

Material Database for the Development and Manufacturing of Safety Components Made of Fibre Reinforced Plastics

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Introduction

Given the growing desire for mobility of people all over the world on the one hand and the urgency of pollution control, the limitation of the world's crude-oil resources as well as the uncertain perspectives of renewable energy sources on the other hand, the long-term necessity to develop vehicles with substantially reduced fuel consumption is indisputable. As a result, higher expenses on lightweight design will probably become profitable thus supporting the application of alternative materials.

High-performance fibre reinforced plastics are materials which offer a high potential to realise lightweight design. However, the application of these materials in safety components which are subject to bending load is still problematic because of their lack of ductility. Solving this problem could be a key to the universal applicability of fibre reinforced plastics in vehicle body components.

Conception of a Material Database for Fibre Reinforced Plastics

The Institut für Kraftfahrwesen Aachen (ika) is currently developing a material database for high-performance fibre reinforced plastics, which will contain data with relevance for crash-related structural components subject primarily to bending load. The database will comprise both pure measurement results and derived material parameters for fibre reinforced plastics made of woven fabrics, multi-axial multi-ply fabrics and unidirectional reinforcing fibres in combination with an epoxy resin.

Standardised tensile tests in longitudinal, transversal and diagonal direction as well as compressive tests in longitudinal and transversal direction are carried out depending on the structure of the textile reinforcement in order to acquire material parameters for the database. In addition to that, the application-specific material behaviour is characterised by tear-out tests and dynamic three-point bending tests with profiled samples.

Material Samples

While all other specimens are produced by manual lamination with subsequent vacuum processing and tempering, the profiled samples made of woven fabrics are manufactured by

sewing cut textiles enclosing a foam core. This preform is impregnated and then processed like the other material samples. All test pieces are finally trimmed by water-jet cutting. The fibre content which results from this manufacturing process is about 55 %.

Utilisation of the Material Database

The objective of the database is not only to offer information for the materials selection during the concept development of a new vehicle component, but it is also to support finite element analyses for the dimensioning of the component. This applies especially to the simulation of safety components with bending load, since the database provides both input data for the corresponding material models and measurement results as the basis of validation.

The database has already been utilised in this way for the development of a material model of a laminate with unidirectional carbon-fibre reinforcement. The model has been validated by the comparison of the load-deflection-curves from the three-point bending tests contained in the database with corresponding simulation results.

Future ways of utilising the database will include the development of a bumper beam made of high-performance fibre reinforced plastics as an example of a safety component which is subject to bending load. Preliminary investigations have already started. The bumper beam will be realised as a prototype, and a spectrum of reinforcing materials which may be applied without an inadmissible change of the properties of the component will be defined. The corresponding laminates will be integrated within the database. A flexible measuring instrument, which is currently being developed at the DTNW (Deutsches Textilforschungszentrum Nord-West e.V.), will enable the component maker to check quickly if a given textile belongs to the spectrum of permissible reinforcing materials.

So the database is to support not only the development, but also the manufacturing of safety components made of fibre reinforced plastics thus making a small contribution to stop the continuous increase in the empty weights of passenger cars.