In-situ test of pultruded parts with the Non-Ionizing Direct Imaging Testing method NIDIT

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1. Introduction
2. Principles of the non-destructive test method NIDIT
3. Examples
4. Conclusions

Pultrusion with control loop

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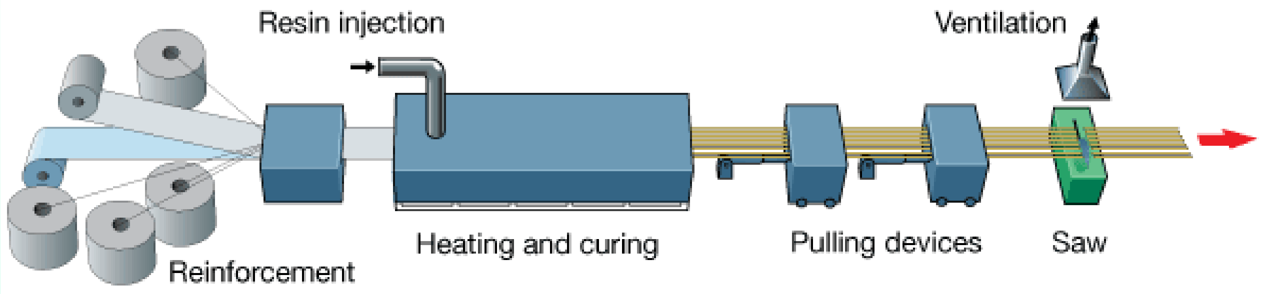
Basic principle of pultrusion plant, https://fiberline.com/pultrusion



- Process parameters: temperature of resin, temperature of die, pulling speed, …
- Desirable: adjust process parameters quickly in a closed control loop
- >> In-situ non-destructive testing (NDT) in the control loop

Control loop with in-situ NDT

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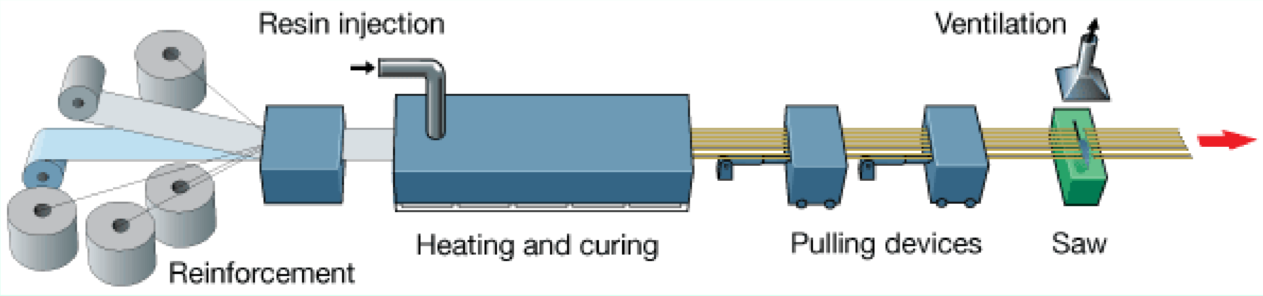

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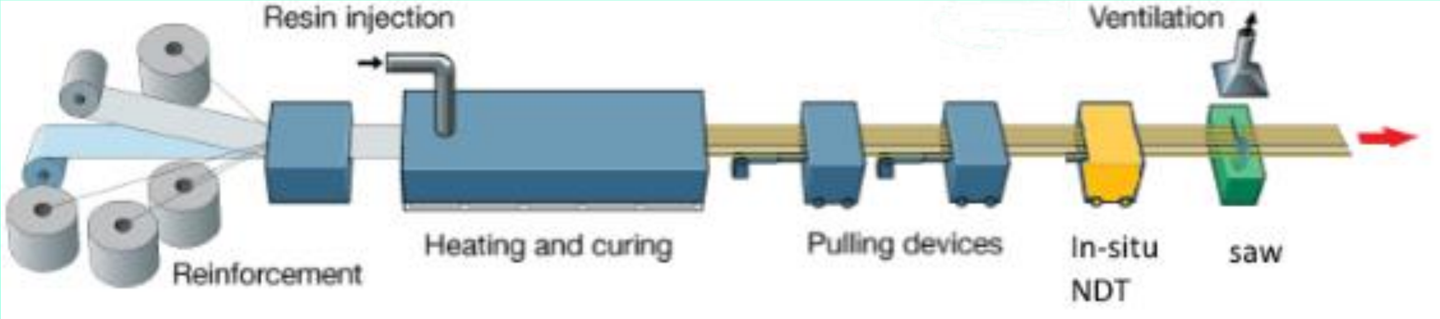

