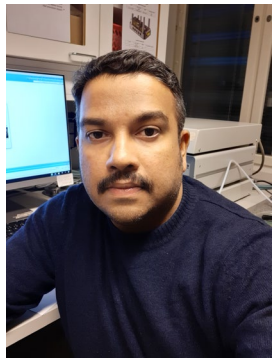
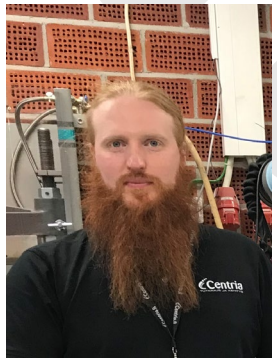
Manufacturing of a recyclable mould with a robot-assisted 3D printer

Egidija Rainosalo

Centria University of Applied Sciences



Rathish Rajan



Simo Huhtanen

Matti Ojala

centria
Research and Development

Centria R&D in a nutshell

Chemistry and Bioeconomy
- Biomass valuables
- Inorganic materials
- Plastic composites and 3D printing
- Low carbon energy

Production Technologies
- Robotics and AI in manufacturing
- Smart wood construction and coating

Digitalization
- Cyber security
- Drones and autonomous devices
- Future mobile networks
- Software and hardware development

Entrepreneurship and Wellbeing
- Holistic wellbeing
- HEALTH tech
- SME business development
- Development of pedagogy

Projects

Services

Training

R&D Staff	All Projects	International Projects	Total Volume of R&D Activities	External Financing Share	Total Sale of Development Services	Value of Project Portfolio
116	122	26	8,6M€	5,6M€	1,8M€	19,1M€

centria
Research and Development

Content

- Introduction to mould making
- Materials of printed mould: requirements, availability, development materials
- Mould printing experience
- Future development of robot assisted 3D-printing at Centria

centria
Research and Development

Plugs and Moulds in composite industry

Conventional mould making process

3D-Designing

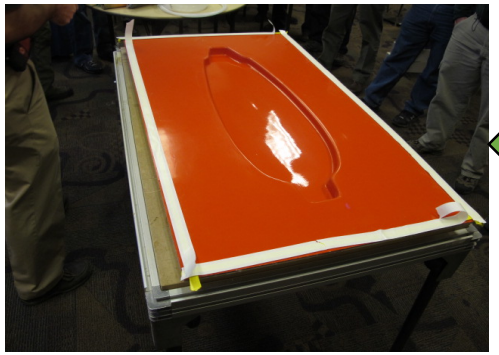
Milling of tooling board

Polyester body filler putty

Sanding and polishing

Coating and finishing

Mould production

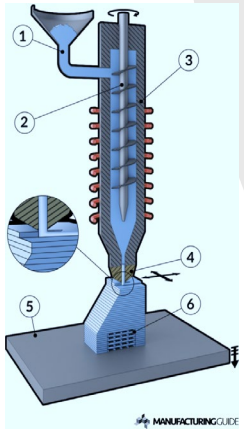


Ready mould

centria
Research and Development

3D printed mould

3D-Designing



3D printing mould

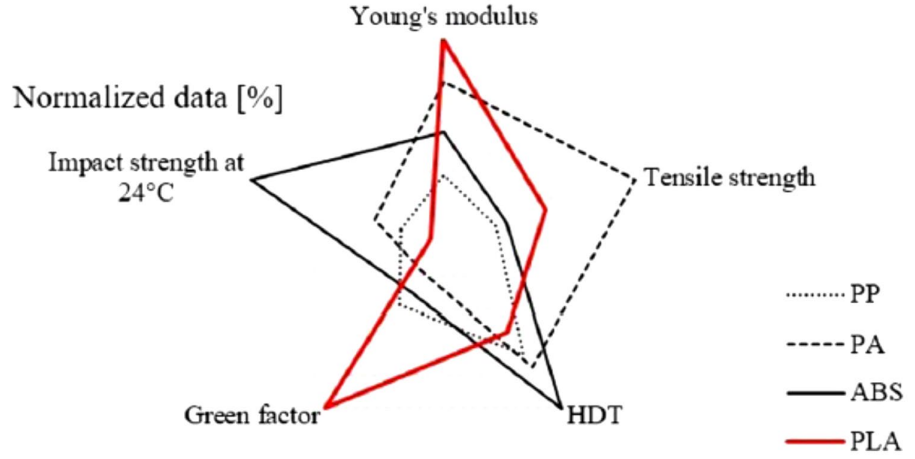
Sanding and polishing

Coating and finishing

centria
Research and Development

Material requirements for 3D-printing (LSAM) of mould

- ✓ Chemical resistance to resin components
- ✓ Withstand resin cure temperature and exotherm of reaction
- ✓ Withstand process parameters (consolidation pressure and vacuum bagging approach)
- ✓ Low thermal expansion (CTE)
- ✓ Tool preparation (sealing)
- ✓ Anticipated use (tool life)
- ✓ Storability/ageing resistance



T.Tábi, T.Ageyeva, J.G.Kovács.
https://doi.org/10.1016/j.polymertesting.2021.107282

	Polyester resin	MEKP	Epoxy resin	Epoxy hardener
ABS	X	X	✓	X
PA6	✓	✓	✓	✓
rPET	✓	✓	✓	✓
PP	✓	✓	✓	✓
PMMA	X	X	X	X

