Technology and experiences in manufacturing highly advanced carbon fiber prepreg

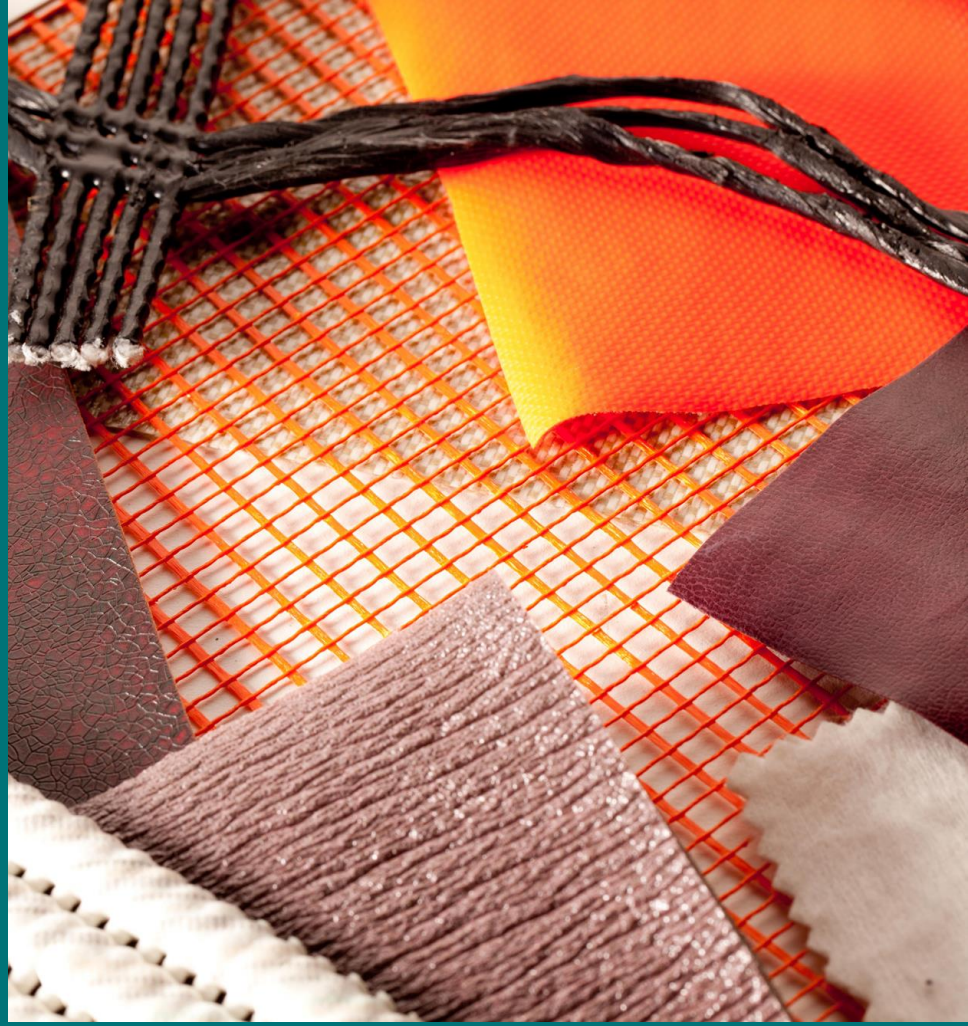
Coatema

2 June 2025

MEMBER OF ATH

Agenda

1. Introduction
2. Market background
3. Technology background
4. Spreading technologies
5. Coating technologies
6. Impregnation technologies
7. Curing / High temperature systems
8. Pilot line layout
9. Proof of concept
10. Summary



1.

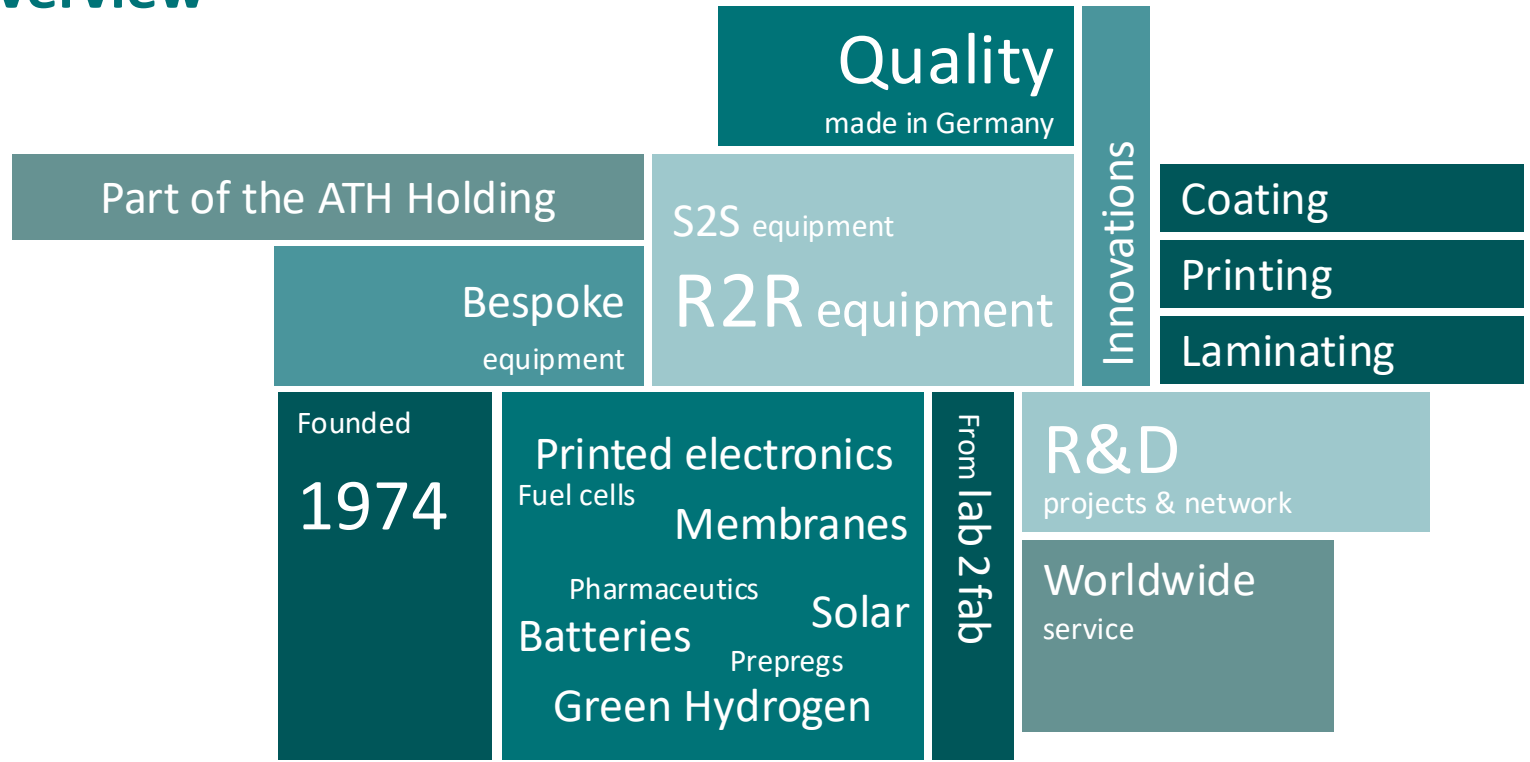
Introduction

Thomas Kolbusch, Director Sales, Marketing, Technology, VP

Thomas Kolbusch

COATEMA Coating Machinery GmbH

Overview


Quality
made in Germany
Innovations
Part of the ATH Holding
S2S equipment
R2R equipment
Coating
Printing
Laminating
Bespoke
equipment
Founded
1974
Printed electronics
Fuel cells
Membranes
Pharmaceutics
Solar
Batteries
Prepregs
Green Hydrogen
From lab 2 fab
R&D
projects & network
Worldwide
service

Group of companies

ALTONAER
TECHNOLOGIE
HOLDING

KROENERT

- ✓ Founded 1903
- ✓ Approx. 200 employees
- ✓ Located in Hamburg

DRYTEC

- ✓ Founded 1995
- ✓ Approx. 50 employees
- ✓ Located in Norderstedt

Coatema®
Coating Machinery GmbH

- ✓ Founded 1974
- ✓ Approx. 50 employees
- ✓ Located in Dormagen

Represented worldwide

Coatema equipment platform strategy for lab2fab

Lab

- ✓ State-of-the-art research and development equipment
- ✓ Sheet-to-sheet to roll-to-roll systems on smale scale & footprint

Pilot

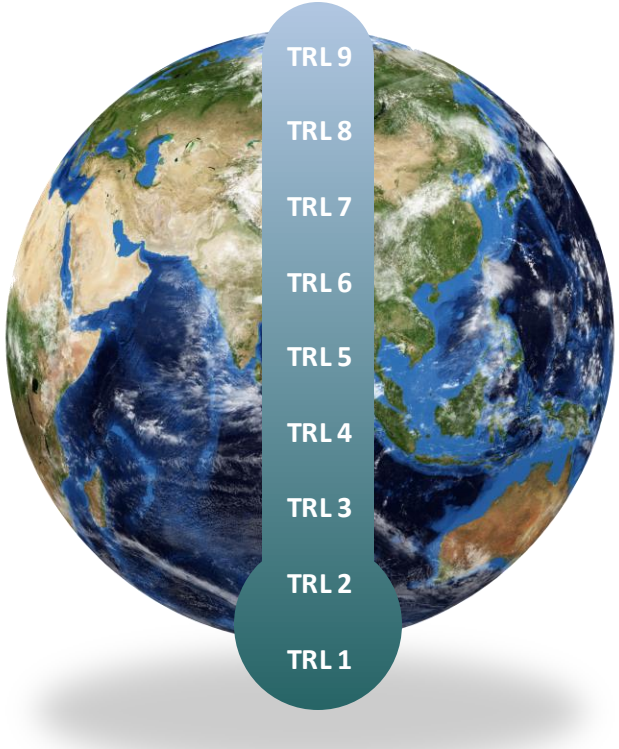
- ✓ Proven processes for printing, coating and laminating equipment
- ✓ Highest-quality pilot lines enable stable pilot production and reduce cost of operation
- ✓ Scaling laboratory equipment to enable pilot production

Production

- ✓ Full-scale production lines
- ✓ Optimize the manufacturing process, including streamlining assembly, reducing material waste, and optimizing the carbon footprint

Our markets – Coatema focus areas

- Green Hydrogen
- Fuel cells
- Batteries
- Solar



- Sustainability
- Digital fabrication
- Printed electronics
- The next thing

R&D centre USP

Process development

- ✓ Feasibility study
- ✓ Ink – process study
- ✓ Process analysis
- ✓ Slot die coating simulations
- ✓ Proof of concept
- ✓ Small scale prototype

Test production

- ✓ Prototyping
- ✓ Near to market testing
- ✓ TRL evaluation
- ✓ Training of staff

Education

- ✓ Coating conference
- ✓ Partner trainings
- ✓ Education of students
- ✓ Workforce training

Development of custom-made design for equipment

- ✓ Prototyping
- ✓ Proof of concept

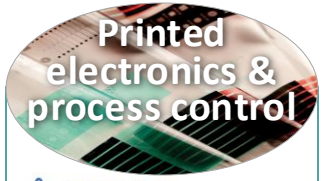
Public funded research projects know-how

- ✓ German funded
- ✓ Horizon 2020
- ✓ Global 2+2 projects
- ✓ B2B projects

Introduction – R&D centre

R&D customers

R&D projects overview 2022 – 2025

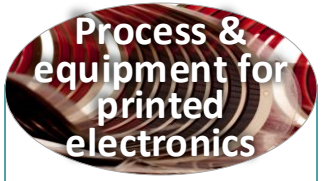


REAL NANO

In-line and real-time digital nano-characterization for flexible organic electronics

NOUVEAU

The NOUVEAU project will develop solid oxide cells (SOCs) with innovative La- and PMG-free electrode materials

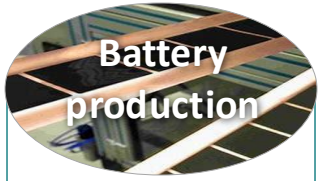


FLEX2ENERGY
AUTOMATED MANUFACTURING PRODUCTION LINE FOR IPVS

R2R production line for OPV solar with integrated backend

FLEX-G 4.0

Upscaling and development of EC based switchable films to decrease energy use in buildings



IDEEL

Implementation of laser drying processes for lithium-ion battery production

SOLiD

R2R process optimization for solid state batteries

pepLAT

Plasmonically enhanced photocatalysis for wastewater treatment

ROLL 2 SOL

R2R nanostructuring of functional films

WATER PROOF

The WaterProof project aims at developing an electrochemical process that converts CO_2 emission

FLEX FUNCTION 2 SUSTAIN

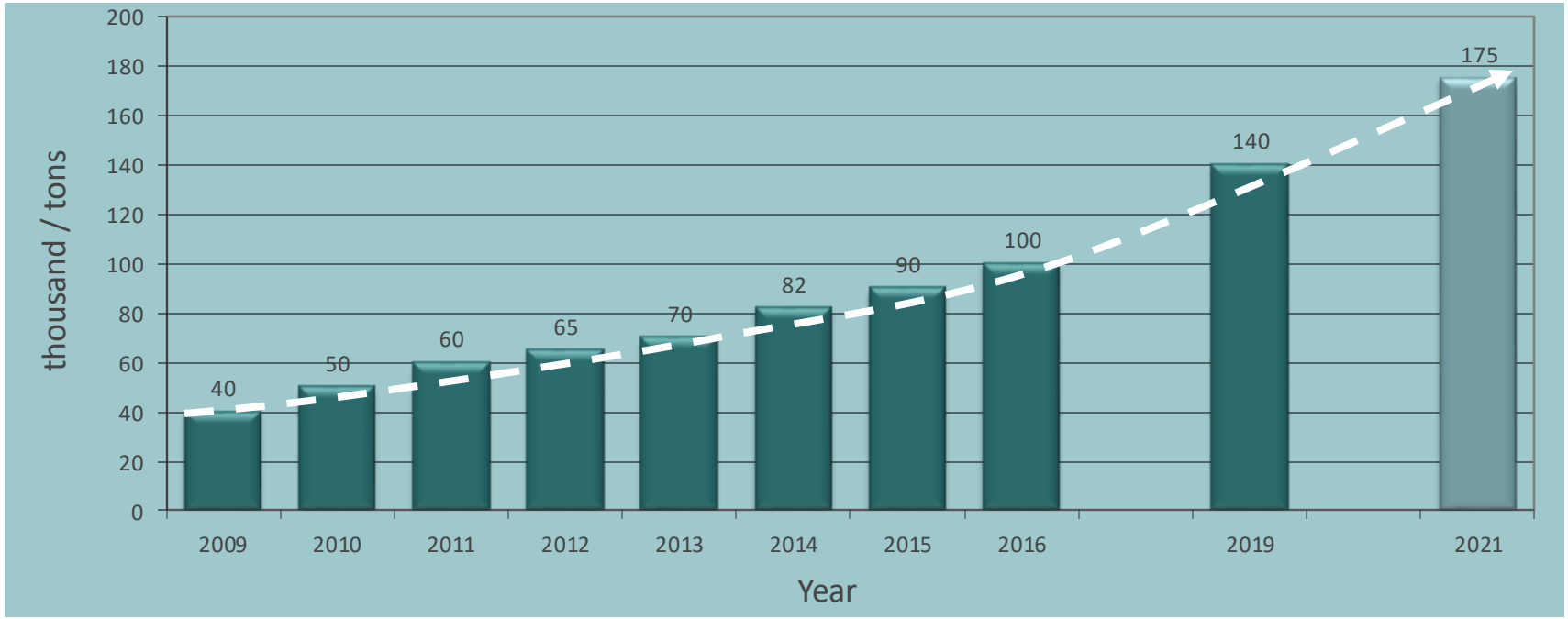
Creating an open-innovation testbed for sustainable packaging

2.