Basics of microwave testing (μT)

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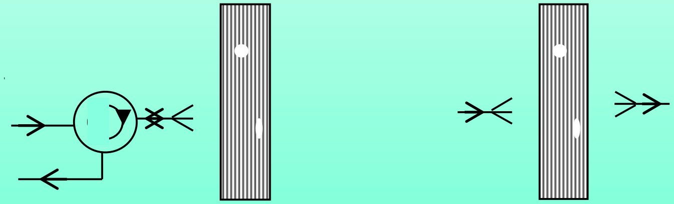
- microwaves: electromagnetic waves in the frequency region 300 MHz … 300 GHz

- microwave testing makes use of local variations of dielectric constant ε_R of the transparent material

- ---> refraction, diffraction and reflection as in optics.

- dielectric constants ε_R: E-Glas 5.8 ... 6.7; epoxy 2 ... 3; air 1.0



Two priciples are possible: reflection and transmission

- >> basically local methods
- may be time-consuming when scanning over certain areas
- direct imaging procedure is desirable

Basics of NIDIT

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X-ray radiography:

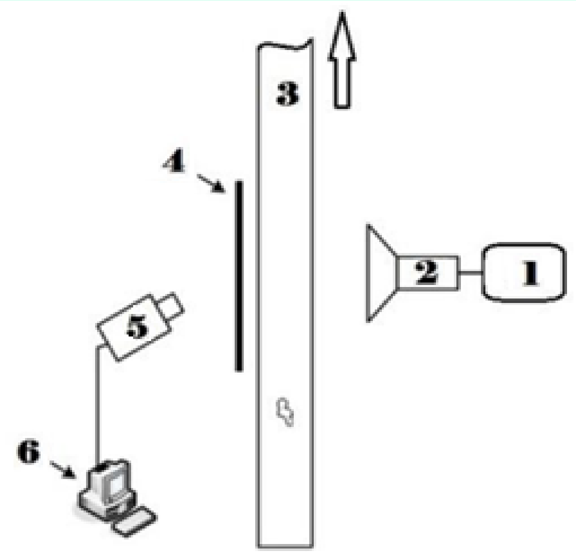
- powerful, direct imaging method of NDT
- high spatial resolution
- however: X-rays are ionizing and therefore harmful >> high safety measures necessary >> limits industrial use

NIDIT:

- If the devices under test (DUTs) are electrically insulating and
- high spatial resolution of X-rays are not absolutely necessary
- **>> direct imaging with microwaves (NIDIT – Non-Ionizing Direct Imaging Testing)**
- microwaves are non-ionizing and therefore harmless

The basic NIDIT setup

(1) microwave source
(2) antenna: irradiates widespread the
(3) device under test (DUT). The homogeneously incident microwave radiation is affected by inhomogeneities, i.e. defects, and such inhomogeneously leaks the DUT. It hits the
(4) microwave absorbing foil which accordingly is heated inhomogeneously. This heat distribution is recorded by an
(5) infrared camera and forwarded to a
(6) computer where it is instantly displayed and represents the defect distribution. Foil and camera act as a microwave detector.



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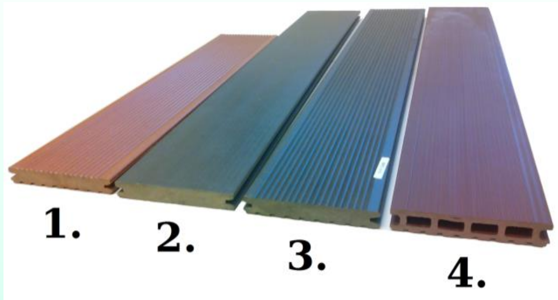
NIDIT test of extruded WPC planks

WPC – wood plastic composite



Tested WPC planks. From left:

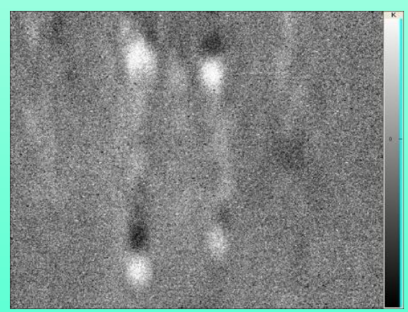
1. profiled with crack
2. plane with crack
3. profiled without defects
4. hollow chamber profile with defects, from construction market

Snapshots of 4 videos of through passing WPC planks

plank1:
profiled with crack,
in the crack region

plank 2:
plane with crack,
in the crack region

plank 3:
profiled without defects,
typical image



plank 4:
hollow chamber profile with defects. Off-the-shelf from construction market. Typical image.

