



North American
Pultrusion Conference

Thermoplastic pultrusion paves the way to mass application

M.Sc. Simon Schwab

Fraunhofer IGCV

Fraunhofer Gesellschaft

- Based in Germany
- World's leading applied research organization
- Founded in 1949
- 76 institutes and research units
- 30,000 employees, predominantly scientists & engineers
- annual research budget of €2.9 billion



Michael Wilhelm (ICT)

Material Properties and Recycling of Nylon 6-based Profiles



David Löpitz (IWU)

From Small Colorful Elements to the Final Profile: A Simulation of the Pultrusion Process



Simon Schwab (IGCV)

Thermoplastic Pultrusion Paves the way to Mass Applications



Fraunhofer



AGENDA

- DRIFT-process route
- Comparison of thermoplastic pultrusion process routes
- Lab analysis of melt pultruded samples
- Overall results of the DRIFT-process
- Future steps

DRIFT-process route

An innovative process-route for load path reinforced injection molded parts

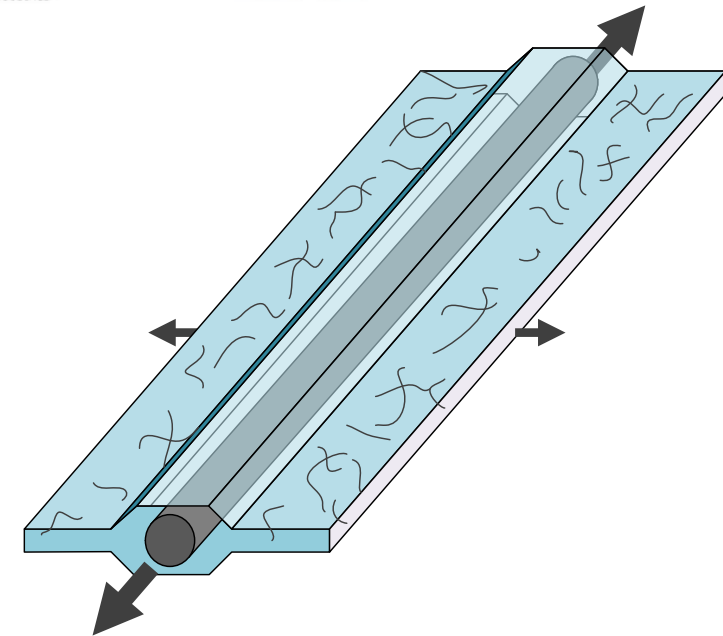
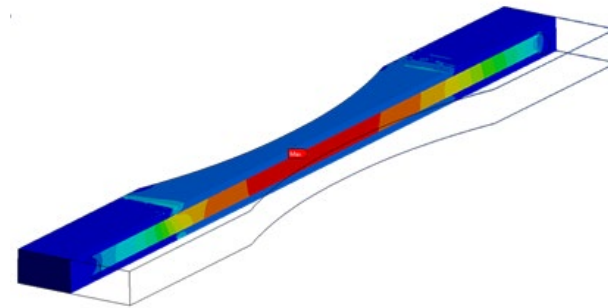
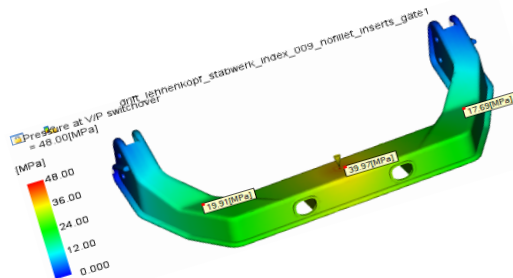
DRIFT-project



- Publicly founded project by the German federal ministry for education and research (BMBF)
- Project partners:



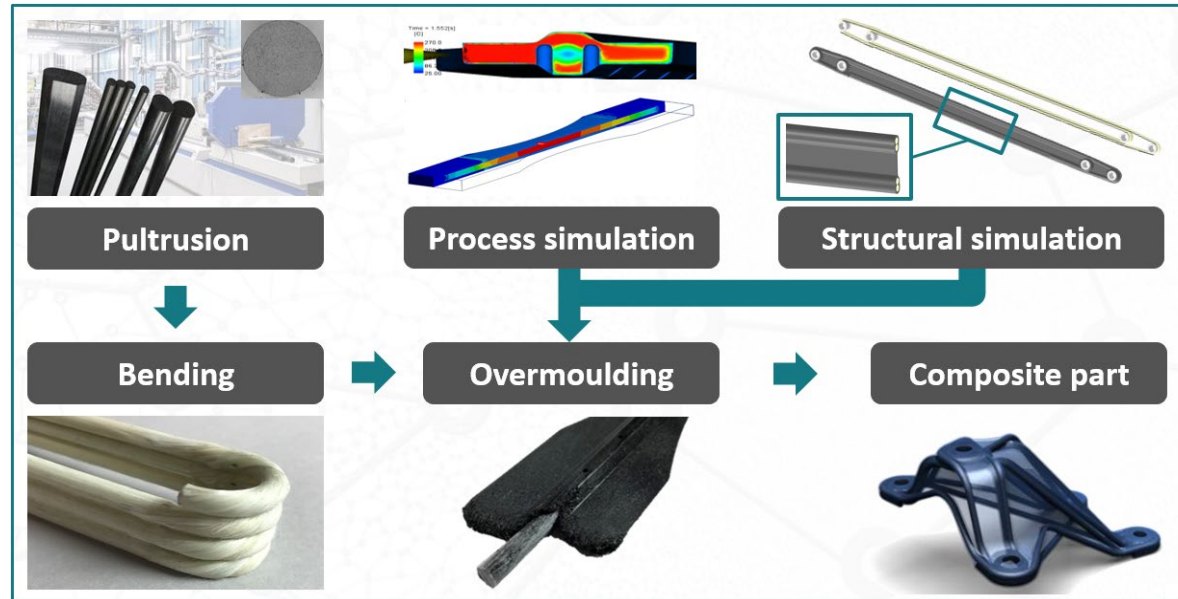
- Budget: 3.03 Million €
- Duration: 01.04.2020 – 31.03.2023



DRIFT-process route



- DRIFT: Wire-shaped inserts for load-appropriate fiber reinforcement of injection-molded thermoplastic components



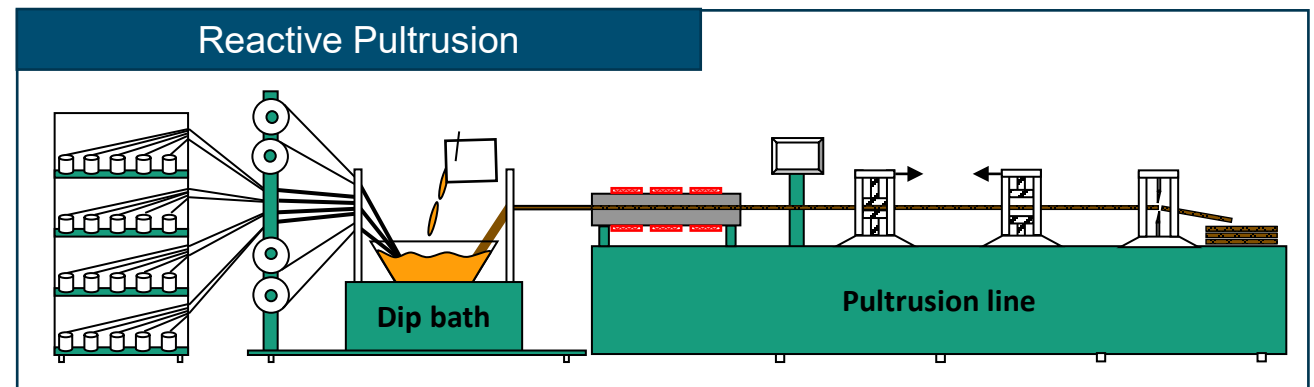
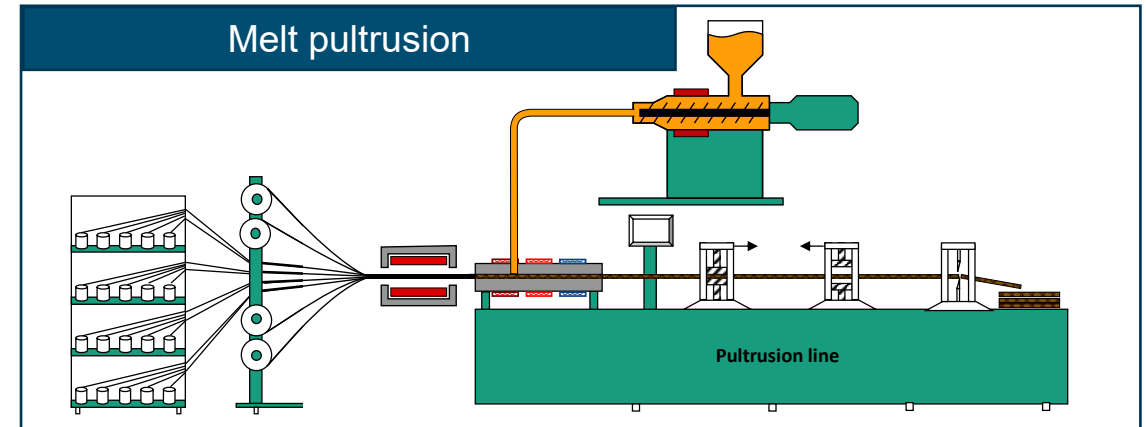
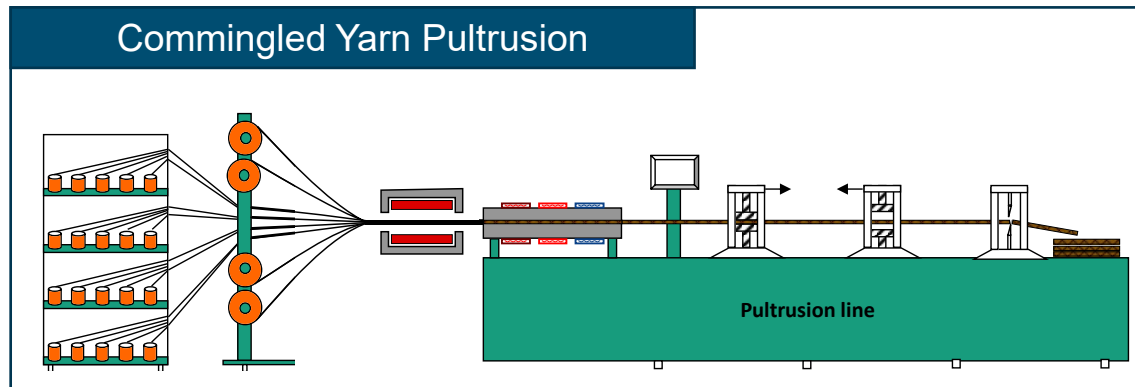
- Benefits:

- Short cycle-times due to combination of highly automated sub-processes (pultrusion, bending technology, injection molding)
- High part flexibility (3D-bending)
- Efficient raw material utilization due to low scrap-rate

Comparison of thermoplastic pultrusion routes

Benefits and drawbacks of melt pultrusion, commingled yarn pultrusion and reactive pultrusion

Thermoplastic pultrusion routes - Introduction



Comparison of thermoplastic pultrusion routes

Melt pultrusion	Commingled Yarn	Reactive pultrusion
<ul style="list-style-type: none">☺ Material variety☺ Material price☺ Very good bonding to injection plastic	<ul style="list-style-type: none">☺ Short impregnation path☺ Simple tool design☺ Scalability☺ Good bonding to injection plastic	<ul style="list-style-type: none">☺ Low viscosity☺ Similar to thermoset pultrusion☺ Scalability
<ul style="list-style-type: none">☹ Scalability☹ Melt viscosity☹ Tooling complexity☹ Additional invest for extruder	<ul style="list-style-type: none">☹ Medium material variety☹ High material costs	<ul style="list-style-type: none">☹ Low material variety☹ Bonding to injection plastic☹ High material costs

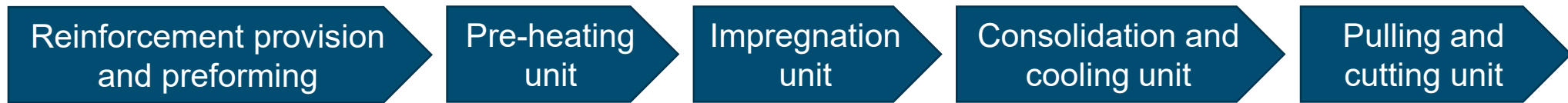
Due to the material variety and higher predicted bonding to the injection molded plastic **melt pultrusion** was chosen as the main pultrusion technology within DRIFT

Melt pultrusion

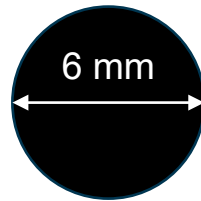
Analysis of melt pultruded samples

Melt pultrusion – General information

- Process steps:



- Target profile:



- Material combinations:

Fiber types
<ul style="list-style-type: none">• Carbonfiber (CF)• Glasfiber (GF)
Matrix types
<ul style="list-style-type: none">• Polypropylen (PP)• Polyamid 6 (PA6)



Material combinations
<ul style="list-style-type: none">• Glasfiber/Polypropylen• Carbonfiber/Polypropylen• Glasfiber/Polyamid 6• Carbonfiber/Polyamid 6

Fiber volume content (FVC)

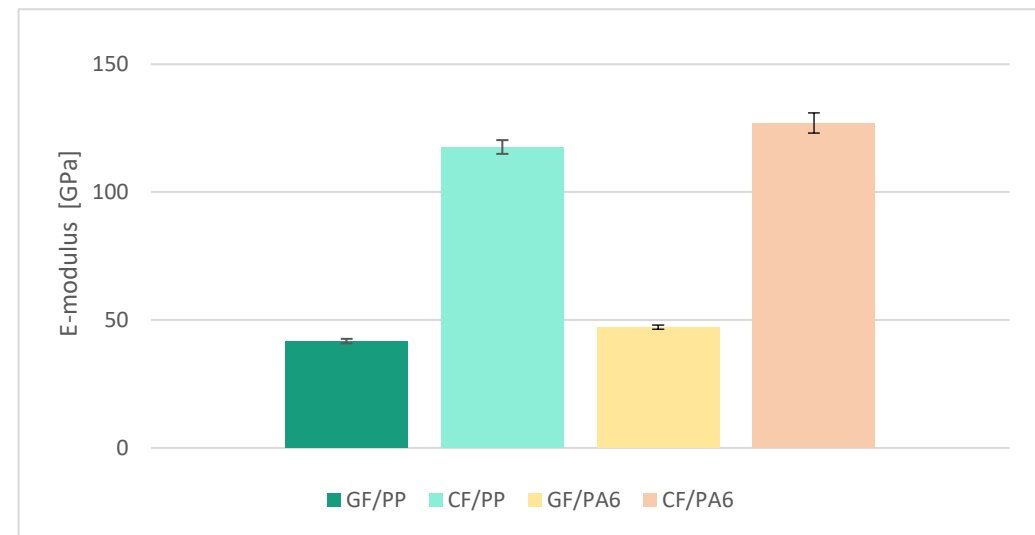
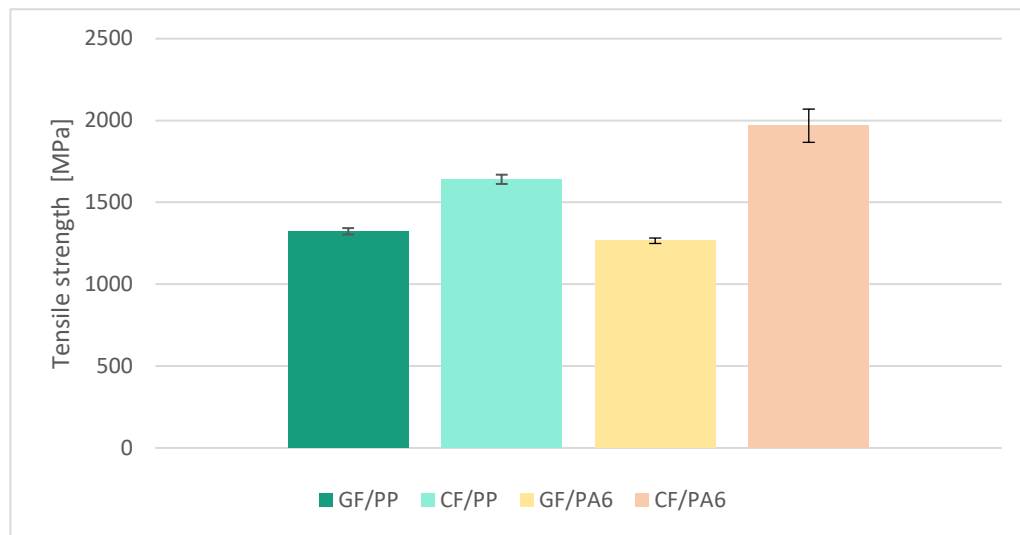
- FVC was determined via wet chemical analysis according to EN 2464:2018

Material combination	FVC [%]	Standard deviation [%]
GF/PP	53.3	1.2
CF/PP	53.3	0.3
GF/PA6	57.6	2.5
CF/PA6	57.8	0.1

Higher FVC was reached with PA6 → Can be attributed to different processability

Tensile properties

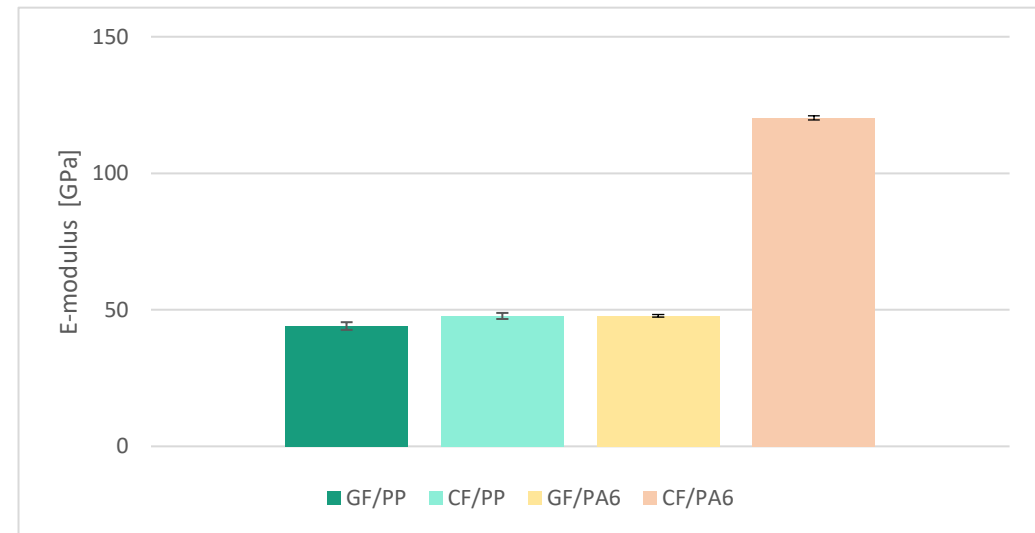
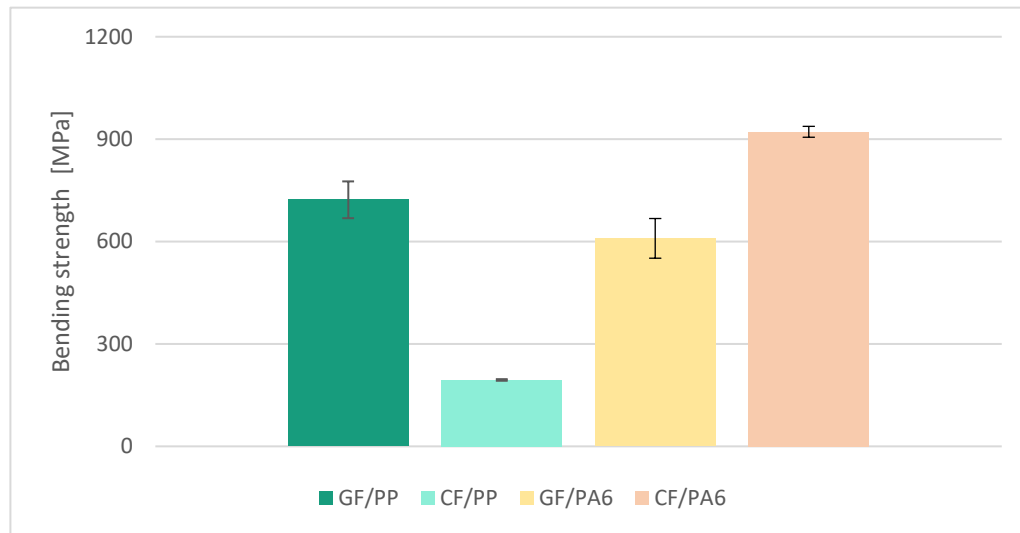
- Tensile strength and stiffness test is based on DIN EN ISO 527
- Specific clamping device was implemented



CF shows significantly higher strength and stiffness. PA6 shows higher stiffness and strength in combination with CF.

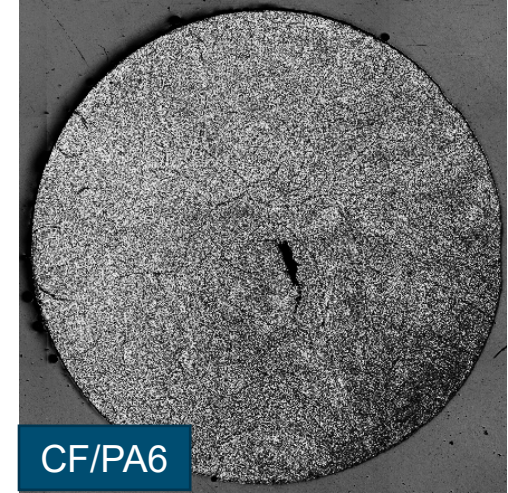
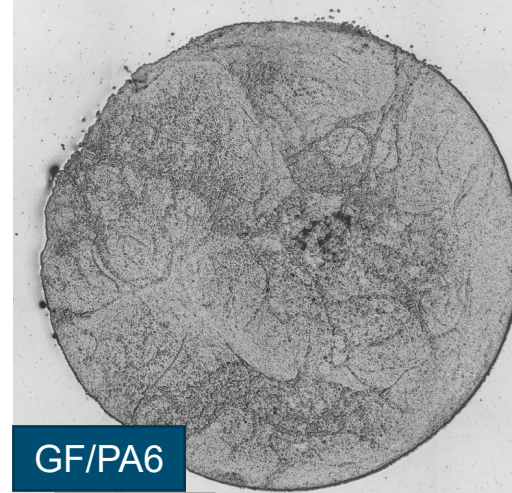
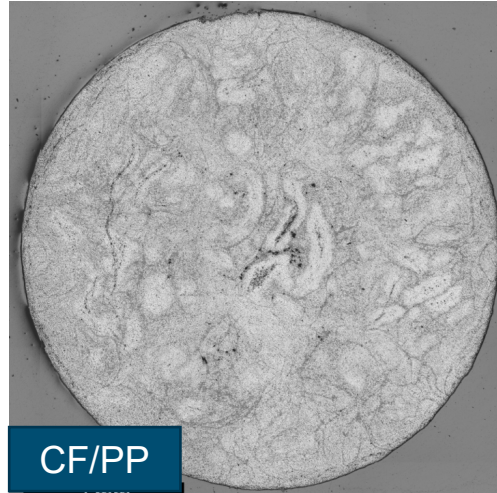
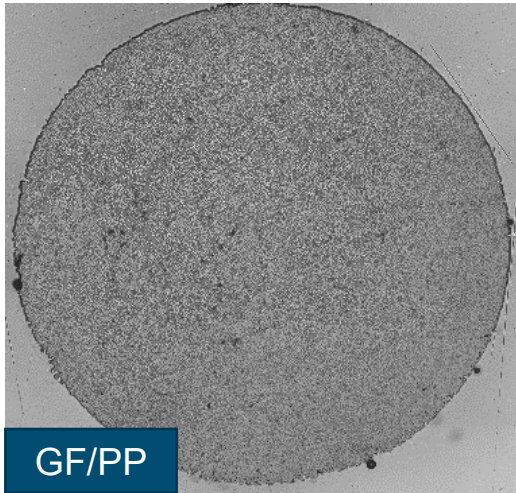
Bending properties

- Bending strength and stiffness is based on DIN 53390 and DIN EN ISO 14125
- Specific testing device was implemented



CF/PA6 shows highest strength and stiffness. CF/PP shows pure strength and significantly lower stiffness than expected → Can be attributed to the pure fiber-matrix-adhesion between CF and PP.

