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Next-Generation Composite Materials and Processes

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Presented at Kompojaosto theme day 22.9.2021:

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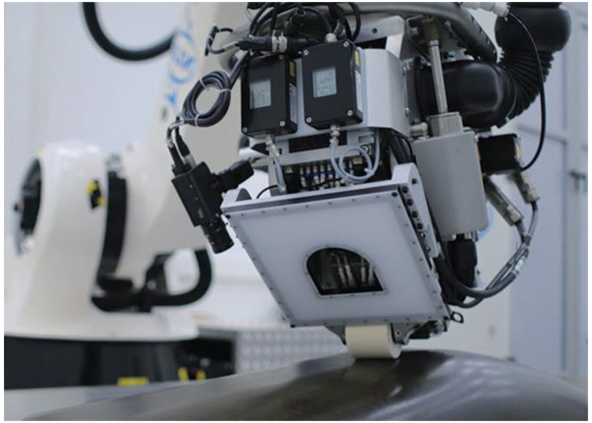
- Sensors for process monitoring
- Thermoplastic epoxy
- Pin-based tooling systems
- Carbon fiber-reinforced concrete
- Hydrogen in aviation
- Various new approaches

Sensors for process monitoring

AFP

- Fives Cincinnati/Lund – Flightware and profilometer
- Danobat – Profactor
- MTorres – Airbus InFactory Solutions, Profactor
- Electroimpact – Aligned Vision (777X wing)
- Coriolis – Edixia
- Coriolis – Apodius at NLR via SuCoHS project
- Electroimpact – Real-time In-Process Inspection Technology

SOURCE | Hexagon and SuCoHS Project, Sep 2019 by project coordinator Tobias Willie (DLR)



Coriolis – Apodius at NLR via SuCoHS project

- Sustainable Cost Efficient High Performance Composite Structures demanding Temperature and Fire Resistance
- Vision sensor mounted onto AFP head
- Detects gaps, twists, FOD, tow start/end positions
- Inline system for speeds >400 mm/s (24 m/min)
- For complex geometries as well as flat panels

SOURCE | SuCoHS Newsletter #3

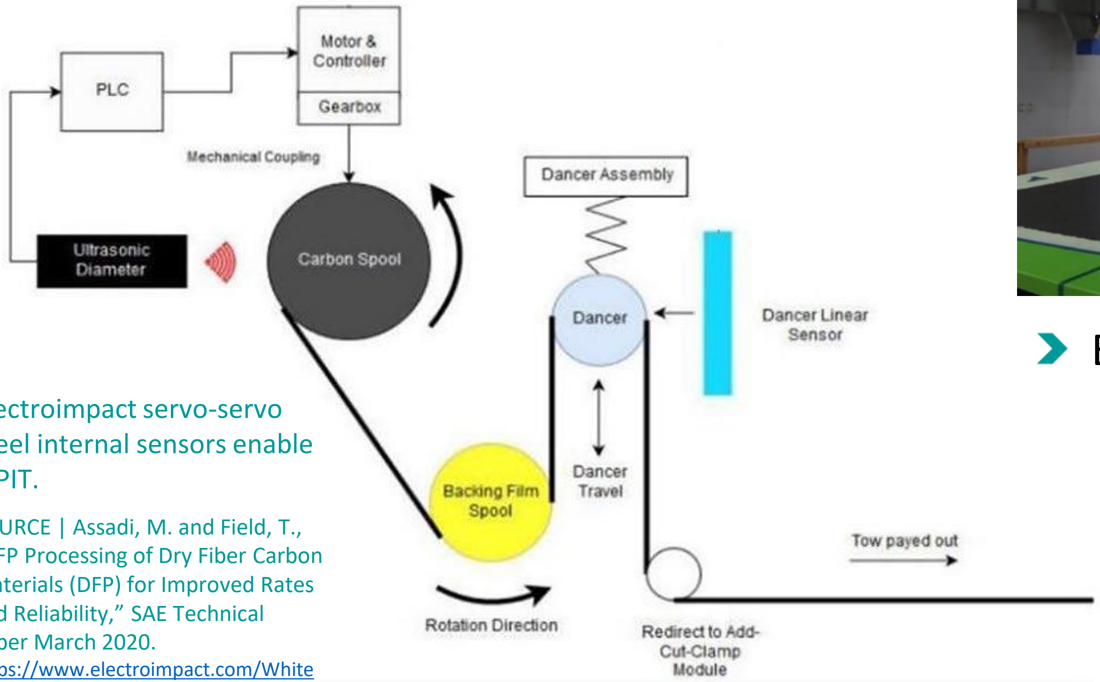
AFP process monitoring

- Coriolis – Apodius at NLR via SuCoHS project
  - Vision system measures differences in the height profile of the lay-up material.
  - It allows the system to pick up every feature on the part's surface, even one micrometer thick, such as backing paper.
  - Provides in-situ quality feedback and process status in real-time.
  - Composites 4.0 capability — add lay-up process and quality data to digital twin – also loop back to simulation for more accurate prediction.
  - Successfully demonstrated with new thin-ply toughened (20% PES) cyanate ester tape developed by FHNW and North Thin Ply Technology.

Hexagon Apodius AFP Inspection System at NLR facilities in Marknesse.
SOURCE | Alexander Leutner, SuCoHS Newsletter #3 – Interviews, July 2020

n|w University of Applied Sciences and Arts Northwestern Switzerland

AFP process monitoring



Electroimpact servo-servo creel internal sensors enable RIPIT.

SOURCE | Assadi, M. and Field, T., "AFP Processing of Dry Fiber Carbon Materials (DFP) for Improved Rates and Reliability," SAE Technical Paper March 2020. https://www.electroimpact.com/WhitePapers/2020-01-0030.pdf

Electroimpact – RIPIT

- Real-time In-Process Inspection Technology
- Servo-servo creel internal sensors
- Detects tow slips >.050 inch (>1,27mm)
- Detects add or cut placement error ±.050 inch
- Increased tension control for higher DFP rates (>100 m/min)

CW
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Sensors for process monitoring

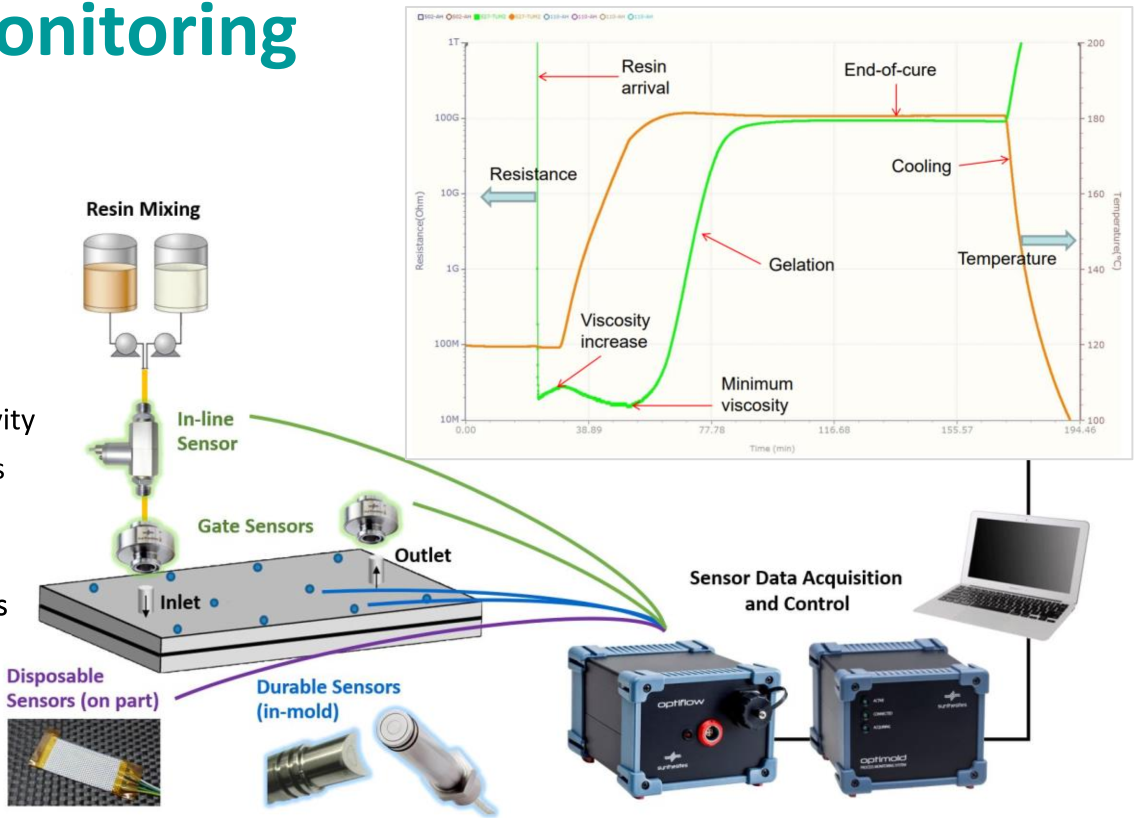
Cure

- Netzsch, Lambient – AC dielectric
- Synthesites – DC dielectric
- Luna Innovations, Technobis – Optical fiber

Synthesites

- Dielectric analysis (DEA) - resin electrical resistivity
- Resin flow + temp + electrical resistance sensors
- Real-time estimating viscosity, Tg, degree of cure
- Used/certified for production by wind blade mfrs and Airbus (Bombardier) A220 resin infused wings

Typical RTM6 cure cycle as measured with Optimold

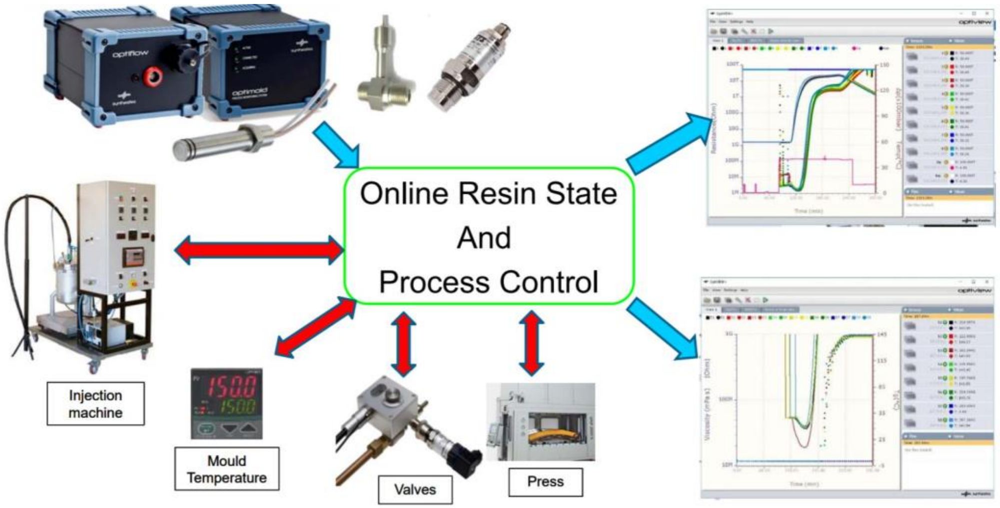


OPTIFLOW and OPTIMOLD units

SOURCE | "DC dielectric sensors for industrial composites production", *CW* blog Feb 2020.

RTM process monitoring

- Synthesites
  - Process control
    - Feed lines open/close based on resin arrival data
    - Heating/cooling and pressure based on resin viscosity
    - Stop cure cycle based on Tg
  - Can reduce cure times by >30%
    (e.g., RTM6 from 2 hrs @ 180°C to 70 min)

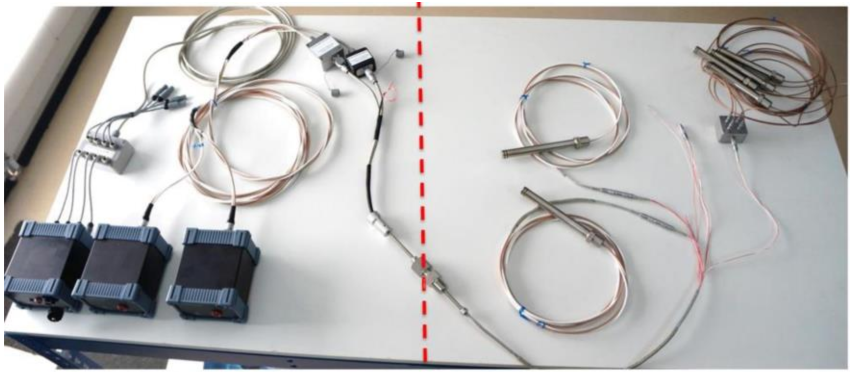


SOURCE | Nikos Pantelelis., "Material characterisation: From R&D to production, a case study," EuroNanoForum, June 2019.

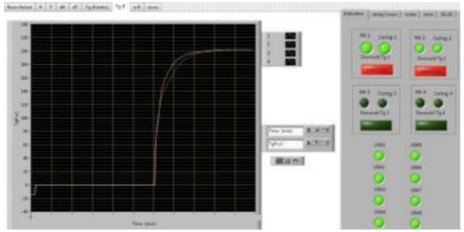
- Working w/ wind blade mfrs to start cooling after target Tg reached in 5 key locations
- Real-time Tg estimation vs. DSC after demolding
  — mean difference 1.6°C isothermal, 2.2°C non-isothermal

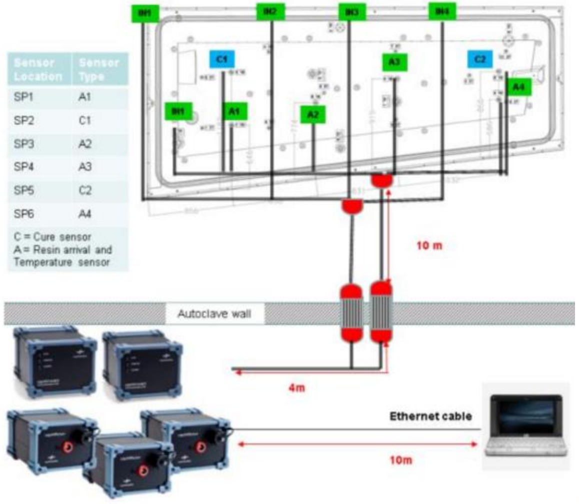
Infusion process monitoring

- Synthesites
  - Demonstration at Bombardier Belfast for **ECOMISE** project
  - Real-time Tg prediction and demolding at targeted Tg



Outside of the autoclave — Inside of the autoclave



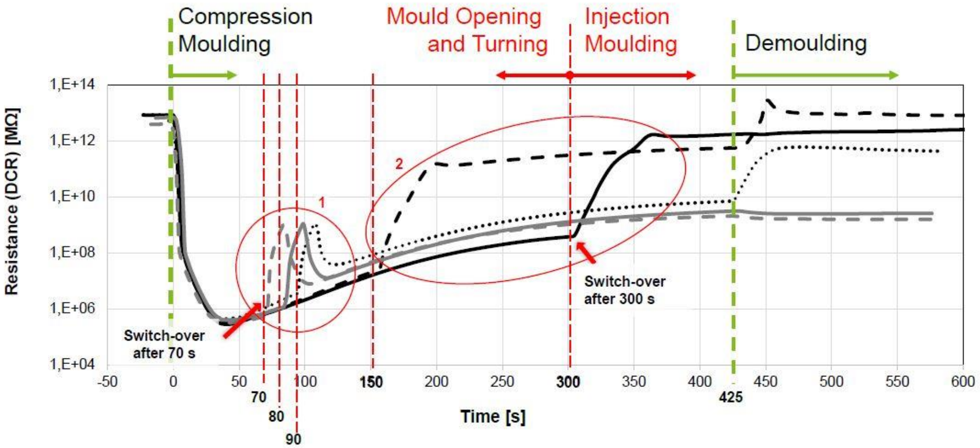


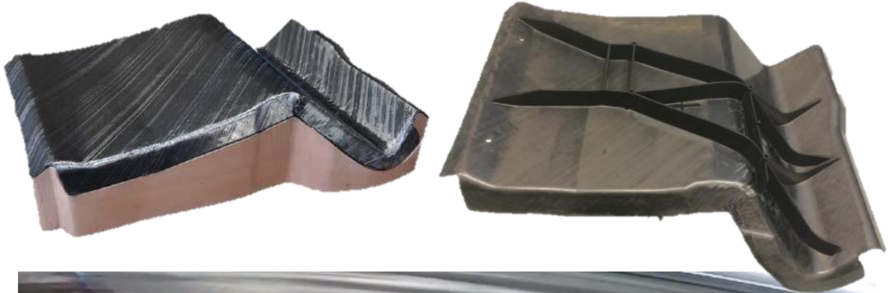
SUOM HUOM:
ColloidTek ~ vastaavankaltaisia prosessiteollisuuden antureita Suomesta
www.collo.fi

SOURCE | Nikos Pantelelis., "Cure monitoring of high-temperature resins for enhancing the manufacturing of advanced composites", EASN Conference "Innovation in Aviation & Space", Sep 2019.

Prepreg process monitoring

- Synthesites
  - 50% reduction cure time of FML (GF/epoxy prepreg)
  - **OPTO-Light** thermoplastic-overmolded CF/epoxy prepreg

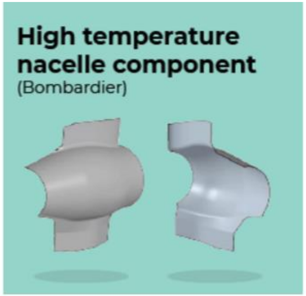




SOURCE | "Thermoplastic overmolded thermosets, 2-minute cycle, one cell", *CW* March 2019

High-temp monitoring

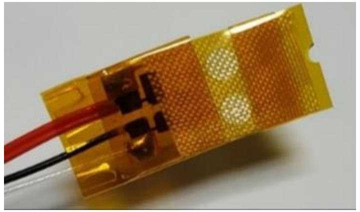
- Synthesites' developments in SuCoHS project
  - High-temp disposable sensor for thin-ply and durable sensor used in direct contact with carbon fiber up to 300°C first ➡ ultimately 350°C
  - Self-sensing technologies to use carbon fibers in the composite for sensing process and structural properties
  - Successful trials with Cytec 5250 BMI, PES-toughened cyanate ester (PFA, thermoplastics)

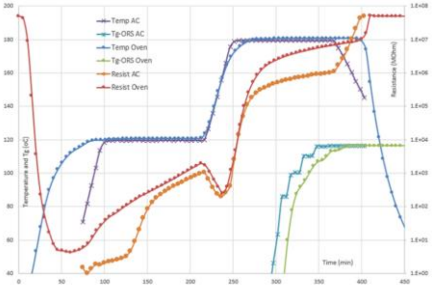


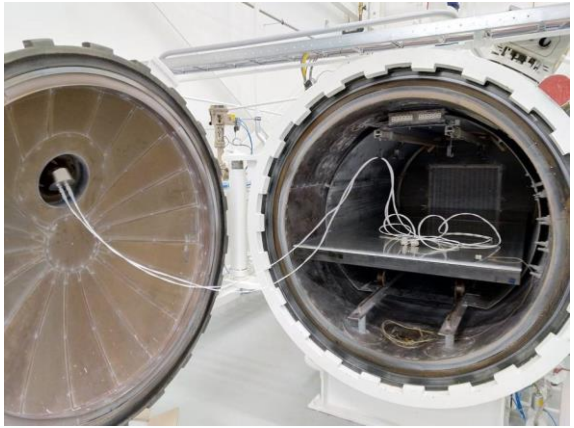
- Reduce # subparts and part complexity
- Tg < 335°C