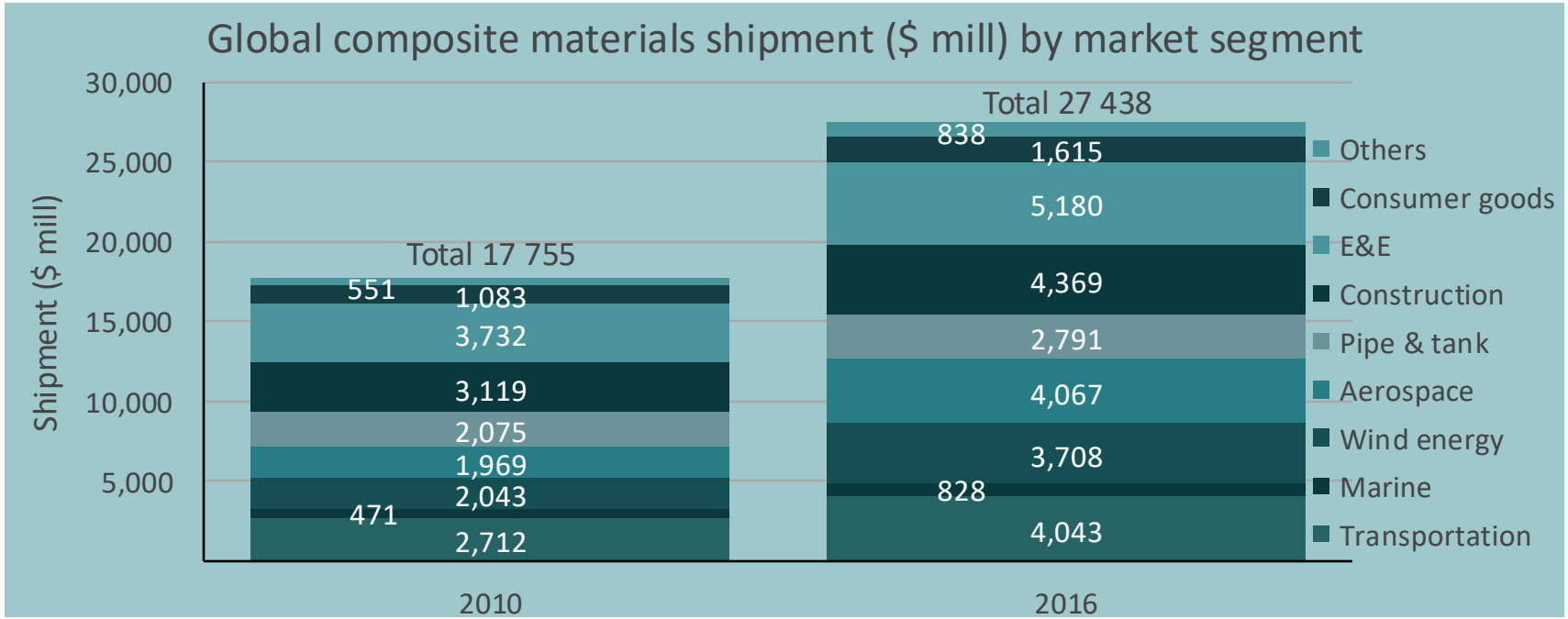
Market background

The market for prepreg

The market for prepreg – the market in total

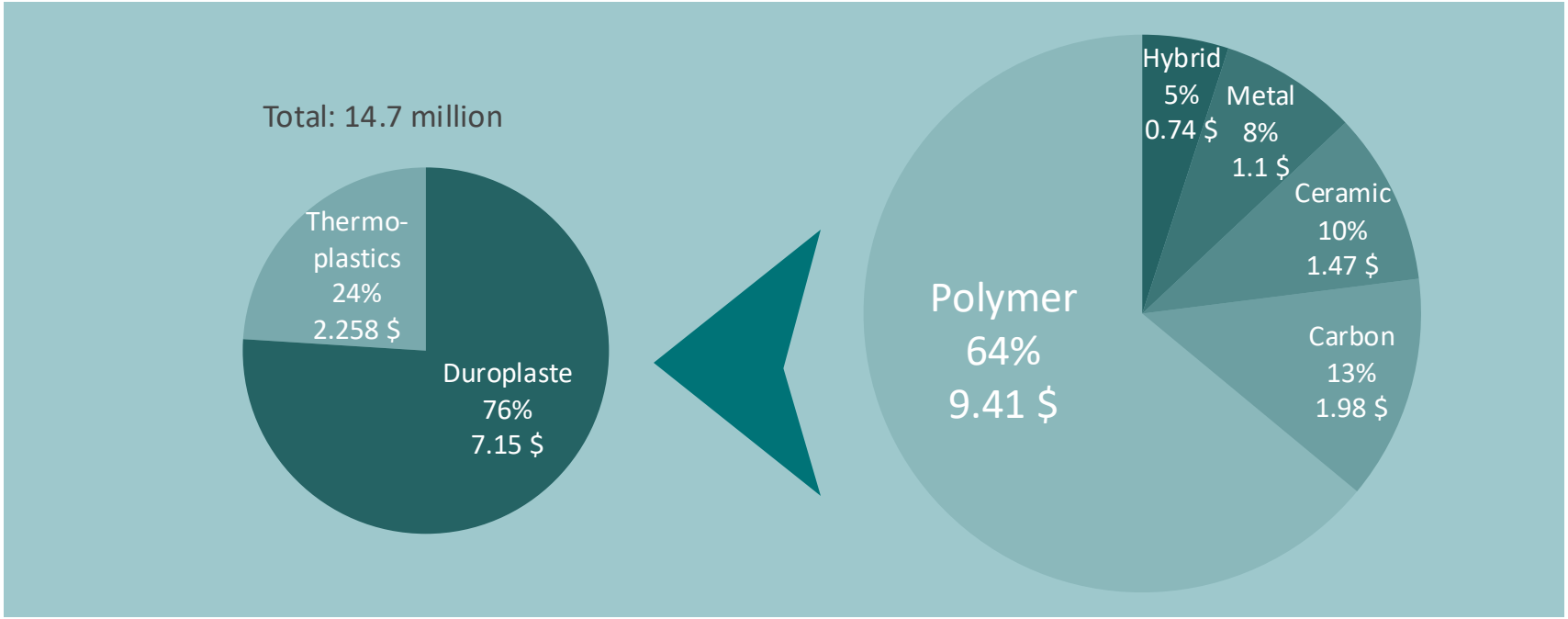


The market for prepreg – the market in total



Source: Lucintel

Current turn over in Bill. US$ for different matrix materials (2013)

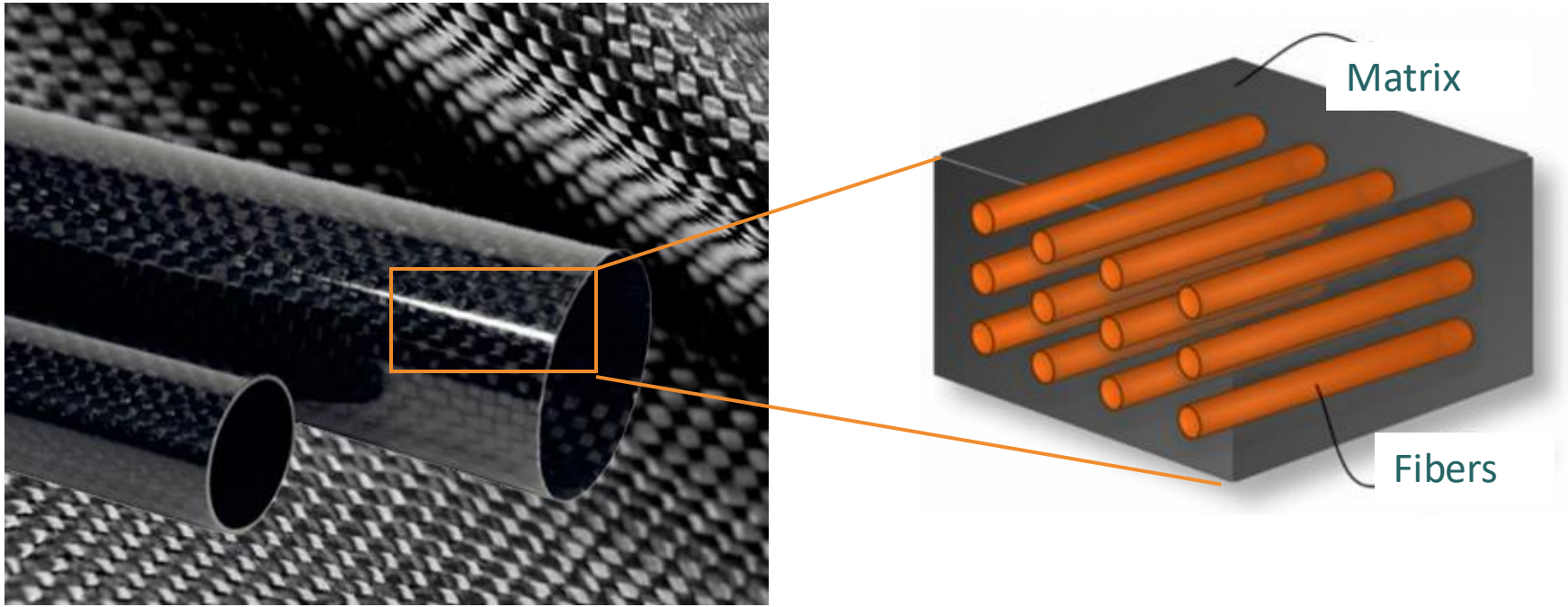


Source: Acmite Market Intelligence e.K.

3.

Technology background

Prepreg



Types of material

Today there are 3 major composite systems

✓ **Thermosetting (duroplastic) resins:**
A polymer that cannot be remolten or reformed once it has been cured.
Curing creates a molecular cross-linking, which is irreversible.
Version B-stage: Curing stops at incomplete crosslinking
Final curing to complete crosslinking after shaping

✓ **Thermoplastic resins:**
A polymer in which the molecules are not cross-linked, or they are cross-linked to a weaker degree. A thermoplastic polymer can be reshaped or reformed by reheating the polymer.

✓ **Hybrid systems**

Fibres and substrates

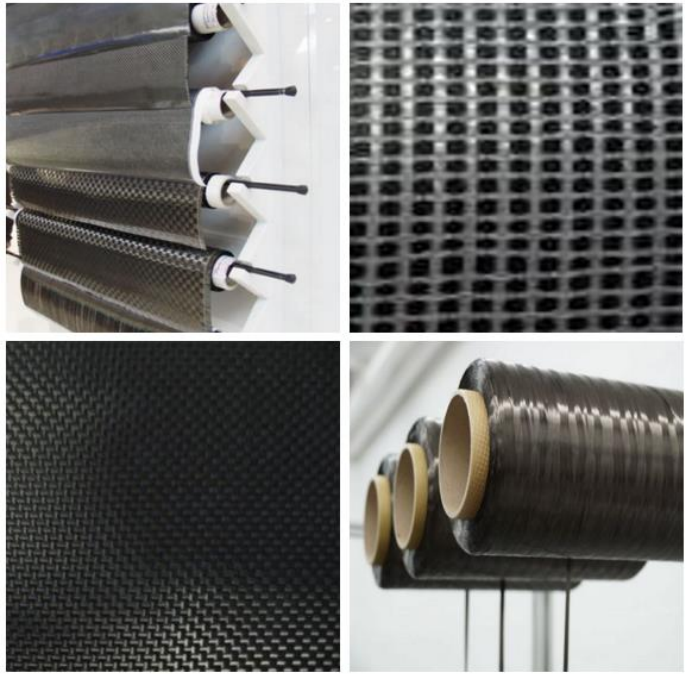
Reinforcement – man made fibres

- ✓ Carbon
- ✓ Glass
- ✓ Polyamide (Nylon R)
- ✓ Aramid (Kevlar R)
- ✓ Basalt

Rovings and textile structure

Rovings and textile structure of the substrate

- ✓ Uni- and Bi-directional structures
- ✓ Woven substrates
- ✓ Multi-directional fibers construction
  - ✓ Layer (cross) structures
  - ✓ Sewed knitted structures
  - ✓ Nonwovens
- ✓ Products with more than one orientation direction, this is influenced by the later desired strength direction



Thermosetting materials

Thermosetting (duroplastic) resins:

- ✓ Solvent based epoxy resins also as chemical or physcal B-stage
- ✓ Hotmelt and solvent free epoxy resins
- ✓ Phenol systems solvent or water based
- ✓ Cyanate Esther systems
- ✓ Polyester / vinyl ester / acrylic resin
- ✓ 1K and 2K products (mostly resins)

→ **Disadvantages:**
Ridgid, not meltable, recycling problems

Specs for thermosetting materials

Specs for thermosetting (duroplastic) systems:

- ✓ **Variation of the coating weight both sides**
  10 – 300 g/m²
- ✓ **Range of viscosity**
  100 – 50 000 mPas
- ✓ **Temperature range**
  40 – 250 °C, standard application temperature 60 – 120 °C
- ✓ **Speed range for different production processes**
  average speed 50 – 80 m/min for film coating process
  average speed 5 – 15 m/min for combined coating and laminating lines
  average speed 5 – 25 m/min for impregnation average speed
- ✓ **Temperature accuracy**
  ± 1K roller surface temperature and dryer accuracy

Thermosetting materials advateges

- ✓ High amount of formulations are possible for every demand
- ✓ Specials are possible
- ✓ Durable and long live time
- ✓ Shiny systems for visibleparts
- ✓ High temperatur resistens for Cyanat esther systems till 350 °C

Thermoplastic materials

Thermoplastic systems

✓	PE	Polyethylen
✓	PP	Polypropylen
✓	PC	Polycarbonat
✓	POM	Polyoxymethylen
✓	PEEK	Polyetheretherketon
✓	PA	Polyamide
✓	PEI	Polyetherimid
✓	PTFE	Polytetrafluorethylen

→ **Disadvantages:**
high viscosities, change of systems for appliance, not finally certified

Specs for thermoplastic materials

Specs for thermosetting systems
powder like materials
✓ solvent thermoplastic resins
✓ extruded thermoplastic resins

Variation of the coating weight
✓ 10 to 300 g/m^2

Range of viscosity
✓ 100 – 200 000 mPas depending on coating or extrusion technology

Temperature range
✓ 80 – 400 °C ± 1K

Speed range
✓ Average speed range for impregnation 0.1 – 10 m/min.

Advanteges for thermoplastic materials

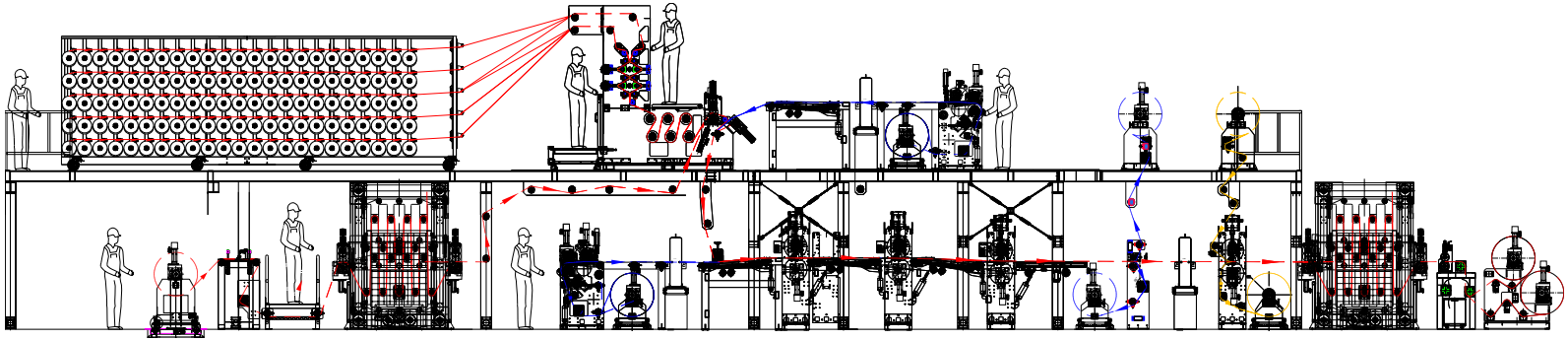
- ✓ High toughness
- ✓ High formability for 3D applications
- ✓ Low density additional wight reducing
- ✓ Quick harding possibilities
- ✓ Mistakes are correctable
- ✓ Plenty of times heatable and formable

4.

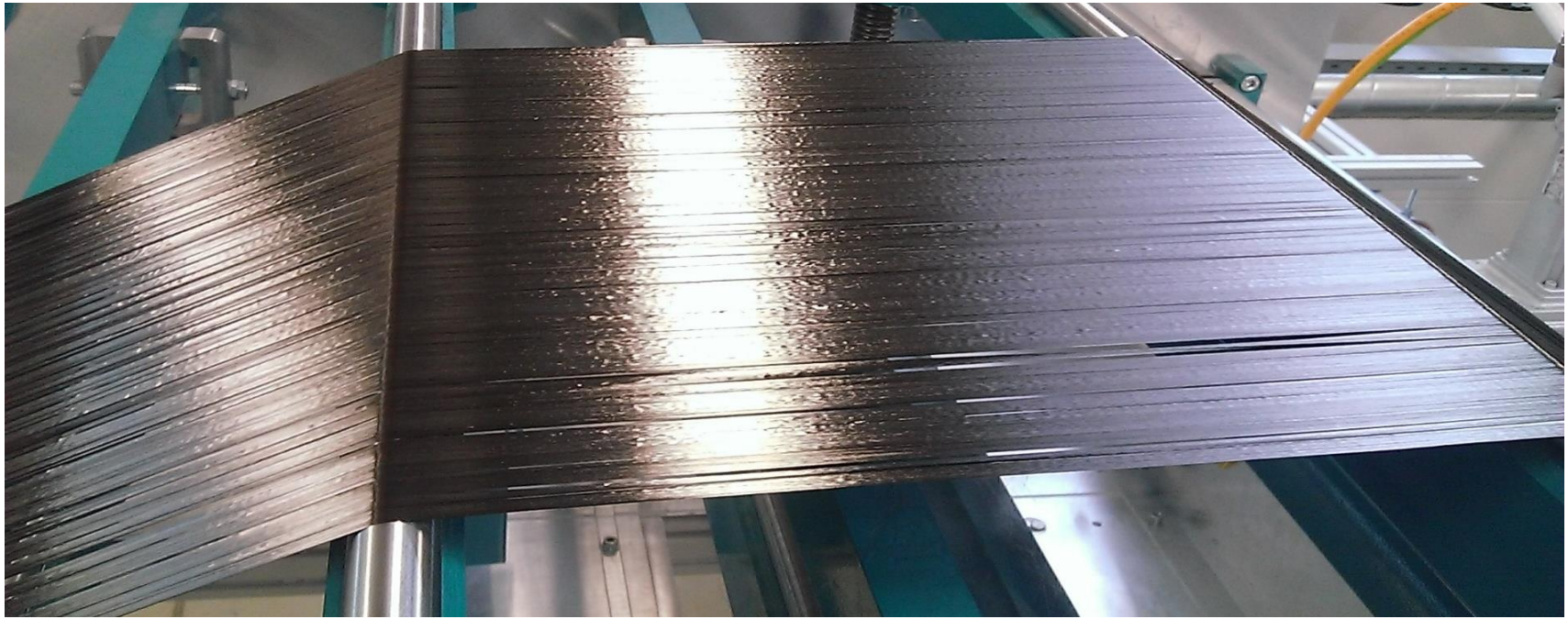
Spreading technologies

Advanteges for thermoplastic materials

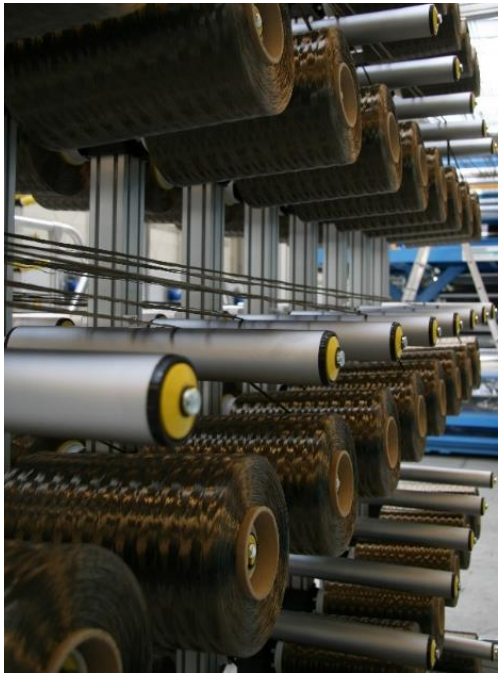
1. **Spreading of fibre**
2. Coating the resin
   a) Thermosetting (duroplastic) resins
   b) Thermoplastic resins
3. Impregnation into the matrix



