Application note N22e

Microwave-Based Non-Destructive Testing of GRP Components

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The Microwave-Based Non-destructive Testing (MWNDT) is well suited to test electrically insulating materials and devices for defects. Here a few examples are given for the testing of components made from glass fibre reinforced plastic (GRP).

Figure 1a shows a photograph of a sandwich structure consisting of a GRP top layer, PVC foam, and a bottom-layer made from carbon fibre reinforced plastic (CRP).

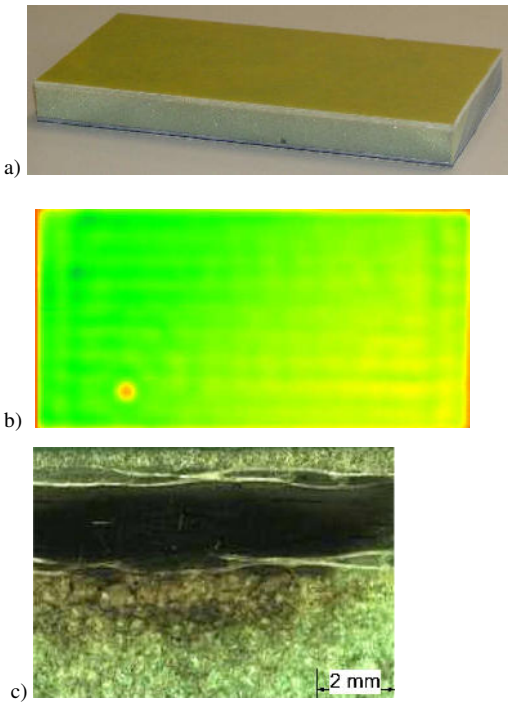


Figure1: Sandwich-GRP/PVC foam/CRP with defect: Insufficiently soaped glass fibres. a) Photograph of the sandwich. b) Microwave C-scan of the sandwich. c) Cross section of defect region

Figure 1b shows a microwave C-scan performed with a waveguide based probe. The indication in the lower left region is caused by a non-intended defect. The cross sectional view through the defect region reveals the source of the indication, namely a region with insufficiently soaped glass fibre bundles.

Figure 2a shows a photograph of a GRP slab which is nominally free of defects.. Figure 2b shows the microwave C-scan of the green marked area, performed at 10 GHz using a coaxial probe.

Remarkable are the small rod-like indications. The one in the upper left part which is marked with a red circle was investigated with an optical microscope (Figure 2c) and with a scanning electron microscope (Figure 2d). It was revealed that a short section of a single glass fibre which is not aligned in the main direction causes this indication.

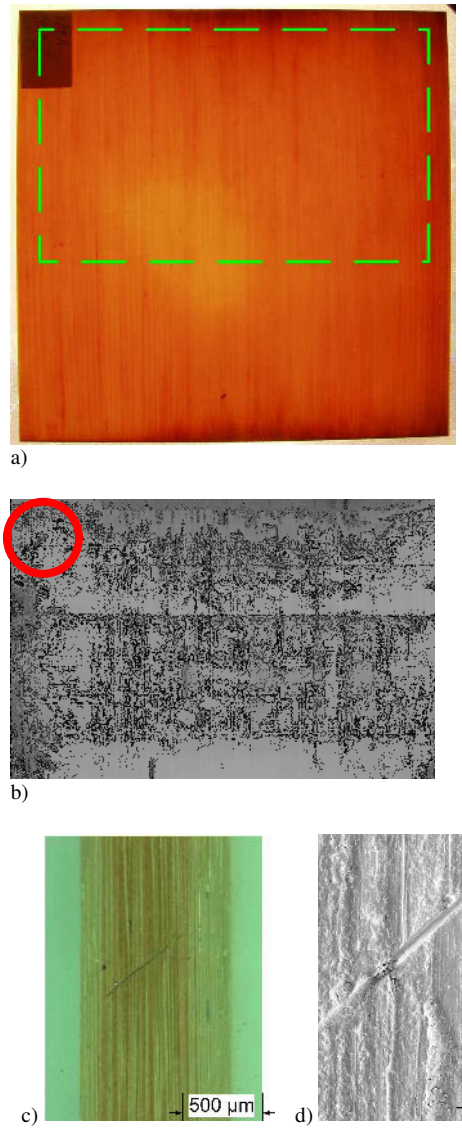
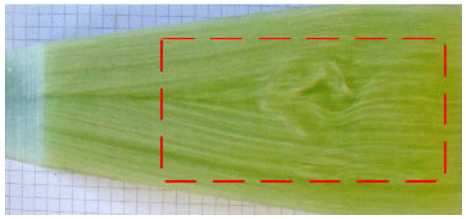