Microscopy



GF/PP shows best results in void content and good results in round shape and surface quality.
CF/PA6 shows void in the middle section and best results in round shape and surface quality

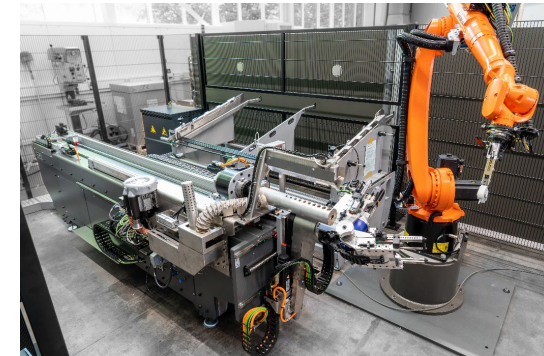
Overall results of the DRIFT-project

Overview of the overall process results

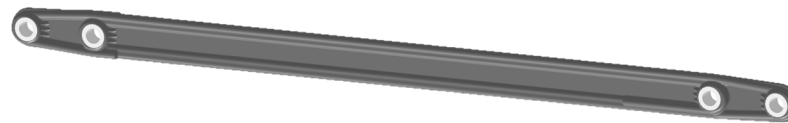
DRIFT – A success story

- The TRL of the thermoplastic pultrusion process has been taken to a new level.

- A bending machine specifically for composite materials was developed



- Two demonstrators for the automotive industry with potential serial production were developed



- JEC Innovation Award finalist (<https://www.jec-world.events/de/program/innovation-awards>)

DRIFT – A success story

JEC PARIS-NORD VILLEPINTE
WORLD 2023 The Leading International Composites Show
April 25-27, 2023

RENEWABLE ENERGIES
BUILDING & CIVIL ENGINEERING
MARITIME TRANSPORTATION & SHIPBUILDING
DIGITAL, AI & DATA
CIRCULARITY & RECYCLING

INNOVATION AWARDS FINALISTS 2023

AEROSPACE
EQUIPMENT, MACHINERY & HEAVY INDUSTRIES
AUTOMOTIVE & ROAD TRANSPORTATION
SPORTS, LEISURE & RECREATION

Official sponsor
KORDSA
THE REINFORCER

Future steps

What's next concerning the DRIFT-process?

DRIFT-process route – What's next?

- Fraunhofer IGCV will implement the process route at the institute together with project partners

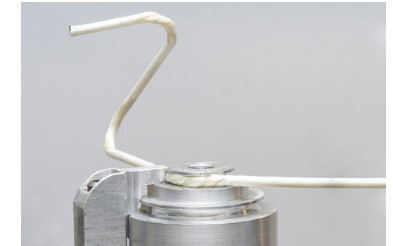
1. Thermoplastic pultrusion technology

1. Process optimization
2. Further material
3. Investment in processing equipment



2. Bending technology

1. Acquired the newly developed bending machine
2. Commissioning of the machine
3. Strategic process and technology development with Wafios to bundle the competences and create knowledge



3. Injection molding technology

1. Further investigation together with strategic partners

- Several project ideas are being pursued and funding applications are submitted



Further project ideas?



<https://www.modersohn.eu/bauwesen/detailseite/betonbewehrung-anschlussysteme/>



<https://www.tradeinn.com/smashinn/de/wilson-burn-100-v4.0-tennisschlager/137525582/p>



<https://www.epoxyworks.com/index.php/building-composite-tubes/>



<https://hockeywebshop.de/feldhockey/hockeyschlager/adidas-de/>

Do you have further project ideas? Feel free to contact us!

Contact

Simon Schwab

Pultrusion

Tel. +49 821 90678-237

Fax. +49 821 90678-40237

simon.schwab@igcv.fraunhofer.de

Fraunhofer Institute for Casting, Composite and Processing

Technology IGCV

Am Technologiezentrum 2

86159 Augsburg, Germany

www.igcv.fraunhofer.de