Resistance to lamination resin chemicals

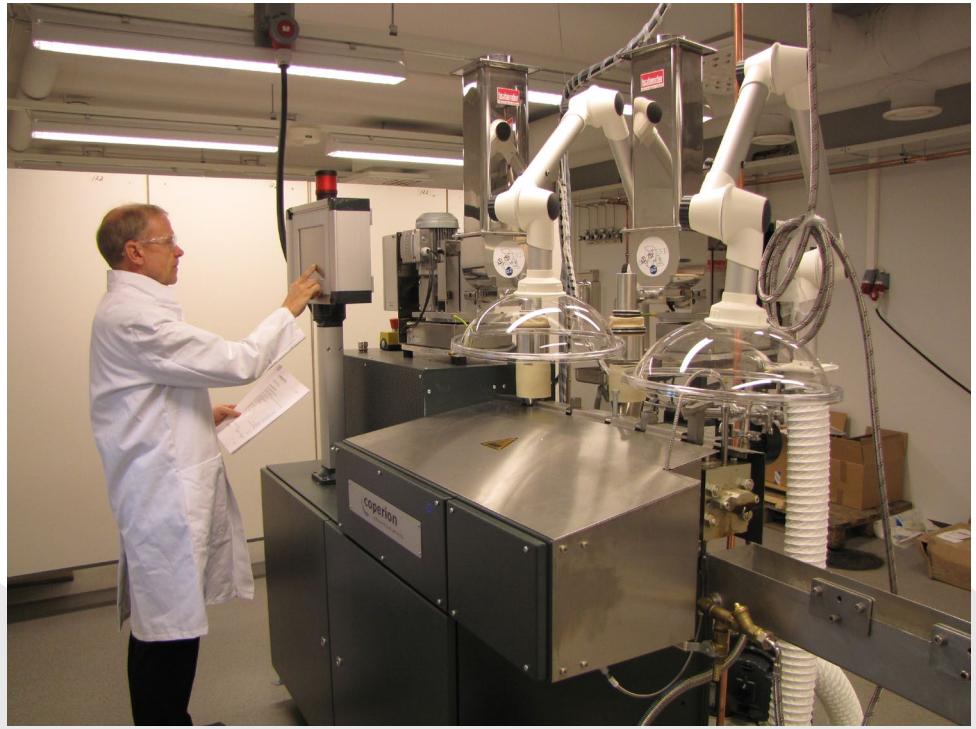
centria
Research and Development

Strategy and compounding

- Cheap matrix → Polypropylene chosen
- Reduced thermal expansion→ wood fibre
- Increased bio-based content → 40% wood fibre
- Recyclable production waste
- Recyclable product

