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A Virtual Seating Trial

Performing Simulation in Parallel with Design Reduced the Development Time of the Metrik Chair

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The Metrik cantilever chair has a sculptural form, which, with varying material thicknesses, polygonal surfaces and rounded edges, is reminiscent of modern transportation design (© Wilkhahn)

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Performing Simulation in Parallel with Design Reduced the Development Time of the Metrik Chair

An integrated approach to simulation and design has a long tradition at BASF. The cooperation with the office furniture manufacturer Wilkhahn shows, with the example of the Metrik cantilever chair, how designers and engineers work together efficiently. This offering will be further extended in the future.

Design and strength are two criteria that often place different requirements on the material properties. In the manufacture of chairs, however, these two aspects play an especially crucial role. The results from the simulation play a key role in harmonizing these different requirements, and finding the right plastic. The chair manufacturer Wilkhahn worked with BASF SE, Ludwigshafen Germany, to develop the Metrik cantilever chair (**Title figure**). After only one and a half years' development time, the chair could be brought to market.

Solving Conflicting Goals in Material Selection

The surface structure of the chair is extremely important in meeting the manufacturer's high standards on the optical appearance. From the start, therefore, the designers held discussions with the technical development department and the material experts at the BASF designfabrik about the first suitable plastic grades, making use of their extensive material library. Professional advice in choosing a suitable material was just as crucial as accurate simulation and computation of the mechanical behavior of the thermoplastics. It can be used to fulfill the requirements on the design, material and strength. Because of the high costs of the required injection molds, it was essential to perform an accurate examination of the feasibility of manufacturing. In the specific example of Metrik, the chief priority was to choose a suitable material from the BASF portfolio of surface-modified polyamides developed especially for the furniture industry. In glass fiber-reinforced plastics, the glass fibers may be visible on the surface, which is particularly undesirable in the case of design objects. To meet the mechanical requirements, however, glass fiber-reinforced materials must be used. The engineering polymer Ultramid SI (SI = surface improved) combines good surface properties with high mechanical strength (**Table 1**). Because of contradictory demands on the mechanical properties of the different components, in particular on the stiffness, experts from the designfabrik and the BASF technical development created the Ultramid SI portfolio. The selection of material grades with different glass-fiber contents permitted an individual balance of mechanical and optical properties.

For the cantilever chair, the material Ultramid B3EG6 SI, with a glass fiber content of 30 %, was first chosen for its good mechanical properties.

Fig. 1. The simulation tool shows the glass fiber orientation expected in the part. The red-marked areas have a high degree of unidirectional orientation, blue shows a low degree of unidirectional orientation (© BASF)

Simulating Mechanical Properties

In the next step, a mechanical feasibility study was carried out with the aid of the Ultrasim simulation tool. The aim was to test, as rapid and in a detailed way as possible, whether the chair meets the requirements of the BIFMA X5.1-2011 standard. A force introduced via a plunger tests the backrest load on the available geometry. The test load, which is applied to the component via the pressure plate, corresponds to the 1112 N standard. The simulation takes into account the entire test rig, from the pressure plate as far as the underframe. Since only the overall kinematics is of importance in this test, areas that can be regarded as uncritical are represented in simplified form in order to shorten the computation. In the case of the cantilever, this meant modifying the geometry in the transition to the underframe. Since the gating design has not yet been specified at this early stage, a simplified material model that does not take into account the glass fiber orientation is sufficient for the first computation. This feasibility study, based on the first simulations, gave a positive result. It showed that the general chair concept can be realized and forms a good basis for its further development.

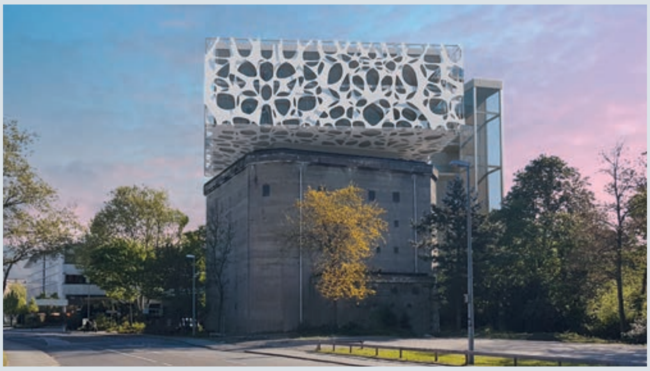
Ultramid B3EG4 SI	20 % glass fibers
Ultramid B3EG6 SI	30 % glass fibers
Ultramid B3EG8 SI	40 % glass fibers
Ultramid B3EG10 SI	50 % glass fibers
Ultramid B3U40G4 SI	Flame retardant, 20 % glass fibers

Table 1. Ultramid SI grades combine good surface properties together with high mechanical strength (source: BASF)

New Creation Center Bundles Expertise

The new BASF Creation Center, which is planned to open in mid-2019, bundles the expertise of the designfabrik, simulation and trend research. A former air raid bunker in front of the factory gates of the BASF Ludwigshafen site will be extended with modern architecture for this purpose. Further BASF Creation Centers are being created at sites in Shanghai, China, Tokyo, Japan, and Wyandotte, MI/USA.

