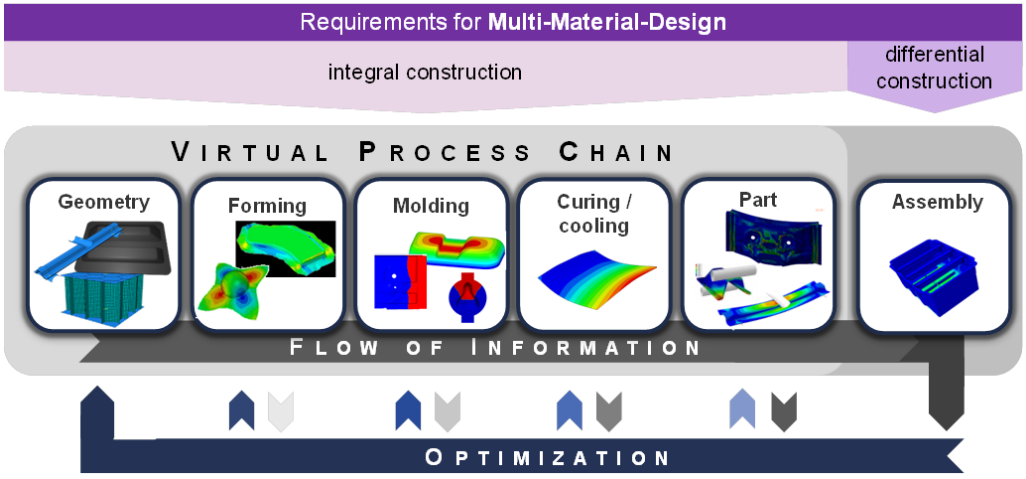
Thermoset Composite Structures for Automotive Lightweighting

- Extended Abstract -

Light weighting has become essential for the automotive sector in recent years to meet the demands of the legislative for low emissions. One of the most promising processes to realize high-volume production of complex parts with an outstanding performance is the HP-RTM (high-pressure resin transfer molding) process chain. This contribution introduces the MMD (materials, methods and process) approach which combines the demand for structural performance and economic efficiency of composite structures. The key of this approach is the collaboration between partners to combine all expertise of virtual and real process chains for the best composite solution.

Figure 1 shows the steps of the virtual process chain. It is essential to ensure that the simulation data can be used and handled in the right format by every simulation tool, thus it is possible to consider every simulation step for the following step to achieve a realistic result.

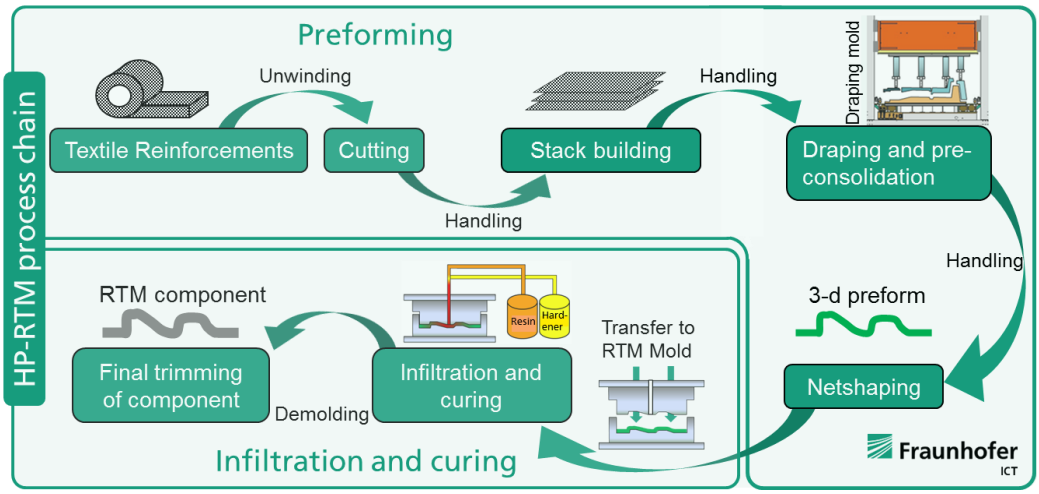
Figure 1: Virtual process chain and necessary simulation steps to simulate a component



The first step of the virtual process chain is the composite part design following the geometry and processing standards for composites. The forming simulation, also known as draping simulation is essential to investigate the feasibility of the draping process and the key for defect-free preforms in the process. The mold flow simulation predicts the infiltration behavior of the preform as well as the curing kinetics of the matrix system at different processing conditions and gives essential input for the design of RTM molds. The virtual designed and simulated part is then proved using a structural simulation in which different loads are applied to test and verify the mechanical properties of the part. The whole virtual process chain is designed to be conducted iteratively with different optimization loops.

The processes chain for the production of composites is shown in figure 2. The main sub-processes are Preforming and Infiltration/Curing. For both raw materials, simulation methods and the challenges of processing will be introduced in the contribution.

Figure 2: HP-RTM process chain for manufacturing of complex CFRP components



After unwinding the fabric the 2-dimensional layers are cut and stacked to the final layup for the preforming process. The stack is then transferred and placed on a draping belt. Two different types of binder can be used fix the stack, thermoplastic and thermoset binders. If a thermoplastic binder is used, the preform is heated up to melt the binder and the hot stack is then draped in a cold preforming mold solidify the binder. If a curing binder is used, the draping is carried out in a hot preforming mold and the preform is demolded after curing of the binder. After trimming the preform to final RTM-mold contour it is placed in the RTM mold to be infiltrated with a matrix system. Infiltration and curing step can be optimized by use of different process variants, HP-IRTM (high-pressure injection RTM) and HP-CRTM (high-pressure compression RTM) to manufacture composites with high fiber volume content in short time. In HP-IRTM process variant, the mold is completely closed by a hydraulic press and the resin is injected with high pressure (60 to 100 bars). After the curing of the resin the part can be demolded. The HP-CRTM process variant uses a small end mold gap during the injection which allows low cavity pressures compared to the HP-IRTM process variant. To achieve the final fiber volume content and part thickness a compression step is carried out after the injection. The last step in the process chain is the final trimming of the component. Beside a variety of fabrics and different layups, the part properties can be adjusted using different matrix systems such as Epoxy resins or Polyurethanes. The mechanical properties of these matrix systems can change the mechanical behavior of a part to tailor the properties to the requirements.

The MMD-approach and the connection of virtual and HP-RTM process chains provides a basis for a holistic development of innovative composite solutions from the initial design to the final component. Further the continuous development of both process chains and their interaction ensures to fulfill future requirements and demands of the market.