- Avoid Ti. APU housing
- Tg < 300°C
- Fire resistance, damage tolerance

- New structure concept
- Higher performance, lower cost
- FST



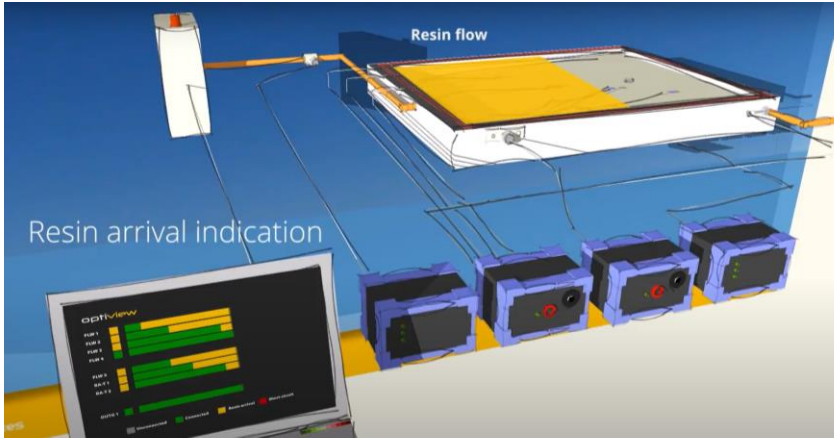


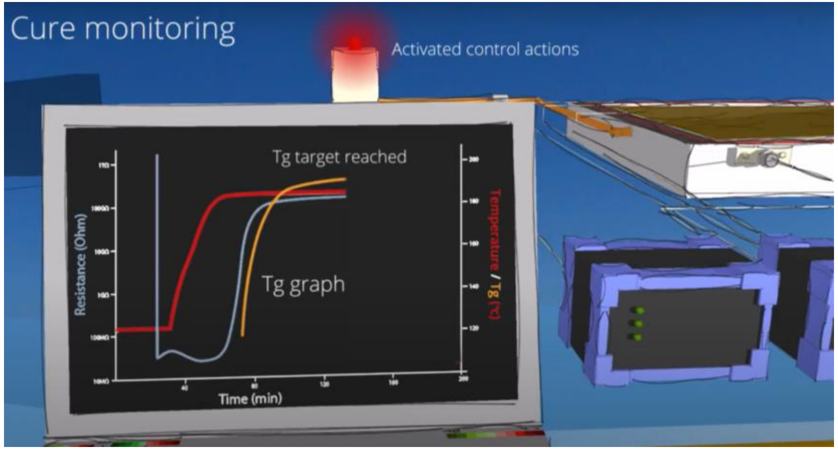


SOURCE | Nikos Pantelelis., "Cure monitoring of high-temperature resins for enhancing the manufacturing of advanced composites", EASN Conference "Innovation in Aviation & Space", Sep 2019. and SuCoHS Newsletter #3 – Interviews, July 2020

4.0 Process Control

- Synthesites
  - Check resin quality and adjust process accordingly
  - Detect accurately resin arrival at critical locations
  - Open/close valves based on sensors' feedback
  - Monitor viscosity changes and decide when to start heating
  - Identify minimum viscosity and decide about pressure
  - Detect unexpected events and follow alternative routes
  - Improve simulation accuracy and design intelligent strategies
  - Real-time cure cycle decisions based on Tg and degree of cure rather than time
  - Real-time quality control for Composites 4.0 and scaled-up composites production
  - Real-time data capture for digital twins

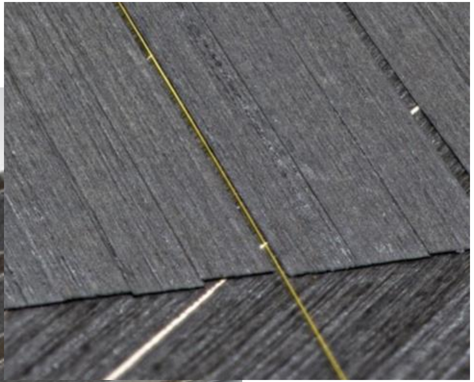


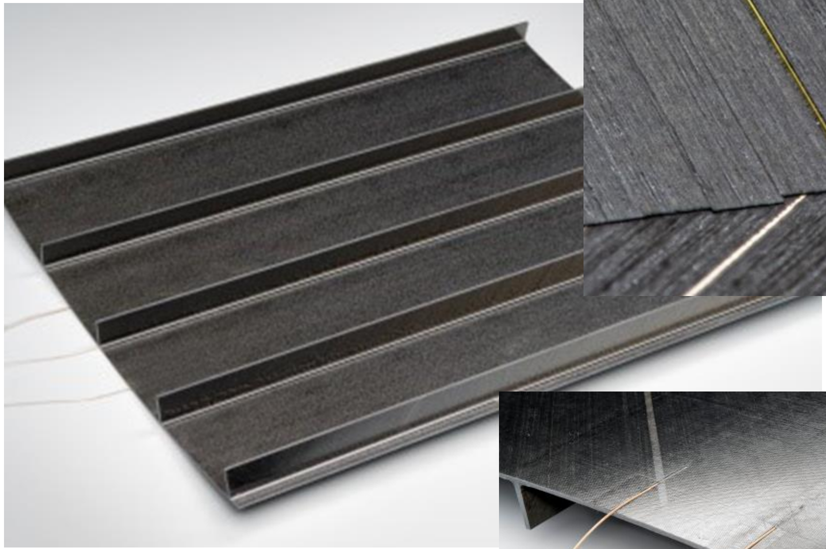


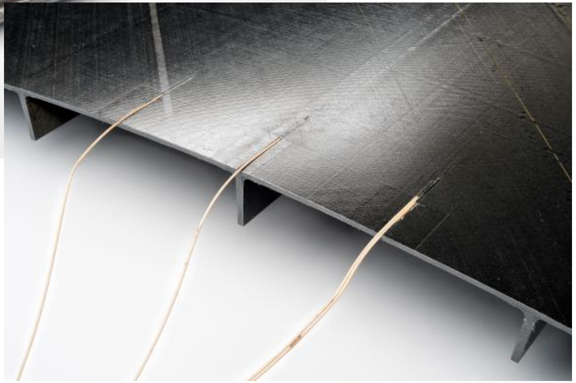
Sensors for process monitoring

- Technobis
  - Fiber Bragg Grating (FBG) measures reflected light translates to strain or temperature
  - Polyimide coated fiber can withstand 300°C (up to 400°C for short periods)
  - Laid via one of 8 feeds in AFP head
  - Cure monitoring: strain transfer into the FBG sensors during the cure process captured by the interrogator
  - PEEK tubes protect optical fiber at ingress/egress
  - Fibers connected to Technobis SwitchedGator interrogation system outside autoclave
  - Demo successful – further tests for structural health monitoring of the composite panels, i.e. thermo-mechanical load monitoring, and damage and impact detection.

Optical fiber placed with AFP







Risk mitigation structure with integrated stiffeners made using AFP and hot forming with embedded optical fibers with FBG sensors.

SOURCE | SuCoHS Newsletter #3 – Work progress and SuCoHS Newsletter #3 – Interviews, July 2020

Reversible Resins

Thermoplastic epoxy

- Dow patent filed U.S. patent 3,317,471 in 1959
- Union Carbide patent
- L&L Products – L-F610 reformable epoxy adhesive
- Cecence K_Series

3,317,471
Patented May 2, 1967

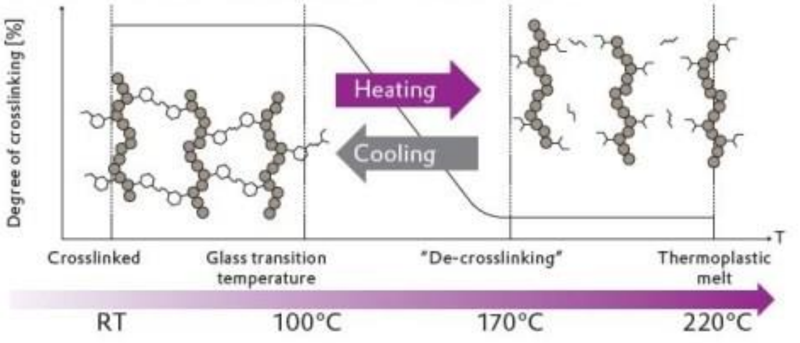
The new composition is the first linear epoxy resin known to the industry. The prior known "cured" epoxy resins were all cross-linked thermoset resins which could not be worked after "curing." The advantages of the new linear resins over the older thermosetting resins are obvious. Thus, for example, the new resins can be repeatedly molded, extruded or drawn whereas the thermosetting resins must be cured in shape and are usually subject to degradation before any softening is apparent.

Deils-Alder

- Evonik "thermoreversible crosslinkable thermoplast-thermoset hybrid"
- Epoxy below 100°C, Thermoplastic above 170°C
- Loss of crosslinks upon reheating

Switchable material behavior without a catalyst

When heated, the polymer network dissolves and the system can be reshaped. When cooled, the network reforms to yield a stable form.



