Take a Seat – Simulation of PU Foam Expansion During Injection Molding of Car Seats

Car seats have a complex structure: frames, load-bearing structures, heating systems, back and seat cushions. The latter are composed of polyurethane foams (PU foam) – often in different degrees of hardness. The ITWM tool FOAM simulates the expansion process during the production of such PU foams – in arbitrary geometries and provides the possibility to digitally calculate foam formation and foam density in advance.

Optimal foaming as a complex process

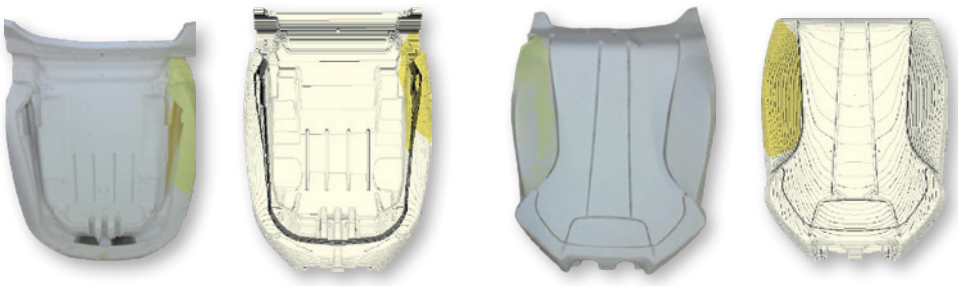
Simulation enables prediction: How does foam spread?

The process is divided into the following steps: First, the material is injected into an open mold, during which the foam already starts to expand. Then the mold is closed and the foam continues to expand until it fills the entire cavity. It is also possible to influence the flow of the foam by tilting the mold in a certain direction. Injection paths, inclination of the mold as well as the amount of material are all important for the injection phase in order to obtain a uniform foam density at the end of the process.

It should also be noted that carbon dioxide is released during foaming. This excess gas is usually removed from the mold by vents. Here again, the arrangement of the vents is important, as incorrect placement can lead to gas bubbles or large cavities. We take all these aspects of the process into account in the simulation with our FOAM tool.

Project objective and collaboration: From experiment to simulation

The objective of the project between Fehrer Automotive, Audi and our institute is to validate these strengths of FOAM. Our main focus was on predicting the expansion of PU foam – also in a real car seat geometry. The latter was provided by Audi, while Fehrer Automotive was responsible for conducting the experiments. At the start of the project, the team selected two foam systems and conducted simplified foam expansion tests for each system supplied by Fehrer. These provided information on the volumetric expansion over time as well as the development of the foam temperature. A specific amount of foam material was injected into a cylindrical tube. The foam height during expansion was measured at the centerline and the foam temperature was measured at the sensor position five centimeters from the bottom. This data served as the basis for the identification step of the input parameters of the FOAM model. On this basis,



FOAM

The simulations (each on the right) show the very good qualitative match with the experiments with regard to the position of a pouring path (yellow) in top/bottom view

“The ITWM has a unique competence in the virtual representation of complex physical processes, from physical and mathematical modeling to efficient numerical computer-aided computation. The cooperation with ITWM is always pleasant and straightforward.”

Dr.-Ing. Johannes Spahn
Audi AG

we calibrated the input data of the model to match the experiments.

After successful model calibration, validation tests were performed in a box geometry under different configurations. In all cases, a certain amount of material was injected into the open box. After injection, the mold was closed with a transparent lid and the foam expansion was filmed with a camera. In this way, the development of the foam front could be closely observed and used to validate the simulation results. Very good qualitative agreement was found between such tests, including those with Audi’s real car seat geometry, and the simulation.

FOAM has demonstrated its value as a simulation tool for predicting foam expansion in complex molds. It enables testing of different injection paths and correct vent positioning in early development phases. By using FOAM, companies not only save a large number of experimental tests, but also time and money.

Further information and simulation videos are available on the website:
www.itwm.fraunhofer.de/pu-simulation-car-seat

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