Figure 2: GRP slab with defects, e.g.. short misaligned segment of a single fibre. a) Photograph of the slab. b) Microwave C-scan of the green marked area. c) Enlarged view of the red marked defect with an optical microscope. d) As c) but with scanning electron microscope.

Leaf springs of automobiles are presently also made from GRP. Figure 3a shows a photograph of one tapered end of such leaf spring. On the right hand side the rovings are unidirectional. The left hand side is a wedge-shaped section. The transmission region seems chaotic, the fibres make up an ondulation. The red marked area, about 85 mm x 50 mm in size, was scanned with a coaxial probe at 10 GHz. The result is shown in figure 3b. The microwave scan largely reproduces the photograph. But in addition to this, details can be recognized which are not recognizable in the photograph. These details are caused by inhomogeneities in lower plies, which visually can not be recognized.

a)



b)

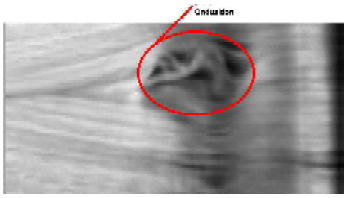


Figure 3: Section of a GRP leaf spring with ondulation (IFC-Composite GmbH) a) Photography b) Microwave C-scan with a coaxial probe.

MWNDT not only can be used to detect defects but also for measurement purposes.

Figure 4a shows a photograph of a GRP pipe with a varying wall thickness. At this short pipe section the wall thickness could be measured mechanically. Results are shown in the violet curve of figure 4b. In most practical situations such a mechanical measurement is not possible but only a measurement from external positions. Here the MWNDT lends itself. The residual three curves in figure 4b show repeated measurements with a waveguide probe at 10 GHz. The normalized phase of the reflected microwave signal is plotted. It can be seen that the reproducibility is very good and that the mechanical measurements are largely reproduced by the microwave measurements. Residual deviations are probably caused by different integration areas.

a)

b)

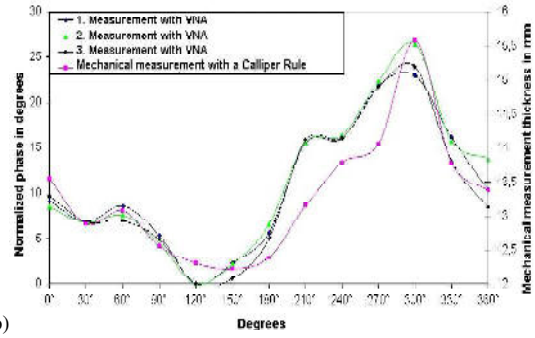


Figure 4: Wall thickness measurement of GRP pipe.
a) Photograph of the measured pipe section. b) Mechanical and microwave based measurement results. For the latter a vector network analogy (VNA) was used.

It should be briefly mentioned that also the fibre to matrix ratio of a GRP part can be determined by microwaves.

This report shows a few applications of the microwave-based non-destructive testing for the detection of defects and for measurements at glass fibre reinforced plastic. Please contact us for available test and measurement equipment as well as for further applications.

We acknowledged the support of the companies IFC-Composite GmbH, IMA Materialforschung und Anwendungstechnik GmbH and Delta Test GmbH as well as the Hochschule Magdeburg-Stendal (FH, University of Applied Sciences) by providing samples and technical advice.

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