Spreading technology



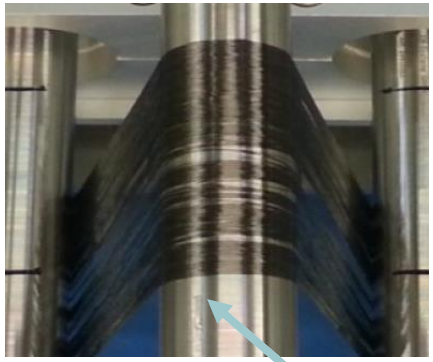
Creel station for carbon bobins



Substrate weight depending on roving fineness and number

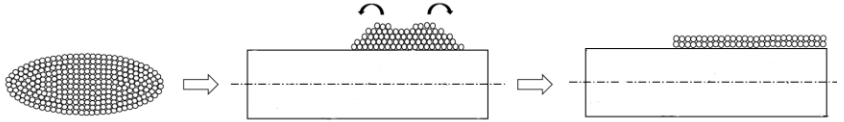
		UD-Width mm	Carbon 1k	Carbon 3k	Carbon 6k	Carbon 6k	Carbon 6k	Carbon 12k	Carbon 12k	Carbon 12k	Carbon 12k	Carbon 24k	Carbon 24k	Carbon 24k	Carbon 24k	Carbon 50k	Carbon 50k	Carbon 50k	Carbon 50k
Filament Number			1.000	3.000	6.000	6.000	6.000	12.000	12.000	12.000	12.000	24.000	24.000	24.000	24.000	50.000	50.000	50.000	50.000
Fineness (tex)	g/1000m		67	200	400	400	400	800	800	800	800	1.600	1.600	1.600	1.600	3.500	3.500	3.500	3.500
Roving Number	pro 1 m		300	200	150	200	250	62	100	125	166	62	83	94	125	34	43	63	71
Substrate weigth	**g/m²**		**20**	**40**	**60**	**80**	**100**	**50**	**80**	**100**	**133**	**100**	**133**	**150**	**200**	**120**	**150**	**220**	**250**
Roving Number	for DU width	600	180	120	90	120	150	37	60	75	100	37	50	56	75	21	26	38	43
Spreading	mm		3,33	5,00	6,67	5,00	4,00	16,00	10,00	8,00	6,02	16,00	12,03	10,67	8,00	29,17	23,33	15,91	14,00
		UD-Width mm	Carbon 1k	Carbon 3k	Carbon 6k	Carbon 6k	Carbon 6k	Carbon 12k	Carbon 12k	Carbon 12k	Carbon 12k	Carbon 24k	Carbon 24k	Carbon 24k	Carbon 24k	Carbon 50k	Carbon 50k	Carbon 50k	Carbon 50k
Filament Number			1.000	3.000	6.000	6.000	6.000	12.000	12.000	12.000	12.000	24.000	24.000	24.000	24.000	50.000	50.000	50.000	50.000
Fineness (tex)	g/1000m		67	200	400	400	400	800	800	800	800	1.600	1.600	1.600	1.600	3.500	3.500	3.500	3.500
Roving Number	pro 1 m		300	200	150	200	250	62	100	125	166	62	83	94	125	34	43	63	71
Substrate weigth	**g/m²**		**20**	**40**	**60**	**80**	**100**	**50**	**80**	**100**	**133**	**100**	**133**	**150**	**200**	**120**	**150**	**220**	**250**
Roving Number	for DU width	1200	360	240	180	240	300	75	120	150	199	75	100	112	150	41	51	75	86
Spreading	mm		3,33	5,00	6,67	5,00	4,00	16,00	10,00	8,00	6,02	16,00	12,03	10,67	8,00	29,17	23,33	15,91	14,00

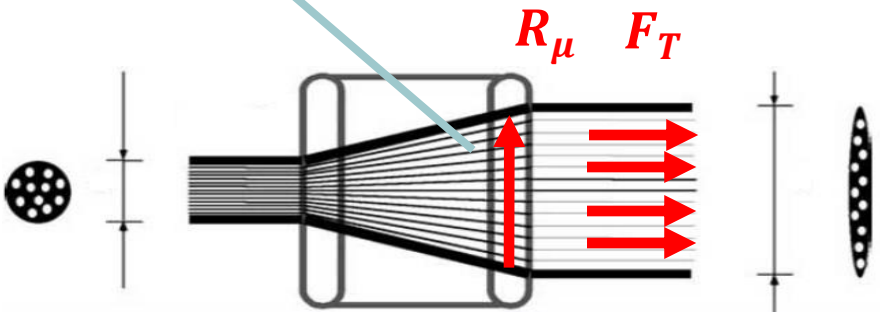
Speading process

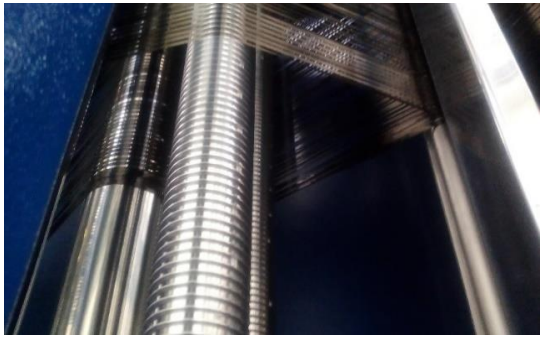


R_μ Friction effect

F_T Pulling / traction for fibre

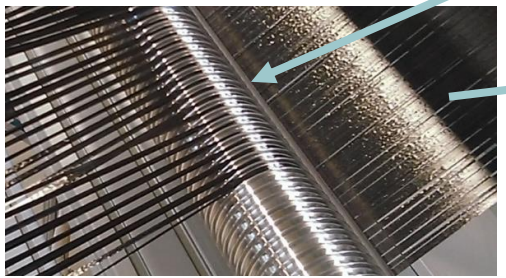




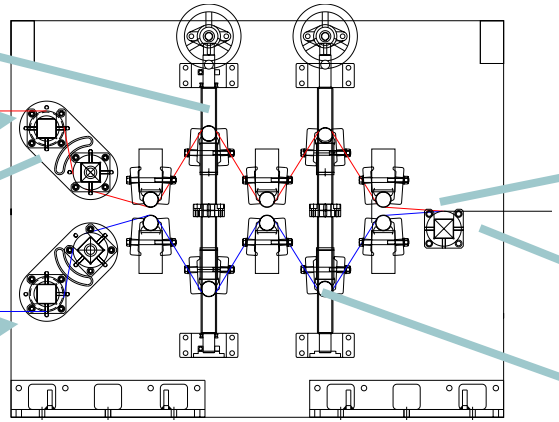


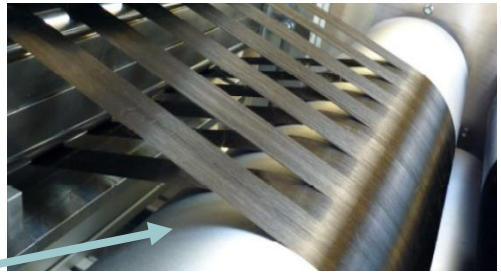
Speading process

Top spreading rods

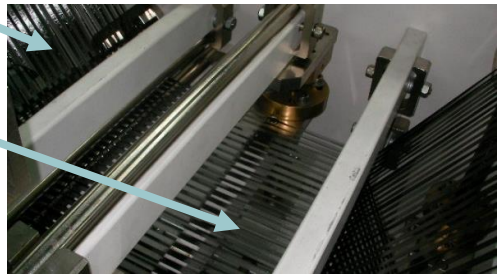


Positioning roller



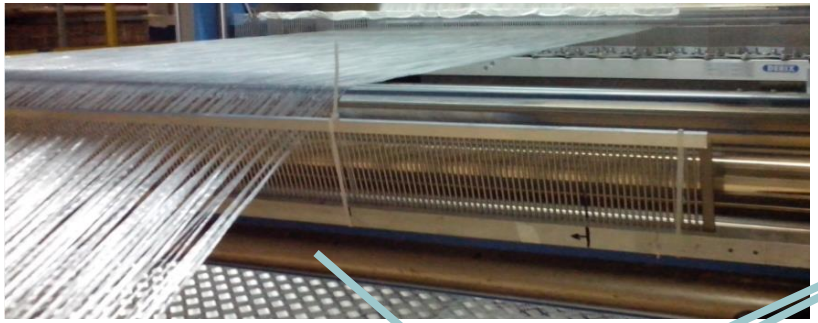


Transfer roller

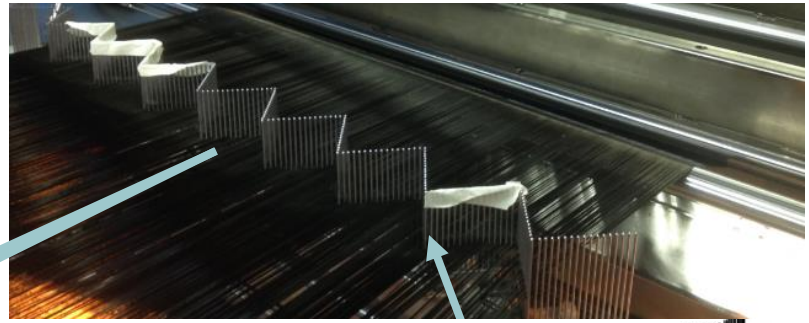


Bottom spreading rods

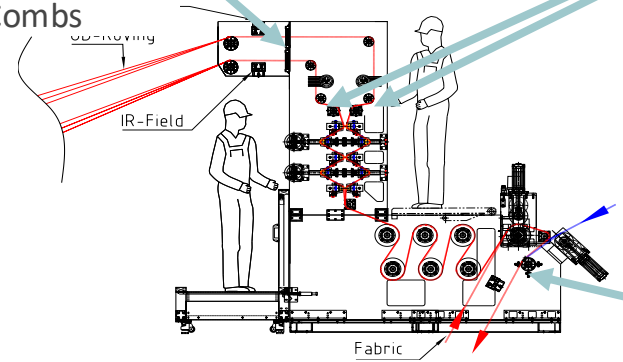
Speading device

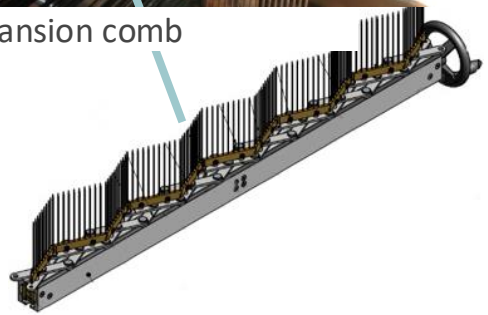


Two units Combs



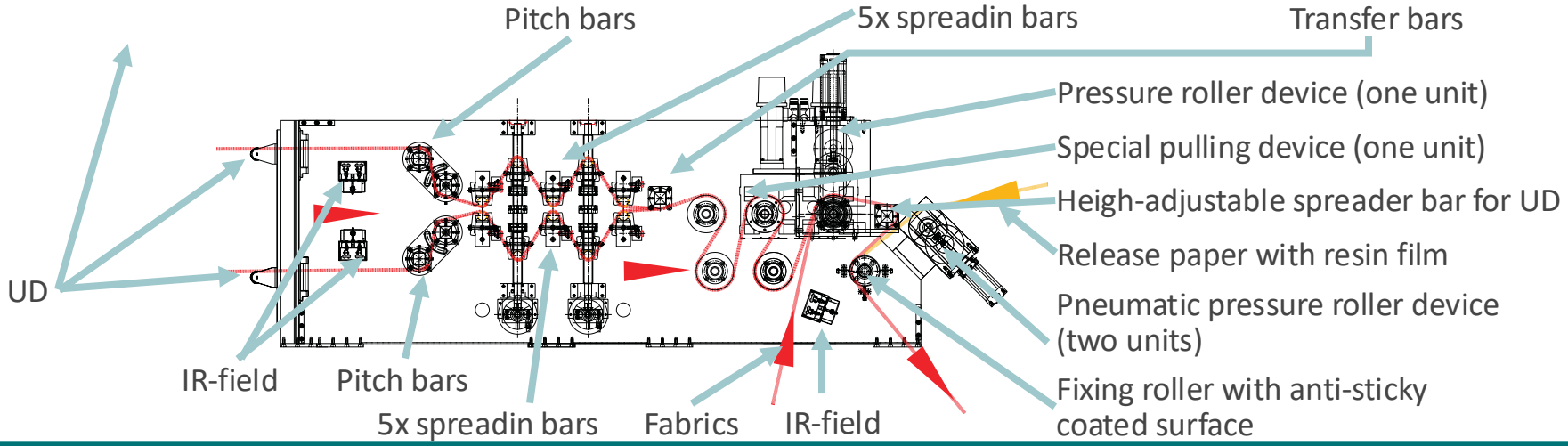
Two units Zig zag expansion comb



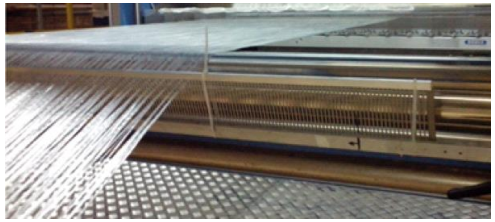
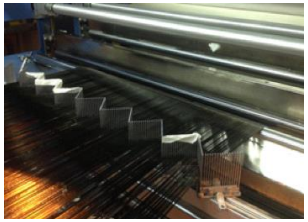
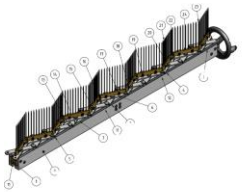


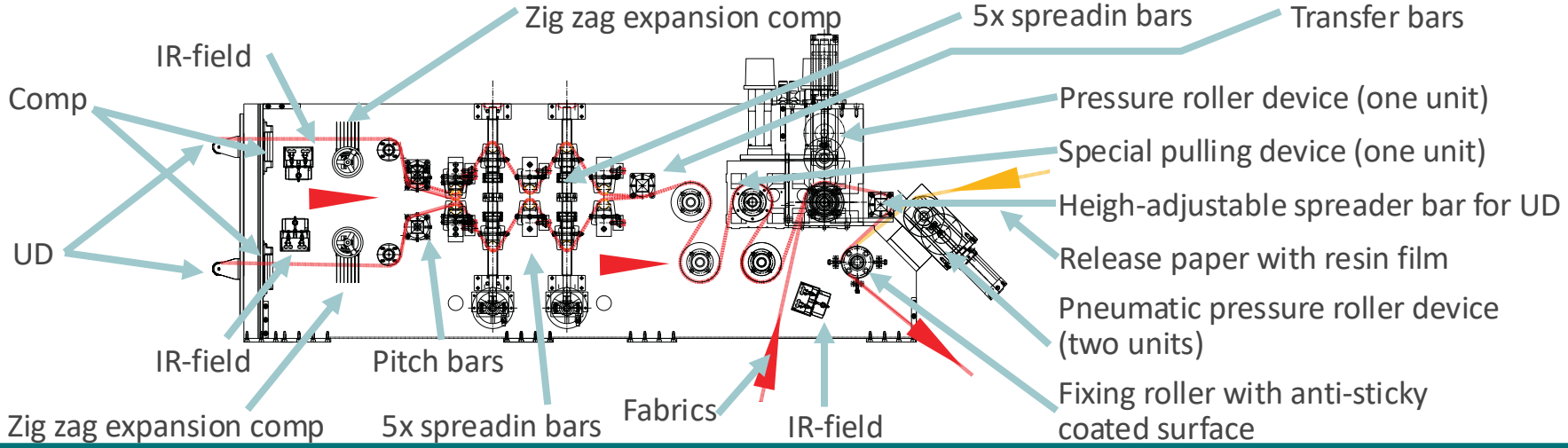
Roller with teflon coated surface

Speading device with pitch bars



Speading device with zig zag expansion comb



Additional possibilities

- ✓ Ultrasonic devices
- ✓ Vibrations bars
- ✓ Cooled bars for higher traction force
- ✓ Topocrom surface of the bars for reducing traction

5.

