

User-Friendly Data-Exchange in the Digital Engineering

Part 6 of the Series: How a Web-Based Interface Supports Data-Handling

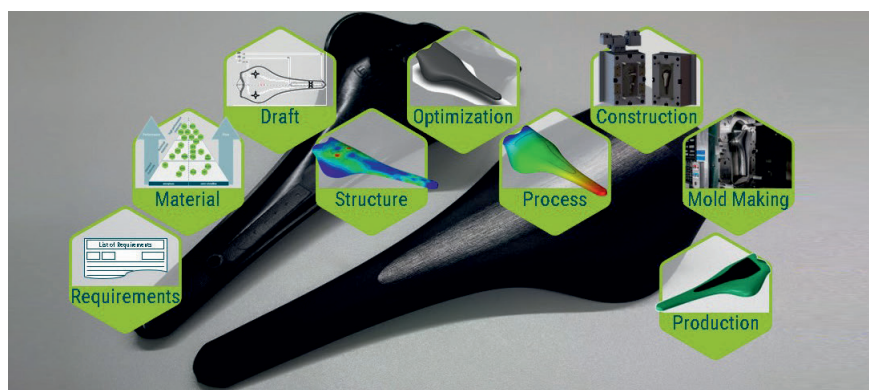
Digital engineering encompasses the complete development chain of a product, from quality requirements to the design of the product and mold, to process simulation and design. The multitude of software applications often requires the handling of information in different data formats. It is not uncommon for information to be lost in the process, which is why PIC 4.0 is researching methods for implementing continuous simulation chains.

In digital engineering, the properties of a product to be developed are simulated and digitally optimized by a digital but physically adequate representation, taking into account the manufacturing process. The consistent use of digital methods and corresponding software (CAx) increases the planning quality along the entire product development and production process [1].

Due to the complex planning and calculation methods in the respective stages of product development (**Title figure**), many software applications are used. On the one hand, the applications are specialized in the simulation at the respective stage and therefore process specifically provided information. On the other hand, the users are also often specially trained in the use of these programs and their evaluation. As a result, data handling across different formats and planning stages – especially in case of iteration loops across domain boundaries – is often challenging.

Loss of Information by Software Combination

One use case is the linking of a computational fluid dynamics (CFD) simulation with structural simulation (**Fig. 1**). Simulation programs specialized in injection molding use STEP files (*.stp, *.step), stereolithography files (*.stl) or a variety of other geometry data in their own and further established formats to generate a calculation mesh suitable for the simulation case. They



Stages of an exemplary product development process for a load-balanced saddle equipped with different tapes © IKV

determine the expected temperature and pressure distribution, provide a filling pattern including the expected defect features (e.g. weld lines) and calculate properties such as shrinkage, warpage, fiber orientation and residual stresses.

The mesh of structure simulation, on the other hand, can be generated differently in terms of shape and granularity of the elements. In order to make comparisons, the meshes must be mapped to each other, e.g. the nodes and edges of the rigid calculation mesh of a filling simulation must be assigned to the more flexible meshes of a structure simulation in order to consider a mechanical load. A loss of information occurs if interpolation is necessary between nodes of one and another mesh, e.g. due to deviating granularity.

Even when mapping between selected programs and formats using com-

mercially available interface programs, information about the granularity of the output mesh is often lost after interpolation or after rounding of edge lengths in the output mesh. Here, it is necessary to keep track of the output mesh as well as basic mesh information such as the size, order and shape of the elements and the structure of a mesh at the respective stage of development.

Development of a User Interface to Facilitate Data Handling

One solution for a user-friendly data handling is a web-based user interface newly developed as part of the Plastics Innovation Center 4.0 (PIC 4.0) research project. It accesses a database with available simulation files and provides insight into how calculation meshes change in the

product development process. In addition, it supports simulation and production processes by generating test plans and automatable optimization routines directly from the application.

For the targeted development of the user interface, a specific use case is considered in which a product for optical applications is to be designed according to defined requirements [3]. This concerns the material selection and the product geometry as well as the manufacturing process. The high requirements on the thermo-optical design of lenses often require a complex development process involving many iterations. Even if the first products have already been produced, the mold geometry often still has to be digitally measured and adapted accordingly. In addition to process simulation in software applications such as Moldex3D, the project focuses also on structure simulation using Ansys or Abaqus to design the optical properties.

From Uploading Geometry Files to Finally Export Machine Settings

The web-based user interface developed in the JavaScript web framework Vue.js (Fig. 2) simplifies the setup of an injection molding simulation in a selected application. It also supports the optimization of setting parameters through the automated evaluation of simulated design of experiments (DoE). The web application guides the operator from the initial upload of several geometry files for part, sprue and cooling channel layout through the entire development process to the export of a machine settings of a desired target machine (module area).

Available models and target applications are displayed in the project preview so that the dataset can be obtained directly via the user interface (simulation setup download simulation). If a corresponding dataset is not yet available for the requested simulation software, it can be generated via the interface (simulation setup create simulation). Some basic information about the available datasets is displayed directly in the preview area (part information).

To set up a new simulation project, corresponding files are first uploaded to the user interface via the geometry import and assembled into a simulation


project for the target application. For this purpose, the individual geometry data for the component, cooling channel layout or sensor positions are combined in a project file suitable for the target application. After the gathered master data for the simulation project as well as the mesh information have been transferred or manually adapted, the project and geometry files are stored in the object database MinIO of MinIO Inc. (USA). Thereby, they are available for further processing of the parameter and structure optimization in the geometry module of the web application.

