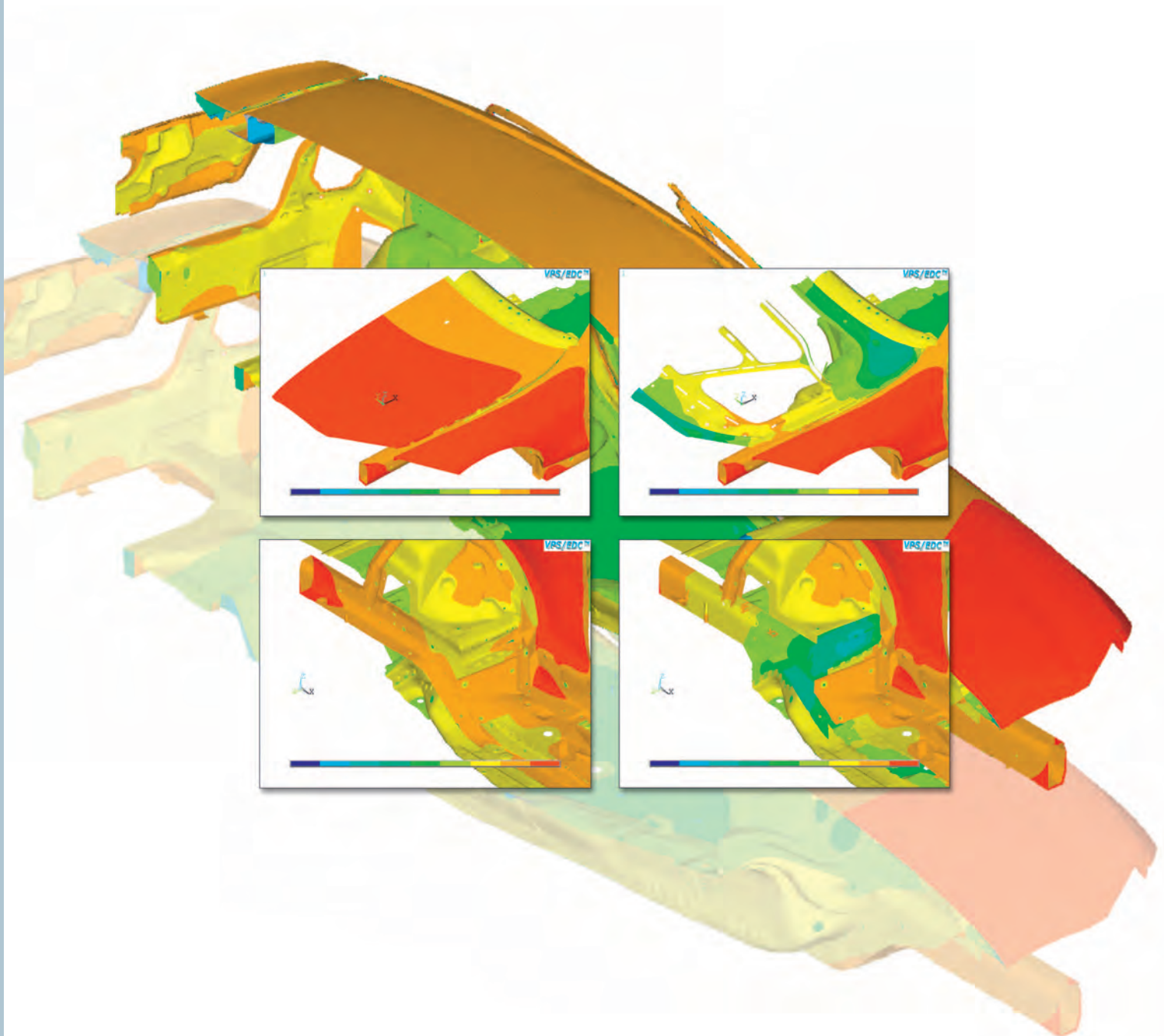


VirtualPaintShop®

A Virtual Process Chain for Body in White Painting



VirtualPaintShop® (VPS)