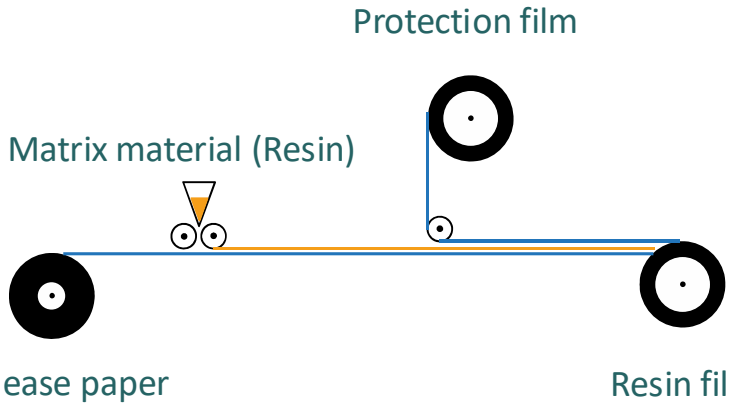
Coating technologies

Substrate weight depending on roving fineness and number

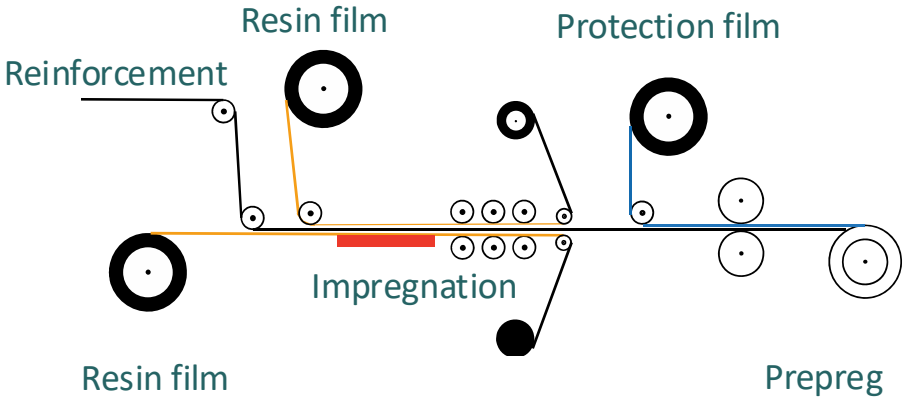
✓	12K spreading per roving to	8 mm add up to	100 g/m²
✓	12K spreading per roving to	10.7 mm add up to	75 g/m²
✓	24K spreading per roving to	8 mm add up to	200 g/m²
✓	24K spreading per roving to	10.7 mm add up to	150 g/m²
✓	24K spreading per roving to	16 mm add up to	100 g/m²

Film transfer method

Step1: Matrix film coating

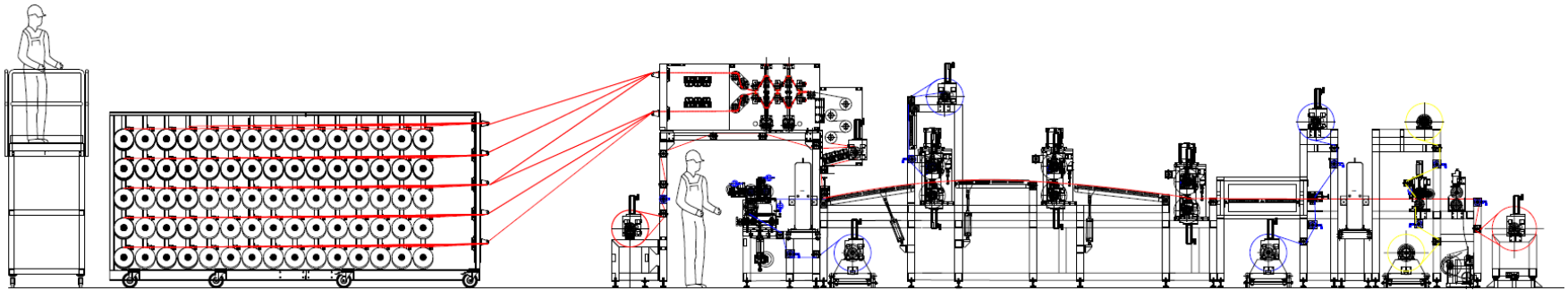


Step2: Prepreg impregnation



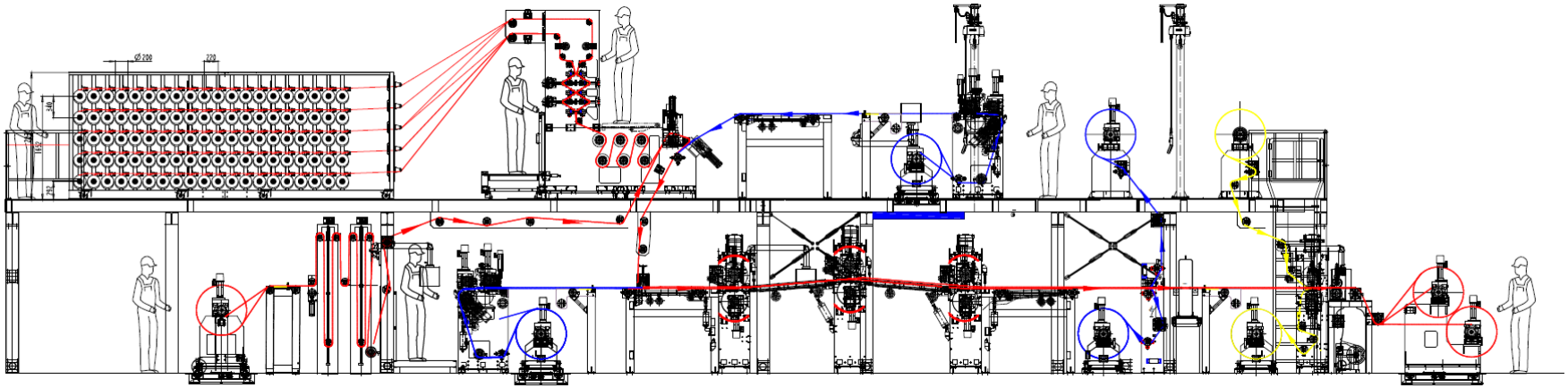
Film transfer method

Lab prepreg coating line



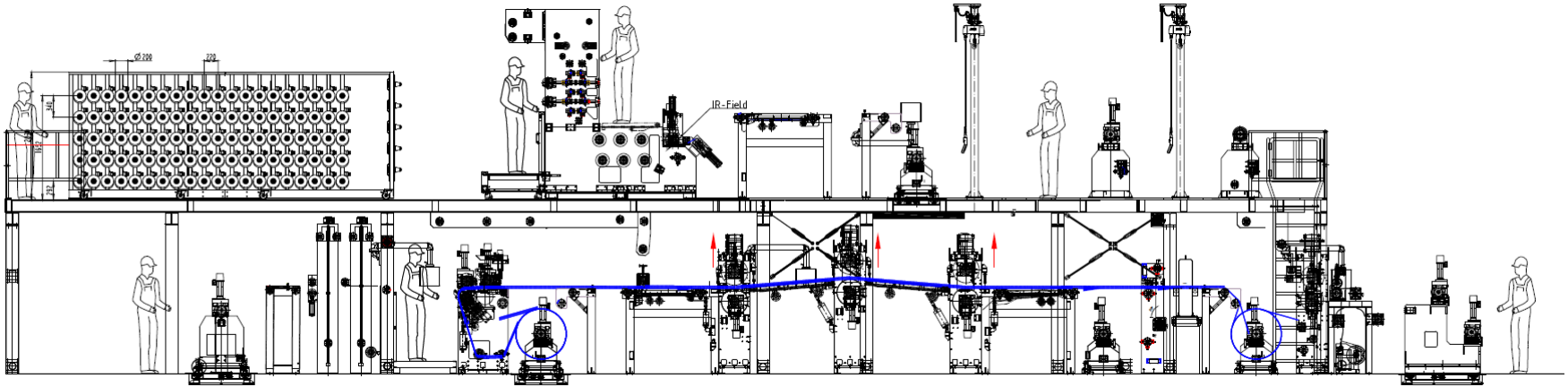
Film transfer method

1 Step process



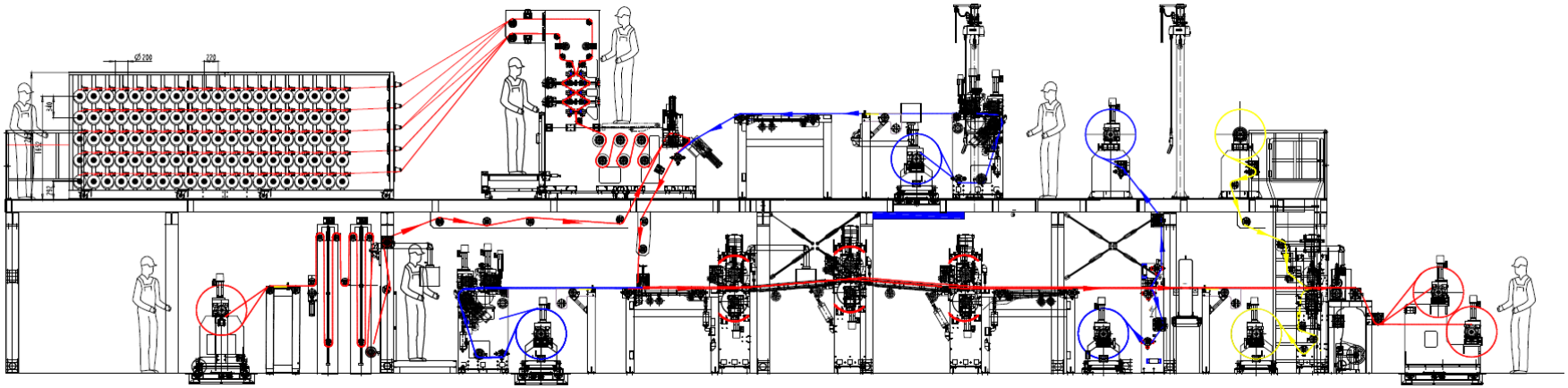
Film transfer method

2 Step process: resin-film coating



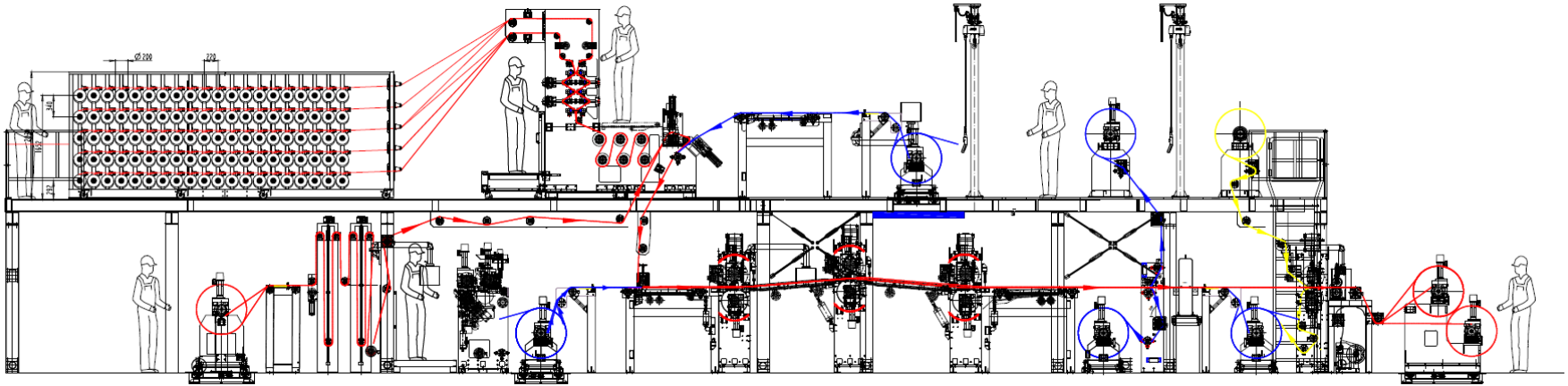
Film transfer method

2 Step process: 1. direct – 2. indirect

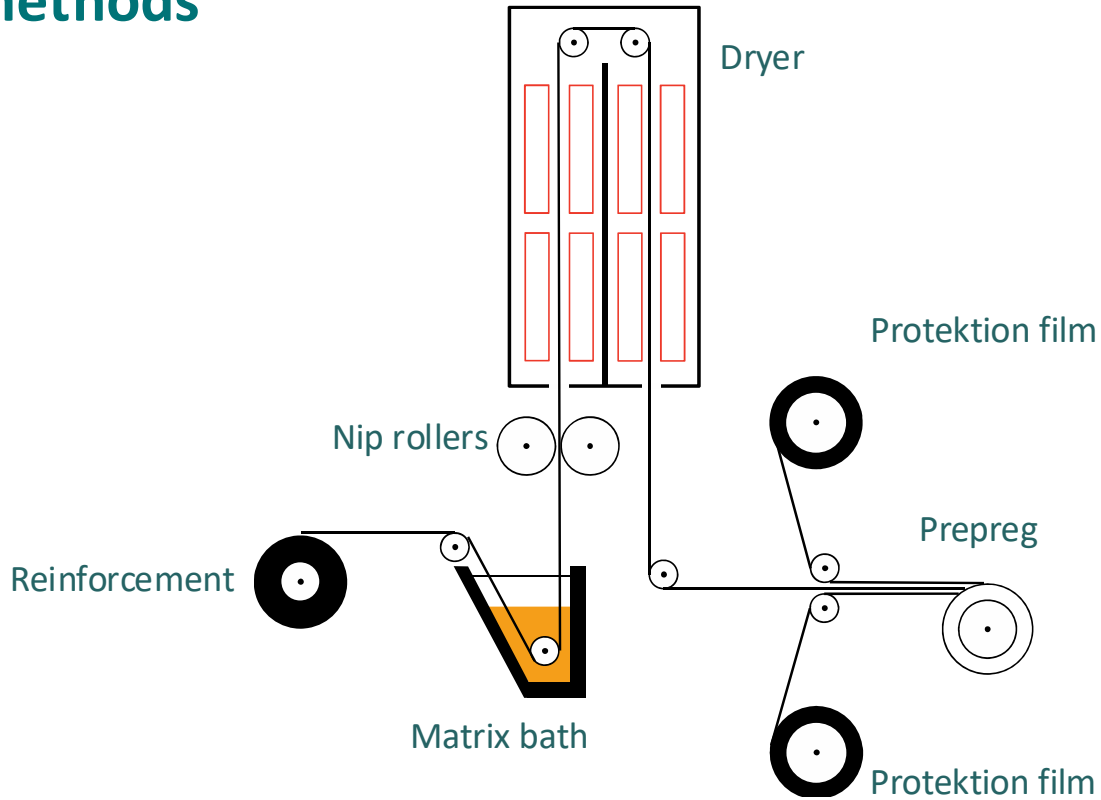


Film transfer method

2 Step process: 1. indirect – 2. indirect

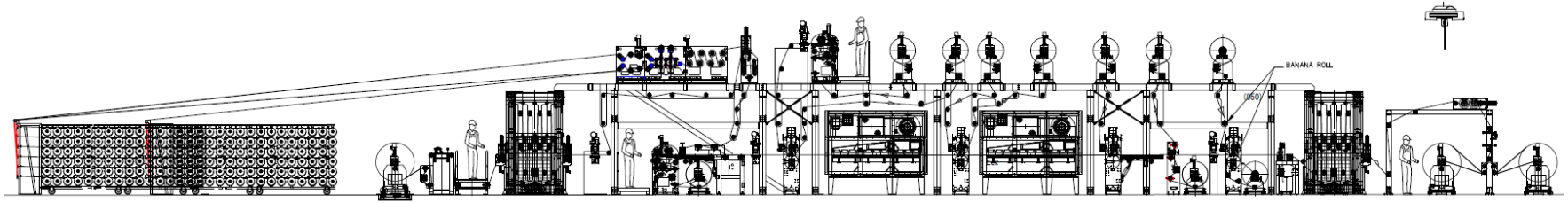


Solvent methods

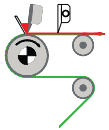


Film transfer method

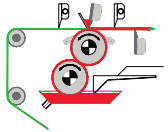
1 Step process for solvent



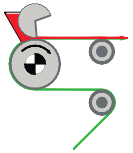
Coating systems



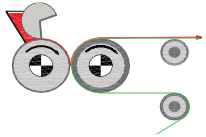
Knife system



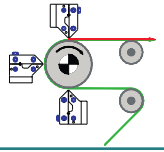
Double side coating system



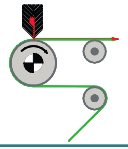
Commabar system



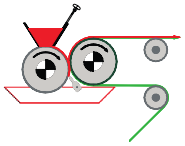
Reverse commabar system



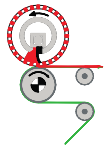
Slot die system



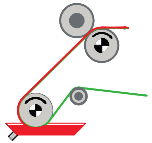
Curtain coating system



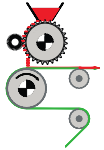
Case knife system



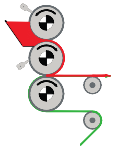
Rotary screen system



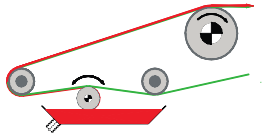
Dipping system (Foulard)



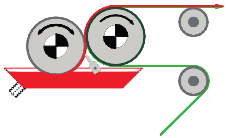
Powder scattering system



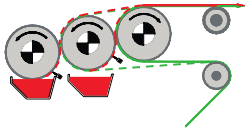
Reverse roll coating system



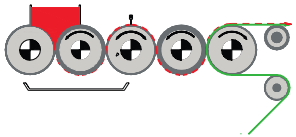
Micro roller coating system



2-roller coating system

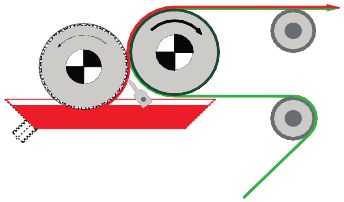


3-roller combi coating system

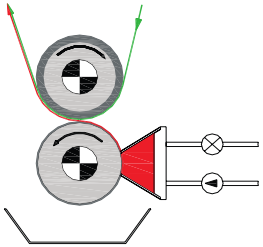


5-roller coating system

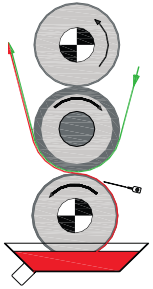
Printing systems



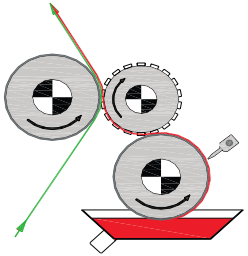
Engraved roller system



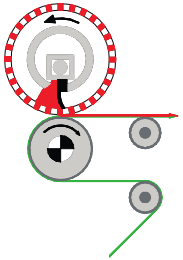
Gravure roller system



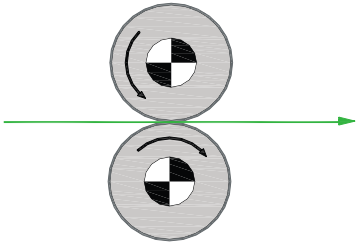
Gravure indirect system



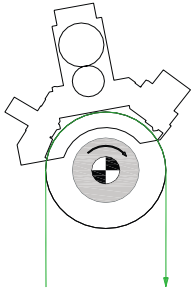
Flexography system



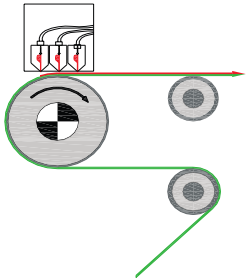
Rotary screen system



Hot embossing system



Nanoimprint system

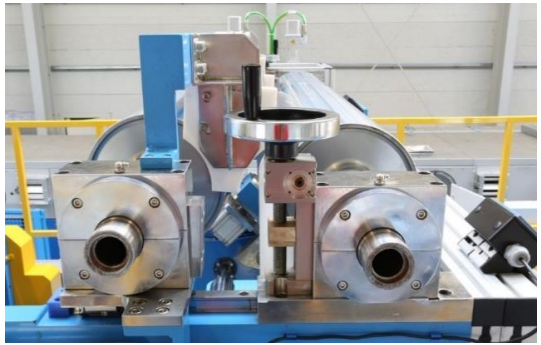


Inkjet system

Indirect coating – concept:

- ✓ Coating is being done on a carrier film
- ✓ Easy to pre-meter the coating thickness
- ✓ Transport on a support carrier to the next steps
- ✓ High accuracy
- ✓ Reproducibility

Indirect coating



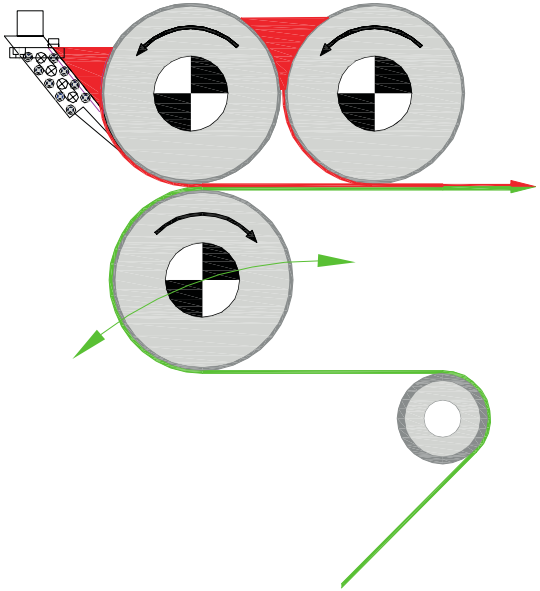
Modular coating system for prepreg

Viscosity

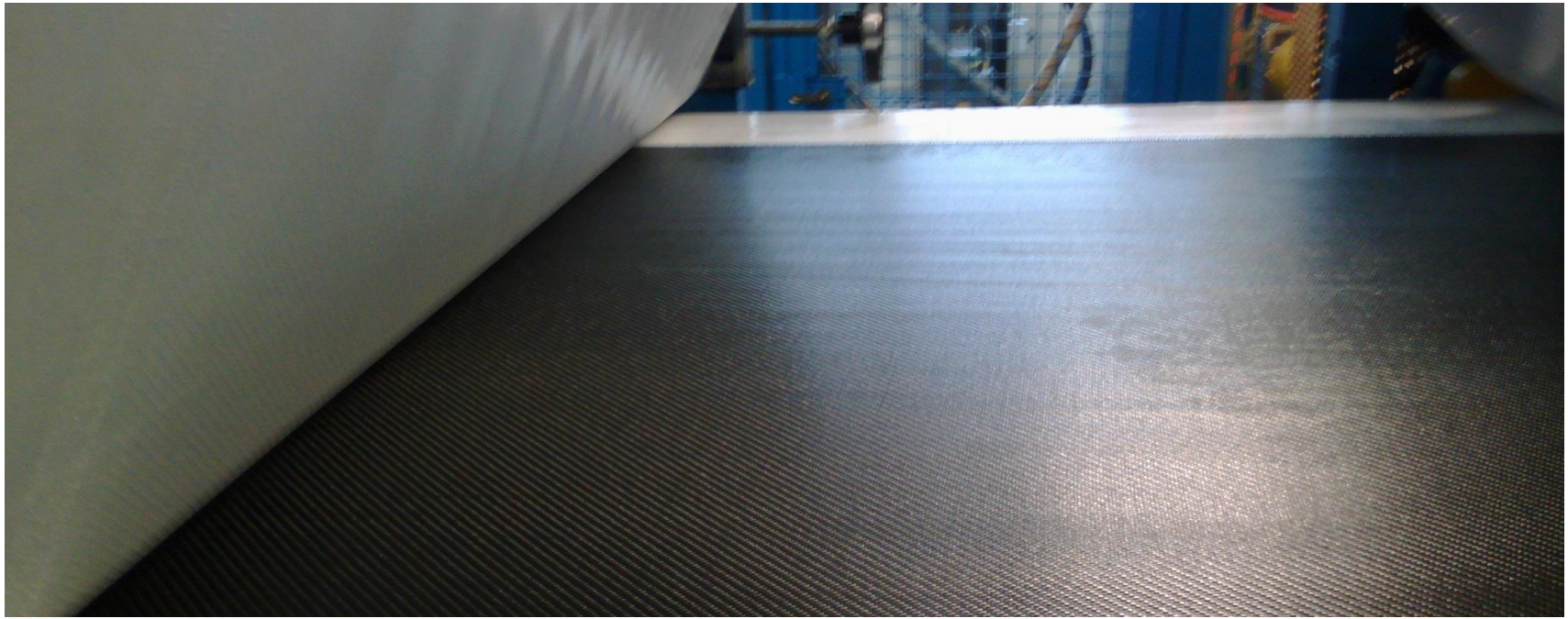
✓ 100 – 200 000 mPas

Temperature range

✓ RT – 250°C

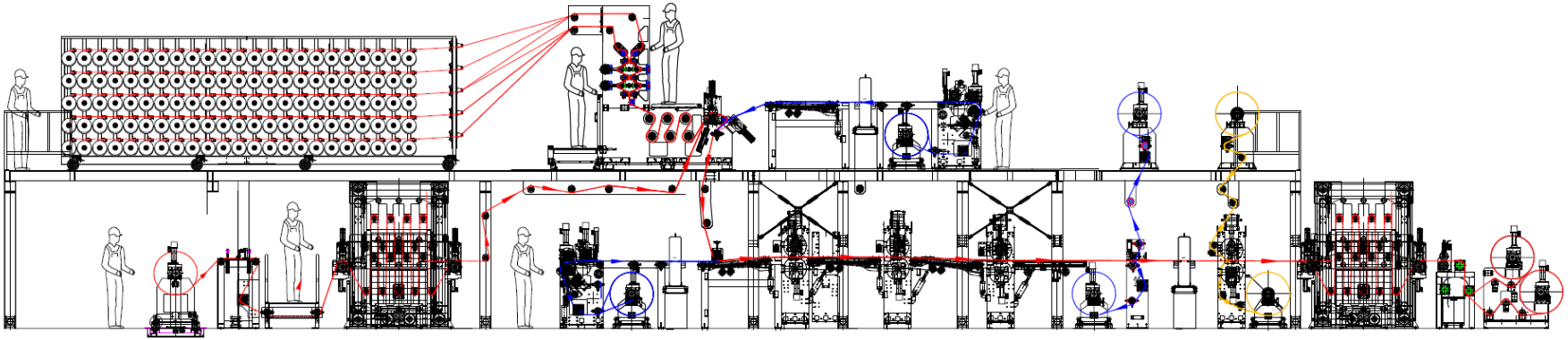


Thermosetting technology

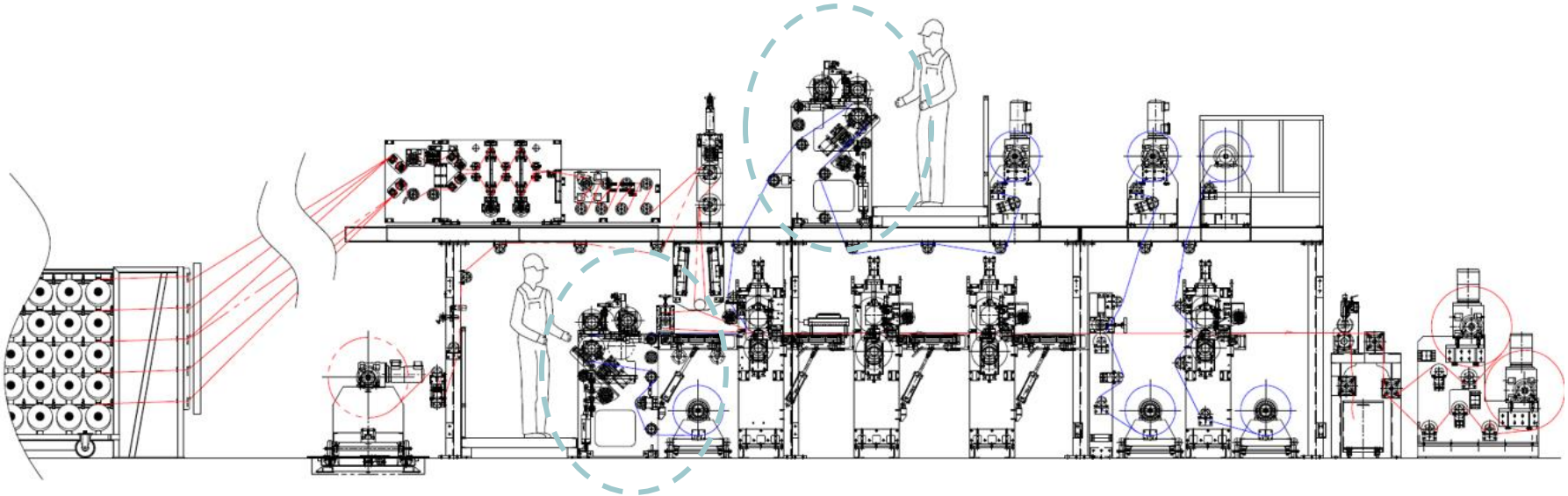


Thermosetting technology

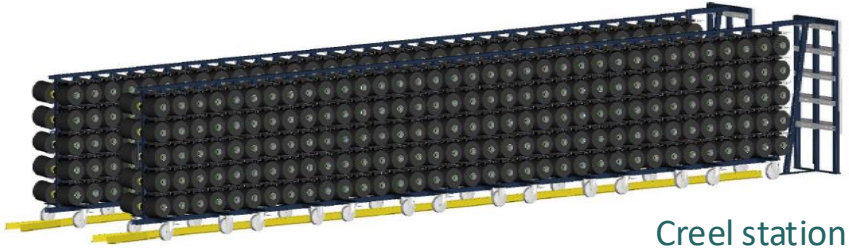
1. Spreading of fibre
2. **Coating the resin**
   a) Thermosetting (duroplastic) resins
   b) Thermoplastic resins
3. Impregnation into the matrix



Indirect coating prepreg line



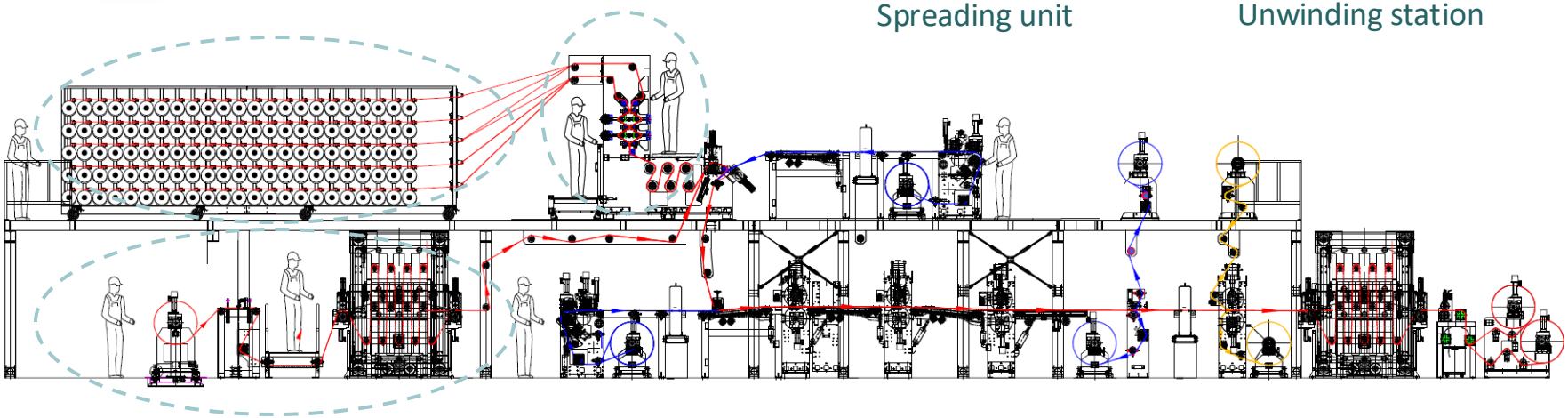
Technology background – layout for thermosetting production line



Creel station

Spreading unit

Unwinding station



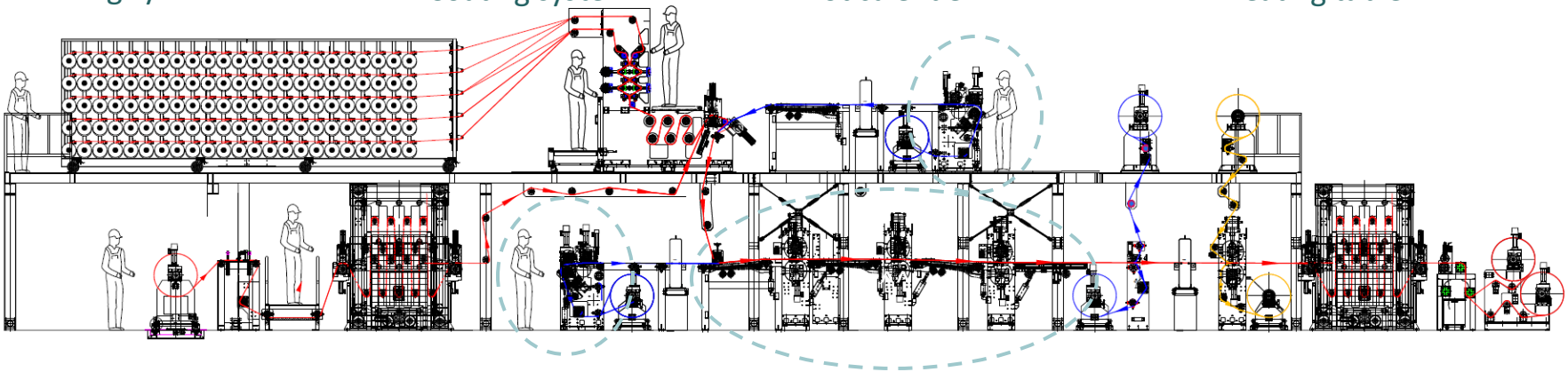
Technology background – layout for thermosetting production line

Coating system 1

Coating system 2

Hot calender

Heating table



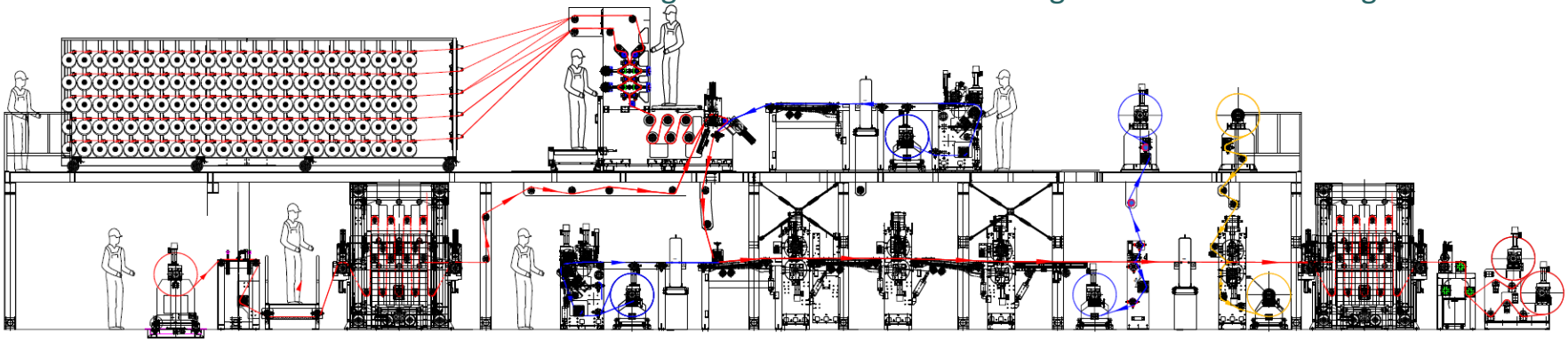
Technology background – layout for thermosetting production line