40% saw dust

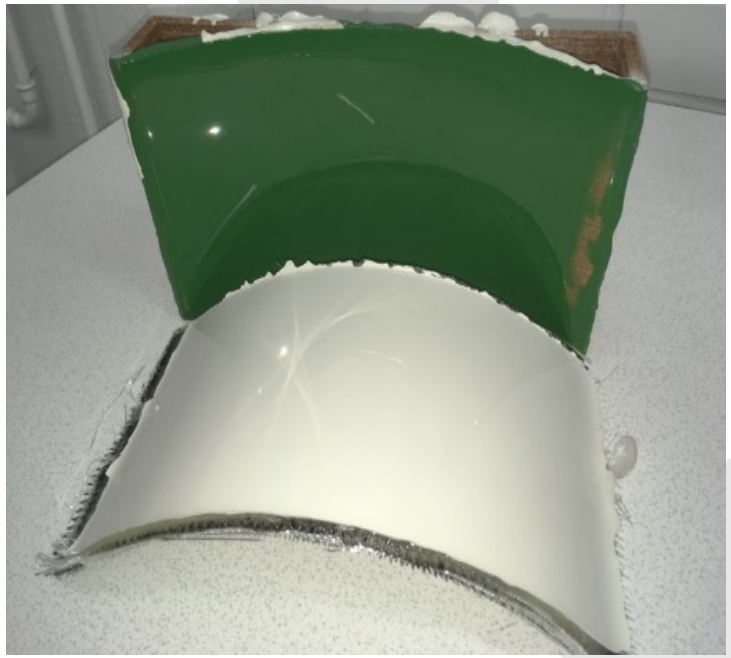
Lyondell Basell
Moplen EP240H

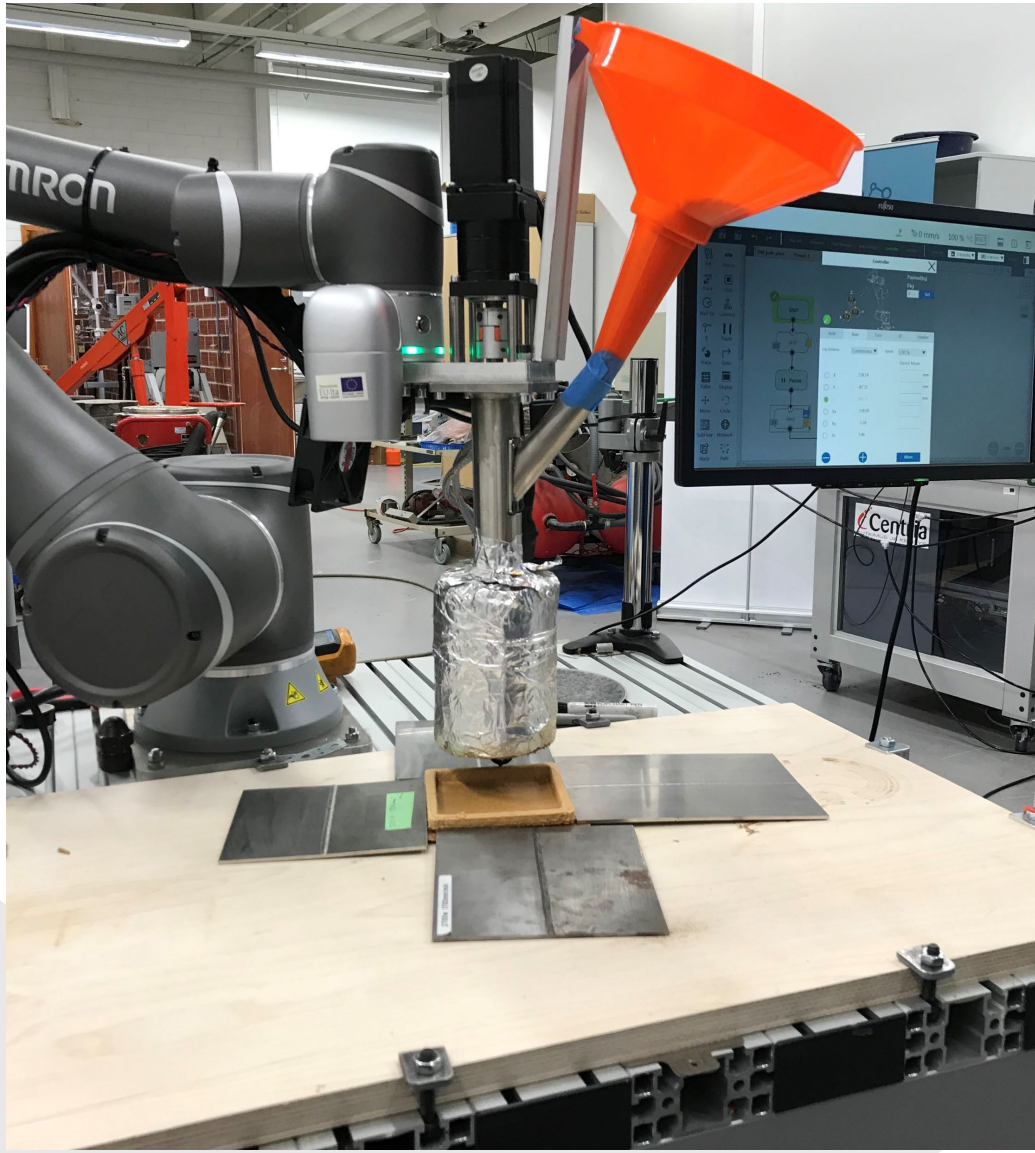


Twin screw extruder, throughput up to 150 kg/day

centria
Research and Development

Robot assisted 3D printing



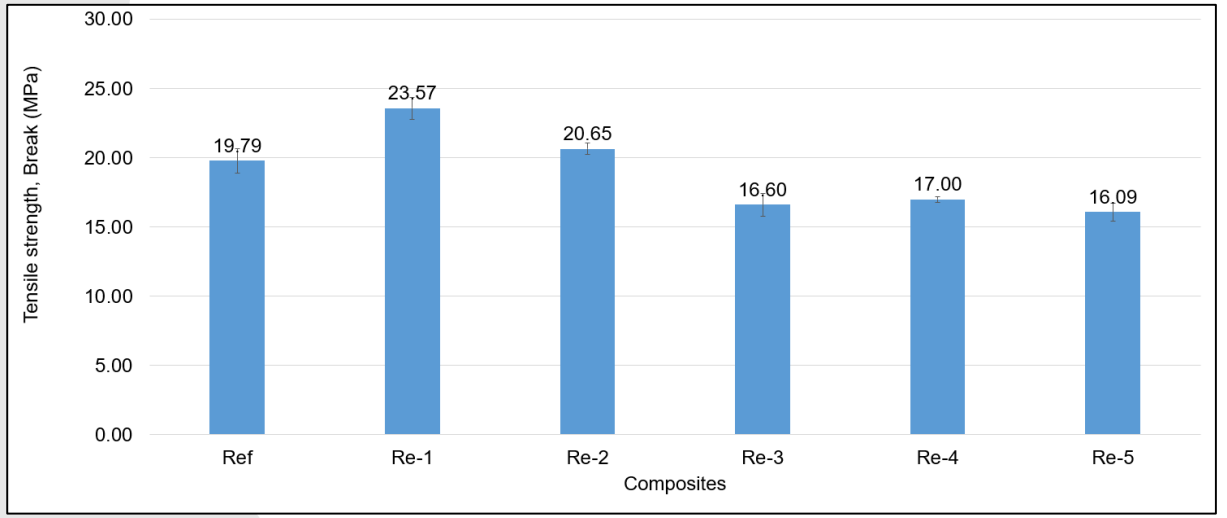


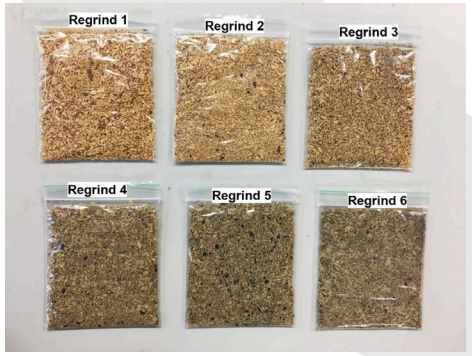
UR10-robot, compressive type screw extruder, weight when unloaded was 6,5kg
Printing speed 100-200 g/h, 3 mm nozzle