Vitrimers

- CIDETEC 3R
- Mallinda

SOURCE | "Hybrid Polymers", pp. 15-16, *Elements #54*, published by Evonik, cited in *CW* blog Dec 2016

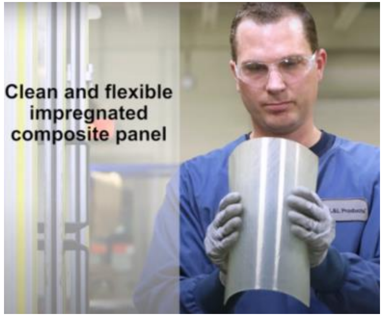
Reversible Resins

- L&L thermoplastic epoxy resins (TPER)
  - Polymerization of linear polymer chains based on epoxy resins
  - Amorphous TP with high strength, stiffness
  - Yield stress = 8400 psi/ 58 Mpa
  - Strain-to-failure up to 40%
  - Tg = 80-90°C, processing at 175-200°C
  - Short cycle times (<15 min)
  - RT stable, 2-yr shelf life

SOURCE | L&L commercial presentation 2015

SOURCE | Chmielewshki, Kaffenberger, "… composites based on a novel thermoplastic epoxy resin matrix", SPE Automotive 2008 and L-F610 data sheet

https://www.youtube.com/watch?v=yetG-AzZVIE

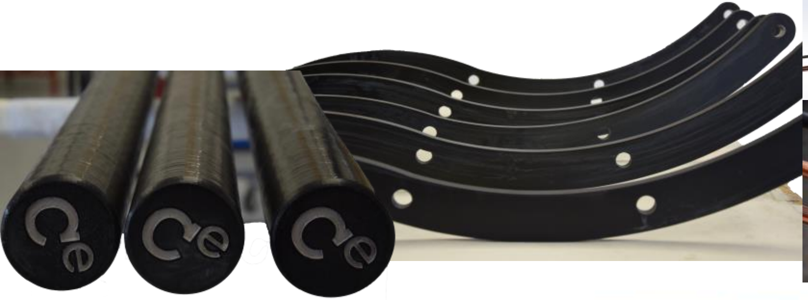


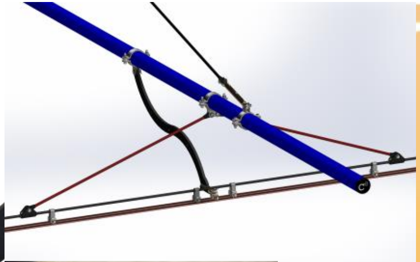
Reversible Resins

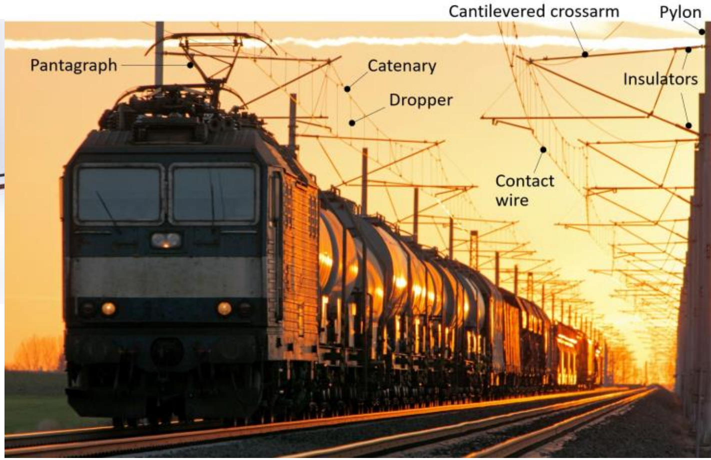
- Cecence K_Series
  - Thermoplastic w/ epoxy components at end of polymer chains
  - Low viscosity (80 cP) at 100°C
    Easily prepregged, 60% fiber by weight
  - Fast compression molding:
    RocTool auto hood in 2 min 40 sec
  - Reformable: K_Plate at 150-220°C, K_Chip at 240°C
  - Epoxy-like bondability, paintability

K_Rod, K_Chip and molded K_Plate

SOURCE | "Industrialization of thermoplastic epoxy", *CW* July 2020







Reversible Resins

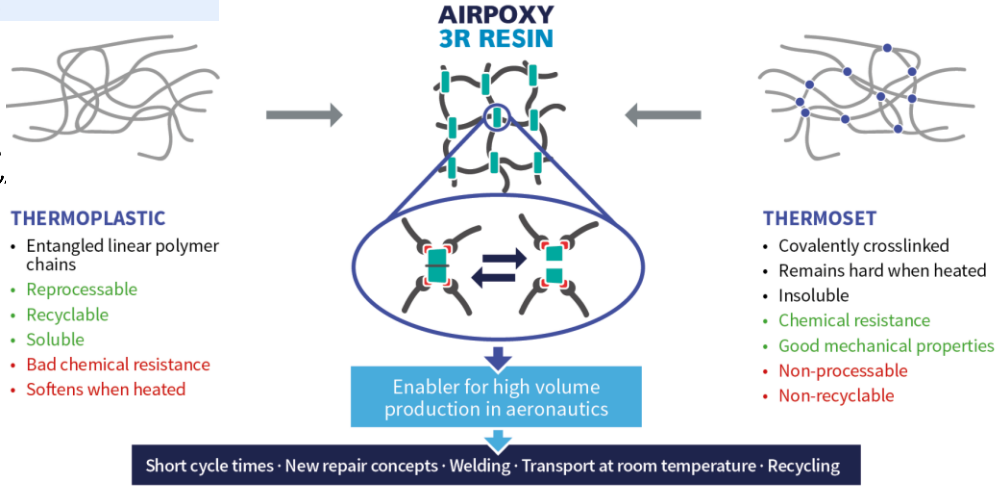
Self-healing and thermoreversible rubber from supramolecular assembly

Philippe Cordier, François Tournilhac, Corinne Soulié-Ziakovic & Ludwig Leibler

Nature **451**, 977–980(2008) | Cite this article

Vitrimers

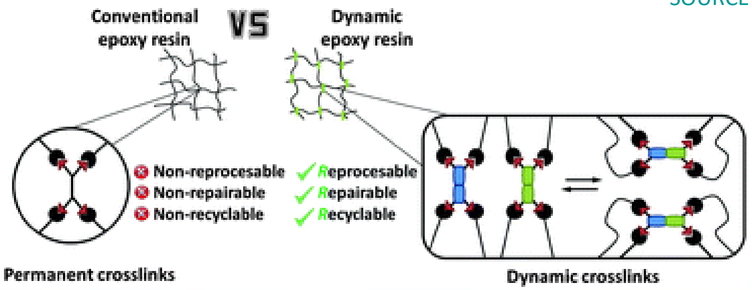
- "Leibler patent US2013/0300020 epoxy thermoset composite which could be [reprocessed/remolded], repaired or recycled" — CIDETEC patent EP 2 949 679 A1 filed 2014
- Catalyst (e.g., Zn salt) essential for reversibility
- Dynamic crosslinks / dynamic exchange reactions
- Permanently cross-linked polymer networks undergo temperature-induced bond shuffling through an associative mechanism allows reshaping and welding



SOURCE | https://www.airpoxy.eu/

CIDETEC Surface Engineering "3R"

- Reprocessable, Repairable and Recyclable
- WO2015181054A1 "Thermomechanically reprocessable epoxy composites and processes for their manufacturing"
- Eliminates need for catalyst
- Working with **Airpoxy, Ecoxy and Harvest (Euro projects)**



Javier Rodríguez, Ibon Odriozola (CIDETEC), "Epoxy resin with exchangeable disulfide crosslinks …" May 2016

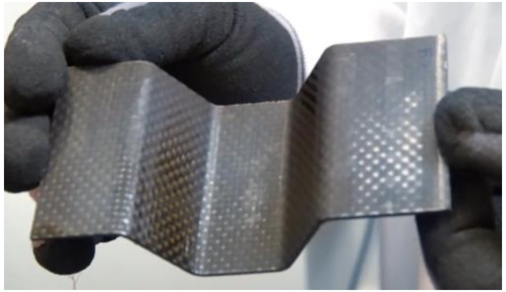
Vitrimers

Airpoxy

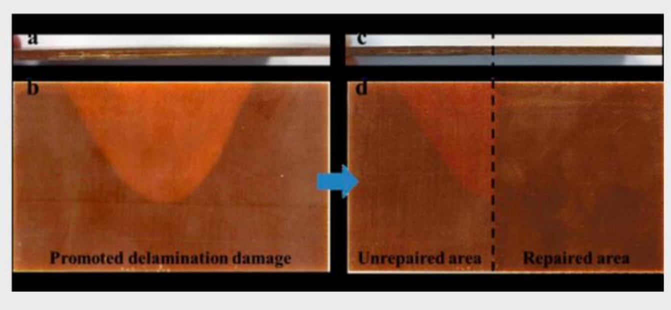
- 11 partners, 6 countries, 42 months – started Sep 2018
- New family of 3R thermoset resins via commercially available dynamic hardeners
- TRL 3 to TRL 5 via 2 aircraft panel demonstrators
- Thermoforming at 80°C
- Enable recyclability
- Transient mechanochromism – material changes color with damage, reversible within in a few hours
- Self-repair

- AIRPOXY project is related to the work programme “Maintaining industrial leadership in aeronautics”. It is a European collaborative project funded by the EU Framework Programme for Research and Innovation, Horizon 2020. With a budget of about €6.5 million, the project started on 1st September 2018 and will last for a duration of 42 months.

cidetec surface engineering | Institut für Verbundwerkstoffe | coexpair | eurecat | ÉIRECOMPOSITES | IDEC | sonaca | CSM Lab | Altair | ARTTIC | UNE Normalización Española



First 3R adhesive. SOURCE | airpoxy.eu/



Delamination in 3R laminate (left) repaired by applying heat and pressure (right).

SOURCE | https://www.cidetec.es/en/top-achievements/3r-leading-technology

Vitrimers

Ecoxy

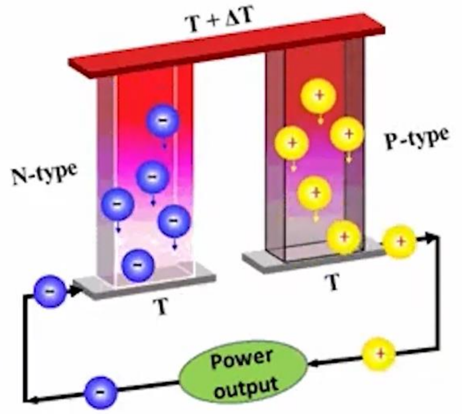
- Bio-based 3R composites – 13 partners, 8 countries
- Improved-property biofibers, novel FR + 3R bioresin
- Pultrusion, wet compression molding and/or RTM
- Mechanical & chemical recycling demonstrated
- Auto seat back and construction window profile demo parts

Lab-scale demonstrators. SOURCE | https://ecoxy.eu/

- The European project, involving twelve partners from eight different countries, has achieved its goal by finishing the enquiry and **development of new thermoset and sustainable materials**, made of a plant origin resin and reinforcements of either linen fiber or biobased PLA. **The investigation has concluded that the developed materials are capable to provide three competitive advantages, the 3R: they are repairable, reprocessable and recyclable**. ECOXY, with CIDETEC as coordinator these years, had a budget of 4.85 million euros, contributed entirely by the European Commission through the Biobased Industries Joint Undertaking (BBI JU) consortium.

