Application Note N29e

Non-Ionizing Direct Imaging Testing (NIDIT) for NDT of parts made from fibre-reinforced plastic (FRP, GFRP, GRP, NFRP)

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1. Introduction

For the non-destructive testing (NDT) of parts made from glass-fibre reinforced plastic (GFRP, GRP), natural-fibre reinforced plastic (NFRP), and further non-conducting (dielectric) material microwave testing (µT) has proved successful. Defects such as inclusions from air or foreign material give considerable indications in reflection and transmission signals. Usually, the momentary test is local; a picture is generated by scanning the surface. This, however, can take a longer time than tolerated. In this report a direct imaging microwave test procedure is described, which even is suitable for thick parts. It uses a transmission method. The advantage over direct X-ray imaging is the lack of need for safety measures because the method uses harmless non-ionizing radiation of low power density. The advantage over thermography, which is also direct imaging, is that also thick parts can be tested in a short time.

2. Test method

The test method is based on earlier work at the research institute Onera in France [1]. There it was called EMIR (Electromagnetic and Infrared). In our application for NDT we call it NIDIT (Non-Ionizing Direct Imaging Testing).

The function principle is shown in fig. 1

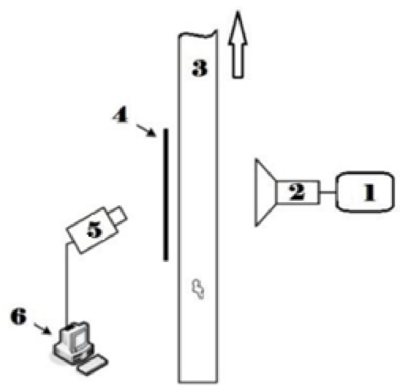
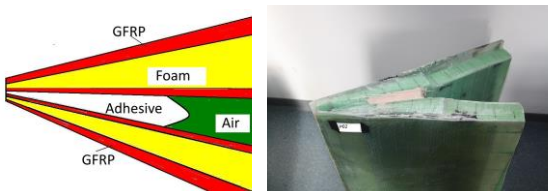


Figure 1: Principle setup for testing with the microwave based NIDIT method

A microwave source 1 (e. g. 24 GHz) and an antenna 2 widespread irradiate the device under test (DUT) 3. On its backside there is a microwave absorbing foil 4. The microwave radiation, which is homogeneously incident on the front side, inside the DUT is affected by defects and thus is inhomogeneously incident on the microwave absorbing foil. So the foil, according to the defects gets an inhomogeneous heat distribution, which is detected by a heat camera 5 and displayed by a computer 6. The heat distribution corresponds to the defect distribution inside the DUT.

3. Test Results

Several samples with artificial defects were tested with this method. In the following test results of rear edges of rotor blades are shown which are shown in Fig. 2.



a) b)

Figure 2: Rear edges of rotor blades of wind power plants consisting of GFRP, adhesive, foam, and air. At the thick end (right side) the distance between the outer surfaces is about 400 mm. a) principle view. b) photo

Air inclusions, delaminations, and irregular distributions of adhesive as artificial defects were inserted into these parts and covered to allow for blind tests. The following pictures were taken at positions were the parts were about 200 mm thick. That means this thickness was shone through by microwaves.

Fig. 3 in the upper part shows a region with five nearly dot-shaped indications. These were identified as air inclusions.

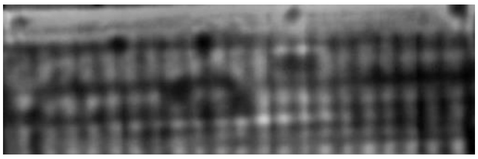
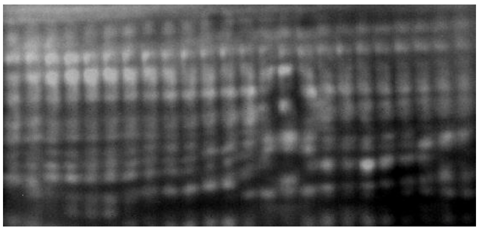


Figure 3: Five dot-shaped indications in the upper part which are caused by air inclusions.

Figs. 4a and 4b show further examples predominantly with delaminations and irregular distributions of adhesive.



a)

b)

Figure 4: Regions with delaminations and irregular distributions of adhesive.

The grid which is seen in figs. 3 and 4 is caused by a flat grid which are inserted into the parts between the GFRP and the foam layers to improve their adhesion. The grid cannot be seen visually from outside.

Presently the test setup is operated with a microwave power of 2 Watt, spread over an area of 250 mm x 250 mm. This area is imaged after about 10 seconds. Then the image is ready. The area can be enlarged by tile-like adding of single images.

Please note, that the power of 2 Watt approximately corresponds to the power of a smartphone. This, however, is radiated much more concentrated. It is irradiated onto a human with much higher power density and still is harmless. This comparison shows that the NIDIT test procedure really is harmless.

A second group of parts which can be inspected by NIDIT are natural-fibre reinforced plastics (NFRP) parts, e.g. wood plastic composites (WPC), see fig. 5.

In such parts cracks can occur during production. One example test result is shown in fig. 6. Clearly the crack can be seen which propagates from the end face into the part.

Figure 5: Natural-fibre reinforced plastic (NFRP), especially wood plastic composite (WPC) with large cracks.

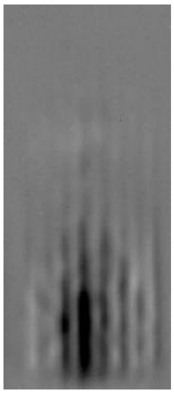


Figure 6: NIDIT image of region with cracks

For more details of the WPC tests see https://fitm.de/wp-content/uploads/2016/11/N37e.pdf

4. Conclusion

Above the NIDIT procedure is described. It is a method for non-destructive testing. It used through transmission with microwaves. It is a directly imaging method and therefore a fast method. It can be used for dielectric parts which may be thick.

Literature:

[1] Balageas D, Levesque P, et al.: "Performance of the EMIR (Electro-Magnetic/InfraRed) thermographic technique and improvement", Thermographie Kolloquium 2005, Stuttgart

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