De-lamination + Lamination station

Winding-station

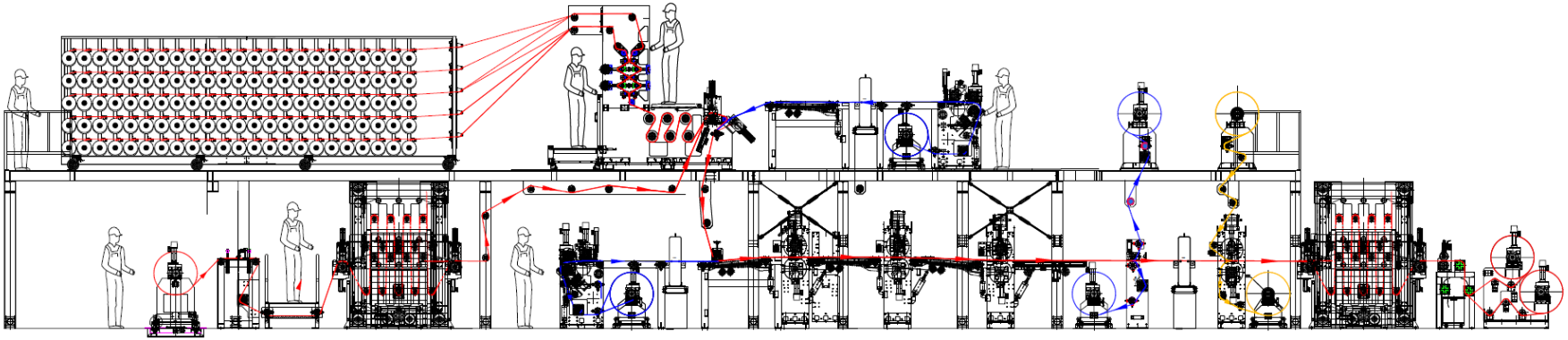
Cutting device

Rewinding station

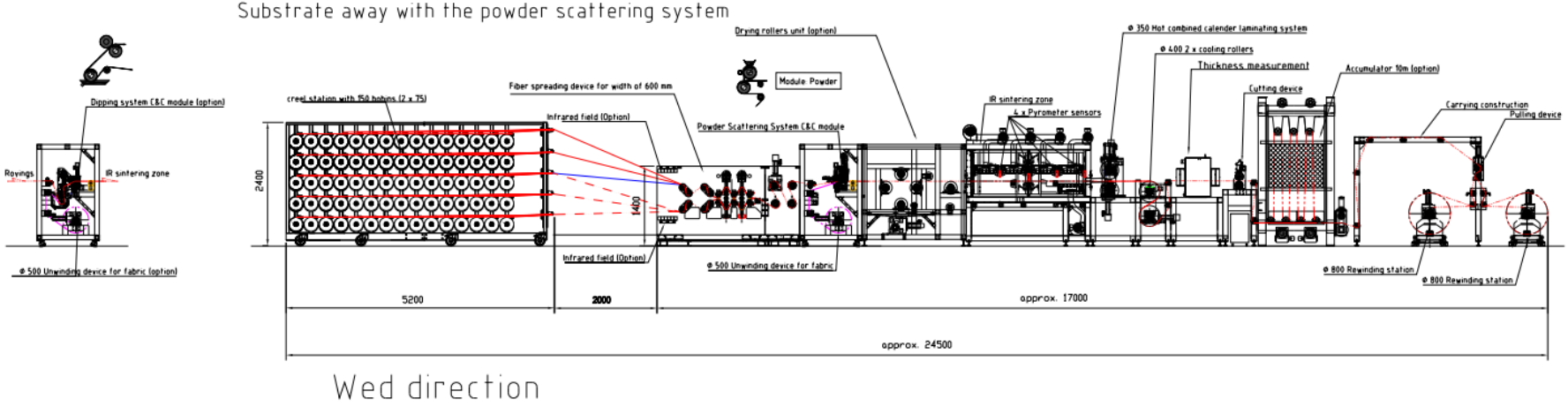


Thermosetting technology

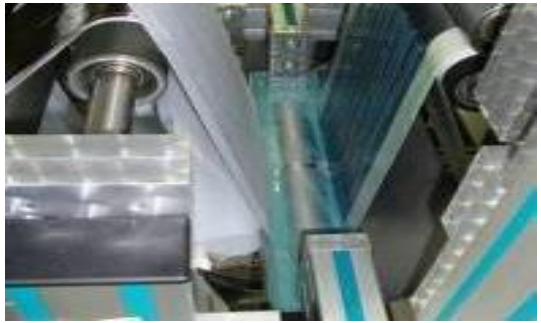
1. Spreading of fibre
2. **Coating the resin**
   a) Thermosetting (duroplastic) resins
   b) Thermoplastic resins
3. Impregnation into the matrix



Production line layouts – thermoplastic process



Dipping / Foulard



Variation of the impregnation weight

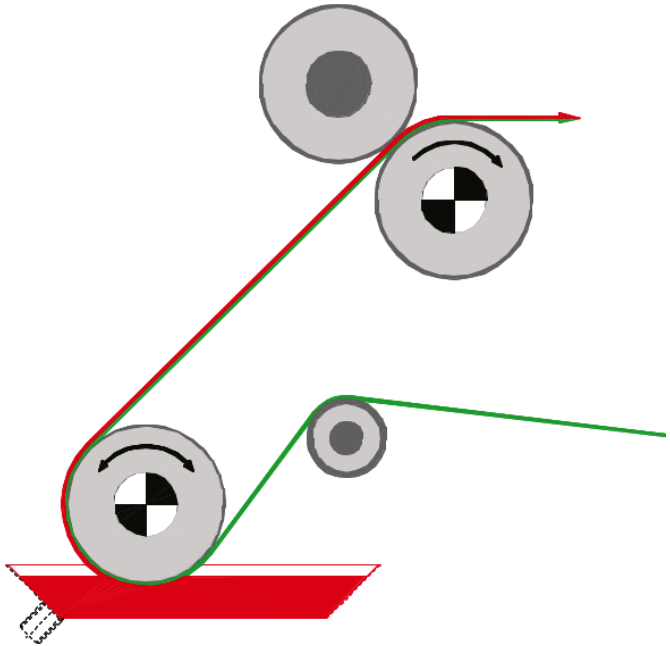
✓ Depending on the fabric / UD tape

Range of Viscosity

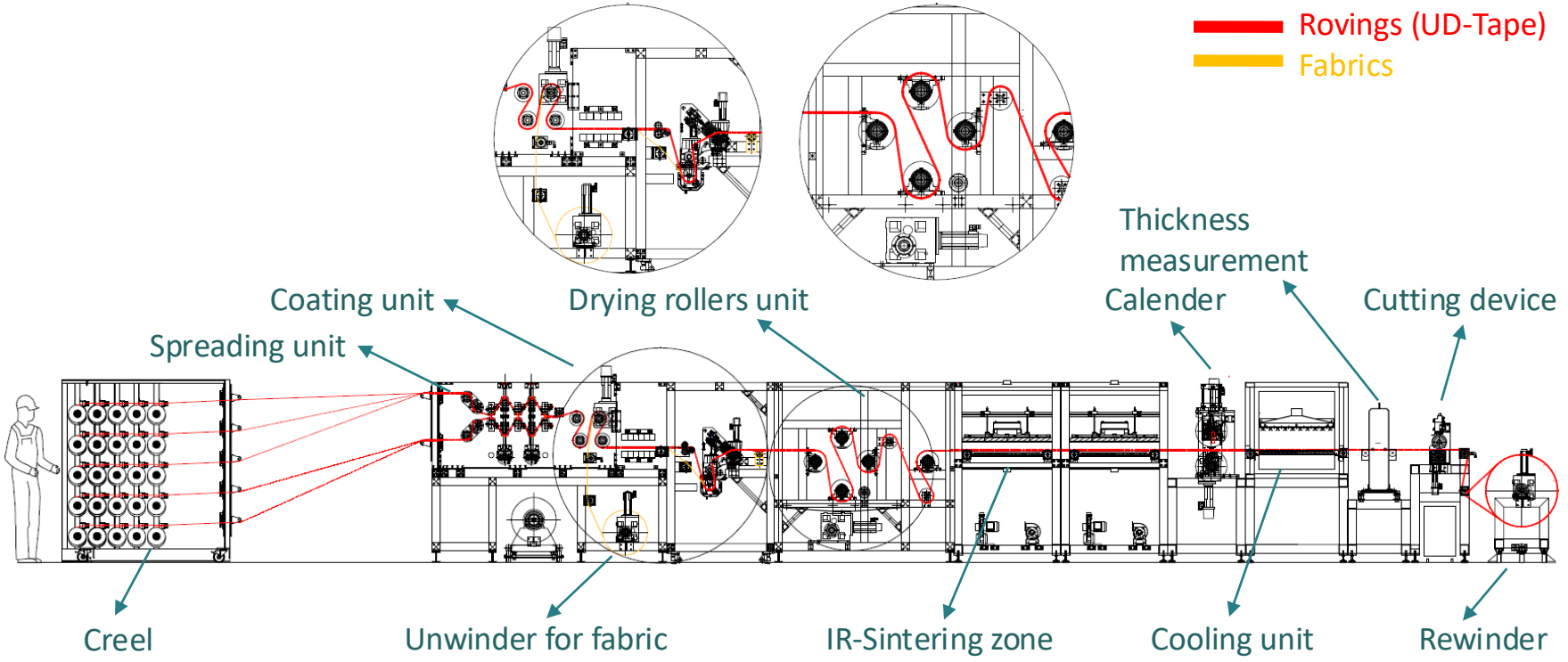
✓ 100 – 10 000 mPas

Temperature range

✓ RT – 250°C



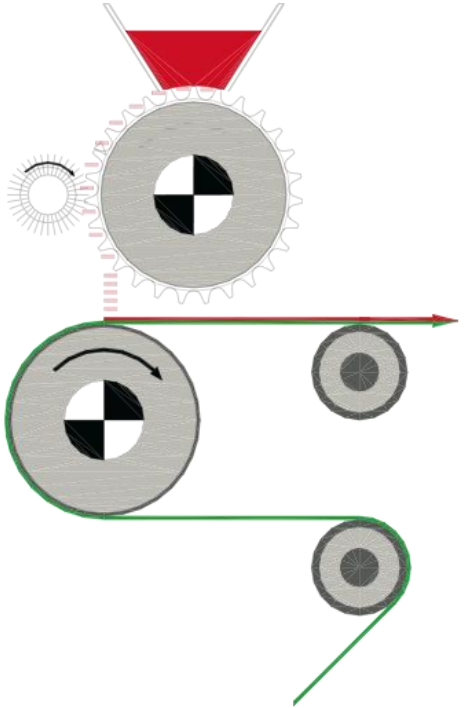
Dipping / Foulard prepreg line



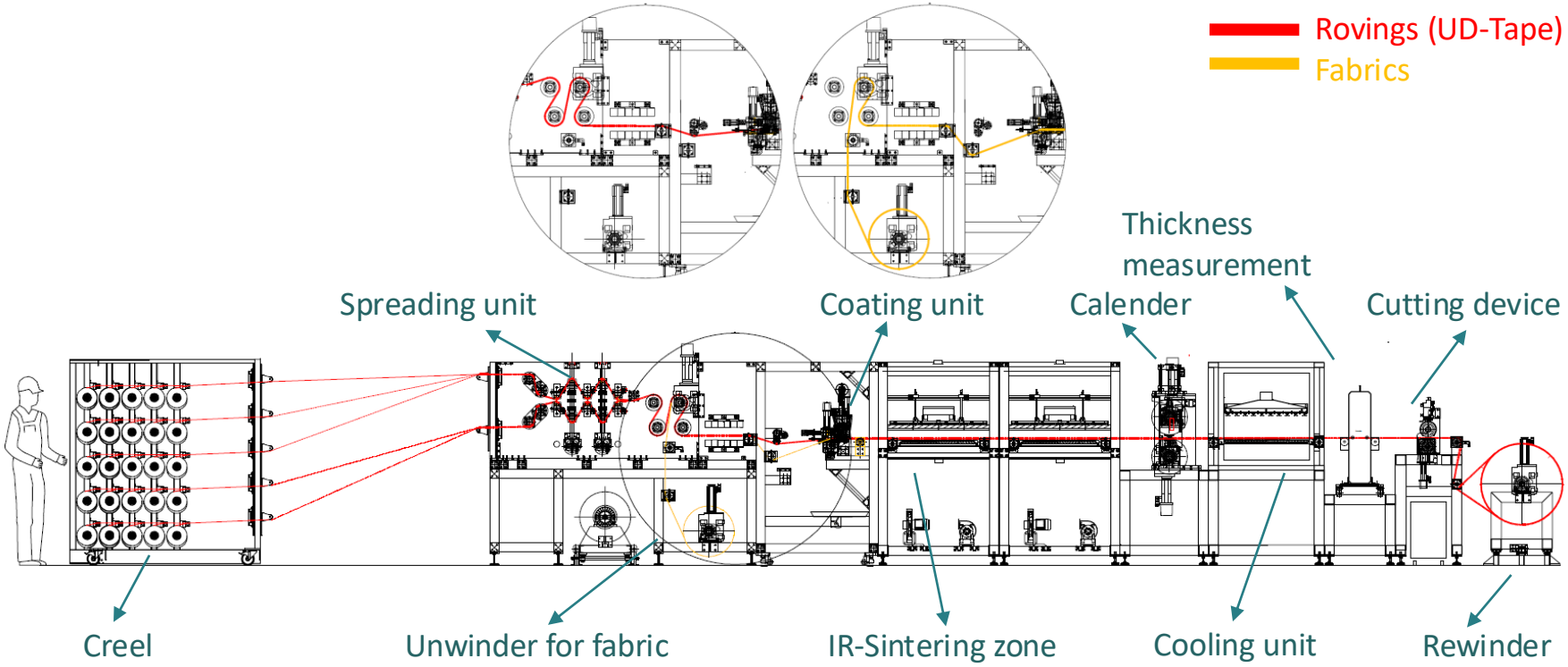
Powder Scattering

Variation of the impregnation weight

✓ 10 – 300 g/m²



Powder scattering prepreg line



Hotmelt / Extrusion

Variation of the impregnation weight

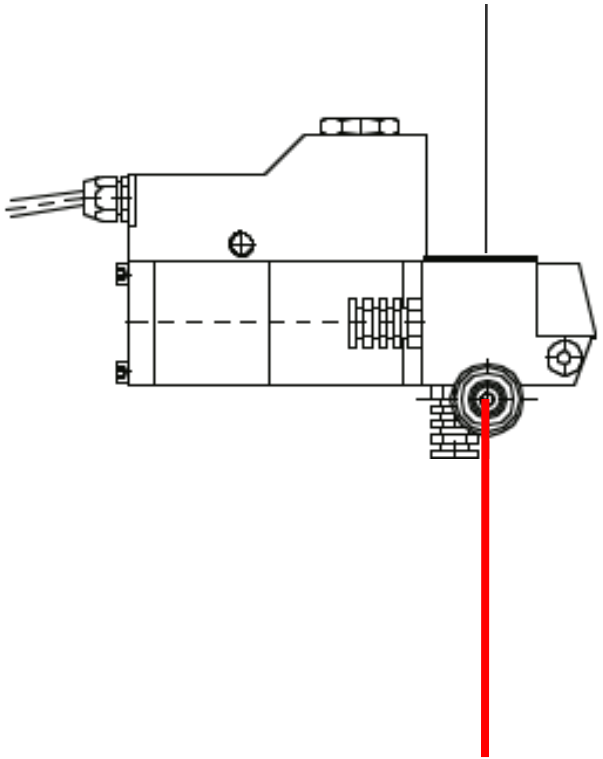
✓ Depending on the fabric / UD tape

Range of Viscosity

✓ 100 – 10 000 mPas

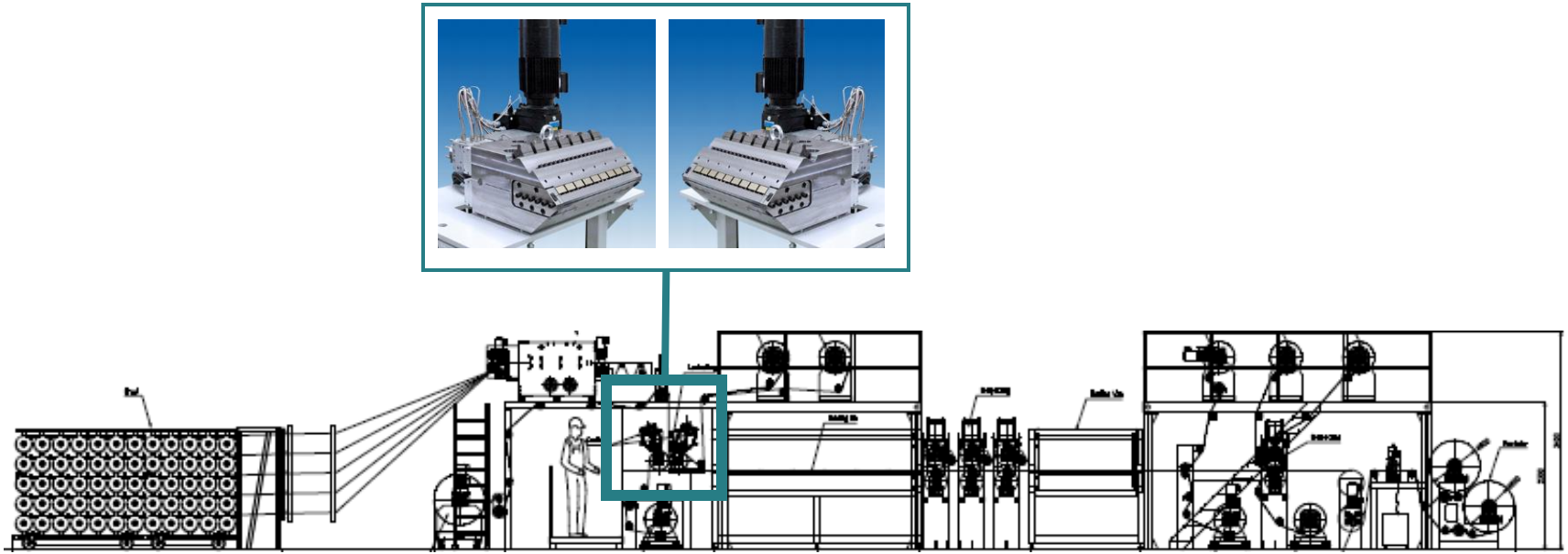
Temperature range

✓ RT – 400°C



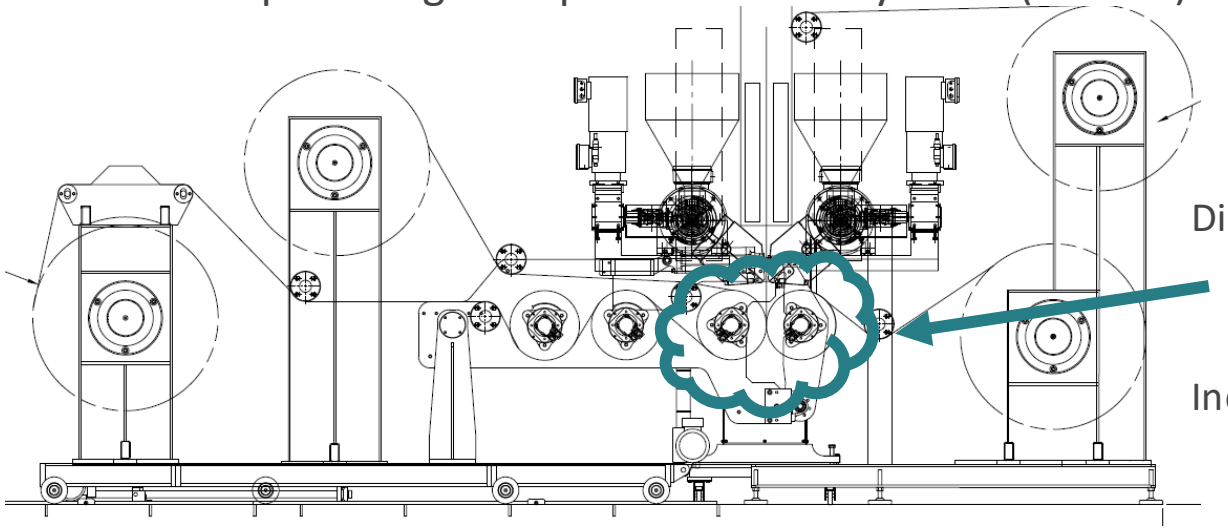
Extrusion die / Hotmelt

Double Side Extrusion of thermoplastic resins



Curing / High temperature systems

For the curing / impregnation process of high-tech polymers (PEEK, PEK, PTFE) temperatures from room temperature up to 400°C are needed
→ Therefor special high temperature roller systems (>300°C) are applied