SUOM HUOM: Reaktiivisista hartseista lisää teemapäivän muissa esityksissä

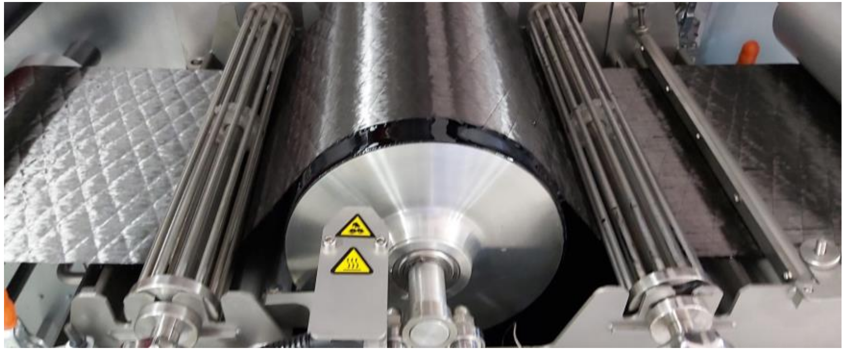
Vitrimers



Harvest

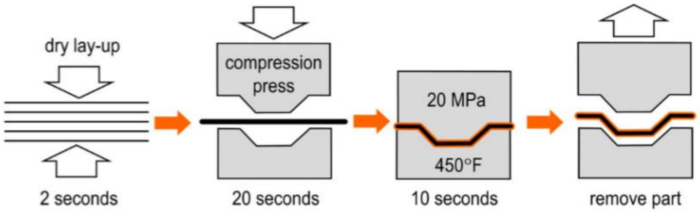
- 11 partners, 6 countries - 36-month project started Sep 2018
- Develop multifunctional, **thermo-electric energy generating (TEG)** structural composites for aviation
- Capable of **SHM, energy harvesting and self-repairing**
- Bio-inspired hierarchical carbon fiber reinforcements (micron-scale CF with nanoparticles)
- Nano-modified 3R matrix (Repair-Recycle-Reprocess)
- Printed ink and roll-to-roll mfg of TEG-enabled prepregs

First nanomodified 3R resin tubular demonstrator (June 2020).
SOURCE | https://www.harvest-project.eu/first-nanomodified-3r-resin-prepregs/



First nanomodified 3R prepreg (May 2020).
SOURCE | https://www.harvest-project.eu/first-nanomodified-3r-resin-prepregs/

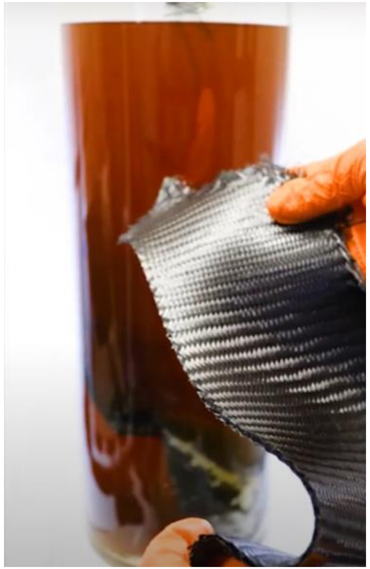
Vitrimers

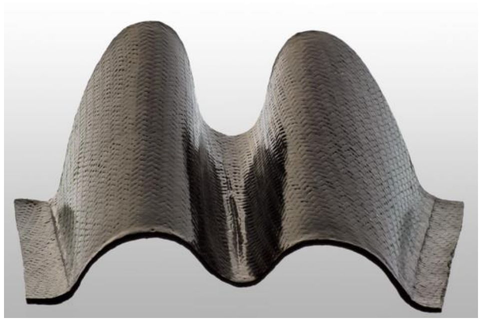


Fast consolidation and compression molding.
SOURCE | Kissounko, Taynton, Kaffer, "New Material: Vitrimers Promise to Impact Composites"

Mallinda, USA

- Vitrimers = new class of polymers based on dynamically exchangeable imine-linked polymer networks without catalysts
- When heated above Tg, fully cured polymer undergoes rapid dynamic covalent bond exchange: TP above Tg - TS below Tg
- Chemistry is highly tunable – Mallinda formulated polymers with Tg from 20°C to 240°C and elastomeric to crystalline
- Liquid resin must be cured/polymerization into solid;
  low viscosity facilitates prepregging;
  then rapid (< 1 min) compression molding
- Closed-loop system for recycling/recovery of polymer and fiber; 30% recycled resin into prepreg without mech. property loss
- Predicting prepreg cost $11-16/lb (19-28€/kg)
  elimination of preforming – direct prepreg thermoforming
  estimated CFRP cost savings 25-30%





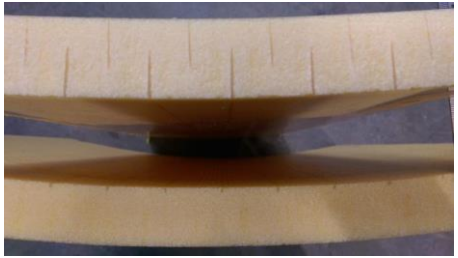
SOURCE | IACMI member spotlight Mallinda

Recovery of fiber and resin.
SOURCE | mallinda.com/the-technology

Pin-based Tooling

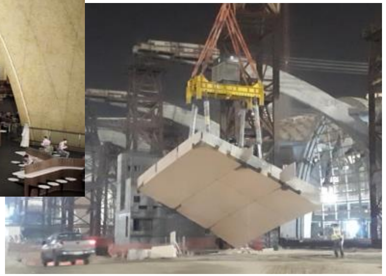
Adapa

- Surface shape from 3D design files - actuates < 5 min
- Bed of linear actuators powered by stepper motors
- Multilayer molding surface attached by magnets
- 3D laser projector aids layup
- Systems customized for panel material, single- or double-curvature and size (1m x 1m to 10m x 20m)
- Options: oven integration, snaps for panel edge precision and vacuum systems for resin infusion



Thermoformed foam takes up less resin.

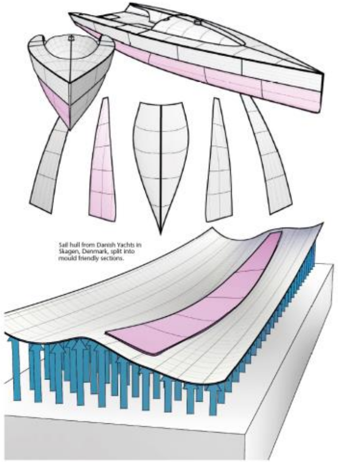
SOURCE | Curve Works



Adapa supplied 85 adaptive molds for production of 40,000 precast concrete panels for Kuwait airport.

Beirut's 5-story North Souk building used Adapa's system vs. disposal of 5,530 molds.

Adapa



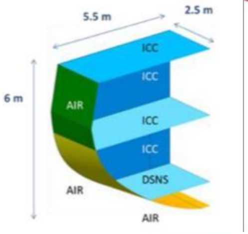
Curved composite sandwich cladding for FiberCore Europe's 21m bridge – 120m^2 weighs < 1000kg.

SOURCE | Curve Works

Solutions for organic façade elements

Curve Works

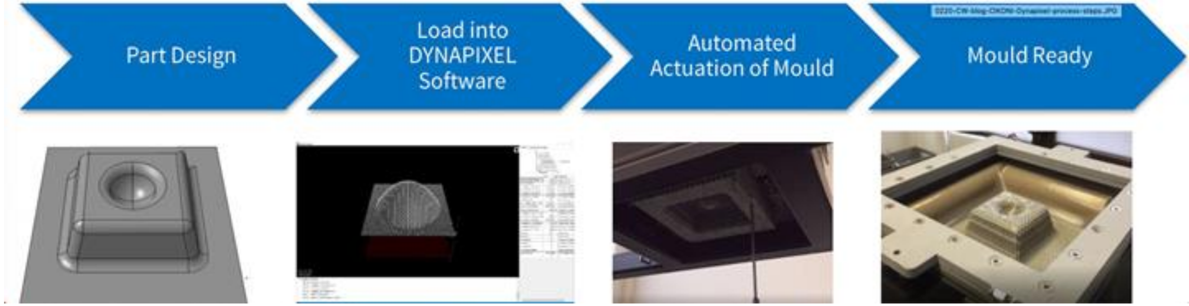
Curve Works FR Tempera panels (rPET core, GF, water-based resin).



Infused 6m hull section.