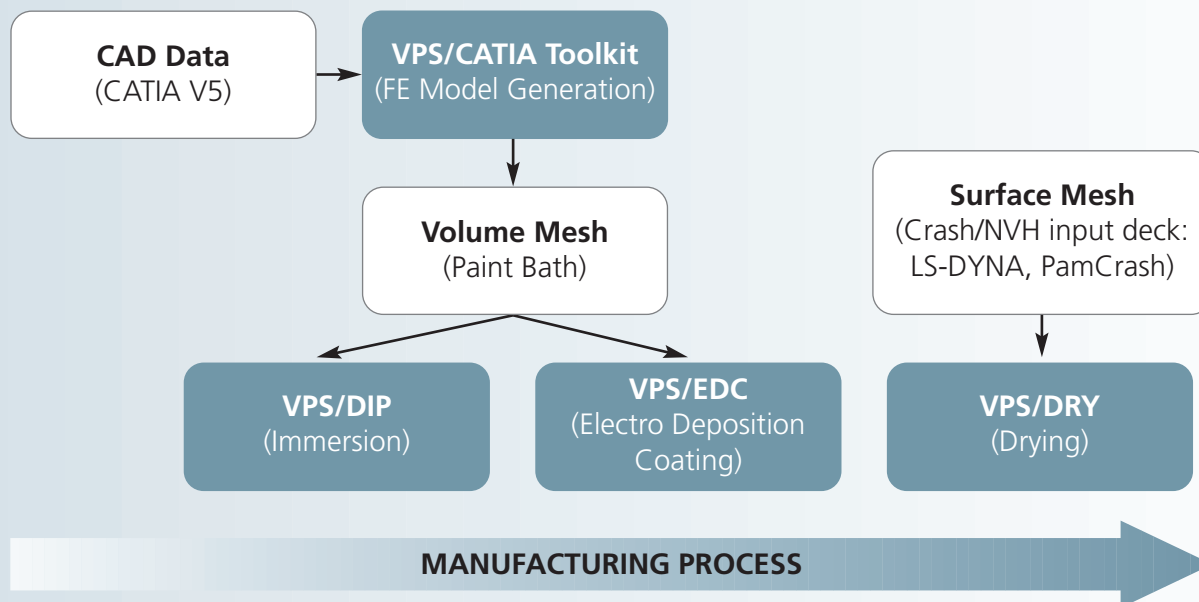
VirtualPaintShop® is a software system for simulation of most aspects of the body in white painting process. With VPS, the results of a body in white painting based on the design can be analyzed, before a physical prototype is available. Moreover, proposed modifications of the painting process can be simulated in order to improve quality and efficiency. Using computer simulation instead of costly and time-consuming trial and error methods can result in impressive cost savings.

VirtualPaintShop® consists of the following modules:

- **VPS/DIP (Immersion)** Calculation of the remaining air during the dipping process
Calculation of the remaining fluid after dipping process
- **VPS/EDC (Electro Deposition Coating)** Calculation of the film thickness during EDC process
- **VPS/DRY (Drying)** Calculation of the temperature profiles during oven process
- **VPS/CATIA Toolkit** Creation of a CAD geometry and mesh required for DIP and EDC simulation

Other modules are available on demand, such as VPS/ESC (Electro Static Coating) or VPS/UV (Ultraviolet Curing). With VPS/ESC you are able to analyze the film thickness resulting from the process of spraying paint, with the module VPS/UV (Ultraviolet Curing) you can calculate the exposure profiles in the UV curing process.

VirtualPaintShop® Process View:



Statement from a customer about VPS:

"VPS is fully integrated into the design process at the BMW Group. Simultaneously to the first crash and fatigue simulations, 90% of all new bodies-in-white are checked by use of VPS. The remaining 10% differ only in minor changes to already checked ones. The expenses for simulation are fully covered by the individual project budgets. Alternative design concepts can be checked to get an optimum temperature distribution for best curing and corrosion protection. Most of the parameter sets of our EC-ovens have been calibrated and added to the VPS database. Adjustment is done internally. Additionally, significant savings in equipment have been achieved at BMW using VirtualPaintShop®."

Stefan Kern, BMW Group

VPS/DIP (Immersion)

VPS/DIP analyzes the dipping and emerging of the body in white into and out of a tank filled with liquid for electro-coating, pretreatment or cleaning.