NIDIT test of pultruded GFRP plank

GFRP – glass fibre reinforced plastic

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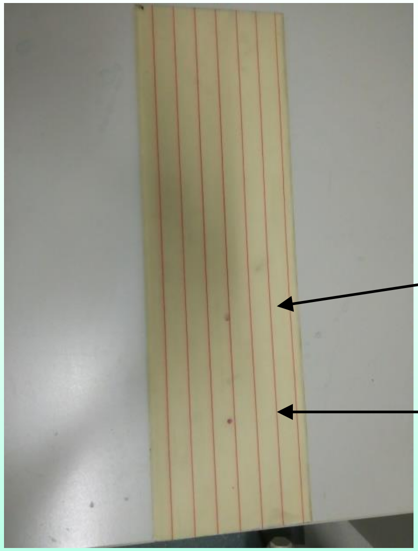
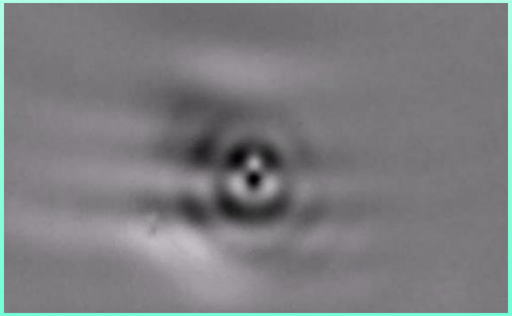


Length (mm)	450
Width (mm)	150
Depth (mm)	2.5

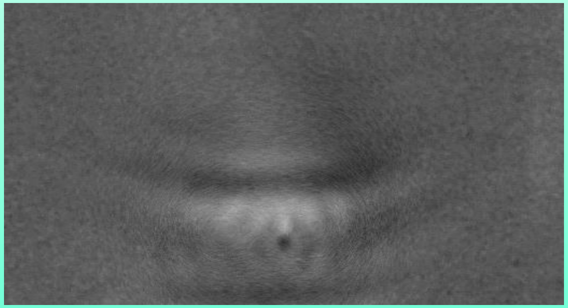
Defect 1:
1 mm diameter artificially drilled hole, 1 mm deep

Defect 2:
1 mm diameter artificially drilled through hole, 2.5 mm deep

Snapshots of video of through passing GFRP plank with artificial defects



Snapshot of video sequence of induced defect 1



Snapshot of video sequence of induced defect 2

Conclusion

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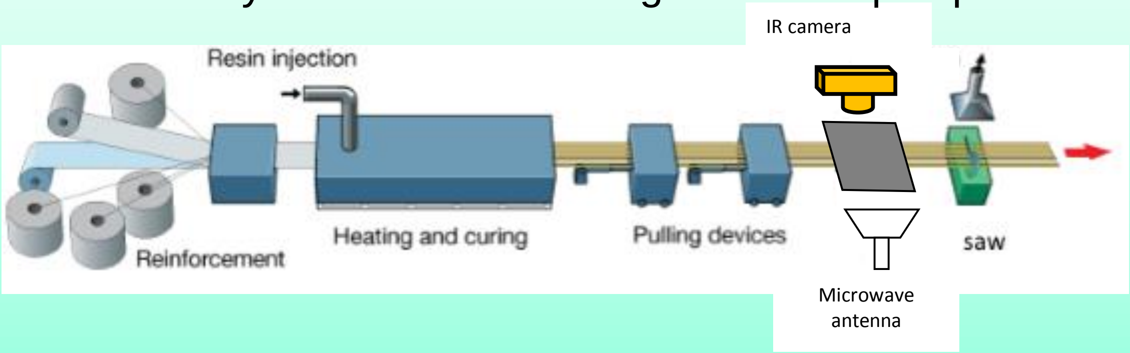
Remarks:

• Sliding difference evaluation for improved defect recognition. Especially suited for 2D-structures, i.e. in pultrusion processes.

• GFRP plate: contacting absorbing foil with sacrificial PE foil in between

Suggestion:

• In-line NIDIT NDT system for fast reacting control loop in pultrusion process



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