Chair of Carbon Composites
TUM School of Engineering and Design
Technical University of Munich

Material Characterization

Measuring the behavior of composites and its constituents

Motivation

Composites are inherently complex due to their heterogeneous nature. They are formed by combining different types of materials; have complex micro and meso structures; and are as a result typically anisotropic. This gives composites a large design flexibility, but also makes their behavior much more intricate than that of traditional materials.

Besides the basic understanding of the complex behavior of composites, at our chair we have further motivations to characterize composite materials, namely, as input for simulation and for structure and process design.

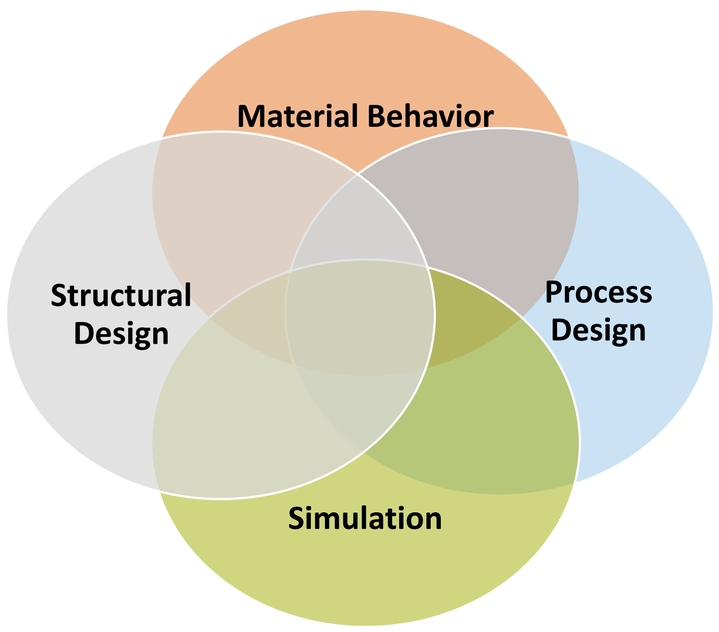

Fig. 1: Motivations for the material characterization

Structural Design

We apply the concept of the test pyramid for the design and dimension of complex composite structures. The base of the pyramid consist on the measurement of typical properties like strength, stiffness and energy absorption, using standard test methods and small size coupons. Going up, we increase the complexity studying the effect of holes and the behavior of detail and sub-component structures.

Simulation

Experimental characterization data is needed on one hand to generate material cards, and on the other hand as validation of the simulation results. For this purpose the geometry of the test object, test setup, the required data and the numerical replicability have to be considered, offering a potentially great challenge.

Process Design

Composites develop their properties during the manufacturing process. At the same time, the manufacturing process needs to be designed around the behavior of the raw materials. Process parameters like temperature and pressure, and the appropriate equipment are selected based on their thermal and mechanical behavior. The optimization of manufacturing processes to efficiently achieve the desired composite properties is a key activity at our chair.

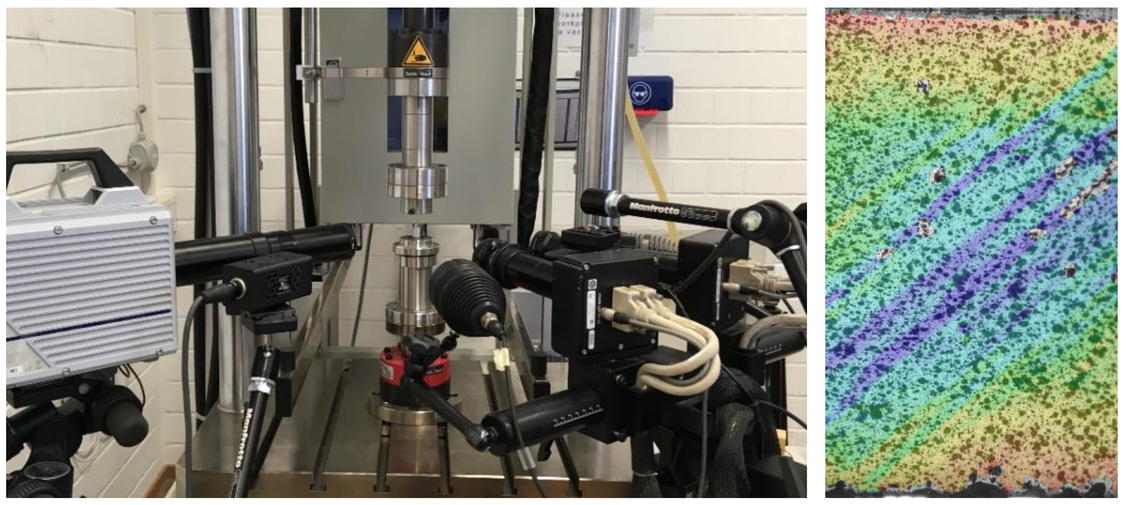

Fig. 2: Left, example of the complex experimental setups used in the dynamic characterization of composite materials.
Right, strain field measured using digital image correlation

Activities

Besides standard testing, we also conduct special activities in the area of material characterization.

Development of test methods

The complex structure and behavior of composite materials makes it challenging to determine their behavior under certain conditions. In such cases we develop test methods individually adapted to the process or material. Some examples are the development of test fixtures, of setups to reproduce manufacturing process and conditions, and of setups and algorithms for optical deformation measurements.

Dynamic Characterization

The behavior of composite materials exhibits a strong dependence on the loading rate. Due to anisotropy, this also depends on the loading direction. In our dynamic testing laboratory, we investigate the strain-rate dependent mechanical behavior using Split-Hopkinson bars and high-speed digital image correlation. Modeling of the dynamic material behavior is relevant to make use of the full lightweight potential of dynamically loaded composite structures like energy absorbers. The determined material properties are used to create material cards for crash and impact simulation.

Thermal Analysis

The thermal properties of a composite and its raw materials determines its range of application and processing. At our chair we apply technics like rheology, dynamic mechanic analysis and differential scanning calorimetry to characterize our materials.

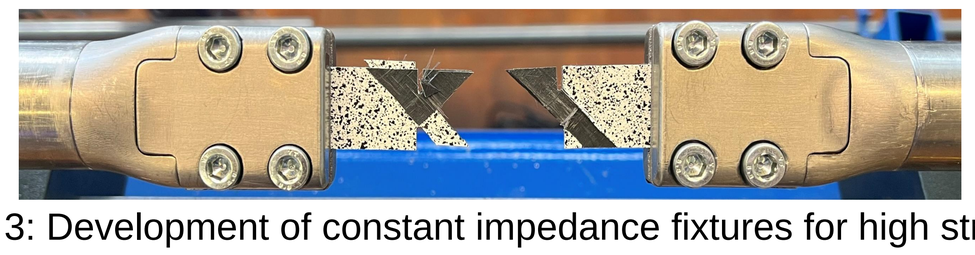

Fig. 3: Development of constant impedance fixtures for high strain rate mechanical characterization

More information and contacts: