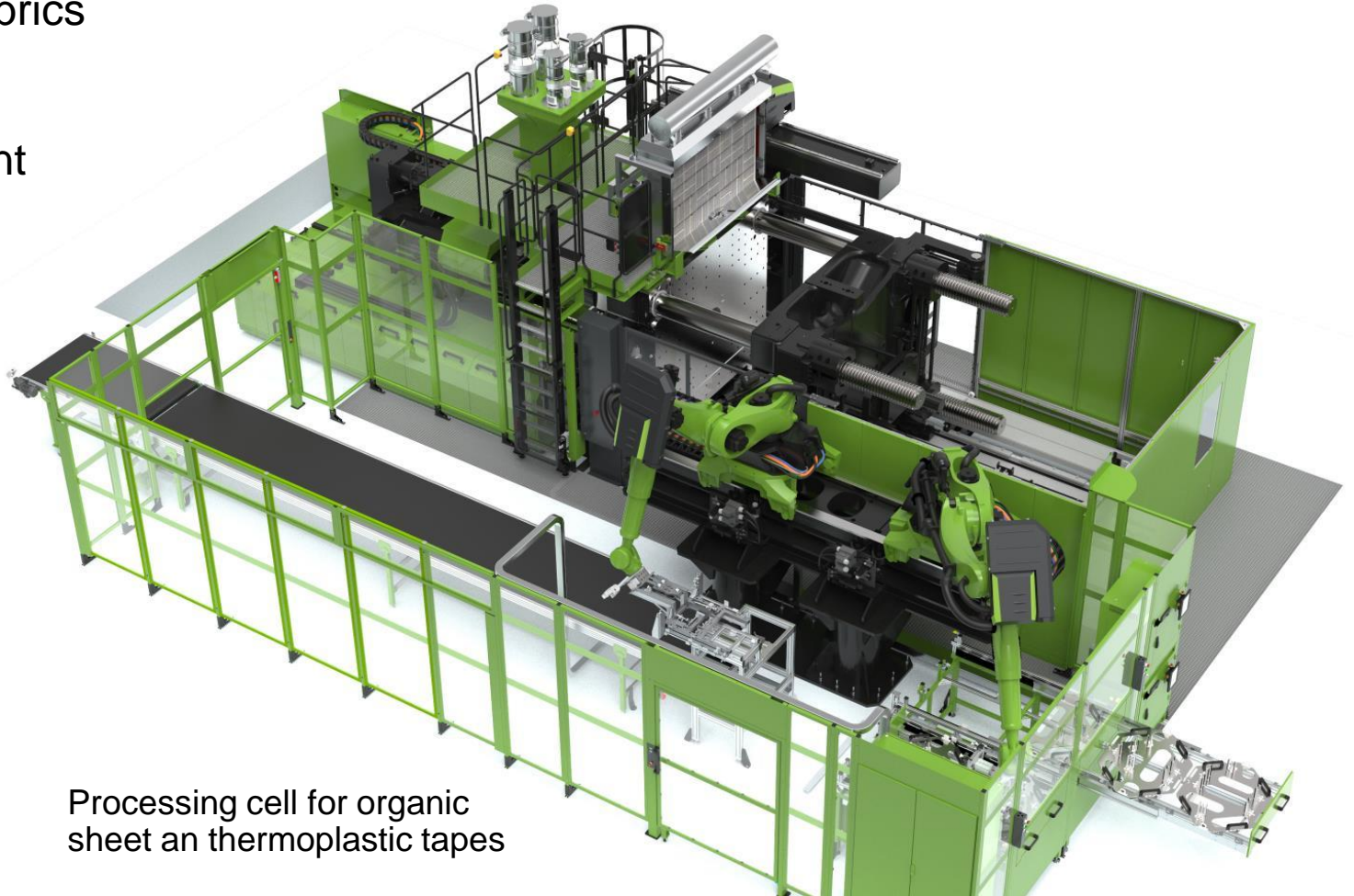


**Thermoplastischer
Leichtbau in Serie**
*Thermoplastic Lightweight
Design in volume Production*

Dr.-Ing. Norbert Müller
Center for Lightweight Composite Technologies

Content

- Thermoplastic tapes based on woven fabrics (organic sheet)
- Tapes with continuous fiber reinforcement and thermoplastic matrix
- Pick-&-place approach for the stacking; stacking unit
- Consolidation with heating-&-cooling; consolidation unit
- Single-step and multi-step approach for the shaping and functionalization
- Summary