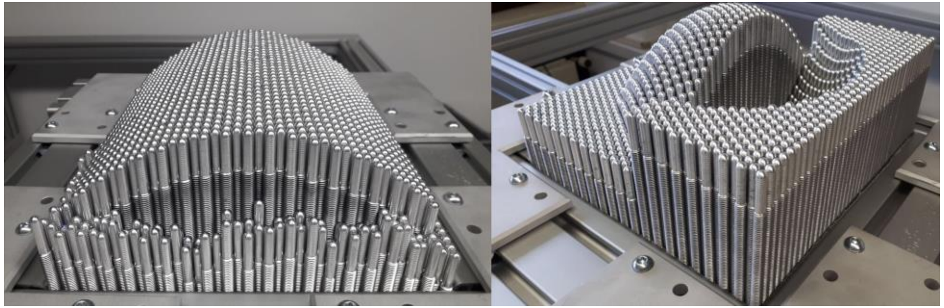
SOURCE | RAMSSES and FIBRESHIP

Pin-based tooling



DYNAPIXEL by CIKONI

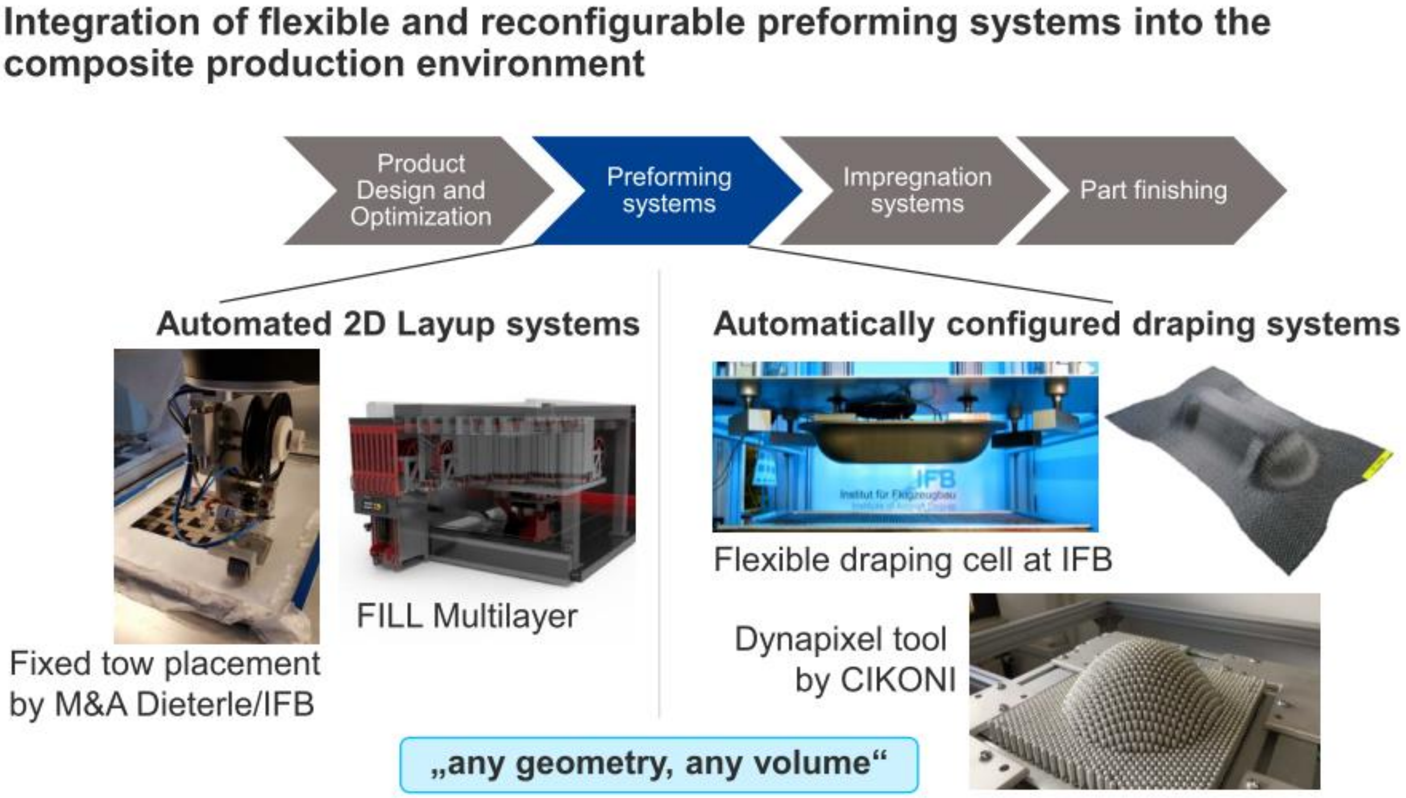
- Compared to ADAPA uses smaller-sized actuators
- Can produce sharp corners and more complex geometries
- Surface interpolated using silicone membrane
  - molding processes up to 180°C
  - 0.5, 1.0 and 3.0 mm thick
- Uses:
  - R&D tooling
  - Preforming
  - Flexible automotive jigs for bonding/adhesive joining
  - Tailored, individualized helmets, protective structures, orthotics



SOURCE | "DYNAPIXEL: automated, reconfigurable molds", CW Feb 2020

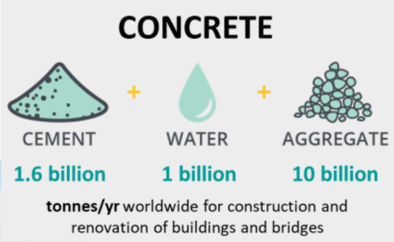
Pin-based tooling

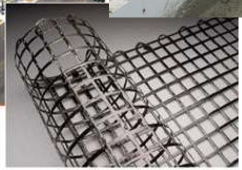
- DYNAPIXEL by CIKONI
  - Joint research project with University of Stuttgart
  - Bring together tailored tow placement processes and automated preforming with DYNAPIXEL.
  - Target: to manufacture any geometry at any volume



CF-reinforced Concrete

- Reduce concrete amount by 50-80%, Reduce CO_2 by 50-70%
- Dr. Manfred Curbach, TU Dresden





C-GRID precast panels
15-25% faster construction

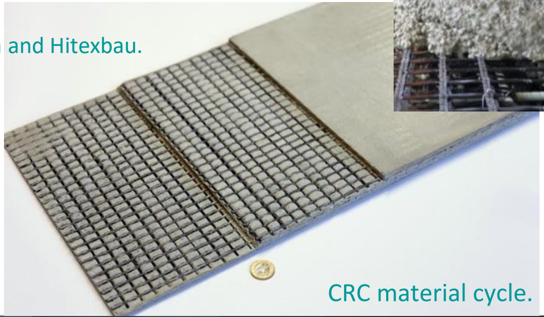
SOURCE | ***CW* Nov 2017**

Two-story, 220-m^2 CUBE building at TU Dresden and Hitexbau CF grid.

SOURCE | © Iurii Vakaliuk, HENN, TU Dresden and Hitexbau.

C3 carbon concrete composite

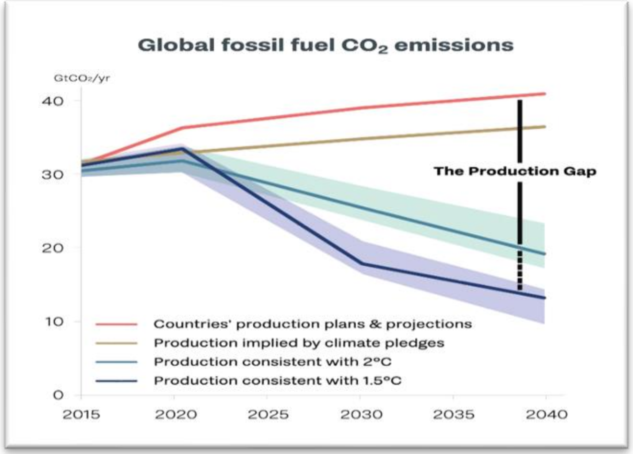
- Largest research project in German construction industry
- >150 partners, 300 projects completed since 2006
- Increasing regulations/standards, applications, products
- Cement production = 6.5% of global CO_2 emissions



CRC material cycle. SOURCE | C3

Hydrogen Economy and Composites

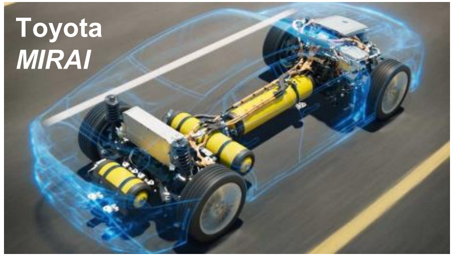
- Hydrogen (H2) is needed to meet zero-emission 2050 targets
- H2 power via fuel cell or direct combustion is being developed broadly for transport, most using Type IV pressure vessels *(plastic liner, carbon fiber/epoxy overwrap)*



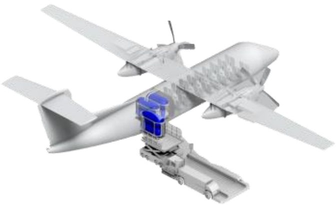
Source | The Production Gap Report 2019

Hyundai *Xcient*

Toyota *SORA*



Toyota *MIRAI*



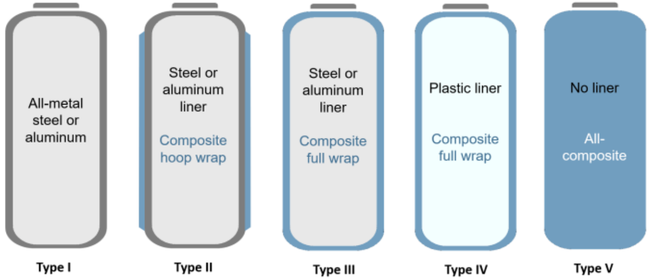
Universal Hydrogen

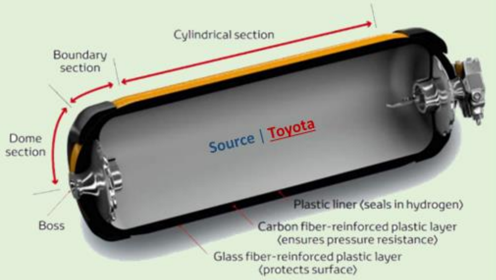
Alstom *Coradia iLint*

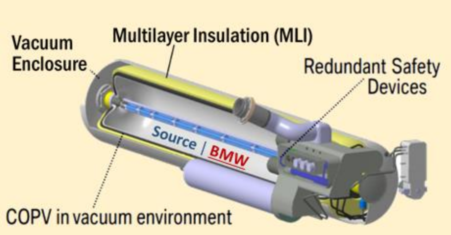
Norled car ferries

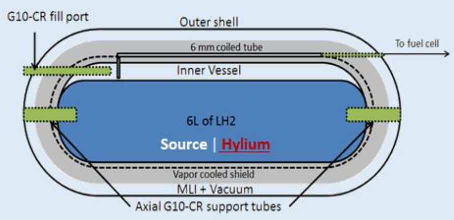
Hydrogen Storage Tanks

- Type IV tanks = most composites but lowest storage efficiency
- Liquid H2 and cryocompressed = most efficient, but least mature for vehicles