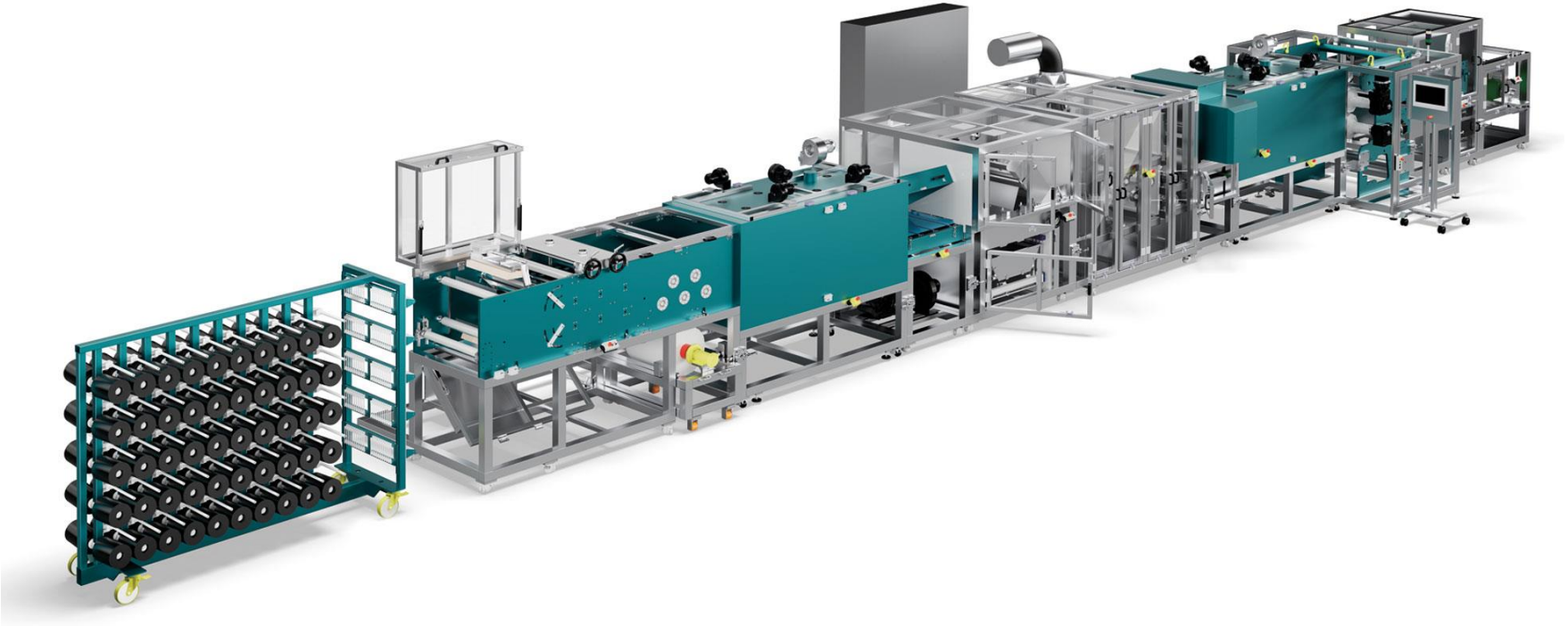


Direct heated rollers (IR)

or

Inductive heated roller systems

Click&Coat™ for Prepreg production



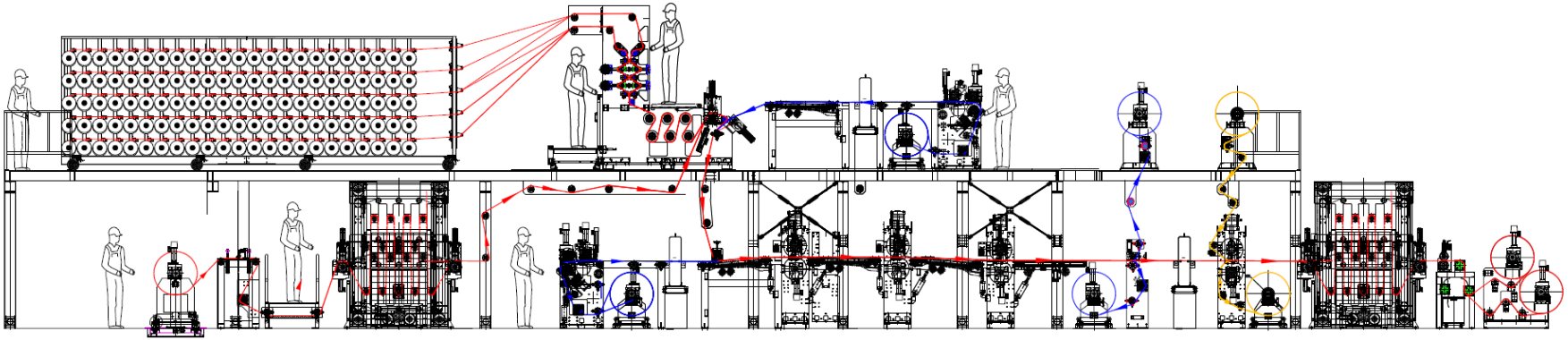
Calendering production scale / High temperature layout – up to 450°C

6.

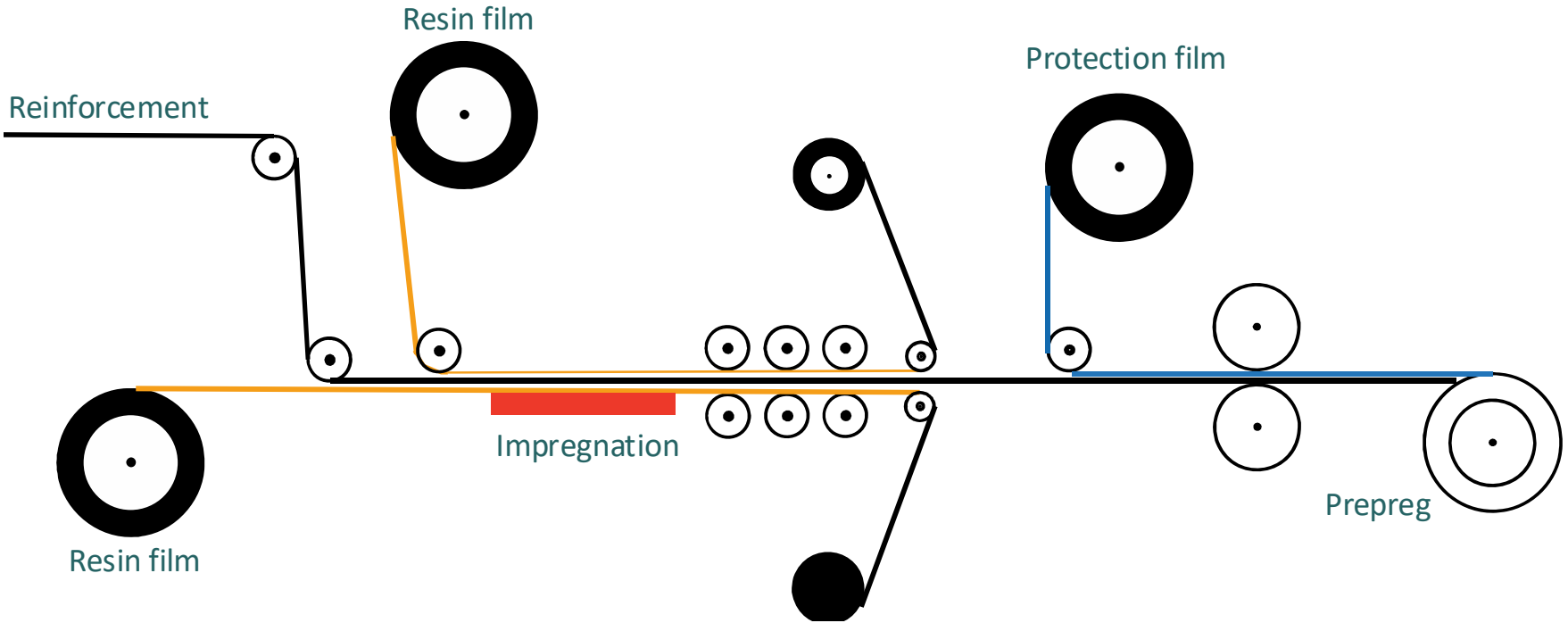
Impregnation technologies

Thermosetting technology

1. Spreading of fibre
2. Coating the resin
   a) Thermosetting (duroplastic) resins
   b) Thermoplastic resins
3. Impregnation into the matrix

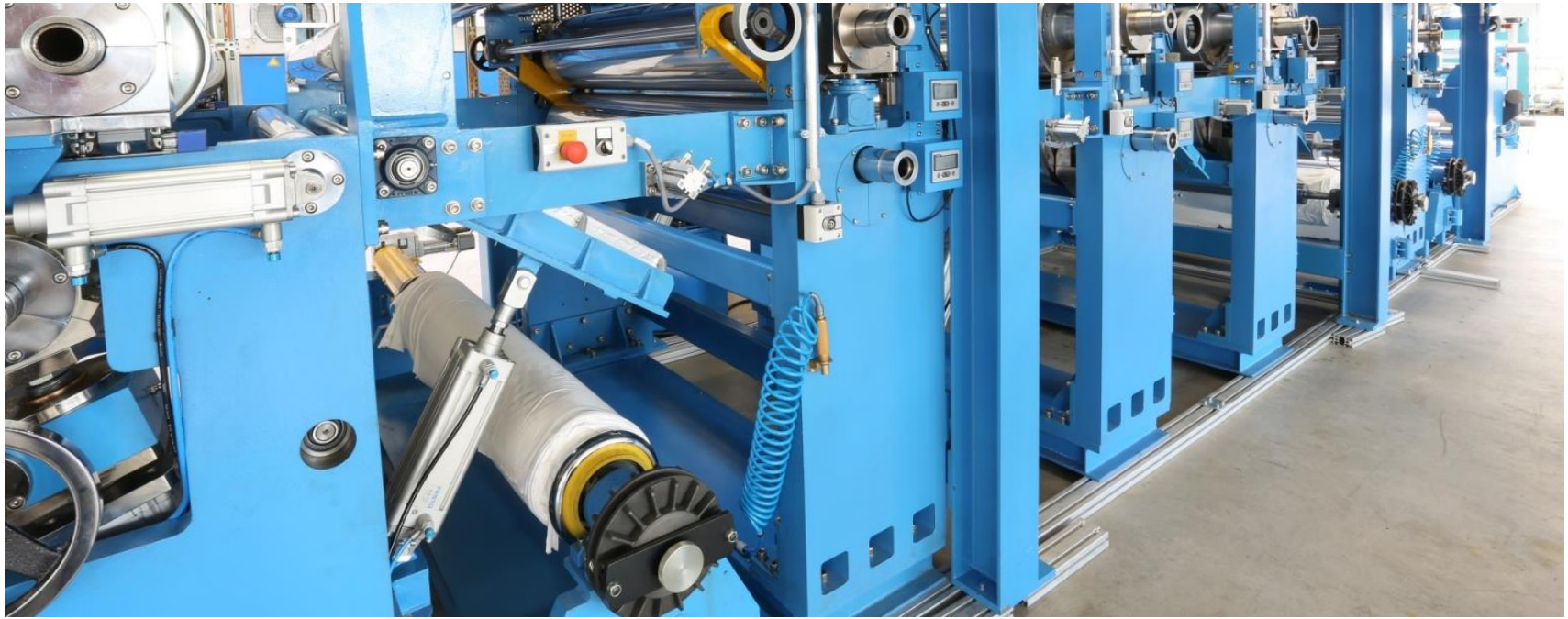


Impregnation technologies

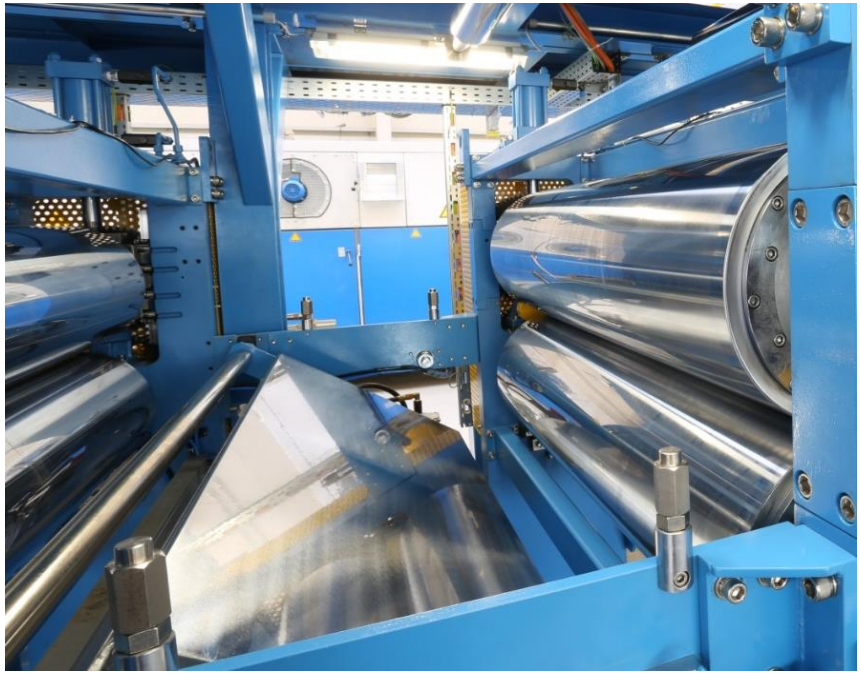


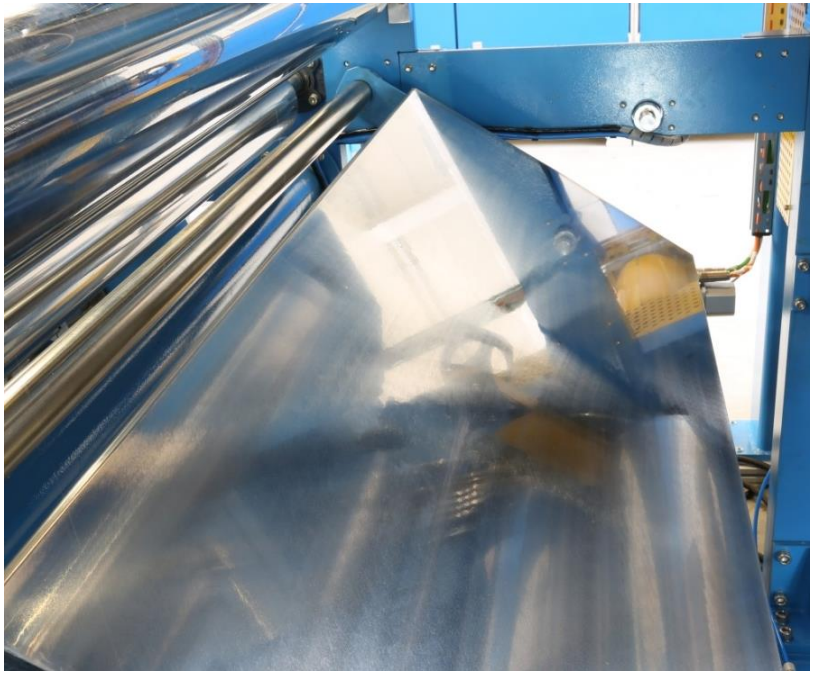
Source: http://files.hanser.de/Files/Article/ARTK_LPR_9783446433007_0001.pdf

Impregnation zone



High precise calender systems with heating table





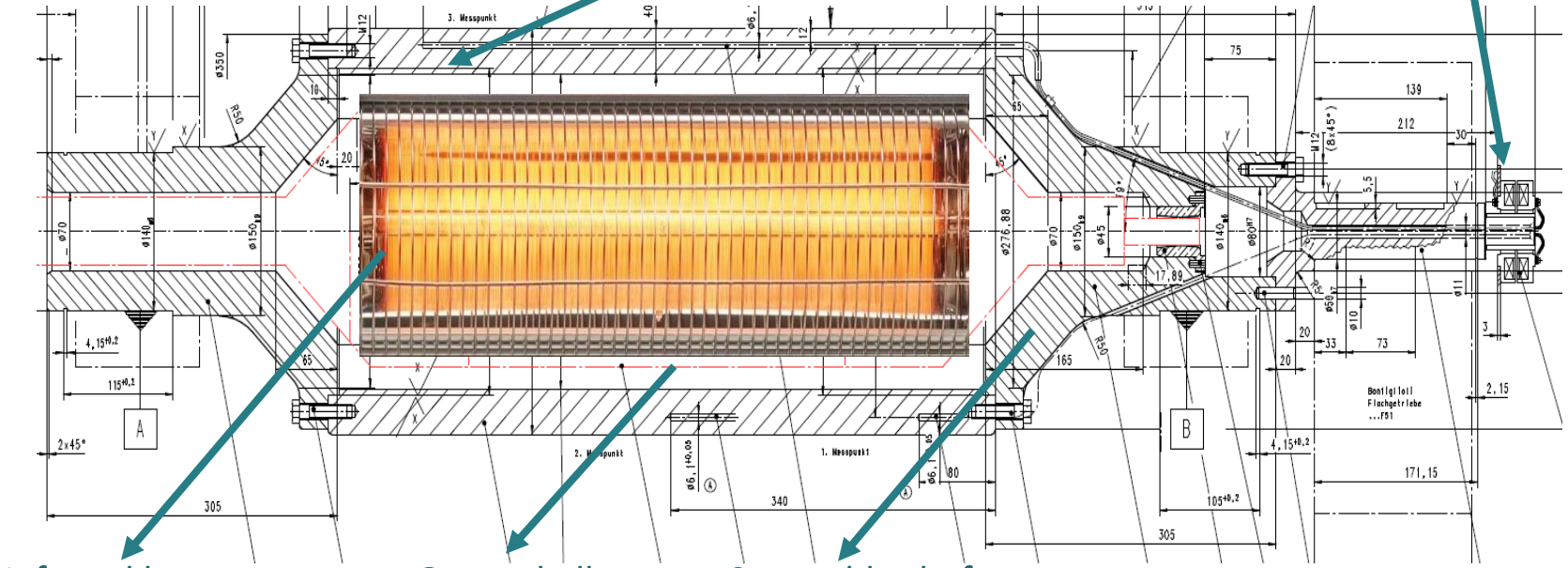
7.