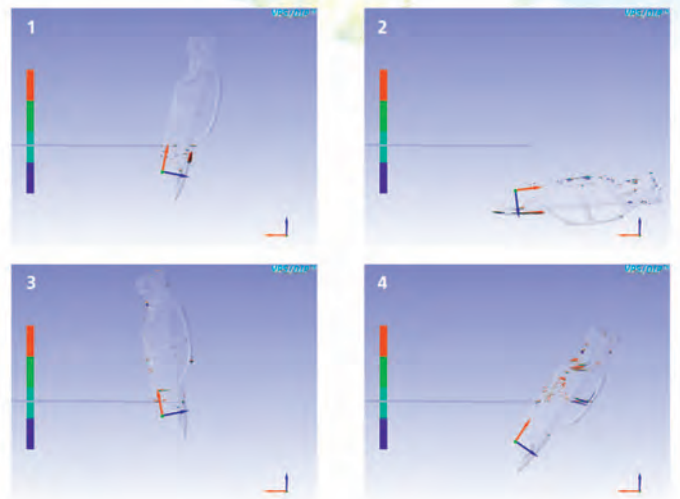
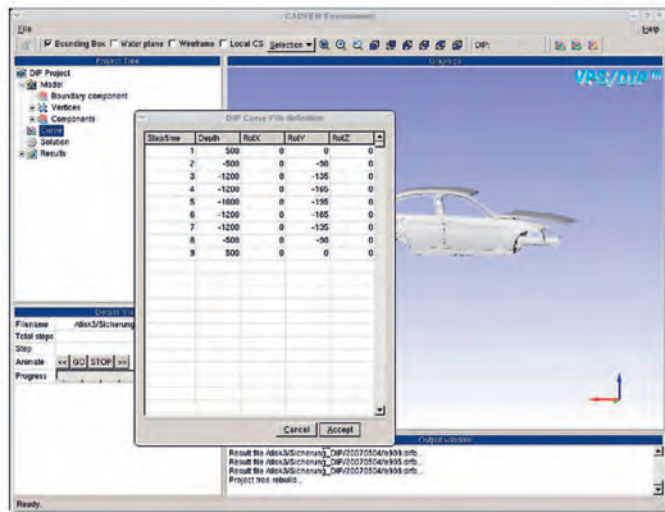
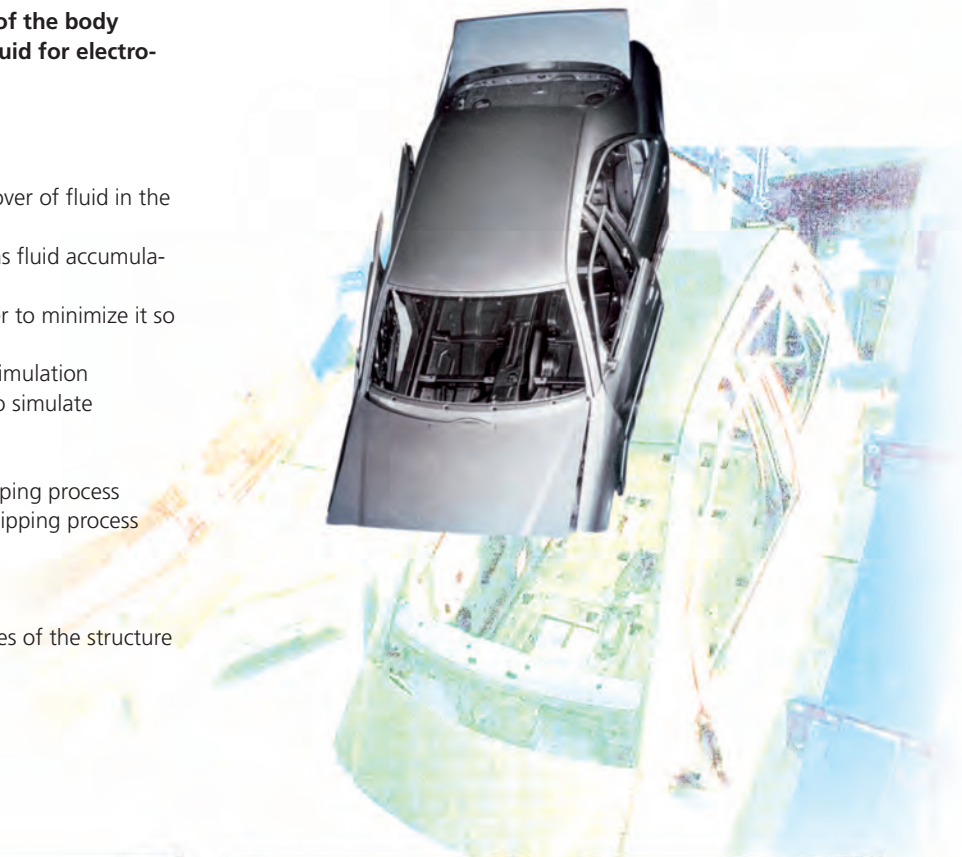
This enables you to:

- Find critical locations with air bubbles or carry-over of fluid in the structure
- Revise structures in order to reduce air as well as fluid accumulations
- Analyze carry-over of fluid after dipping in order to minimize it so as to reduce pollution of consecutive basins
- Optimize your body in white for the VPS/EDC Simulation
- Create or optimize the dipping curve in order to simulate prospective processes.

Result: - Remaining air during the dipping process
 - Remaining fluid during the dipping process

Method: Uses a special unique solver

Prerequisite: - Volume mesh filling all cavities of the structure and the surrounding bath
 - Dipping curve

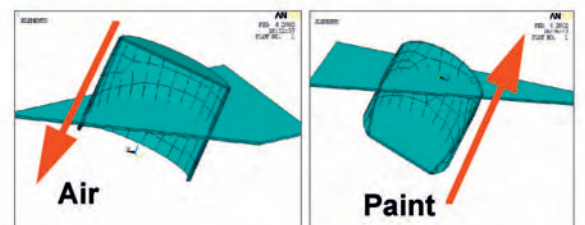


Top right: Body in white model shown in the graphics window of VPS/DIP / The graphic environment of VPS/DIP is able to handle very large and complex meshes very effective and comfortable.

Middle left: The simulation project parameters can be defined in a problem oriented user interface.

Middle right: Results showing the remaining fluid above the bath level and the trapped air below.

Bottom right: Simple examples allow easy understanding of the principle.



VPS/EDC (Electro-Deposition Coating)

VPS/EDC analyzes the electro-deposition coating of car bodies.

With VPS/EDC you can calculate the deposition of base coat layers on complete bodies in white generated by the electro-static field inside the e-coat tank.

Thus you are able to:

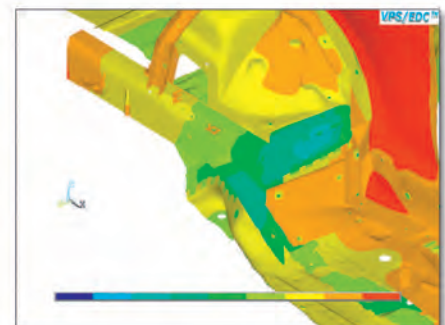
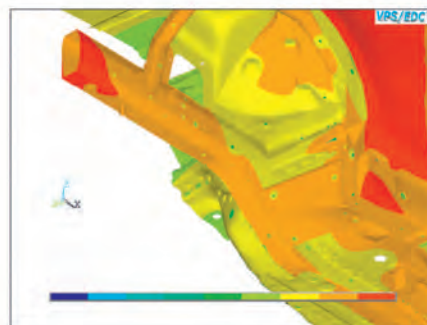
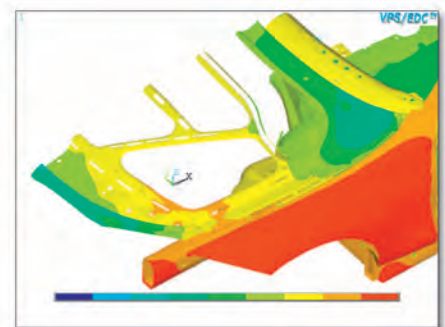
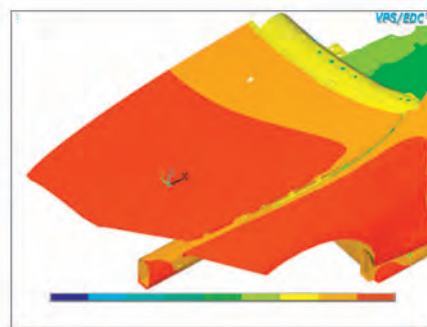
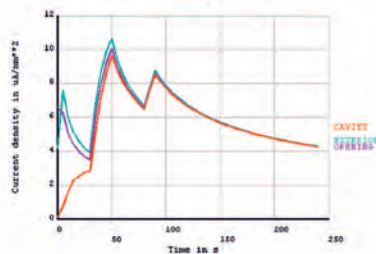
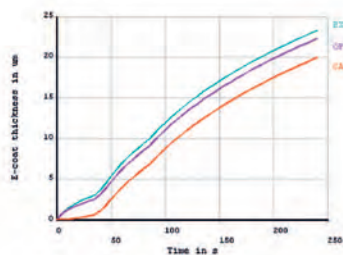
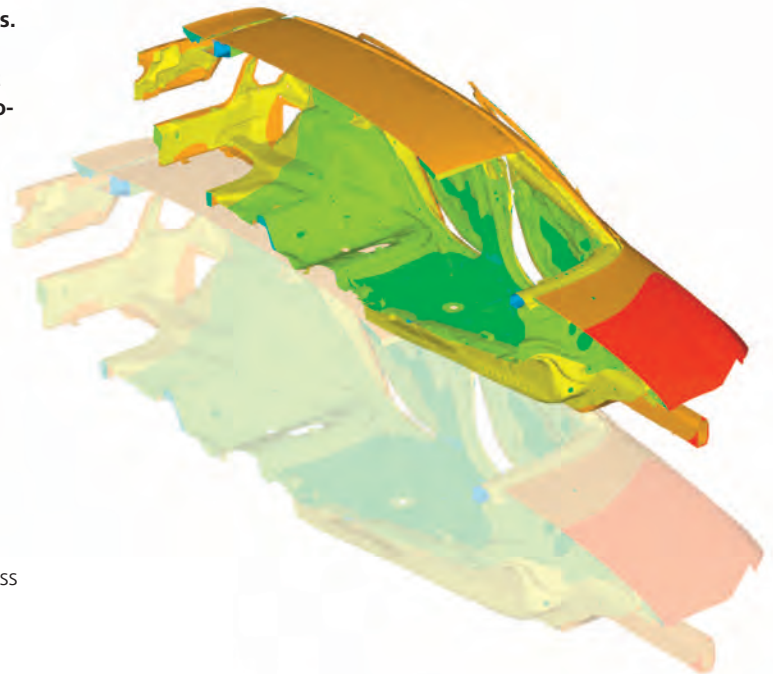
- Find critical locations of insufficient layer thickness
- Revise structures in order to improve the intrusion of electric current into cavities
- Adapt and optimize the electric voltage program or anode placement in the tank
- Analyze the effect of a change of the paint material
- Analyze consumption of resources like electrical power or paint
- Reduce production losses by fail-safe design
- Reduce expenses of in-process quality inspection
- Reduce expenses for physical prototypes.

Result: Shows paint thickness during the e-coat process

Method: FE-Simulation on electrostatic field based on customized ANSYS®

Prerequisite:

- Volume mesh filling all cavities of the structure and the surrounding bath
- Calibrated deposition properties
- Electrical process data



Top right: Contour plot of film thickness on the full body in white.

Middle left: Curves for film thickness and current density over time during coating process on example locations.

Bottom right: Contour plot of film thickness for several views on the body in white.

VPS/DRY (Drying)

VPS/DRY analyzes the detailed history of temperature versus time at any location of the body in white during the drying process. It helps you to analyze the energy transport from heat sources of the oven into hidden interior parts of the body in white. In an early design stage you will be able to identify cold spots or critical locations in terms of temperature slope.