Processing cell for organic sheet and thermoplastic tapes

Trends in Composites for Automotive Applications

Flashlights



Technologies and Parts

- Organic sheet and HP-RTM in series production
- SMC und Carbon-SMC
- Foam injection molding widely used
- Specific applications in focus:
leaf springs, roofs, door modules ..

Manufacturing Technology

- Fully automated productions cells
- Multi step processes

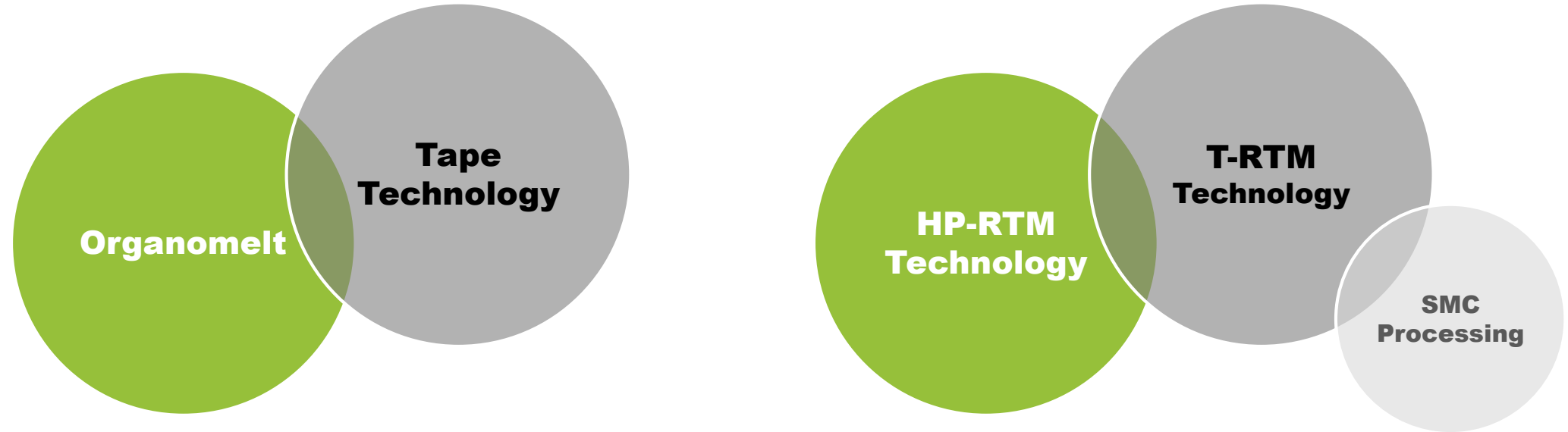
Materials / Semi finished Goods

- Pultruded profiles
- New flat composites materials, Cross-Ply
- Thermoplastic UD-Tapes

Driving Boundaries

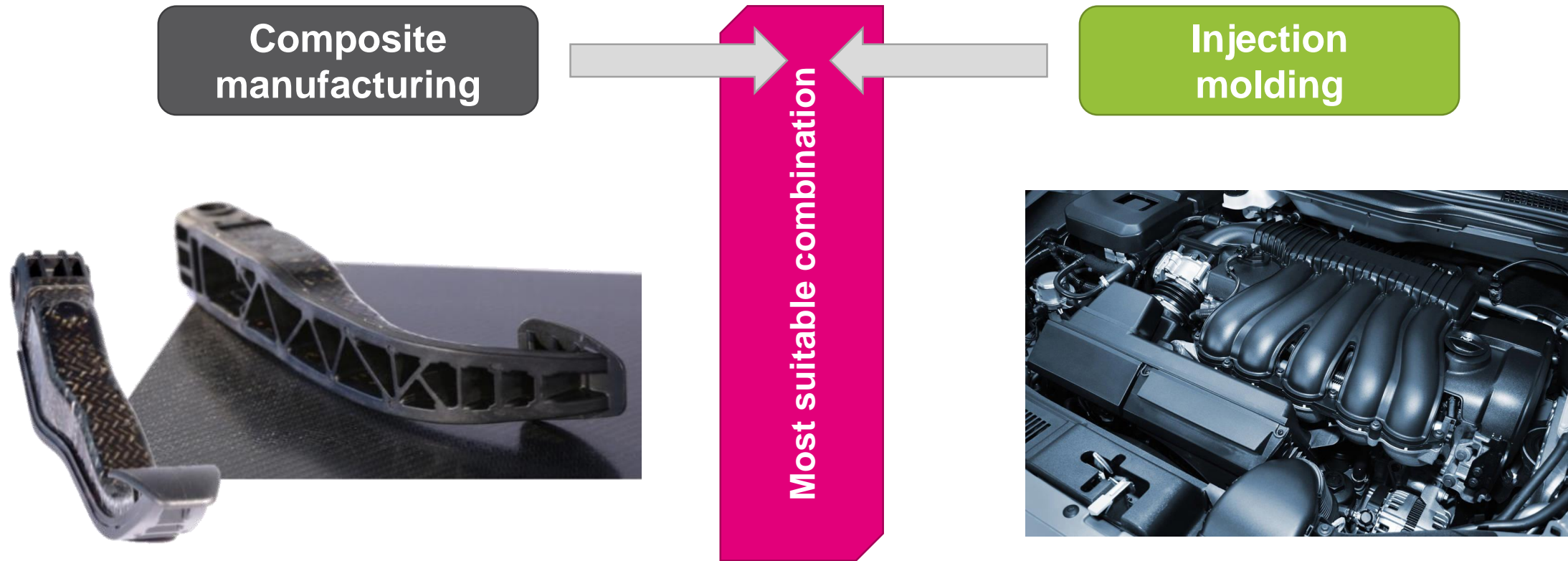
- Electric Vehicles
- Circular Economy - Recyclability

Center for Lightweight Composite Technologies

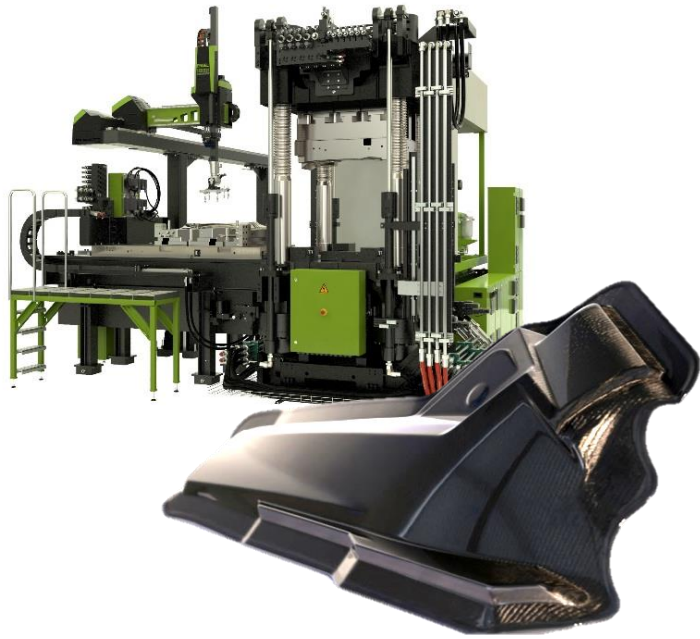


Can Composites enable new large-scale Substitutions?

Bringing injection molding and composite manufacturing together



Examples – Systems and Solutions for ...



**Composites based on
Curing Resins (Thermosets)**



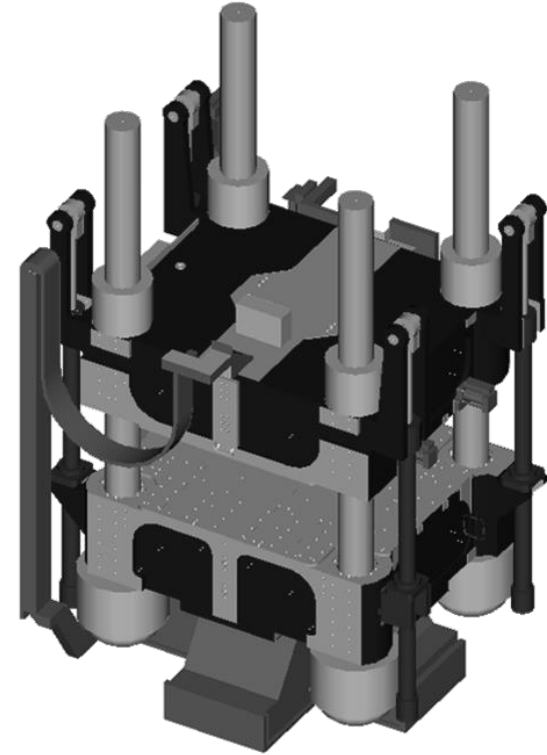
**Composites based on Heating,
Melting and Cooling (Thermoplastics)**

ENGEL v-duo

Technology for Composite Presses

Press for
HP-RTM (eg.)
with vertical
closing direction

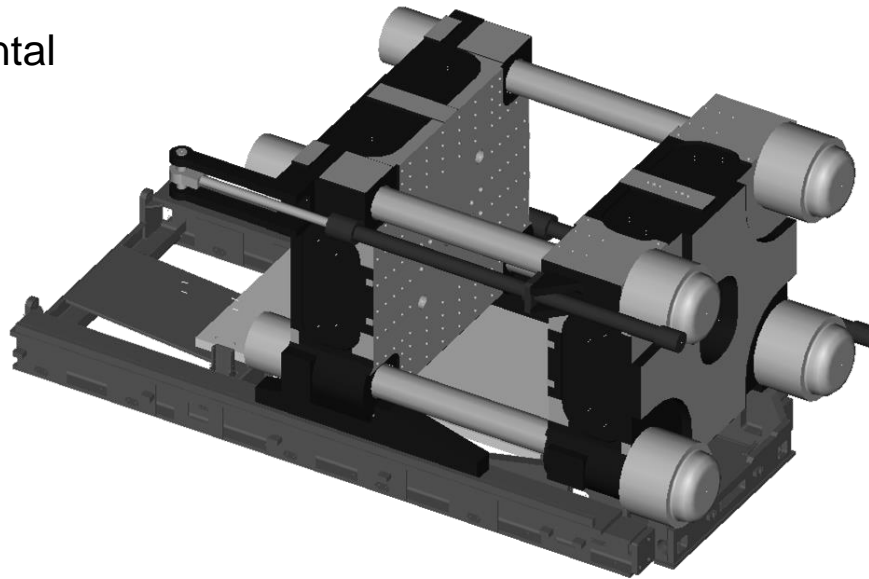
ENGEL v-duo



Tonnage 400 – 3.600 tons

Clamp unit of an
injection molding
machine with horizontal
closing direction

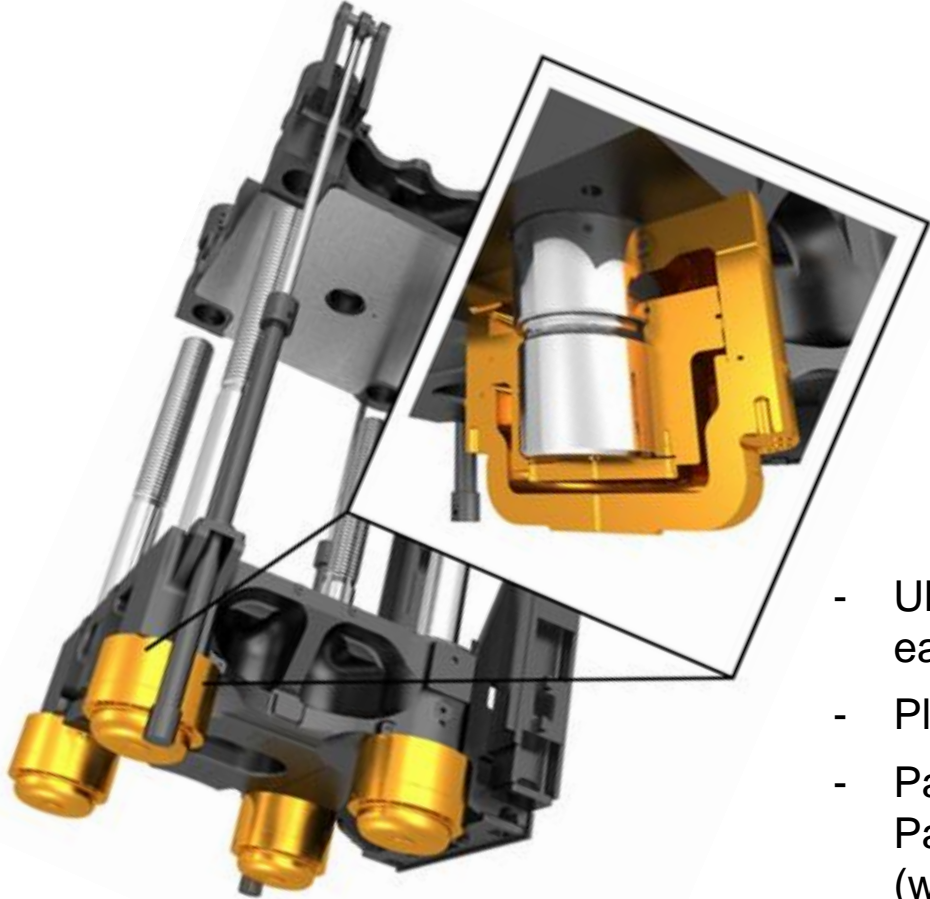
ENGEL duo



Tonnage 350 – 5.500 tons

ENGEL v-duo

Cushion Pad and Platen Parallelism Control



- Ultrasonic sensor on each tie bar
- Platen parallelism 0.2 mm
- Parallelism on the Part 0.05 mm (with parallelism control)
- Active correction of part wall thickness
- Coining and precision opening