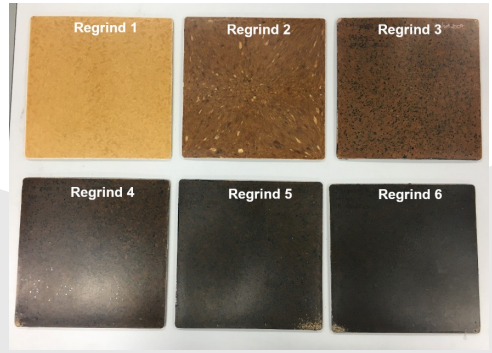
centria
Research and Development

Recycling of coated mould

- Multiple recycling
- The mechanical property after two recycling cycles remained same as virgin WPC



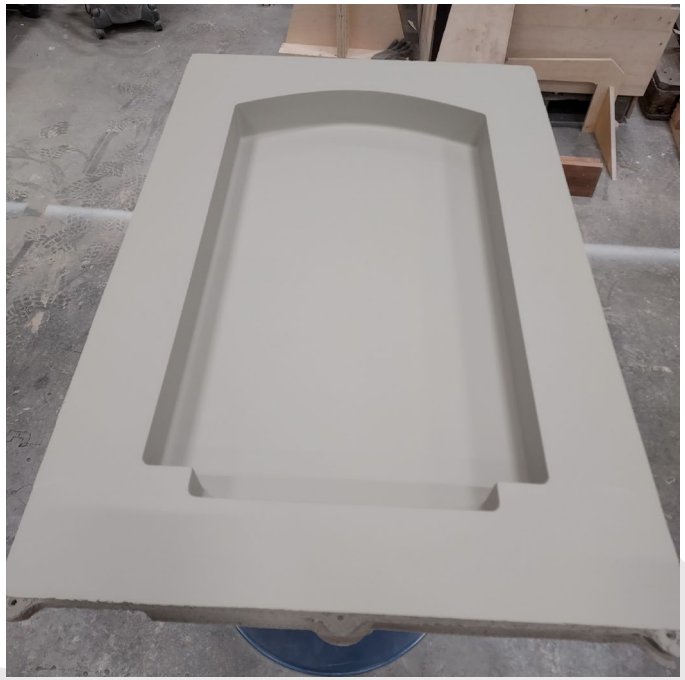




centria
Research and Development

3D-printing of moulds using thermoplastic material

925 x 590 x 81 mm



CNC machining at MMI Company Ab Oy

centria
Research and Development

Some thermoplastic fiber reinforced materials for LSAM in the market

Manufacturer	Product	Polymer	Fibre	Content, (%)	Tensile Modulus, (GPa)	Tensile Strength (MPa)	Extension at Break, (%)	Tg, °C HDT, °C
UPM	Formi 3D	PLA	Cellullose	20 or 40	3,6 or 5,4	39 or 48	4 or 2	(53°C)*
Stora Enso	DuraSense® 3D Plus 50	PP	S-wood	50	2,7	45	7	(75°C)*
Polymaker	PolyCore ASA-3012	ASA	Glass fibre	20	7,237	101	2,6	Tg 98°C, 97-104°C
Sabic	AC004XXAR1	ABS	Carbon fibre	20	11,8/2,9	89/18 **	1/0,7**	101°C
Victrex	PEEK 90CA30	PEEK	Carbon fibre	30	28	275	1,4	Tg 143°C, 342°C

* Polymer of same type

** Printed test specimens: along print/perpendicular to print direction

centria
Research and Development

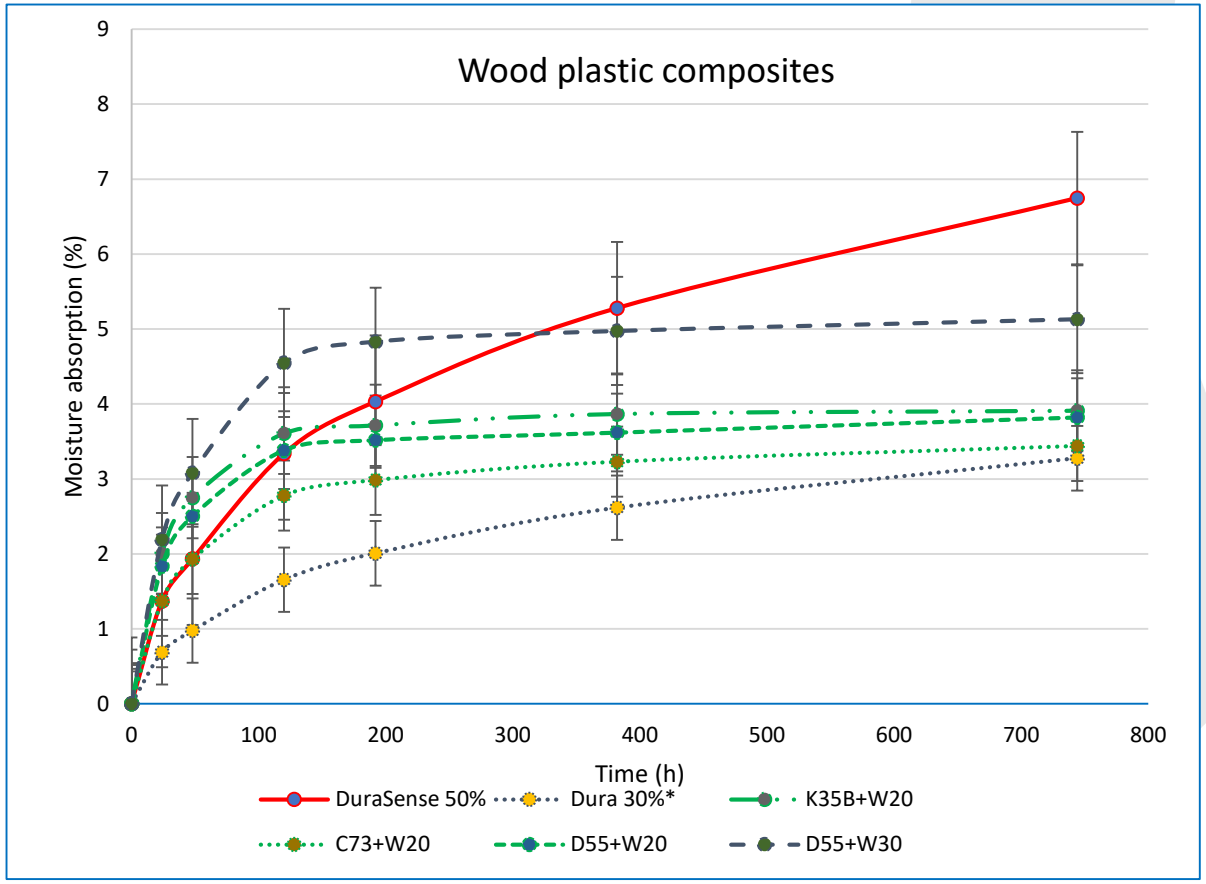
Thermoplastic biobased 3D-printing materials compounded at Centria

