RecyCarb – process optimization and online monitoring in the recycling of carbon fibre waste for the re-use in high-grade fibre reinforced plastics

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Introduction:

The project investigated besides different kinds of carbon fibre waste; different nonwoven processes (web formation and bonding methods) and an online fibre orientation analysis. RecyCarb focused on the following aspects:

- Investigation and quantification of carbon fibre waste by examining the process ability
- Online and offline quality monitoring regarding different process stages during the nonwoven production
- Re-use of own nonwoven production waste to produce re-recycled nonwovens

Experimental and Results:

- **Waste treatment and fibre opening**
  - Regarding two types of waste: off cuts and pyrolysed fibres
  - Fibre preparation by using a modified cutting and tearing process
  - Quality classification of obtained fibres considering their characteristics (e.g. fibre length distribution, fibre strength, fibre fineness etc.)
- **Nonwoven technology**
  - Web forming through airlay technology (isotropic nonwoven structure) or carding process (anisotropic nonwoven structure)
  - Web consolidation and bonding with two different methods: needle-punching and/or stitch-bonding
- **Quality Monitoring** (Online and offline image analysis of fibre orientation)
  - Further development and adaption of NOS 200 to rCF by using light dome and image analysis software especially for covering sewing threads
  - Investigation of the fibre orientation of different process stages (online and offline)
    - Airlay web (target value 1:1) and airlay nonwoven (target value nearly 1:1)
    - Carded web (target value: at least 2:1) and carded nonwoven (target value: 1:2)
  - Investigation of the fibre orientation over the whole working width (offline)
  - Investigation of the fibre orientation at different areal weights (offline)

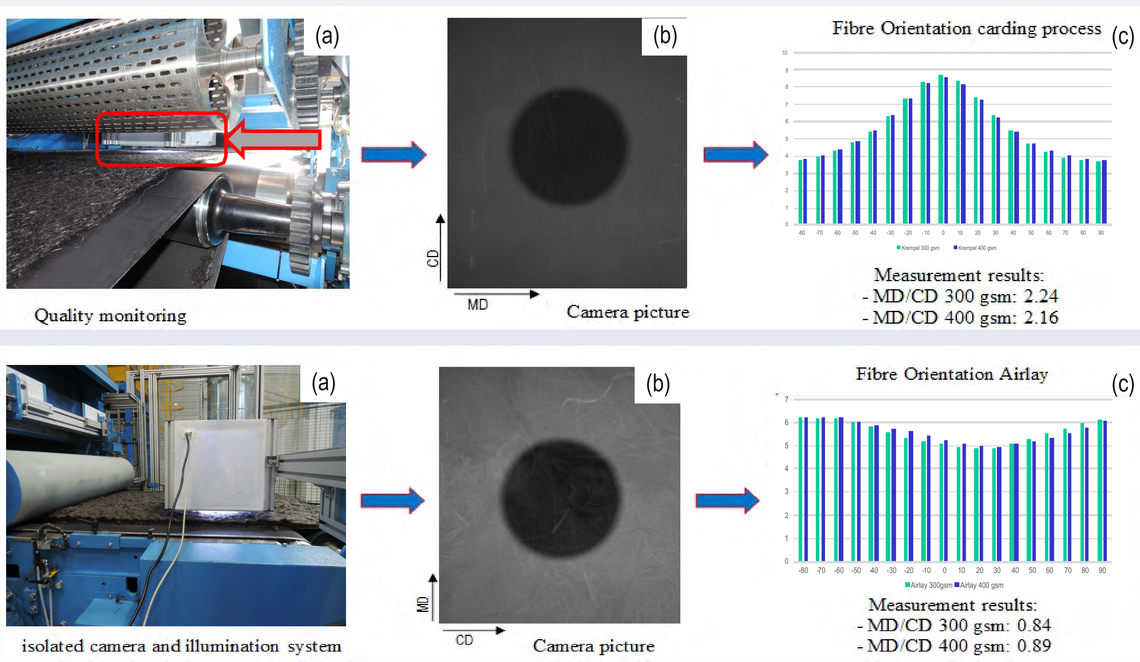

Figure 3: Online quality monitoring: (a) Modified camera system during airlay process (b) Camera picture (c) Fibre orientation of the airlay web

- **rrCF production**
  - Examination of repeated processing of rCF-nonwovens by analysing fibre length and fibre orientation
  - Investigation of the process ability during the rCFRP production by using the hand lay-up method and to prove the resulted fibre orientation

