SUCCESS STORY

CHASE
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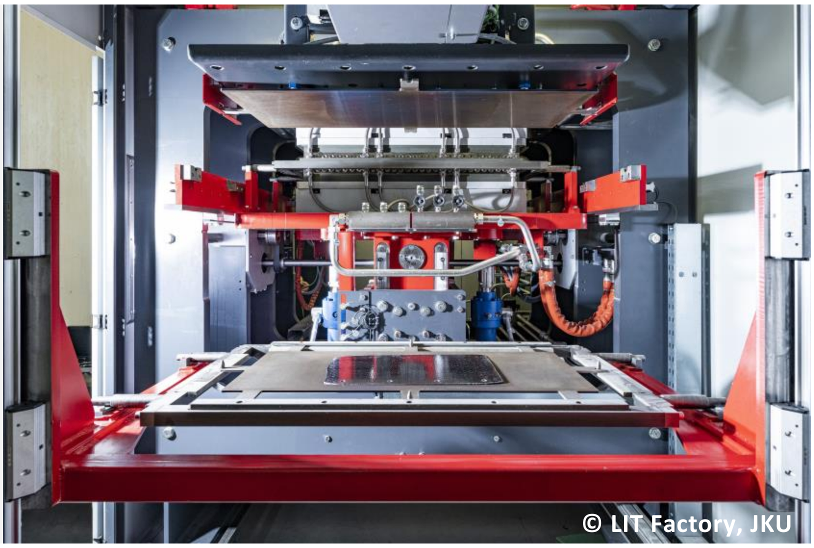

MODELING THE CONSOLIDATION PROCESS OF THERMOPLASTIC COMPOSITES

PREDICTION OF ESSENTIAL QUALITY PARAMETERS IN THE PRODUCTION OF CONTINUOUS FIBER REINFORCED SEMI-FINISHED PRODUCTS

Continuous fiber-reinforced composites with a thermoplastic matrix have become increasingly important in recent years because, in addition to their excellent mechanical properties combined with low weight, they offer advantages over thermoset composites, such as the possibility of functionalization by back injection and mechanical recycling. Another advantage is the short processing time since the matrix polymer does not have to crosslink and cure.

In the processing of thermoplastic unidirectional (UD) fiber-reinforced composites, the consolidation process plays an essential role. Here, a layup consisting of several UD tapes is processed into a sheet-like semi-finished product and a material bond is created between the individual tapes. For this purpose, the tape layup is positioned between two carrier tools and consolidated in a heating and cooling press under pressure and temperature. This project aimed to verify the usefulness of computer-aided modeling for process optimization and the correlation of critical process parameters with that of the quality of the semi-finished product.

Three criteria play a crucial role during consolidation: (i) the thermodynamic behavior during heating and cooling, (ii) the bond quality between the individual tapes, and (iii) the change in the semi-finished product geometry due to possible squeeze flow. To model these aspects, an existing solver in OpenFOAM® was adapted to predict the heat transfer between the presses, the carrier tools and the semi-finished product. Accurate and robust modeling of the time-dependent thermodynamic behavior is central in this context insofar as the material

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properties are temperature-dependent and thus relevant physical phenomena are influenced.

To validate the simulation, experiments were conducted at both a laboratory and an industrial-scale consolidation facility. The experiments at the laboratory consolidation facility focused mainly on basic investigations of anisotropic squeeze flow, while the experiments at the industrial-scale consolidation facility validated the applicability of the simulation to an industrially relevant process.

With the developed simulation approach, the temperature at different points of the tape layup can be accurately modeled throughout the entire consolidation process for both laboratory and industrial scale. In addition, very good agreement has been shown with experiments in terms of squeeze flow and, subsequently, semi-finished product dimensions. Moreover, comparisons with mechanical tests have shown that the chosen approach also provides very good predictions for modeling the bond strength. Thus, the dependence of the semi-finished product quality on the process parameters temperature, pressure and time is represented in the simulation.

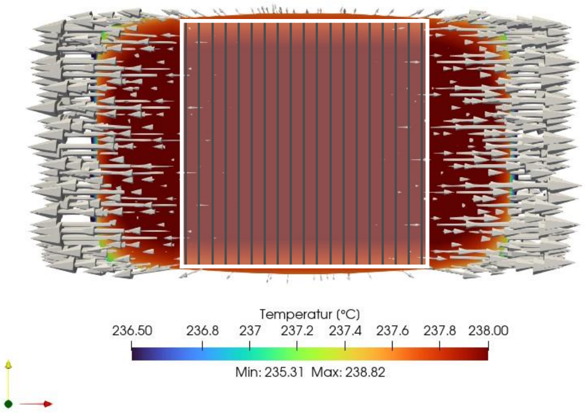

Abbildung 1: Representation of the squeeze flow of a UD tape layup. The white square represents the original shape of the layup. The unidirectionally aligned fibers are shown in black.

With this work, we were able to successfully demonstrate that simulation makes a significant contribution to process design and optimization, which in turn has a positive effect on material, time and energy efficiency of the process.

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- Covestro, Deutschland
- ENGEL, Österreich
- FACC, Österreich
- Renolit, Deutschland

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