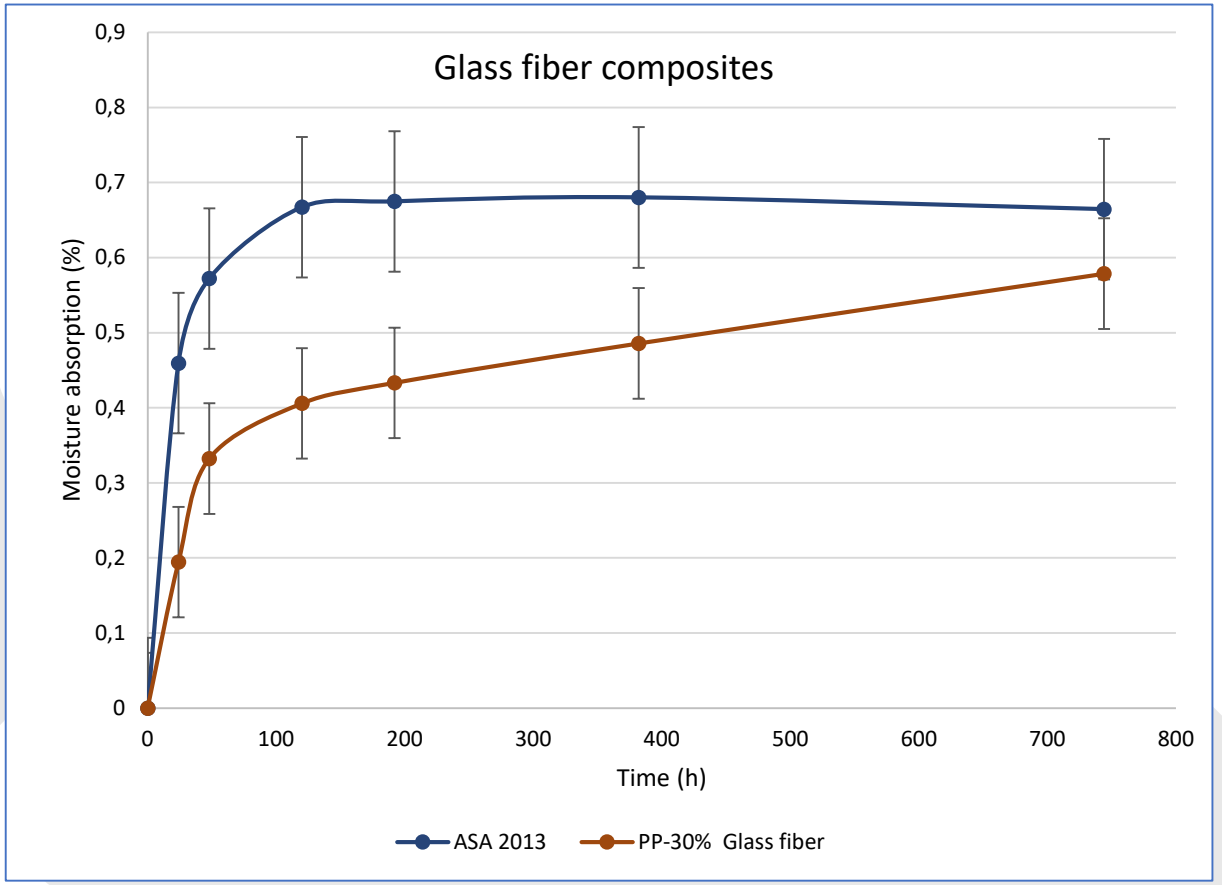
Manufacturer	Product	Centria modification	Tensile Modulus, (GPa)*	Tensile strength (MPa)*	Extension at break, (%)*	Tg, °C HDT, °C*
BrightPlus	BrightBio® LOIMU-K35	Added 20% spruce saw dust	1,76	40	22	Tg 57°C
BrightPlus	BrightBio® LOIMU-D55	Added 20% spruce saw dust	1,3	35	110	49°C
BrightPlus	BrightBio® LOIMU-C73	Added 20% spruce saw dust	3,2	66	5,2	Tg 57°C
Stora Enso	DuraSense® 3D Plus 50	Added neat PP, final fibre content 30 %				

