear Static
2. Modal Analysis
3. Frequency Response Analysis

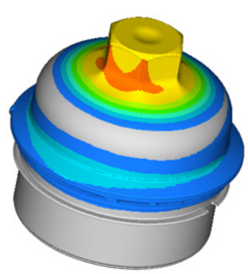
The differences in the results are shown in the following images.

Comparison of stresses under pressure:

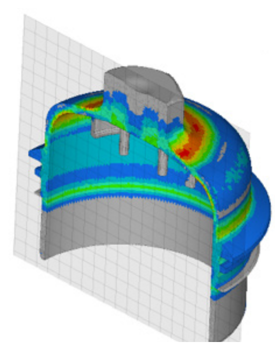
ISOTROPIC



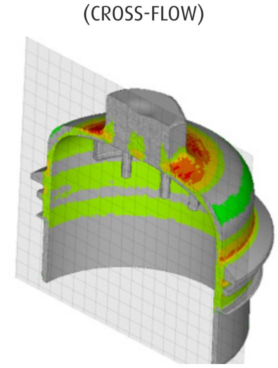
ORTHOTROPIC



ISOTROPIC: VON-MISES



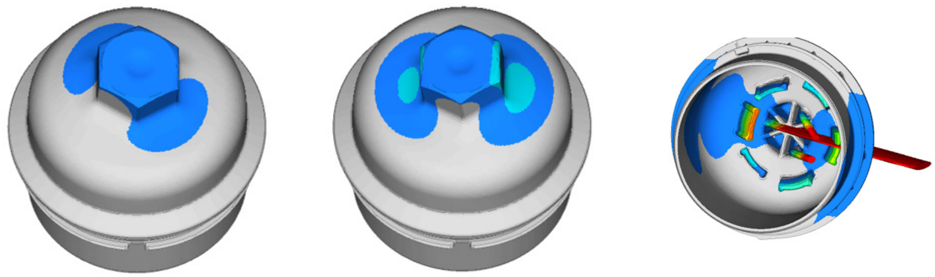
ORTHOTROPIC: MID Principal Stress (CROSS-FLOW)



The anisotropy of the material shows a high influence on the displacement and stress distribution

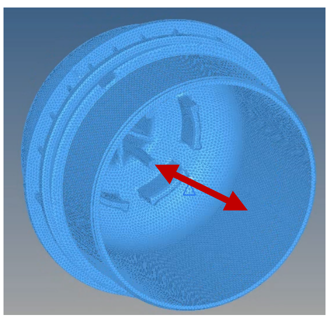
MAC Correlation:

MODE 2 | MODE 3 | MODE 9 | MODE 5

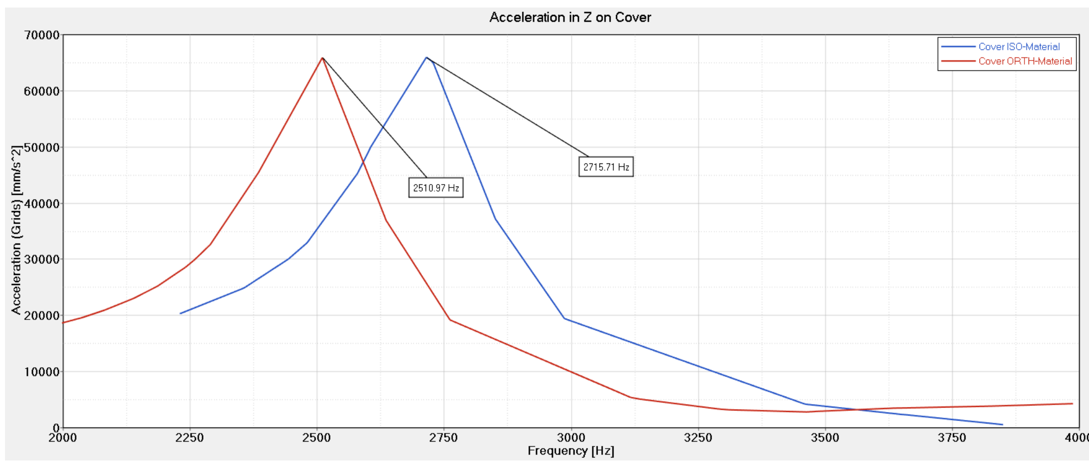


Comparison of different eigenmodes via MAC-Matrix and shape visualization - High influence of the anisotropic material distribution

Comparison: Frequency Response Analysis



unit excitation (acceleration) in z-direction over frequencies



The different modal basis has a large influence on the dynamic response of the component

The described workflow, using CONVERSE to map the results of the injection molding simulation on to the structural solver (e.g. OptiStruct) is highly efficient and allows for the results of the simulation to be improved during daily work.

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