Seminar im Rahmen des GRK 2078

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Titel: **Carbon fiber reinforced polymer structures - process technologies and their challenges**

Abstract

Global sales of cars increased significantly over the last years and many governments have introduced limits in CO2 emissions in order to reduce the pace of global warming. The consumption and hence the CO2 emissions can be reduced by reducing the weight of a car. The use of high strength steel, Aluminum and Magnesium have proliferated in modern cars and allow the manufactures to stay with the metal stamping processes they are used to and allow them to make use of the existing stamping lines. A much higher light weight potential is available with Carbon fiber reinforced composites. The production technologies to produce them have had to be developed or refined to suit the mass production approach of the car manufacturers. Using continuous fibers to manufacture complex parts is challenging and requires new approaches along the value chain, from design, stress analysis, process engineering to the manufacturing process.

The process technology of first choice for the manufacture of automobile cfrp parts was the High Pressure RTM process (HP-RTM). Typically woven fabrics or non-crimp fabrics (NCF) have been used as semi-finished material. These fabrics have to be cut to size, stacked and formed in the desired three dimensional shapes to fit precisely in the RTM mold. The process of cutting, handling, and forming has had to be developed. With its low in-plane bending stiffness of the individual plies, it was a challenge to get to the point of a fully automated system with high reliability.

The forming of reinforcement fabrics is a challenge by itself. The continuous fibers do not stretch in their longitudinal. The main mode of forming is the shear deformation and in-plane bending, referred to as draping. Different draping approaches have been developed, the most suitable being the sequential

draping technology. This approach is using a full size mold at the bottom side and individual segmented tools on the top side. The segmented tools close in a pre-determined sequence. With the flexibility of this technology the fiber orientation can be influenced and wrinkle being avoided as far as physically possible. The challenges arising out of continuous fiber materials will be discussed.

The second process technology suitable for the mass production of cfrp parts is the liquid compression molding process (LCM). In this process the full ply, full stack of fabrics are being applied with the resin in an open process, by means of a spreading nozzle which is moved by a robot and pours the resin on top of the stack of fabrics. For semi-complex geometries, the LCM process does not require a preforming process. The resin on the fabrics helps to level the fabrics to reduce the risk of wrinkles. Still for more sophisticated parts, the preforming and HP-RTM is needed.

Carbon fibers are relatively expensive. In order to reduce the cost per part, the processes need to be material efficient, meaning waste of material need to be avoided. The segmented preform technology is very efficient in minimizing the waste of fabric material coming of the roll. Higher efficiencies can be achieved by using fiber placement technologies which lay-up individual fiber bundles or tapes. In the lecture, different technologies will be discussed.

Recently continuous fiber reinforced thermoplastic (cfrtp) has become a very interesting alternative to thermoset cfrp materials. The benefit of the thermoplastic matrix is its toughness which makes the material less sensitive to impact. Furthermore are thermoplastics easy to be processed and have significantly shorter cycle times. Such cfrtp can be used in form of semi-finished Organosheet, which is an impregnated woven fabric. It can be heated-up above melt temperature and being thermoformed in a press or injection molding machine. The semi-finished Organosheet has the disadvantage, that the fiber orientation is typically 0°/90° and comes as a standardized sheet. This means that there are significant cutting losses to bring it in the shape needed for the individual application. A better approach is the tape-laying process. Standardized narrow tapes are used and laid down on a table, to generate tailored blanks, with the flexibility to have individual fiber orientations, thickness variations and near net shape geometries.

With the new Fiberforge tapelaying system and the Fibercon tailored blank consolidation system, a new benchmark has been set in the industry for the manufacture of part specific thermoplastic tailored blanks. The new Fiberforge tapelaying system allows to lay UD tapes with any fiber orientation, near net shape, fast and reliable to generate a part specific tape layup. The machine is capable to process four different types of tape into one layup. The lecture will introduce the features and performance which have been achieved, based on several applications. To fully utilize the capabilities of the Fiberforge system, Dieffenbacher has seen the need to find a reliable solution to consolidate the tape layup of discrete blanks. Based on the research activities and newest inventions of Fraunhofer ICT the Fibercon system could be developed which fulfills the needs of large scale production. The Fibercon has exceptional capabilities to eliminate air inclusions between the layers and reduce impregnation defects of the tapes. Fiberforge and Fibercon together are the key elements of the tailored blank manufacturing line. The concept of such a fully automated production line will be disclosed.

Alle Interessenten sind herzlich eingeladen.
Prof. Dr.-Ing. Thomas Böhlke