Optimization of Quality Models and Neural Networks


As soon as the geometry data is available, a trial plan can be generated via the DoE-module in order to determine and analyze the effects of relevant parameter variations by simulation. For this purpose, the user interface generates a trial plan in the background based on the desired factor combination and simultaneously triggers simulation tasks for the respective trial points. These are sent directly to the selected simulation program via the in- »

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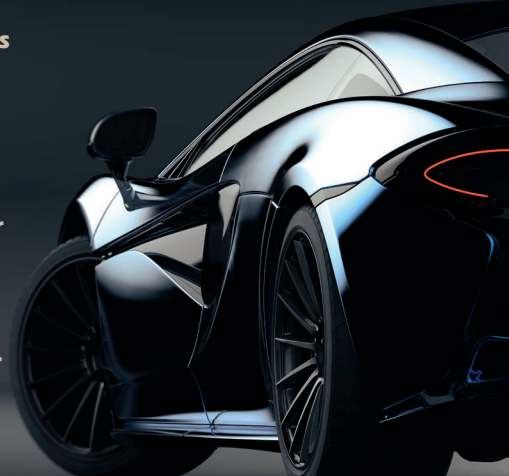
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The Authors

Univ.-Prof. Dr.-Ing. Christian Hopmann

has held the Chair of Plastics Processing as Head of the Institute for Plastics Processing (IVK) in Industry and Craft at RWTH Aachen University, Germany, since 2011.

Pascal Bibow, M.Sc. RWTH, has been working since September 2016 on intelligent production systems at IKV. Since January 2020, he has been managing director of the Plastics Innovation Center 4.0; pascal.bibow@ikv.rwth-aachen.de

Ben Liu, M.Sc. RWTH, has been working since April 2019 on automated data exchange for targeted analysis with respect to Digital Engineering in injection molding.

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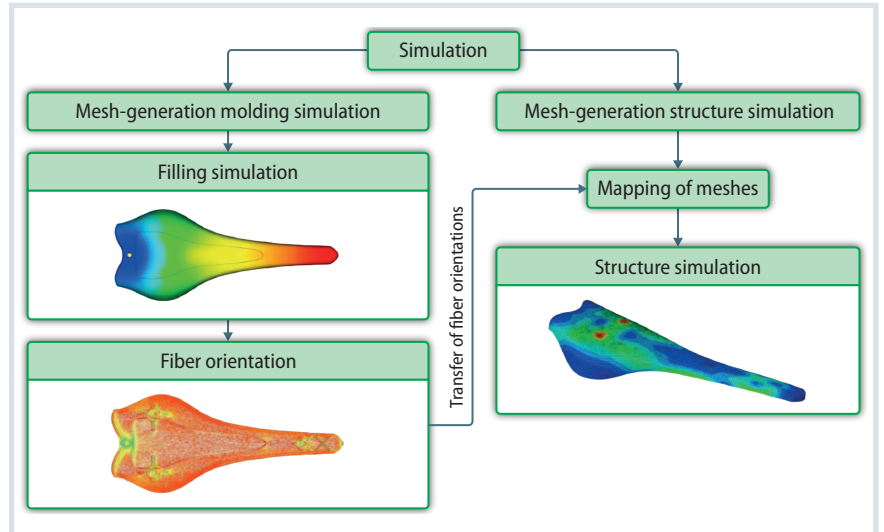


Fig. 1. Linking CFD and structure simulation to get an ideal product design [2]

Source: IKV; graphic: © Hanser

interface to set up and start simulation of trial points independently of the target application in the user interface.

The corresponding module enables the optimization of the setting parameters and generation of machine-settings on the basis of the simulated test

plans. On the one hand, optimization based on quality and process models from statistical analysis is planned, and on the other hand, data-based optimization, e.g. with the aid of neural networks.

In the module for geometry optimization, the automatable iteration of

File name	software	Operations
PiCase_Artikel.mfe	molDEX3d 2020	preview select
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Zentrierrippe_Artikel.mfe	molDEX3d 2020	preview select
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Fig. 2. The web-based user interface supports initializing an injection molding process simulation independent from the target application

Source: IKV; graphic: © Hanser

the process and structure simulation is carried out up to the simulated ideal of the component geometry. Each iteration includes both the necessary mapping of the calculation meshes to each other and the storage of the meshes with the relevant mesh information. This ensures that changes in the calculation mesh can be tracked by the mapping and that it is possible to jump to any point in the iteration. The final geometry as well as the recommended process settings are conclusively displayed in the module.

Data Standards Enhance Individual Workarounds

The web-based user interface is already capable to connect to the Moldex3D simulation environment. Simulation projects can thus also be created and initiated outside the actual simulation application. Due to the modular character of the user interface, the implemented methods can also be individually further

developed and reused, for example to send parameter combinations of a simulated test plan directly as an order to the injection molding machine.

In the following, the PIC 4.0 also focuses on the integration of the potential data standard VMAP, which was developed by industry representatives along the value chain in a research project "Virtual Material Modeling in Manufacturing" completed in 2020 [4, 5]. It is intended to facilitate the consistent exchange of information between applications in digital engineering and thereby further increase the functionality of the user interface. Thereby, information about the calculation mesh might automatically be extracted by the presented user interface without the necessity of application-specific formats or converters. At the same time, a unified data format like VMAP might support automation of a quality-oriented data exchange and comparison between models in digital engineering and high-frequent data from real production processes. ■

The Series Continues

In the following article, the authors report about digital shadows from setting up and testing initial PIC 4.0 Testbeds, as well as their storing and processing by smart agents. It will be published in one of the next issues. The previous part has been published in issue 5/2021.

➤ www.ikv-aachen.de/forschung/efre-pic-40/

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