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Non-Contact Inline Monitoring of Thermoplastic CFRP Tape Quality Using Air-Coupled Ultrasound

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Besides the aerospace industry, fibre reinforced plastics have also spread towards many further applications such as automotive, civil engineering as well as sports and leisure articles. Their superior strength and stiffness to mass ratio made them the number one material for achieving high performance. Especially continuous fibre reinforced plastics allow for the construction of structures which are custom tailored to their mechanical loads by adjusting the paths of the fibres to the loading direction. The two main constituents of CFRP are carbon fibres and matrix. Two possibilities for matrix material exist: thermosetting and thermoplastic matrix. While thermosetting matrix may yield better properties with respect to thermal loads, thermoplasticity opens a wide range of applications due to weldability, shapabilty, and compatibility to e.g. injection moulded thermoplastic materials.

Thin (0.18 mm) thermoplastic continuous fibre CFRP tapes with a width of 100 mm were examined using air-coupled ultrasound. Transducers were arranged in reflection as well as transmission setup. By slanted incidence of the ultrasound on the tape surface, guided waves were excited in the material in fibre direction and perpendicular to the fibre direction. Artificial defects – fibre cuts, matrix cuts, circular holes, low velocity impacts from tool drop, and sharp bends – were produced. Experiments on a stationary tape showed good detectability of all artificial defects by guided waves. Also the effects of variation in material properties, fibre volume content and fibre matrix adhesion being the most relevant, on guided wave propagation were examined, to allow for quality assessment. Guided wave measurements were supported by destructive analysis.

Also an apparatus containing one endless loop of CFRP tape was constructed and built to simulate inline testing of CFRP tapes, as it would be employed in a CFRP tape production environment or at a CFRP tape processing facility. The influences of tape conveying speed on detectability of artificial defects as well as material properties were elaborated and recommendations for implementation in production scale inline monitoring are given.