Curing / High temperature systems

Roll design parameters

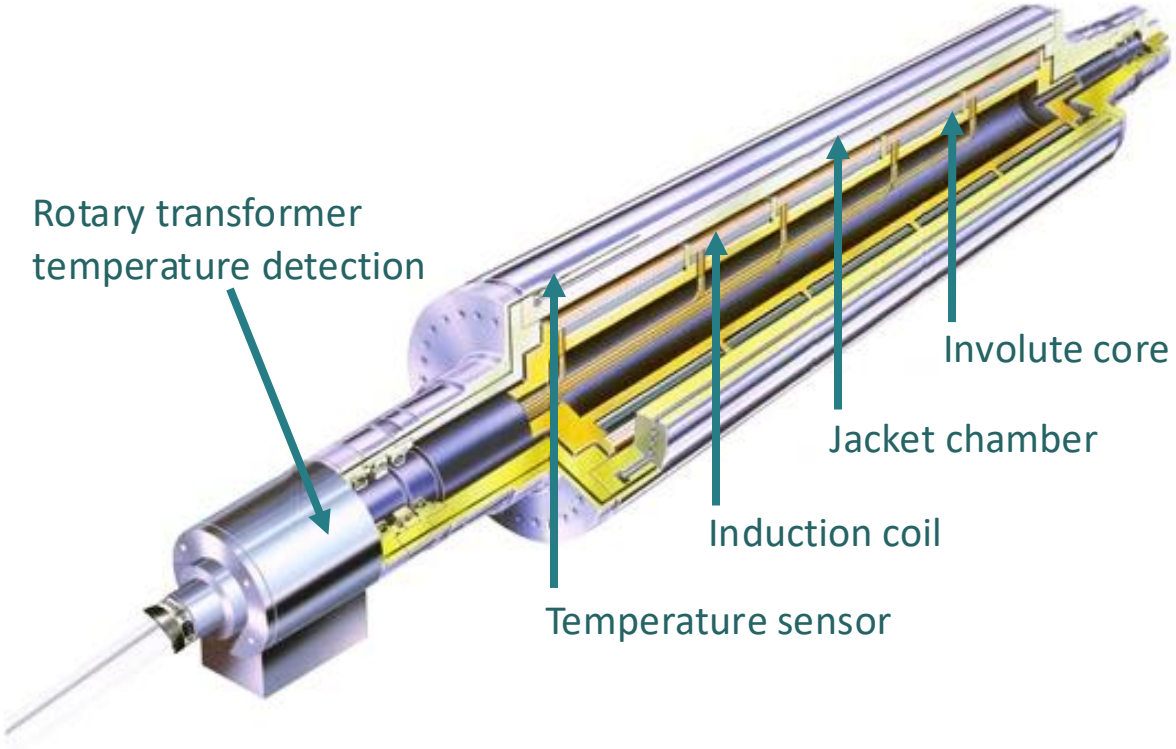
- ✓ Geometrical Dimensions
  - ✓ Diameter, surface width (WOB), journals
- ✓ Media
  - ✓ Type, flow amount, flow speed, pressure, temperature range
- ✓ Roll material for shell, journals and interiour
  - ✓ Stainless steel, carbon steel, 42CrMo4 with hardened surface
- ✓ Tolerances
  - ✓ True running, cylindricity, surface roughness
- ✓ Surface coating
  - ✓ Chrome, teflon, ceramic, rubber, etc…

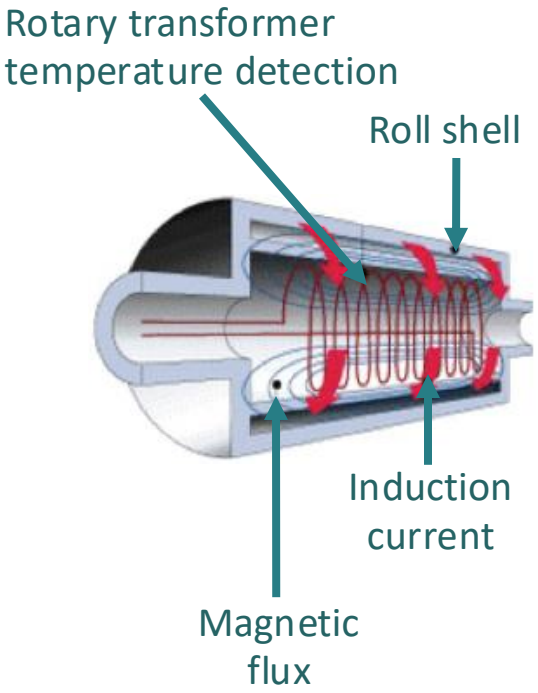
Direct heated roller (IR)



Source: Wumag texroll

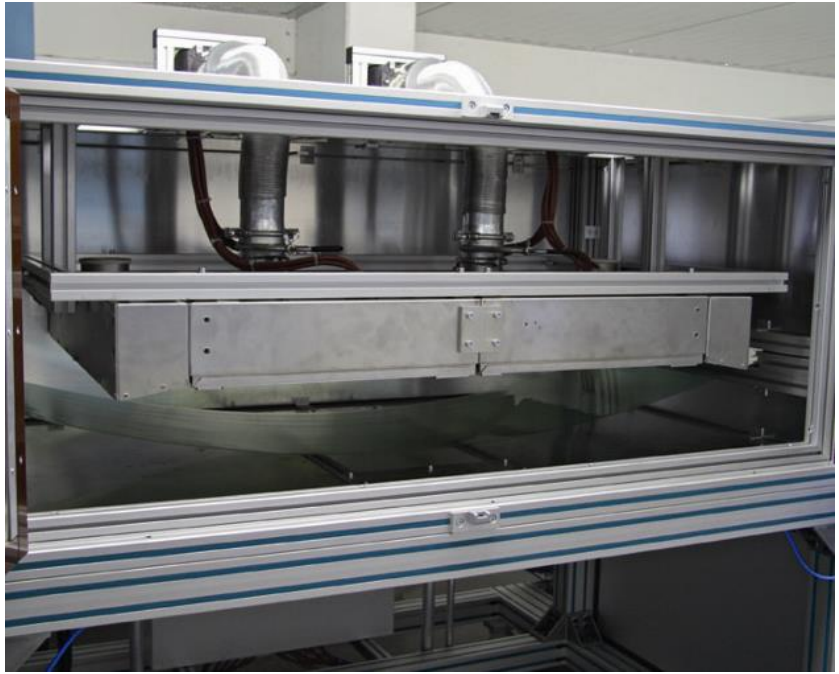
Direct heated roller (IR)





Source: Tokuden

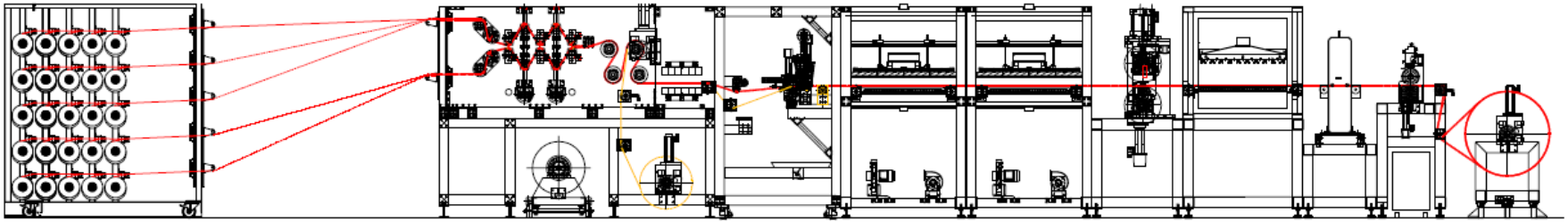
Drying with IR technology



Drying with IR technology

Production line layouts – thermoplastic process

High precise calender systems with IR-sintering dryers



8.

Pilot line layout

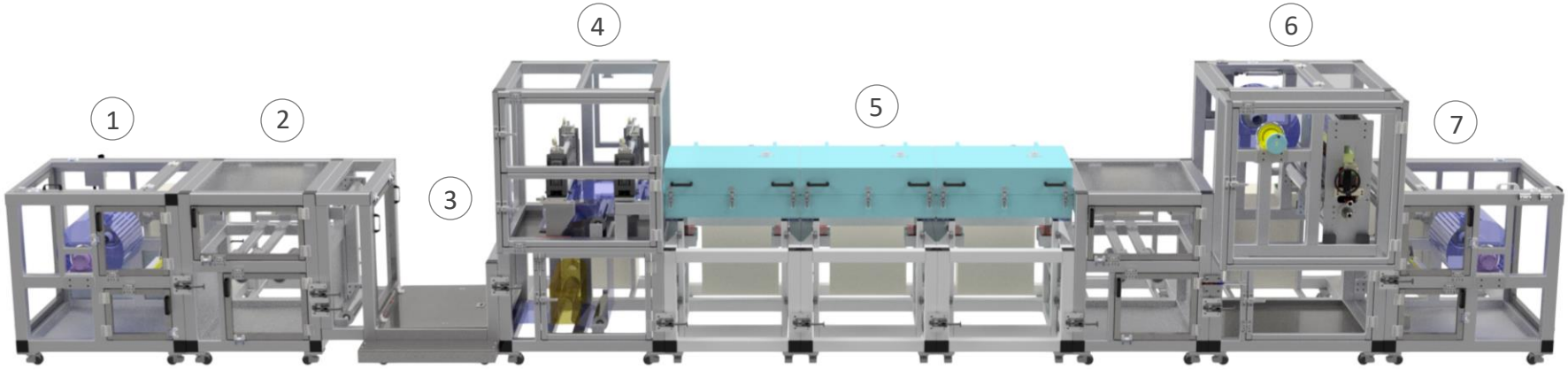
All line layouts in Click&Coat™ design

Here are a few benefits of the Click&Coat™ approach:

- ✓ Over 40 coating, printing and ancillary modules available
- ✓ Award winning C&C design for connecting and aligning modules
- ✓ Easy three – wire eletrical connectors
- ✓ Siemens S7 software solution
- ✓ Fast set up time for new processes or increased through-put
- ✓ Over 40 coating and printing systems for plug in and out
- ✓ Patented C&C design for connecting the modules

Overview of product features & options for Click&Coat™

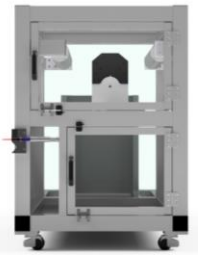
LAYOUT FEATURES (as shown in drawing above)					
1	Unwinder	4	Coating station	7	Laminating and rewinding
2	Edge guiding system	5	Dryer		
3	Podestral	6	Edge guiding system		



Click&Coat™ R2R

Click&Coat™ your own ideas


Winder


Corona


Podestral


Coating


Inkjet


Dryer


Laminator


Rewinder

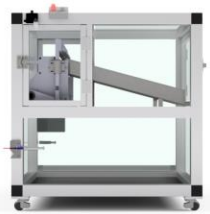

Chemical treatment bath


Inert Coating and laminating

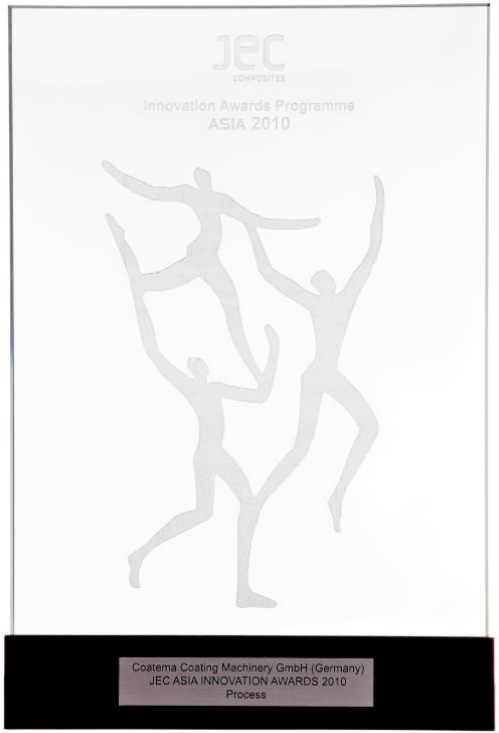

Registration control


Turning device


Lamination


Cutting

Click&Coat™ for Prepreg production



Click&Coat™ for Prepreg production

Click&Coat™ for Prepreg production

Click&Coat™ for Prepreg production

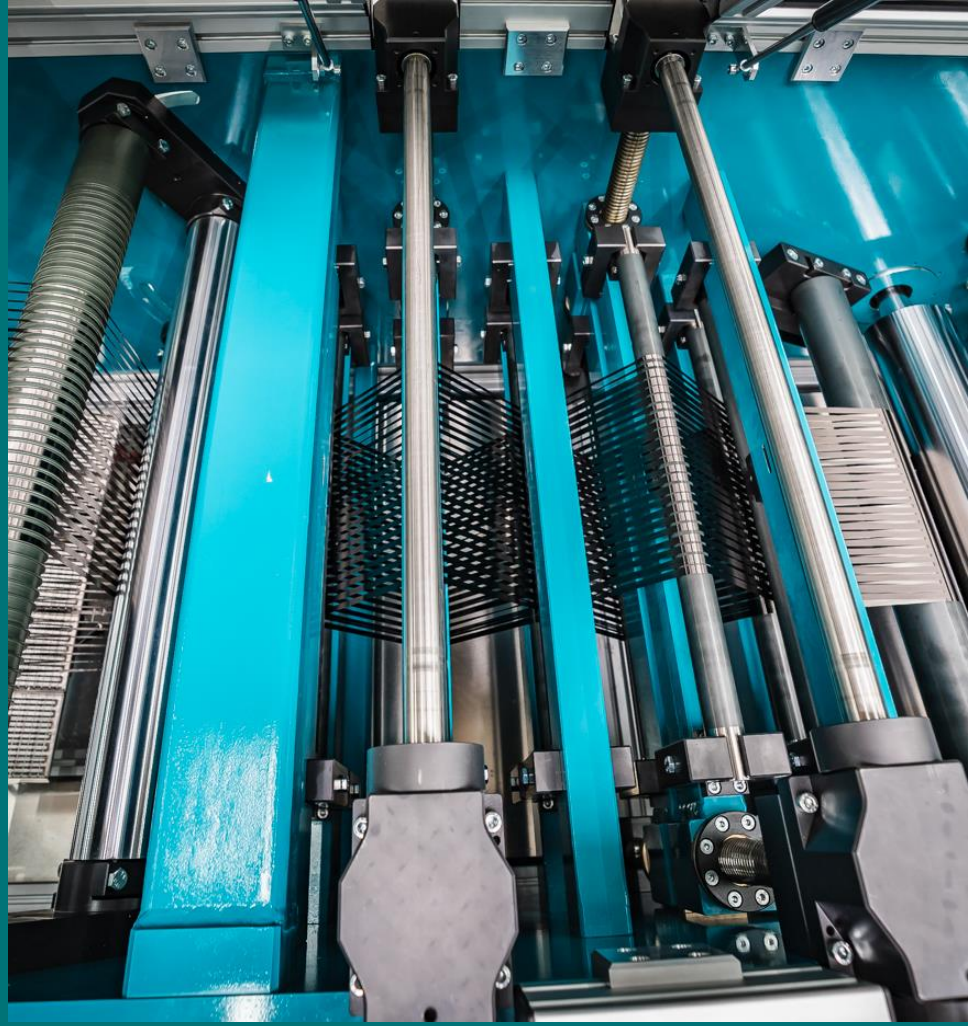
Click&Coat™ for Prepreg production

Pilot line layout

Press Button to
show the video

9.

Proof of concept



Production line layouts – thermoplastic process

Production line layouts – thermoplastic process

Production line layouts – thermoplastic process

Production line layouts – thermoplastic process

Production line layouts – thermoplastic process

10.

Summary

Bridging the gap

Needed for success in prepreg processes:

- ✓ Pilotscale to Production scale product portfolio is key, Coatema is offering this.
- ✓ Reproducible results in every step of scale?
- ✓ Reality check if the approach is really scalable?
- ✓ Is the approach an approach for the real life production environment or is it rocket science?
- ✓ Are economies of scale reachable and when?
- ✓ High temperature thermoplastic prepregs are the future, development needed here.
- ✓ Coatema can demonstrate high temperature thermoplastic applications, ask us.

Do not hesitate to contact us!

Anything missing?

Let us know and we will make it happen!

Our R&D centre is worldwide the most versatile centre for coating, printing and laminating.

Sales department:
sales@coatema.de

Download
broschures & presentations

Coatema

Thank you

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