Based on detailed temperature versus time results, you get a deep understanding of the:

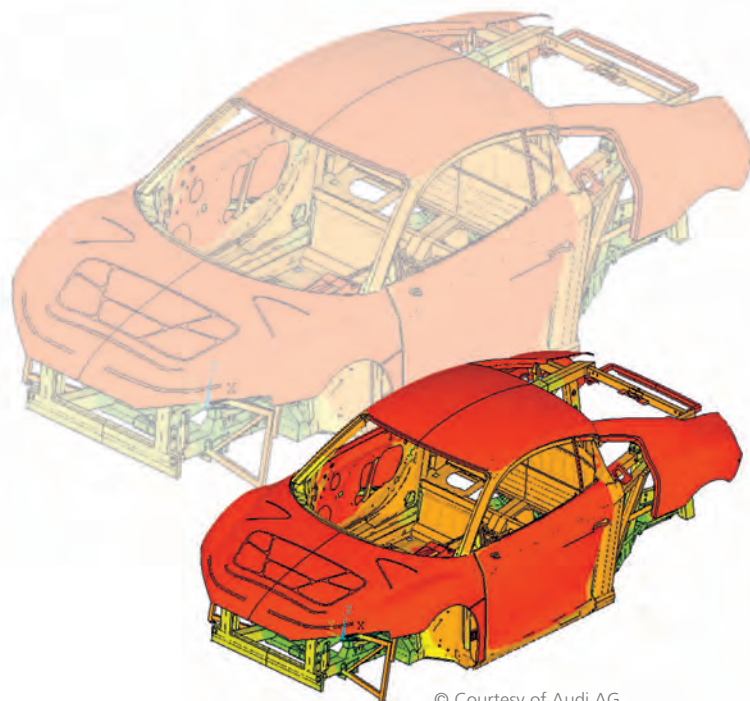
- Dwell time within a selected temperature range
- Hardening state of paint and adhesives
- Bake hardening state
- Thermal deformation and stress.

Result: Temperature profile during the oven process

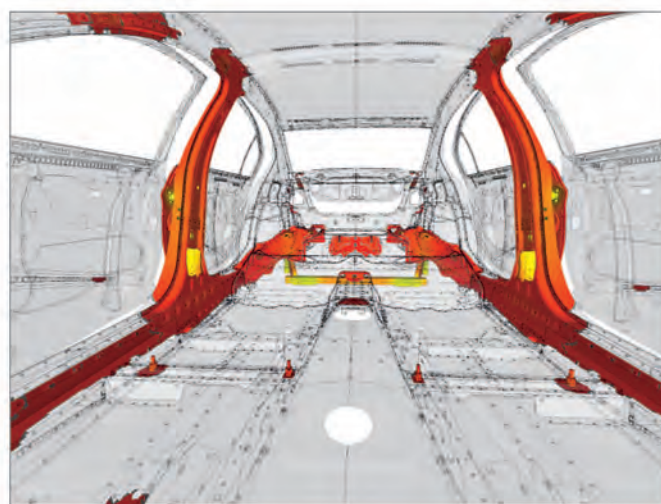
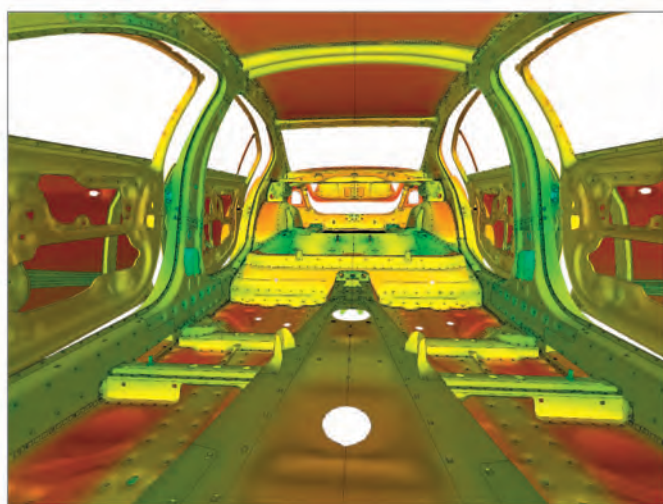
Method: FE-Simulation of the temperature on a body in white structure (based on ANSYS®); automatically analyzing the geometry for boundary conditions according to the oven description

Prerequisite: - FE Mesh of the body in white structure
- Description of the oven

VPS/KIN, a module for the simulation of chemical reactions, is available as an add-on module for VPS/DRY. With VPS/KIN you are able to analyze the chemical hardening status of paint and cohesive and material properties during the oven drying process.