The Creation Center is intended as a key module for supporting future plastics customers. The core of the new concept is the link-up of the real material world with the new possibilities opened by the virtual representation of their properties. Visual 3D tools, such as the HoloLens mixed reality glasses contribute to a better common understanding of material properties and application requirements. The customer can view the complex geometries of a part in the actual environment. This can reduce the time from the first idea to market launch.



The past meets the future: a former air raid bunker at the BASF factory perimeter in Ludwigshafen, Germany, becomes the new home of the Creation Center (© BASF)

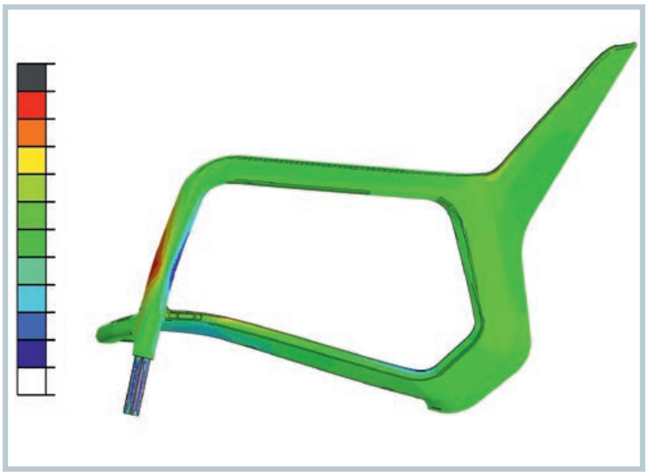


Fig. 2. The chair is deformed under a defined test load. The principal stresses here are the tensile loading (red) and compressive stress (blue) (© BASF)

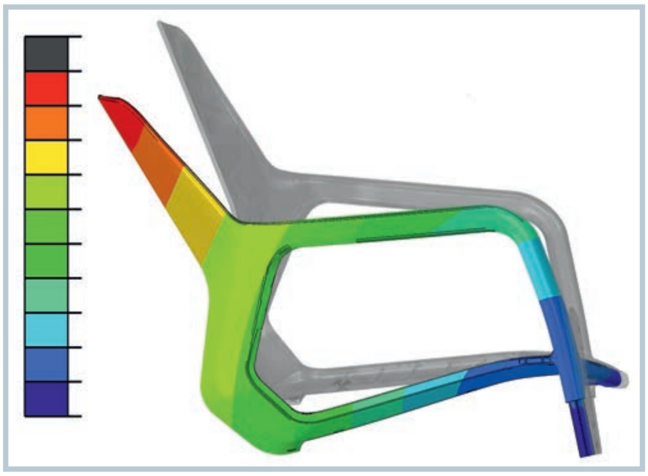


Fig. 3. The simultated deformation of the seat pan under service load (red: high deformation, blue: low deformation (© BASF)

Modified Geometry and Overall Concept

Based on the results of the feasibility study, the geometry was modified, and a gating concept was subsequently developed. Consequently, the manufacturer decided to continue the development using the Ultramid B3EG4 SI grade with only 20% glass fiber content. With this material, the two key requirements on strength and stiffness could be fulfilled. The anisotropic fiber distribution resulting from the injection molding process has a crucial effect on the mechanical properties. The anisotropy must therefore be correctly taken into account in order to obtain reliable mechanical simulation results for the material (**Fig. 1**). Based on this information, it was possible to work out a gating concept. The process simulation allowed the local glass fiber orientation in the part to be determined. The weld lines occurring during injection molding are especially important. Due to the anomalous orientation of the glass fibers at the end of the flow path, the surface is locally influenced, which, particularly in the case of furniture articles, has a significant influence on the appearance of the chair. Furthermore, the weld line can also exert a negative local influence on the strength of the part, which is also taken into account in the mechanical simulation. In addition, other effects that are essential for the surface quality were also considered, for example uniform flow velocities at the surface, which give an indication of marks that can be expected, or the holding pressure supply, which is relevant for sink marks.

The mechanical simulation was performed with both service and test loads, and, according to the standard, the part must not fail under the test load (**Fig. 2**). As in the feasibility study, here, too, the load is applied to the part via a pressure plate. Deformation (stiffness), material stress and any critical regions (strength) are modeled by means of the Ultrasim failure value. It was found that all the regions were dimensioned according to requirements.

Overall, the simulation showed that the seat frame withstands the required backrest load and, under service load, the deformations, at 115 mm, lay within the desired range (**Fig. 3**). In addition, the weld lines were not located in highly loaded regions, and could therefore be regarded as uncritical from a mechanical point of view.

Summary

The simulation with Ultrasim can predict whether the chair withstands the planned loads and whether precise statements about the load-bearing strength and deformation apply. In addition, the simulation software provided valuable indications of the surface quality – an aspect that plays a major role in the design. Thanks to the process simulation, statements about the size of the injection molding machine could be made in advance. The example of part development of a new design chair shows how closely design and part simulation go hand in hand. ■

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Service

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