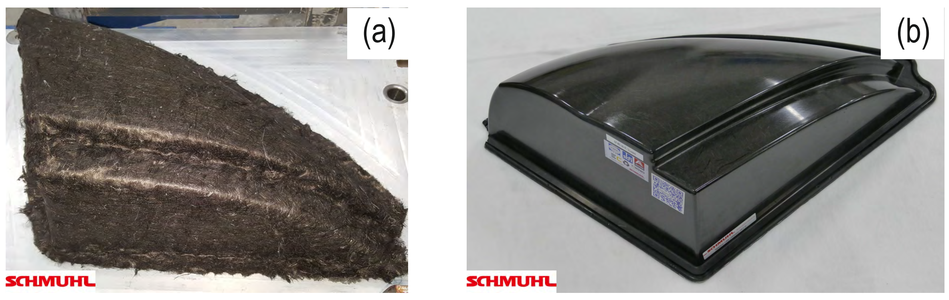

Figure 4: (a) Draped rCF- airlay - nonwoven (b) rCFRP fender

- **Production of fibre reinforced composites**
  - Three different types of composite manufacturing processes are considered:
    - Hand lay-up method with pressing at the STFI
    - Resin transfer moulding by vacuum impregnation at SCHMUHL
    - Wet lay-up with autoclave at Eissmann Cotesa
  - Composites based on carded nonwovens with different fibre volume contents (FVC) by using RTM were produced and flexural strength up to 469 MPa in fibre orientation and flexural moduli up to 25.3 GPa were achieved (shown in fig. 5)

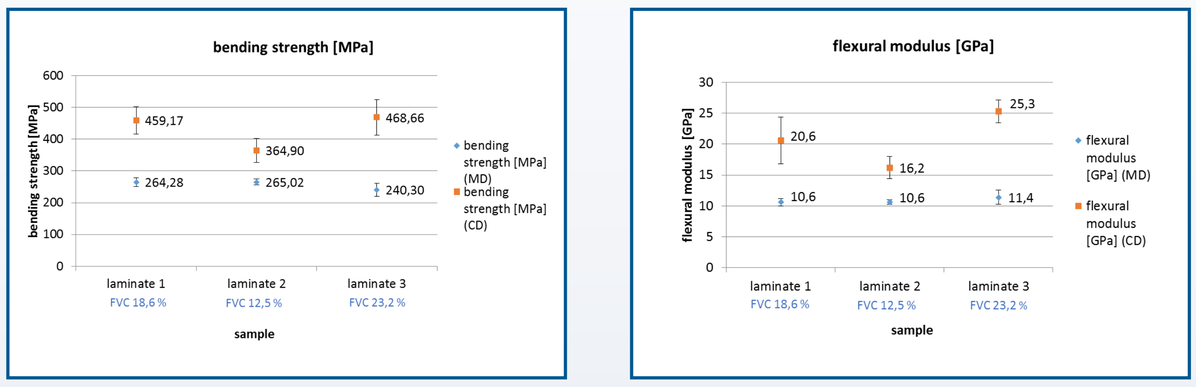

Figure 5: Mechanical properties of composite materials with different fibre contents

Conclusion:

During the project following results have been achieved:

- Analytic methods and quality classification were defined and successfully applied
- Online quality-monitoring, which considers the specific conditions of rCF processing, is successfully tested
- Re-use of nonwoven offcuts (so-called "rrCF") as starting material for the next nonwoven process is successfully tested
- Demonstrators made of prepregs combined with manual lay-up and autoclave technology (cf. fig. 6) or by using the RTM process (shown fig. 4)

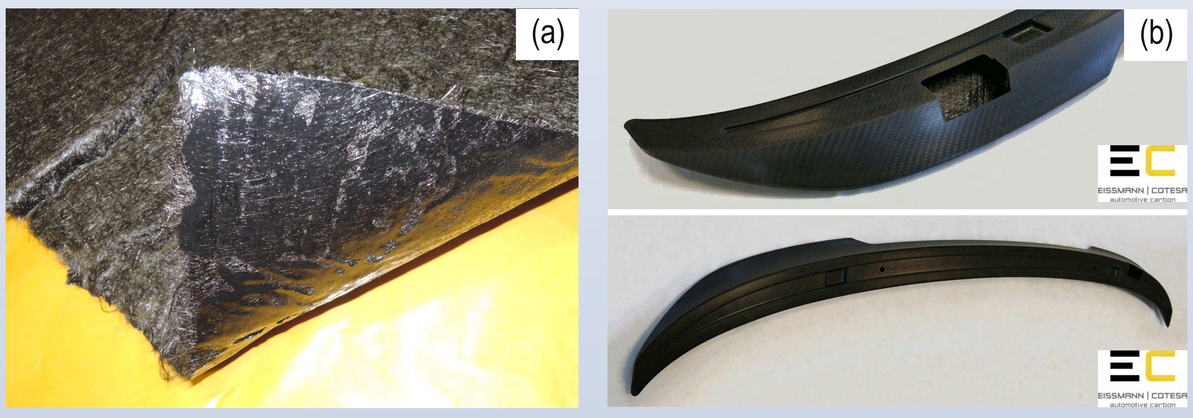

Figure 6: (a) rCF- nonwoven - prepreg (b) Front spoiler (autoclave process)

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