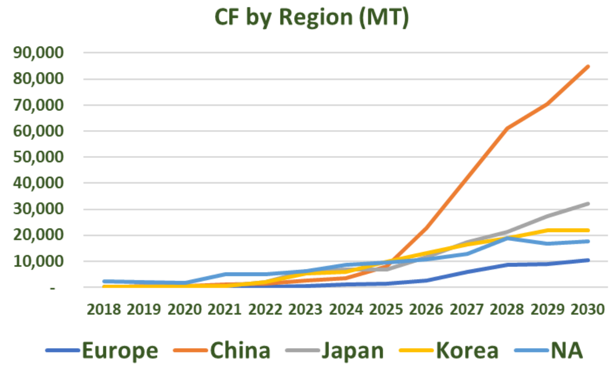
Compressed Gas (CGH_2)	Cryo-compressed (CcH_2)	Liquid (LH_2)
350 – 1,000 bar	≤ 350 bar	1 – 4 bar (ambient pressure)
290 K/ 17°C (ambient temp.)	64 K/ -203°C	20 K/ -253°C
Type IV	Type III inner, vacuum + MLI, metal outer	Type I inner, vacuum + MLI, metal outer
+ Decades of use, + Proven safety – Expensive, – Least efficient *most carbon fiber*	+ Most efficient, Safety benefits *(low burst pressure, vacuum)* – Issues with long-term vacuum – Complex, Least mature *some carbon fiber*	+ Decades of large tanks + Highest H_2 density – Cryogenic temps – Safety and Weight issues *least carbon fiber*

CompositesWorld

Opportunity for Carbon Fiber (CF) in H2 Storage Tanks

- CF in metric tonnes (MT) = (vehicle production) x (CGH_2 tanks per vehicle) x (fiber weight)
- H2 tank market **> 1.5 times 85,000 MT** [1] industral carbon fiber market by 2028

[1]*(AJR Consultancy forecast,* ***CW*** *2019 Carbon Fiber conference)*



Global Number of Vehicles

Applications		2018	2019	2020	2021	2028	2030
Heavy Duty Land Transport	Trains	-	52	2	3	845	985
	Buses	108	1,259	2,122	2,893	39,575	41,200
	Trucks	103	167	228	369	47,850	54,620
Light and Medium Duty Land Transport	Cars	2,791	6,739	6,909	15,300	596,000	754,585
	Vans	49	167	121	263	4,100	6,590
	Sanitation	6	10	60	112	788	797
	Sweepers	1	6	10	9	12	15
	Construction	3	3	3	80	1,020	1,750
	Bikes/Scooters	42	40	30	25	20	20
Marine	Ships/Ferries	3	5	6	4	11	13
	Total Vehicles	3,106	8,448	9,632	19,271	691,233	861,794
Carbon Fiber (Tonnes)		**504**	**1,474**	**1,841**	**3,410**	**138,380**	**166,650**

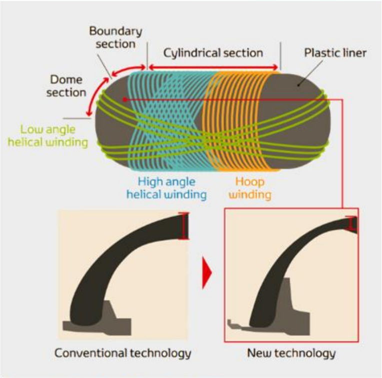
270,000
4,100,000
92,000,000

Current Global Vehicles
(ICE, EV, etc.)
Annual Production

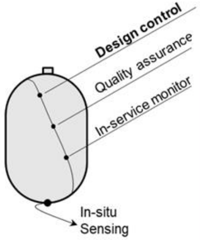
SOURCE | CW Tech Days: Composites in the Hydrogen Economy, May 18 and 25, 2021

How to reduce cost of CGH2 tanks

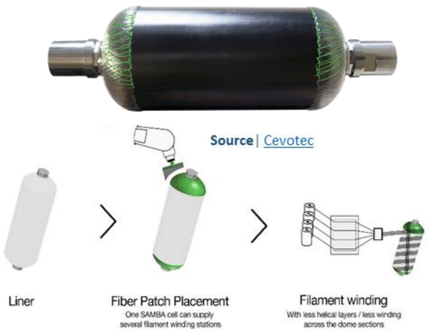
- Reduce cost of carbon fiber (CF)
  - Textile PAN precursor, faster oxidation
  - Lower safety factor, tailor fibers for more optimized tanks
- Replace CF with lower-cost fibers
  - UMOE Advanced Composites uses glass fiber
- Toyota reduced CFRP by 20% for 5.7 wt% storage
  - Deleted high-angle winding (≈25%), hoop winding inner layers
- Structural optimization, alternative processes
  - CIKONI exploring 8.0 wt% storate via **digital design optimization**
  - Cevotec cut CFRP by 20% via **FPP (Fibre Patch placement) on domes**
  - **HP-RTM** of overbraided or 3D filament wound liner
  - Universal Hydrogen, Noble Gas Systems using **dry fiber braids**
  - Use **sensors** to monitor tanks, feed back to optimize designs

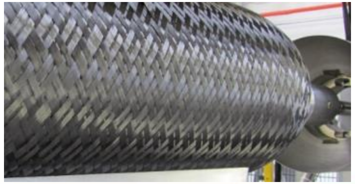


Source | Toyota *Mirai* FCV posters, 2017



Source | Com&Sens





Up to 15 tanks (50-mm-dia.) can be RTM molded simultaneously. **Source** | BBG GmbH & Co. KG

https://www.youtube.com/watch?v=Of1Nz7l3J64&t=39s

CW Trending

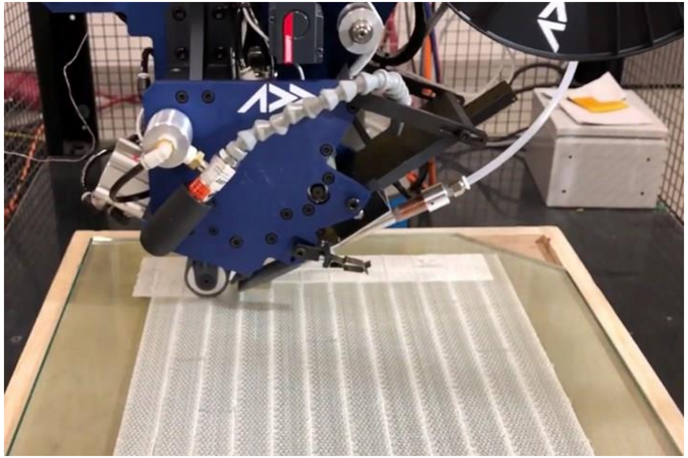
- New video series started in 2021
- First episode:

Democratization of composites

- Automated AFP cells for SMEs
- More in-house capability (e.g., dry tape)
- Portals
  (online ordering of tools, parts à la Amazon)
- Robotic CT and other NDT
- Robotic injection molding

AFP cells for SMEs

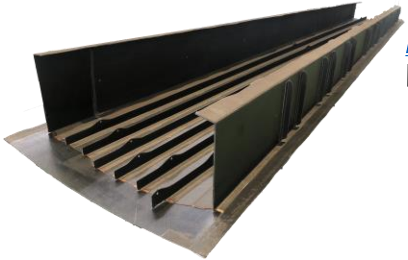
- **Effman** (Shebrooke, Quebec, Canada) composites automation specialist
- uCOMP project integrated **Addcomposites AFP** head into Fanuc robot
- **Goal** = high-permeability preforms for RTM, Light RTM using automated cells that are affordable for SMEs



Effman installs AFP-XS as part of project to enable AFP for SMEs
Feb 2021

New tape production lines

- **MTorres** (Torres de Elorz, Spain) composites technology specialist (AFP)
- Converts 50K carbon fiber tow or 4800 tex glass fiber roving 5-10X faster vs. current tape suppliers
- **Goal** = high-permeability dry tape that enables affordable, large composite structures and small-batch new materials
- Initiated for wind blade manufacturers and automotive, demonstrated in one-piece lower wingbox for Clean Sky 2

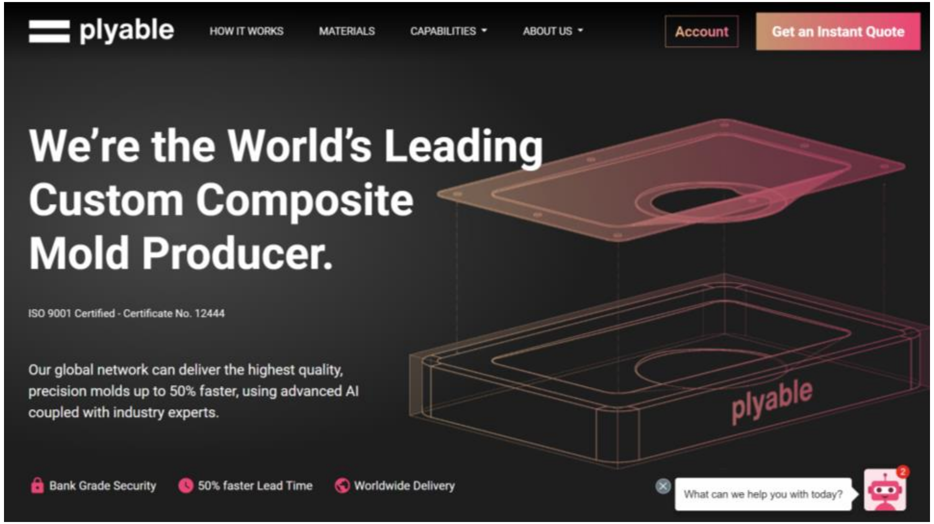


Advancing the OOA infused wing box
Mar 2021

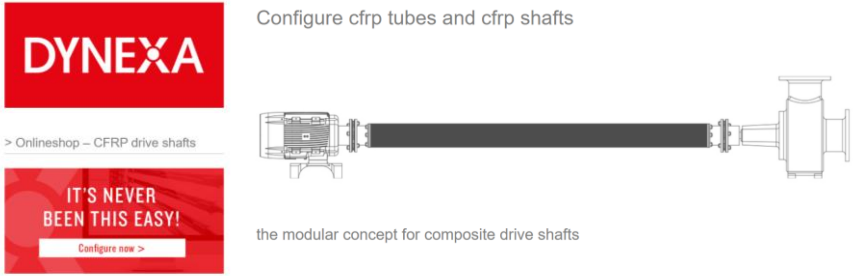
Novel dry tape for liquid molded composites
Feb 2021

