Development of Spun Yarn Made from Recycled Carbon Fibers for Reuse in Load-Bearing Components

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ITMA 2015 Speakers Plattform 15.-17.11.2015
1 Introduction
1 Introduction – Different Spinning Machinery at ITM

Lab Ring Spinning

Industrial Ring Spinning

Rotor Spinning

AirJet J20V3

Texturing Machine

DREF 2000/3000
1 Introduction – Special Textile Machinery for rCF

Special rCF Card       Special rCF Draw Frame     Special rCF Spinning Frame
2 Motivation

Carbon Fiber Waste
2 Motivation

1. Rising demand for carbon fiber and their applications
2. High amount of waste in the production and preforming
3. Increasing percentage of used carbon fiber
4. High purchase price of carbon fiber
5. Disposal problem of CF waste

→ Need for reuse of the used carbon fiber (rCF)
→ DFG Project CH 174/34-1
2 Motivation

- Hybrid Yarn:

  Schematic Yarn Structure

- Staple Fiber Yarn:

  Schematic Yarn Structure

Yarn Count: 200-2000 tex
2 Motivation

Advantages and Challenges of rCF Yarn Production

+ Useful disposal of carbon fiber waste
+ Re-use for load-bearing components
+ Implementation as hybrid yarn for thermoplastic application
  → cheap and fast consolidation of CFRP
+ High mixing level of the rCF fiber and thermoplastic matrix
  fiber allows optimum consolidation
+ Higher Drapeability with Carbon Staple Fiber Yarn in
  Preforms
  – Brittle CF and lack of crimp problem. i.e. need improved
  spinning process → low fiber damage for high strength
  CFRP
3 rCF Hybrid Yarn

- **Mixing**
  - rCF- Staple fiber
  - Thermoplastic fiber
  - Fiber Mix

- **Carding**
  - Carded Web
  - e.g. UD-Winding

- **Drafting**
  - Draw Frame Sliver
  - Hybrid Yarn

- **Consolidation**
- **Fabric Production**
- **Yarn Formation**

- **CFRP**
3 rCF Hybrid Yarn

I. Material for Hybrid Yarn

Types of Fiber used in this Project:

1. Cut Primary Carbon Fiber
2. CF Waste of semi-finished products manufacturing
3. CF Waste of pyrolyzed CFRP parts
4. Cut Primary PA6 Fiber
3 rCF Hybrid Yarn

I. Material for Hybrid Yarn

Carbon Staple Fiber

PA6 Staple Fiber
3 rCF Hybrid Yarn

II. Opening and Mixing rCF and PA6 fiber

Mix of rCF and PA6 fiber
3 rCF Hybrid Yarn

III. Web Formation

ITM Special rCF Card

Roller Distances

Metallic Card Clothings

Carded rCF Web
3 rCF Hybrid Yarn

IV. Drawing to sliver

rCF-Sliver

Slivers with 30%, 50% and 70% vol. rCF
3 rCF Hybrid Yarn

V. Spinning to Yarn

rCF Hybrid Yarn
4 Testing rCF Hybrid Yarn

Fiber Cross-Section

→ Very good mixing of fiber

PA6 (big grey dots)

CF (small white dots)
4 Testing rCF Hybrid Yarn

Yarn strength

60 mm cut rCF
4 Testing rCF Hybrid Yarn

Consolidation

UD-Winding Frame

Consolidated Plate

Hot Press with Vacuum
5 100% rCF Yarn (Cut Fiber)

Card Sliver with 100% rCF

Draw Frame Sliver with 100% rCF

100% rCF Yarn, 880tex
6 Outlook

Pending Investigations:

- Twist of rCF Yarns
- Spinning of 100% rCF Yarns (Pyrolysis)
- Improving Matrix Fiber
- Testing of Carbon Fiber Characterization
- Yarn Simulation

Further Investigations:

- Industrial Production of rCF yarns
- Manufacturing of semi finished parts and CFRP

Source: RJTA Vol. 15 No. 1 2011
Thank you for your kind attention!

We would like to thank German Research Foundation (DFG) for the financial support for this research work!

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