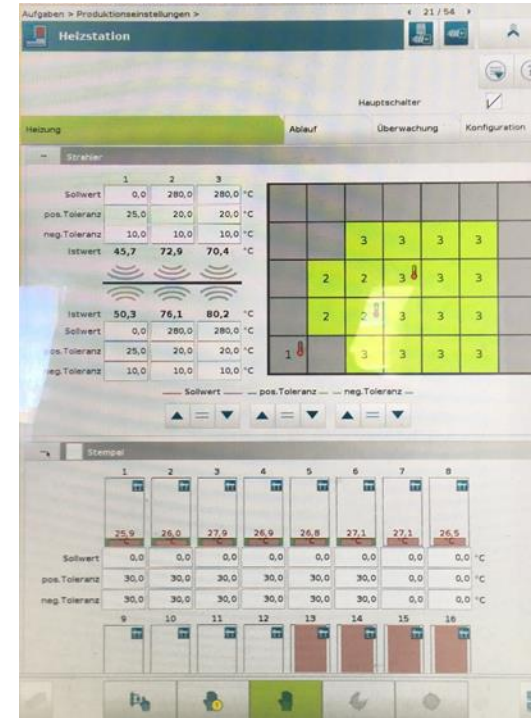


Thermoplastic based Composite Technologies

Woven Fabric in Thermoplastic Matix

Organomelt

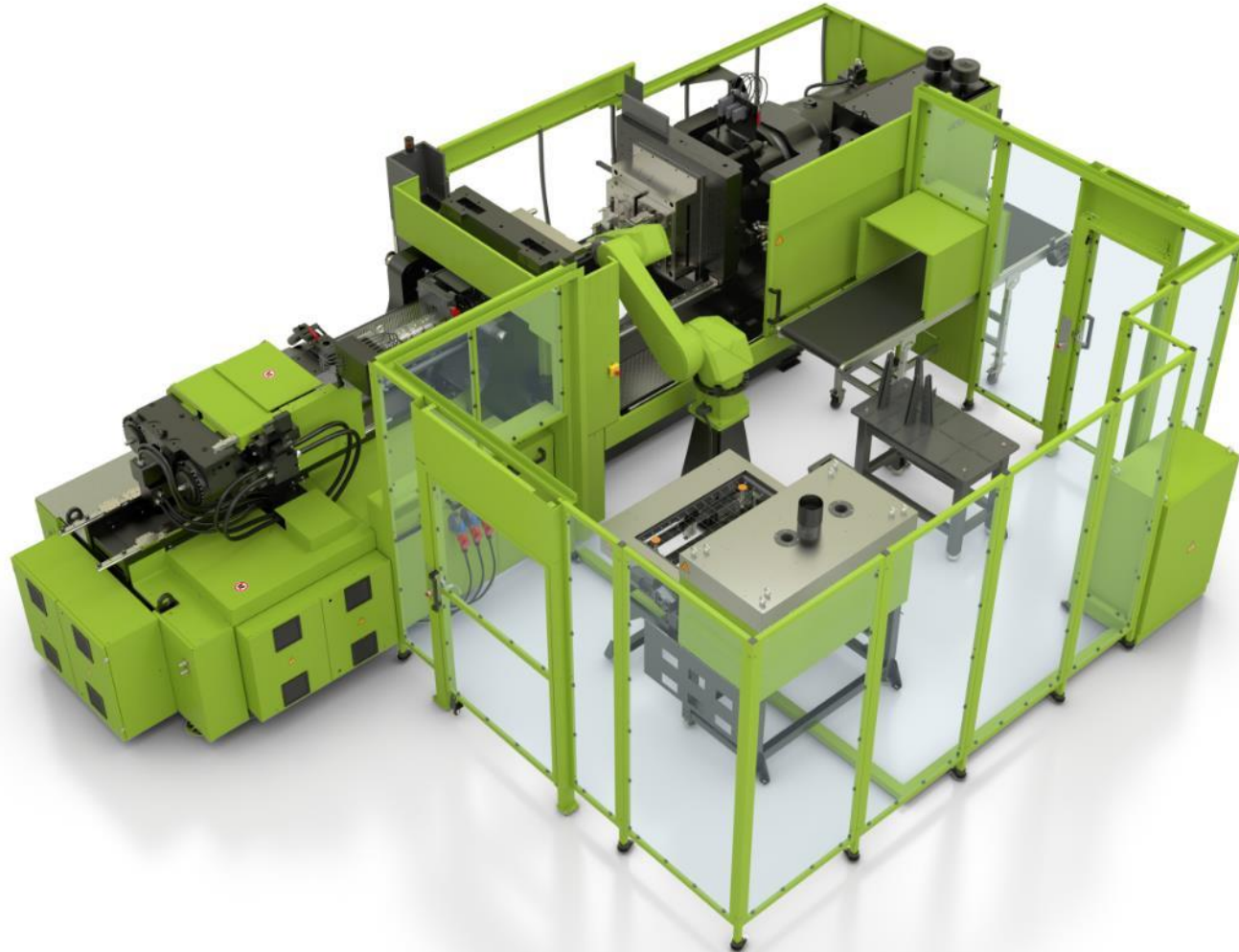
Established Technology for Organo Sheet and Cross-Ply Materials