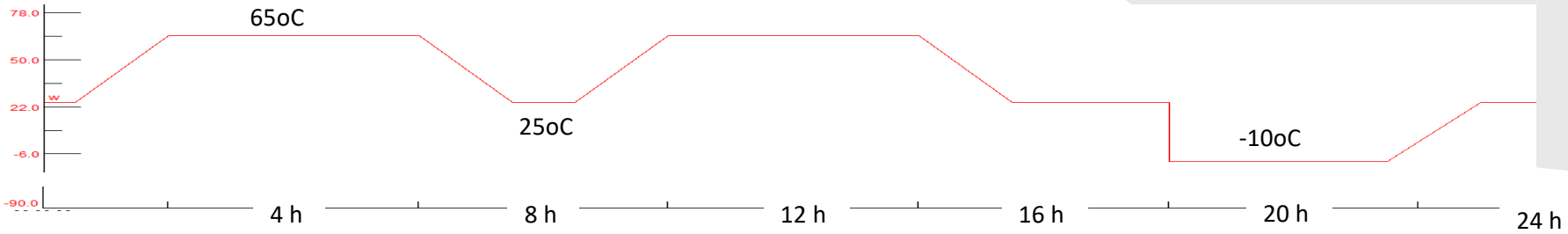
*Properties of polymer without fillers

centria
Research and Development

Weathering – cycling 23→65→-10^{0}C, RH 93%



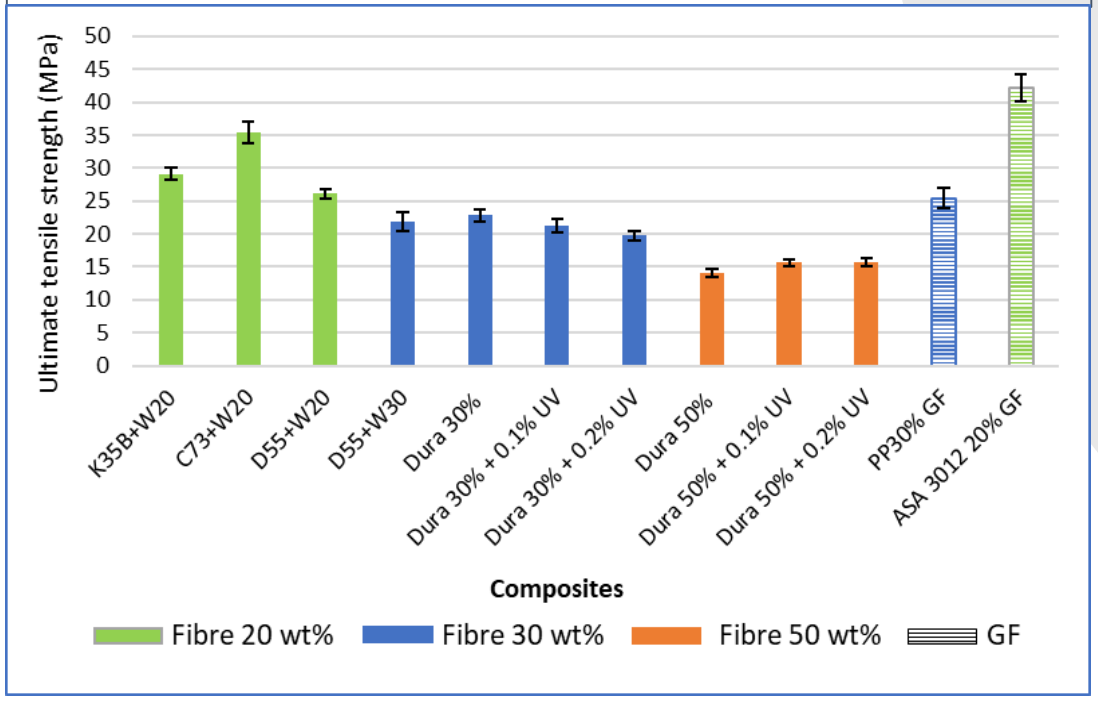




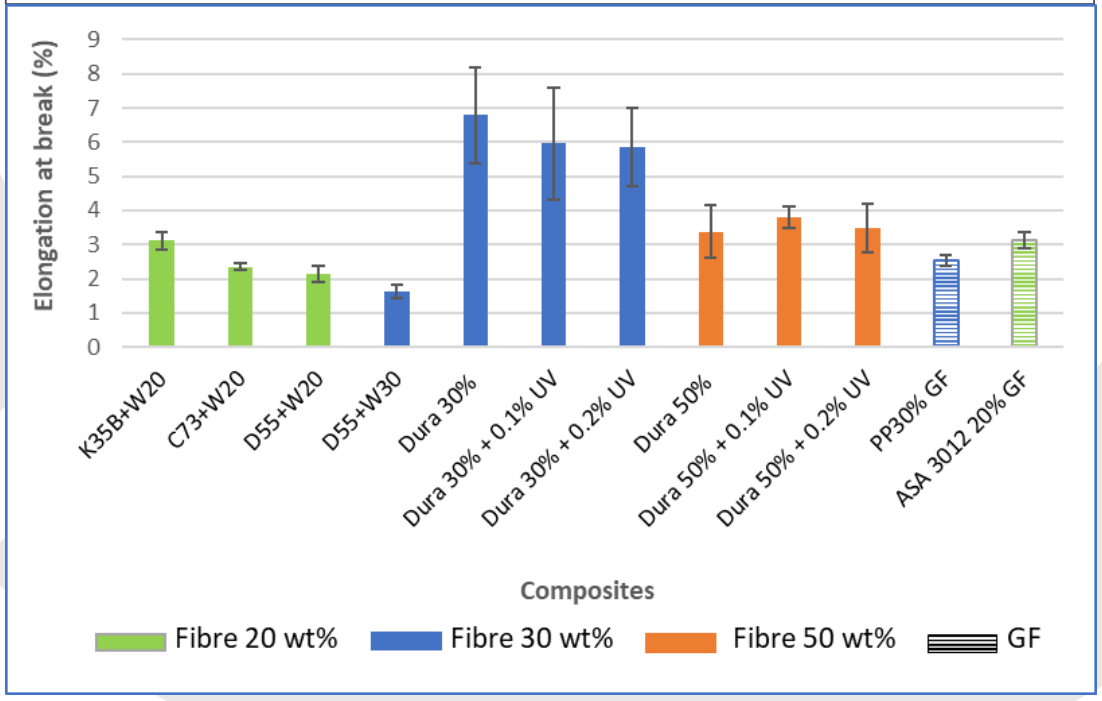
centria
Research and Development

Tests - mechanical properties before weathering

Tensile strength, MPa



Elongation at break, %



centria
Research and Development

Summary of benefits when 3D printing moulds using thermoplastic natural fiber filled materials

- Modern technology more attractive to workers