© Courtesy of Audi AG



Top right: Temperature results example of an Audi R8.

Bottom left: Contour plot of temperature with a view in the cabin.

Bottom right: Contour plot of temperature with the same view like bottom left but transluency for elements above a specific temperature level.

VPS/CATIA Toolkit

The creation of the so called master geometry and meshes used in the EDC and DIP simulation is a very challenging task due to the huge amount of data and the required high level of detail. The whole body in white has to be filled by a volume mesh representing the fluid cavities connected through all the holes and openings.

The VPS/CATIA Toolkit process includes CATIA based interactive and automatic functions for the geometry manipulation and meshing in order to make the modelling process economically affordable.

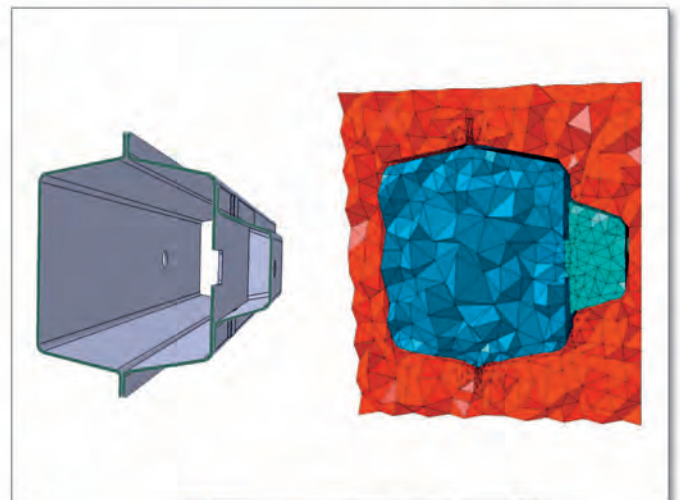
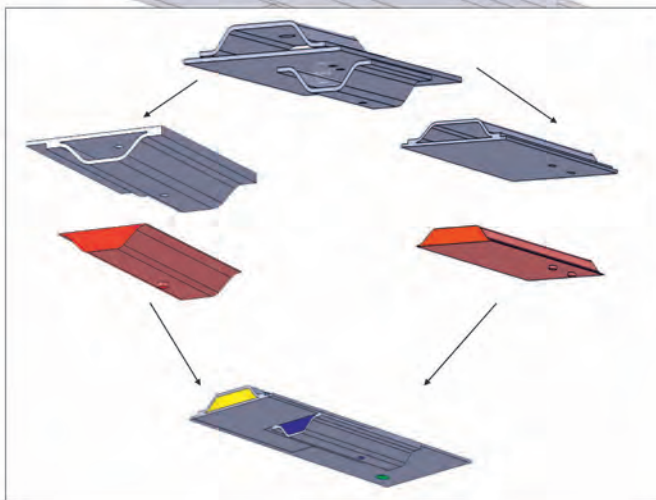
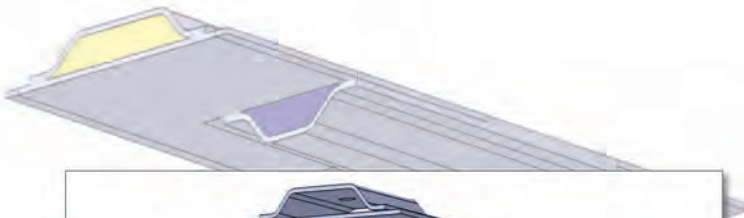
Result:

- VPS EDC/DIP master geometry
- Volume mesh required for EDC/DIP simulation

Method: Tools supporting the workflow for geometry manipulation and meshing

Prerequisite:

- CAD data of the body in white; CATIA V5 preferred



Top right: Typical CATIA Toolkit mesh containing with high level of detail.

Down under: Principle of volume creation.

Bottom right: Resulting volume mesh within cavities connected through holes.

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