- Fully automated handling of blanks and parts
- Precise regulation of the infrared heating process
- Control of IR-heating, handling, and molding with ENGEL CC300

Processing of Organic Sheets and Tape Blanks

Employing a horizontal Clamping Unit



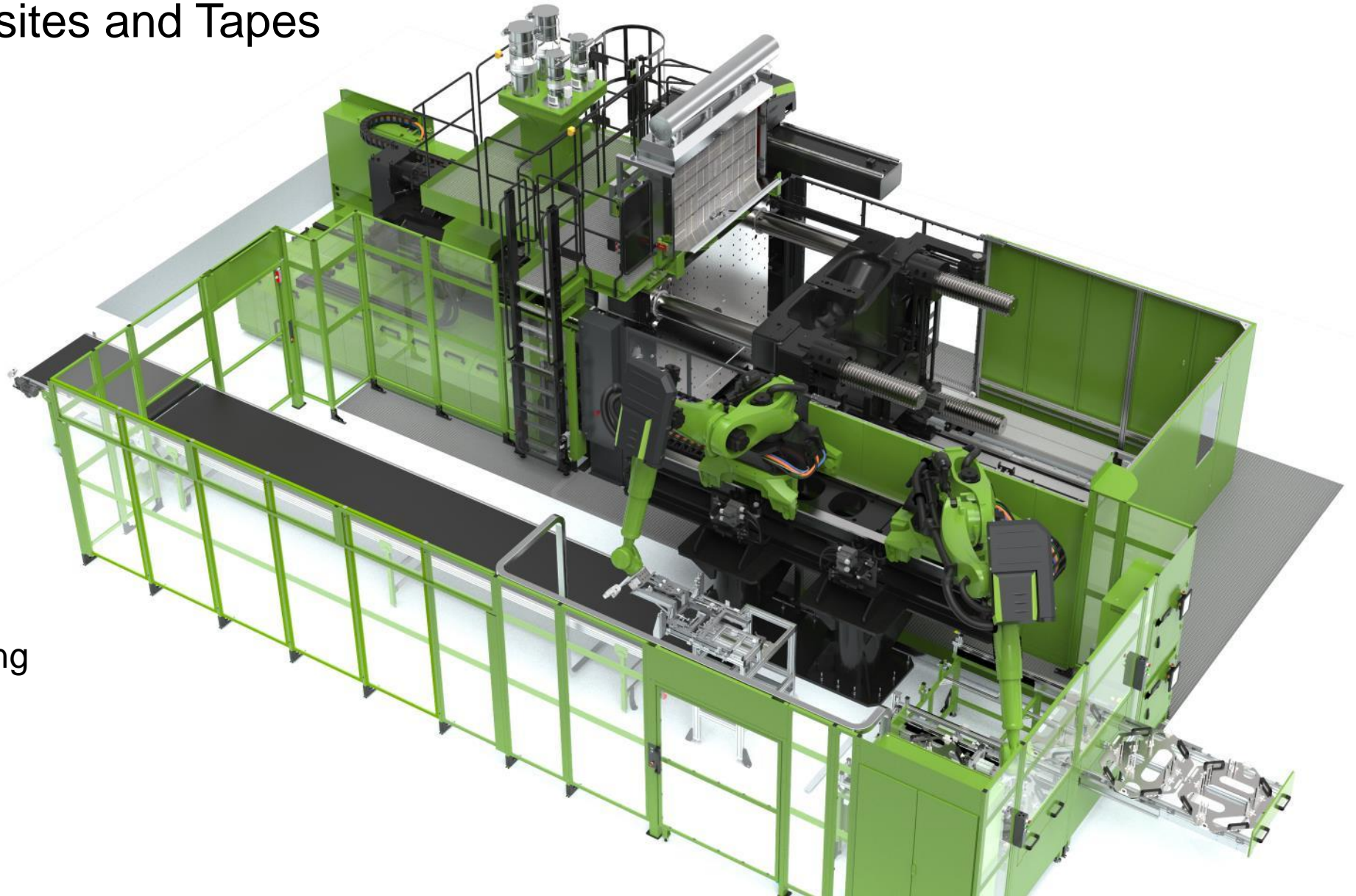
Articulated Robot (Hot Handling)