- Less hand work
- No or less dust, improved health of people
- Easier sandable
- Wearing of tools lower than in case of glass fiber
- Possibly improved business profitability through implementing new business model

Environmental benefits

- Recyclable/re-manufacturable product
- Environmental benefits: less waste, waste is recyclable
- Biobased materials used

Reduction by 3D printing mould with WPC

-62,3%

CO_2-equivalent

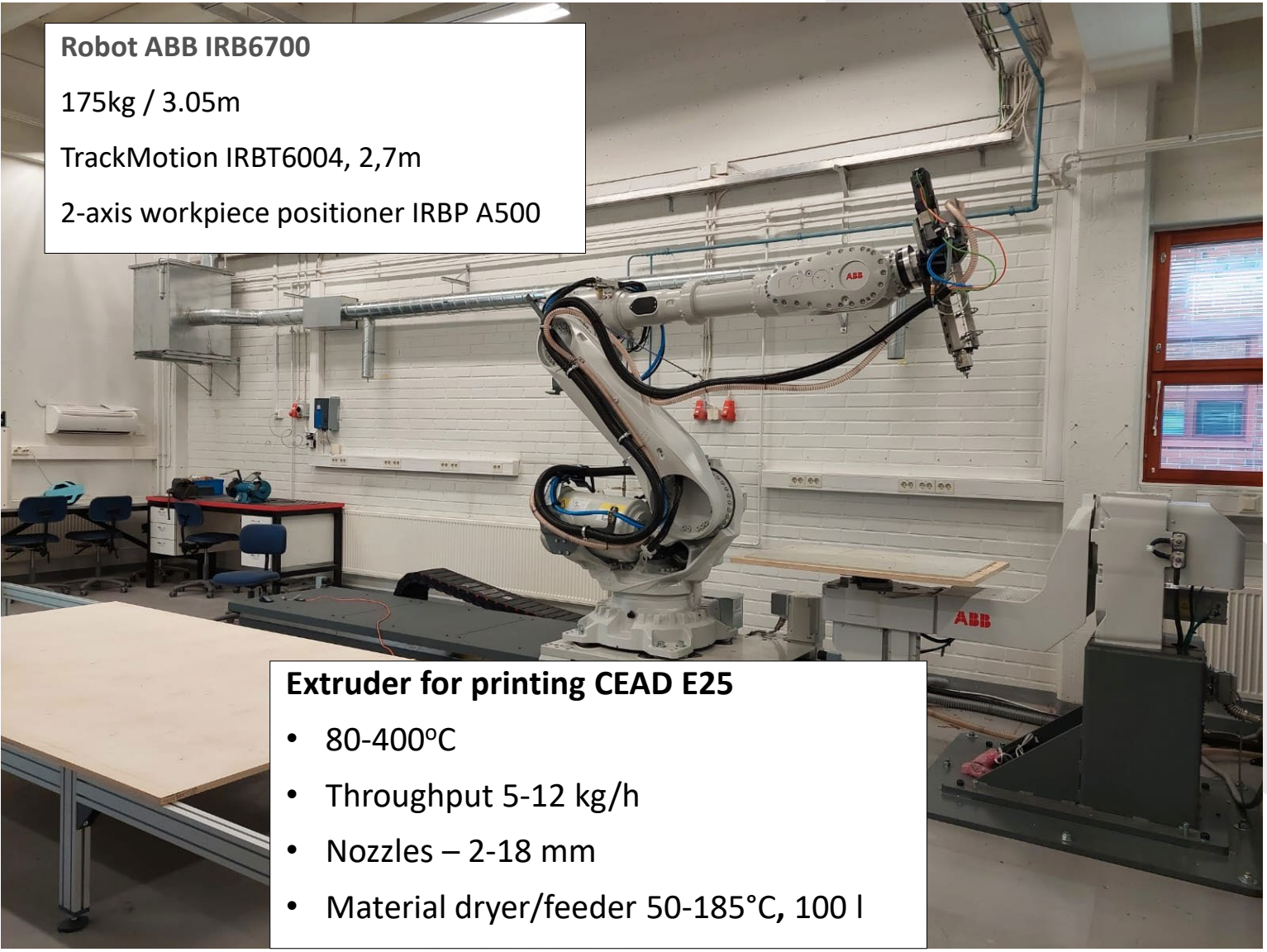
Additional reduction by recycling 3D printed mould

