Improvement of dynamic testing procedures for crashworthiness of composite transportation structures

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Abstract

Governments and policy makers put pressure on a variety of industries to comply environmental regulatory mandates, and alleviate the climate changes. For example, 'FlightPath 2050' from the Advisory Council for Aviation Research and Innovation in Europe (ACARE) sets ambitious goals on reducing CO2 and other emissions levels to mitigate environmental impact. With such increased demands, the interests in lightweight materials have become more prevalent for global transportation manufacturers and operators to achieve weight reduction of transportation structures and therefore reduce fuel consumption. Weight reduction strategies will help to attain low-emission transport by using less energy to operate the vehicle.

The use of composites materials in automotive and aerospace structures is an effective way for the transport industries to achieve such goals. However, the design of composites structures is more challenging compared to their counterparts with metallic materials due to their anisotropic behaviours. A key challenge associated with the development of lightweight and cost-effective composite vehicle structures is to ensure a high level of safety in crash scenarios. The safety aspects related to the ability of the structures to protect an occupant from the serious injuries in crash events promotes underlying interests in the energy-absorbing characteristics of these materials.

The development of new transportation structures relies on a wide test programme generally based on a building block approach, which is consistent with the process of validation from the coupon level up to the full scale structure. Whereas the lower level of the pyramid provides material data from coupons, the higher levels deal with complex tests on components up to full vehicle to gain insight in the complex failure modes expected in full-scale structures. At coupon level, the reliable and accurate material characterisation of fibre-reinforced plastics (FRP) composite materials under varying loading conditions is essential. Although the use of Finite Element (FE) software is widely used during design and analysis processes, experimental testing is indispensable to provide the essential input data for these simulations. Therefore, experimental testing plays a crucial role in the design of composite structures.

This investigation reports experimental challenges and its solutions on dynamic material characterisation of carbon/epoxy composites at intermediate strain rates that are particularly relevant to automotive crash events. To establish comprehensive and effective test method, new technical concepts are examined to obtain reliable experimental data. In addition, strain measurement capabilities are extended by adapting optical full-field measurement, so-called Digital Image Correlation (DIC) technique. An improved test method providing reliable stress-strain data based on benchmarking of the data from the literature could be reached.

Keywords: *Fiber-reinforced composite materials, Test method, Intermediate strain rate, Digital image correlation (DIC),*

Biography

Sanghyun Yoo is working at German Aerospace Center (DLR) and he is currently a PhD student at University of Stuttgart, Germany. He hails from the Republic of Korea. He has completed a Master of Engineering by research in Aerospace Engineering at the Royal Melbourne Institute of Technology (RMIT) in Melbourne, Australia. After the completion of his Master degree, he started his position at DLR within EU project, ICONIC– Improving the crashworthiness of composite transportation structures, in 2017