



## 1. Introduction

GFRP pipes often contain layers of sand with resin. The non-destructive ultrasonic testing of parts made from such a material combination is difficult, because the back surface echo normally is very weak. There was the expectation that microwave testing has advantages for this purpose.

Therefore, several samples made from such materials were investigated with microwaves. Here we report on a segment of a pipe section and an elbow.

A first test was to make sure that the microwave attenuation in such devices is small enough to allow for a testing throughout the whole wall thickness. This test corresponds to the observation of the back surface echo in ultrasonic testing. Furthermore artificial defects should be inserted into the samples and recognised by microwave testing.

## 2. Test Method

The test method is based on the measurement of microwaves, which are radiated by an antenna into the sample, reflected, and received by the same antenna. A network analyzer generates the microwave with a frequency of 24 GHz and measures the reflected signal. These measurements lead to two measured values, which are 90° shifted in phase. They are called real part and imaginary part. The sample surfaces are scanned like a grid. For the display of the scan the projection angle was tuned such that the indication showed as distinct as possible. This projection angle is in the plane which is made up by the real part and the imaginary part of the reflection coefficient. For the measurements described below an open waveguide was used as an antenna. For details on microwave testing refer to (in German)

<http://www.hs-magdeburg.de/fachbereiche/f-iwid/ET/Personen/Hinken/forschung/N19d.pdf>

## 3. Measurements

At first a bended plate was investigated, see fig.1. To ensure that the complete thickness of the plate can be tested, on the back side (concave side) a small metal plate of size 10 mm x 5 mm was placed. Then the sample was tested from the front side (convex side). Fig. 2 shows the result as a pseudo colour image. The red indication results from the metal plate. Therefore it is confirmed that the sample can be tested throughout the complete thickness of 22 mm.



Figure 1. Bended Plate with dimensions 200 mm x 200 mm x 22 mm.

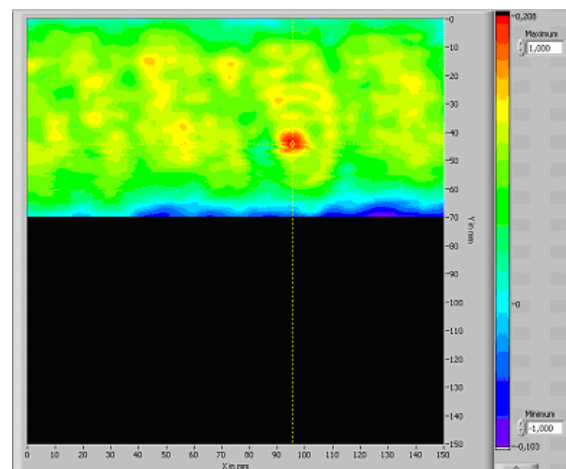


Figure 2: Microwave scan of the bended GFRP plate with a small metal plate on the back side.

Now, three shallow milling grooves were inserted on the back side, each 12 mm wide and

with depths of 0.5 mm, 1.0 mm, and 2.1 mm, respectively. The latter completely penetrates the chemical protection layer.

Fig. 3 shows the microwave scan. All three defects can be recognised as the white indications. Their values are above a threshold which was set manually.

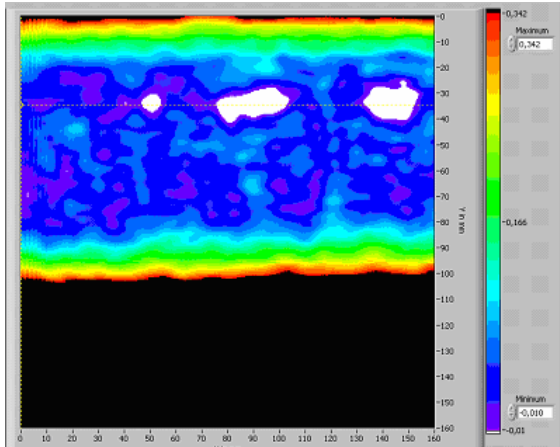


Figure 3: Front-side microwave scan of banded plate with shallow milling grooves on the back side. These cause the white indications.

A further sample that was investigated is shown in Fig. 4: an elbow made from GFRP with sand. In the region of the red arrows, on the inner side a small metal plate of size 10 mm x 5 mm was inserted. Between the thick red arrows the perimeter of pipe was scanned from the outer side.



Figure 4: Elbow from GFRP with sand, wall thickness about 5 mm

Fig 5 shows the result. The vertical direction corresponds to the axial direction. The horizontal direction corresponds to the angle,

extending from 0° to 360°. The small metal plate is clearly recognised as the red indication.

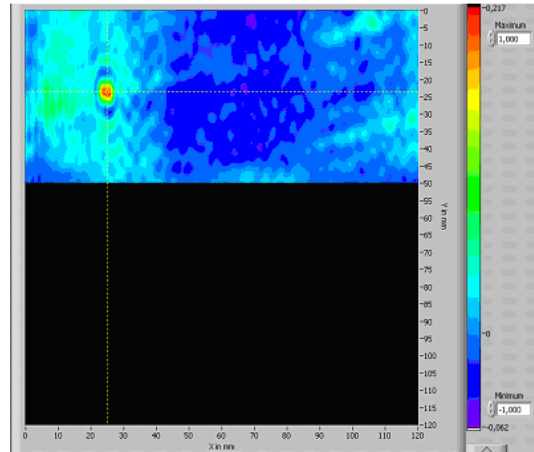


Figure 5: Microwave scan from the outer side of pipe section with a small metal plate at the inner side. Horizontal: angle with span 360°, vertical: axial coordinate with span 50 mm

#### 4. Conclusions

It was shown that GFRP pipes with layers of sand and resin can be non-destructively tested by microwaves. Especially, samples with wall thicknesses of up to 22 mm could be investigated throughout the whole wall thickness using the reflection method. It should also be possible to test samples with thicker walls.

Furthermore it was shown that even small thickness reductions of the chemical protection layer on the inner side can be recognised from the outer side.

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