-14,4%

CO_2-equivalent

Inventory: Ecoinvent 3.1. database in Simapro software LCA assessment method: ILCD midpoint+

Investments



Robot ABB IRB6700

175kg / 3.05m

TrackMotion IRBT6004, 2,7m

2-axis workpiece positioner IRBP A500

Extruder for printing CEAD E25

- 80-400°C
- Throughput 5-12 kg/h
- Nozzles – 2-18 mm
- Material dryer/feeder 50-185°C, 100 l

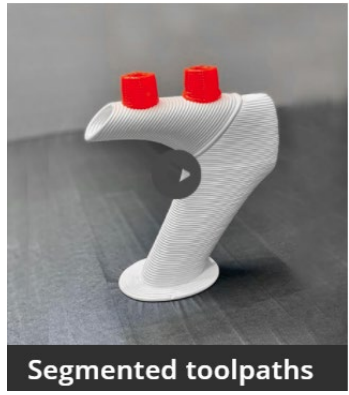
Software for advanced printing

- 45° printing
- Printing on non-plain, e.g. curved shapes
- Multidirectional printing

Machine vision system

- Camera, scanner
- Software


45 degrees toolpaths

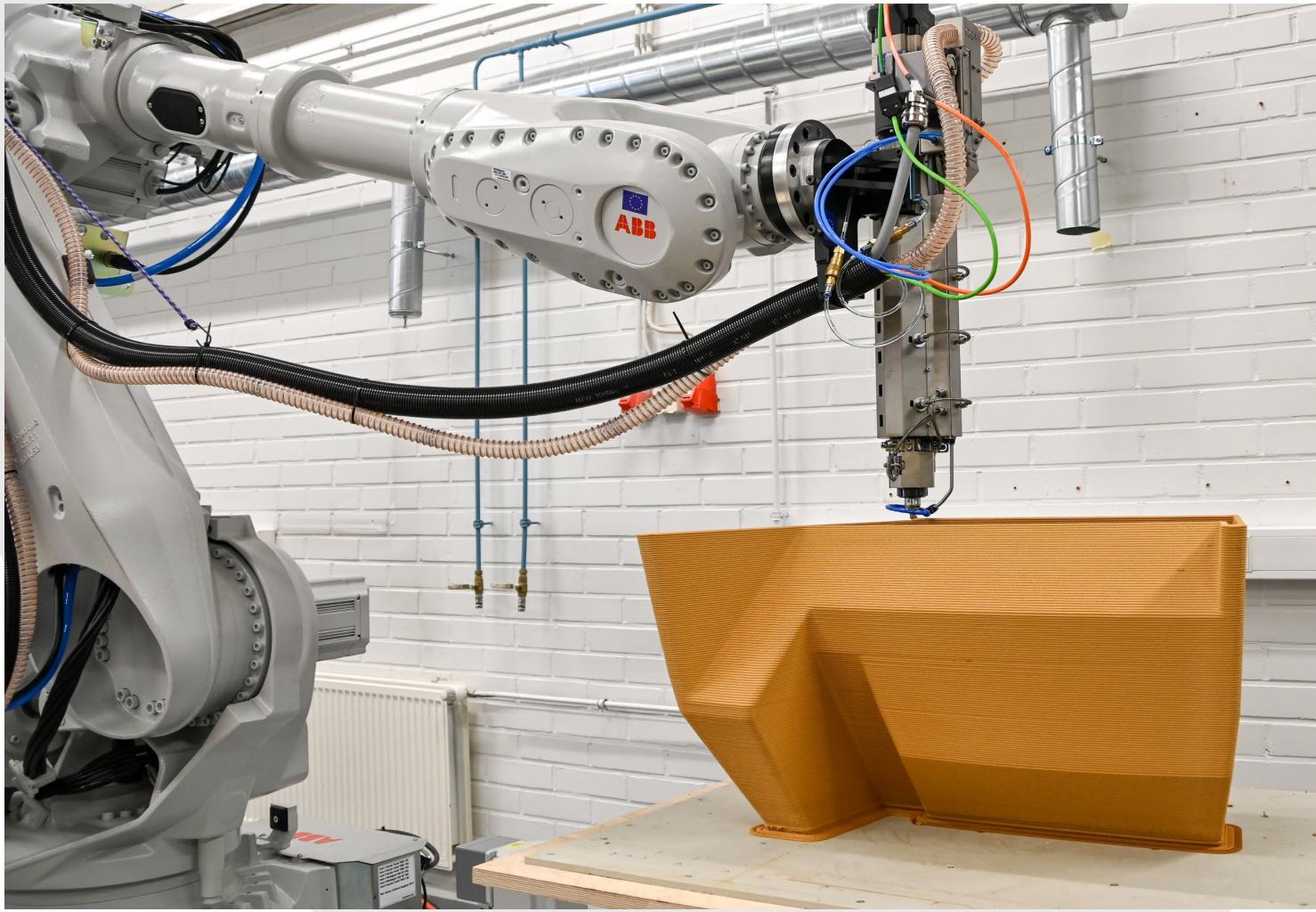

Segmented toolpaths


Nonplanar toolpaths

centria
Research and Development

Future

- Further material testing and development
- Printing parts for boats and eventually boat hull
- Printing using recycled grinded material
- Development of surface modification methods



centria
Research and Development

Kiitos!

egidija.rainosalo@centria.fi
+358 447250264

centria
Research and Development

R&D enablers

VENEPRINT

Kokkola Karleby

Vipuvoimaa EU:lta 2014–2020

Euroopan unioni

ECOLABNET

Interreg Baltic Sea Region

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND

centria Research and Development