

Topic: Material and structural behavior – simulation and Testing: Fiber Resin and Laminate Design for optimized performance and manufacture

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Investigation of pre-cured carbon fiber/epoxy-laminates for modified co-curing process

Fiber-reinforced polymers (FRP) are increasingly used in lightweight applications due to their superior weight-specific mechanical properties compared to metallic materials. One of the main drawbacks still is the necessity of complex and costly toolings during the curing process of the resin. Complex toolings are necessary due to the lack of stiffness of the matrix prior to cure. Joining fully cured parts, which could be done to mitigate this problem, potentially causes stress concentrations, can form initiation sites for failure and requires additional manufacturing effort. In an effort to reduce the need for complex toolings and joining methods, the use of pre-cured carbon fiber/epoxy-laminates in a modified co-curing process is analyzed in the presented work. Due to their inherent stability, these laminates can be cured using simple toolings, but due to the incomplete polymerization at the time of joining they also can develop a strong bond to compatible, uncured FRP material in a co-curing process. The study is carried out using prepregs and non-crimp fabrics (NCF) infiltrated by resin transfer molding (RTM) process.

In order to obtain parts of reliable quality and to optimize the co-curing process, thorough knowledge of the curing process of the utilized materials is necessary. In the project presented, cure characterization was performed using differential scanning calorimetry (DSC), rheology and Dielectric analysis (DEA). These methods were used to quantify the curing process and their potential to be used for quality assurance during the manufacturing process was examined. As a direct measurement of the degree of cure poses difficulties, the glass transition temperature (T_g) was identified as an accurately and easily measurable indicator of the degree of cure.

When using pre-cured laminates in a co-curing process, their stiffness and strength can be utilized to simplify toolings. To investigate the feasibility of this, pre-cured laminates of different degrees of cure were characterized mechanically with a focus on stiffness and strength. Additionally, the surface properties (surface energy, surface topography) of the pre-cured samples were investigated and the influence of peel ply type, degree of cure and surface treatment methods was studied.

Aside from the mechanical properties of the pre-cured components, the bonding quality of pre-cured laminates co-cured with uncured laminates was analyzed by measurement of the apparent interlaminar shear strength (ILSS) and the interlaminar fracture toughness energy under mode I loading (G_{IC}).

Based on these results, the practicability of the modified co-curing process is evaluated and the optimum process parameters for production of complex FRP parts using pre-cured components in co-curing are summarized.