Online portals for composites

- **plyable** – Online tool design, distributed manufacturing network
- **DYNEXA** – Online composite shaft design, customer configurator
- **Airborne** – On-demand manufacturing of CFRTP laminates

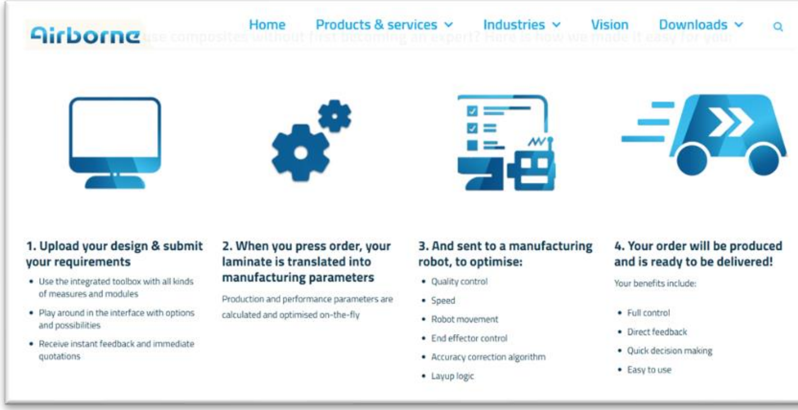


[Vertical Aerospace used Plyable to go from CAD to first flight in less than 90 days](#)
May 2020



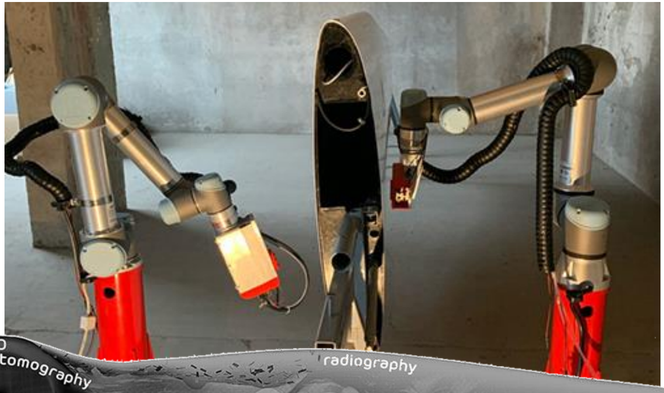
In 3 steps, you develop your own economically attractive and quickly available solution based exclusively on your load data. You don't have to be a composite expert or deal with jointing technologies. We take care of that for you. Our configurator is available to you day and night … digitalization in lightweight design.

https://www.dynexa.de/en/about-cfrp/configure-cfrp-tubes-and-cfrp-shafts.html



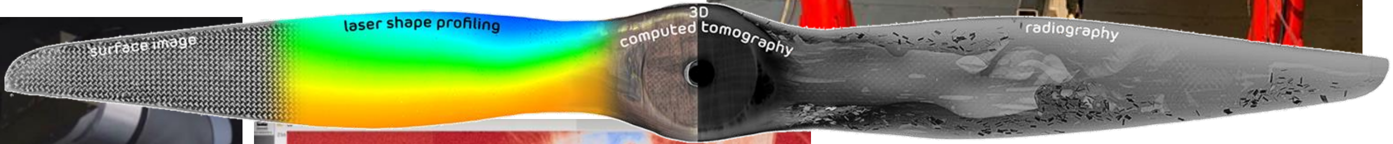
https://www.airborne.com/automation-solutions-advanced-composites/on-demand-manufacturing-portal/

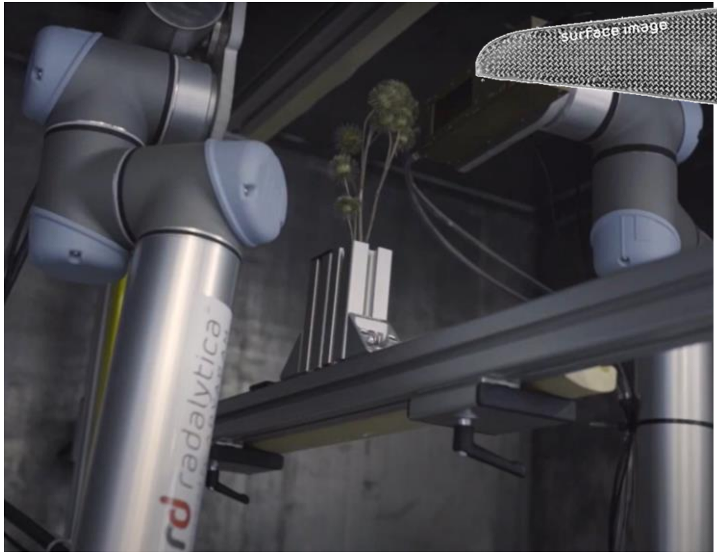
radalytica.com – blog
coming soon on *CW*

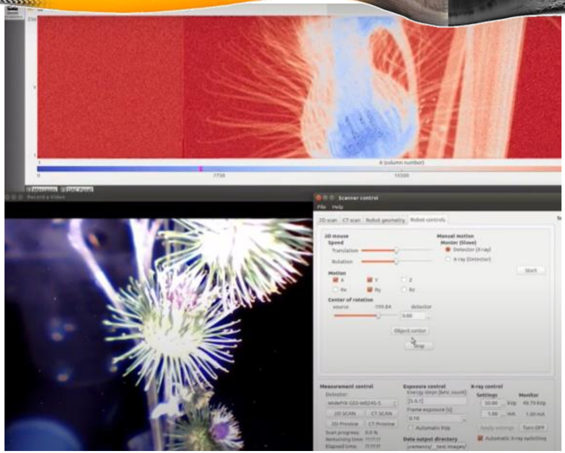


Robotic CT and NDT for SMEs

- **Radalytica** (Czech Republic) specialist in robotic NDT
- RadalyX computed tomography (CT), one robot emits x-ray, other uses photon counting detectors
- **Goal** = high-sensitivity NDT for large 3D shapes affordable for SMEs (less than half the cost of current CT systems)





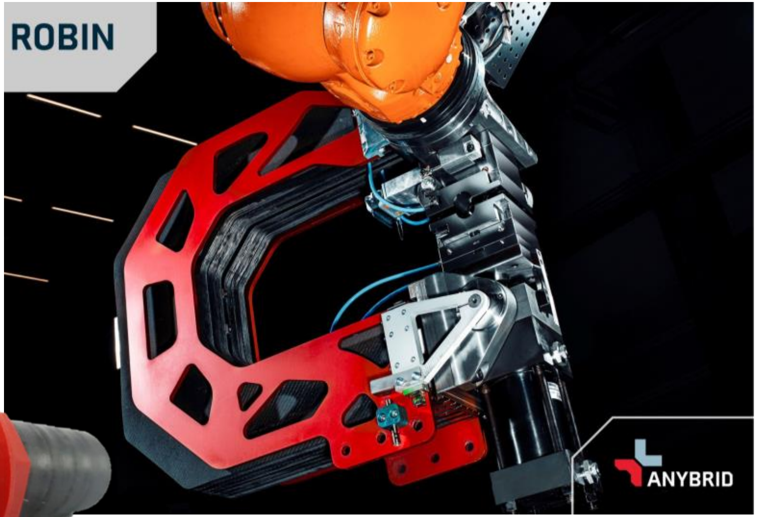


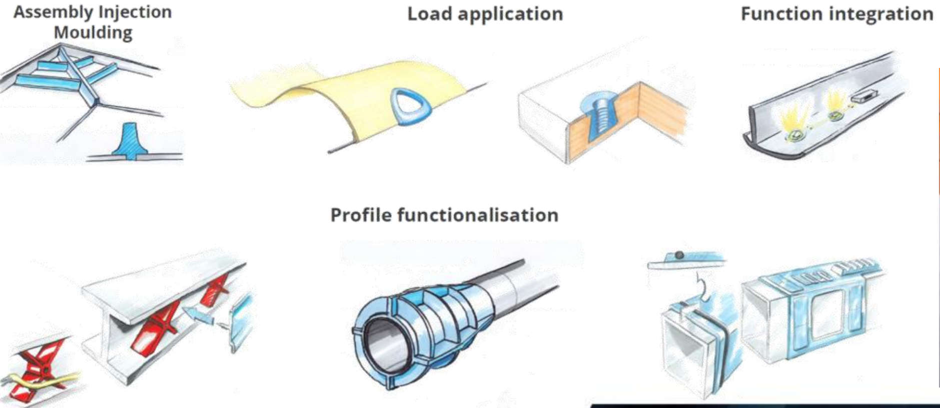
https://www.youtube.com/watch?v=3PJYvhdzHI0

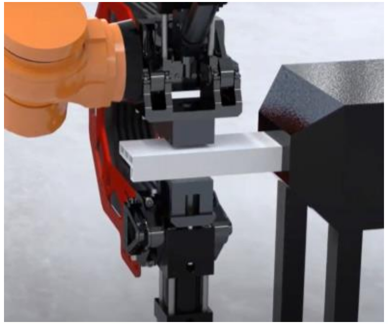
anybrid.de – blog
coming soon on *CW*

Robotized injection overmolding

- **Anybrid** (Czech Republic) spin-off from ILK at TU Dresden
- ROBIN system lowers hurdles for injection molding and hybrid structures
- Flexible automation, compact injection for lower tool costs, lightweight locking system (6-10 tons of force, up to 1 meter cantilever)
- **Goal** = functionalized, hybrid components for smaller series and large 3D shapes







Kiitos mielenkiinnosta!

- Kysymyksiä ja kommentteja?