- Placement of the organic sheet or the tape blank in the infrared oven
- Insertion of the heated material in the mold (hot handling)
- Removal of the finished part

Processing Technology for large scale Production

Thermopl. Composites and Tapes

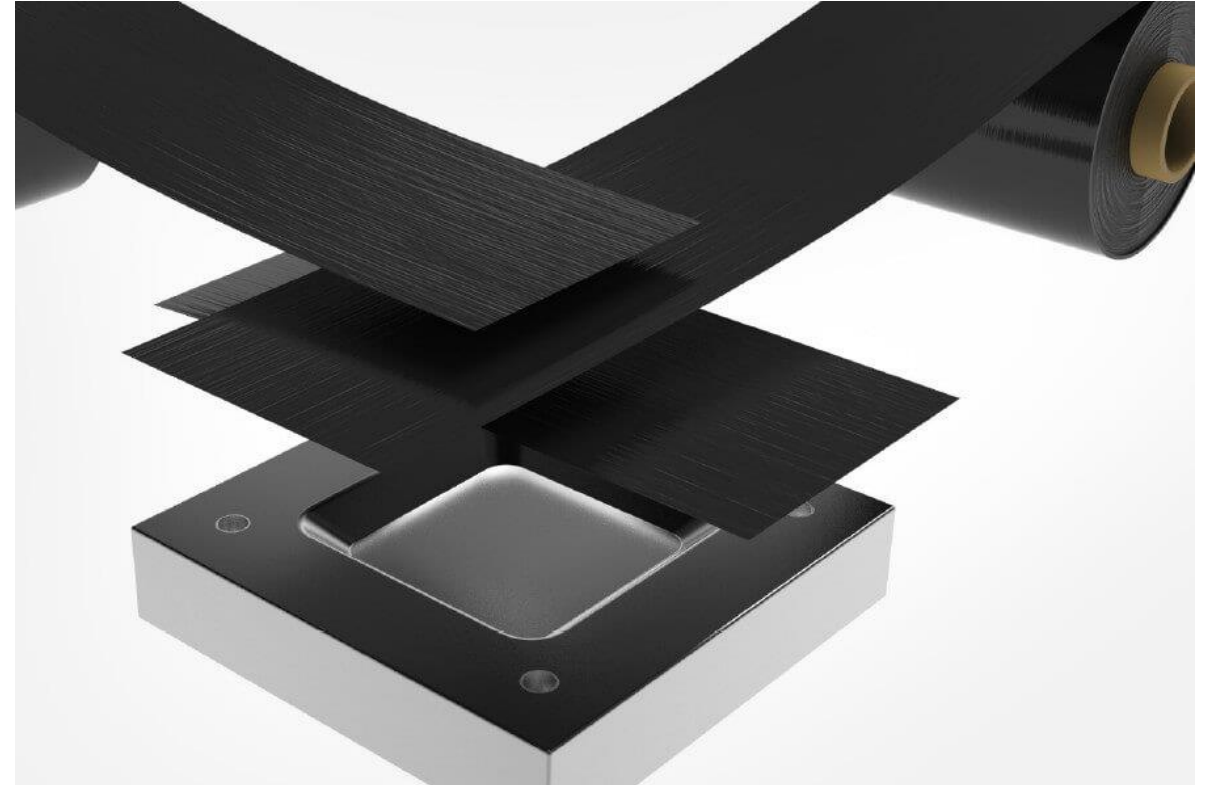
- Rapid one-sided heating of thin composite materials
- Fast handling between IR oven and mold
- Shaping of the composite and molding of any functional elements in one shot



From woven Fabric to Tape-based Composites



Tablet cover with woven fabric organic sheet, decorative film layer, and injection molded outer edges



www.cfrt.covestro.com – CF-Tape

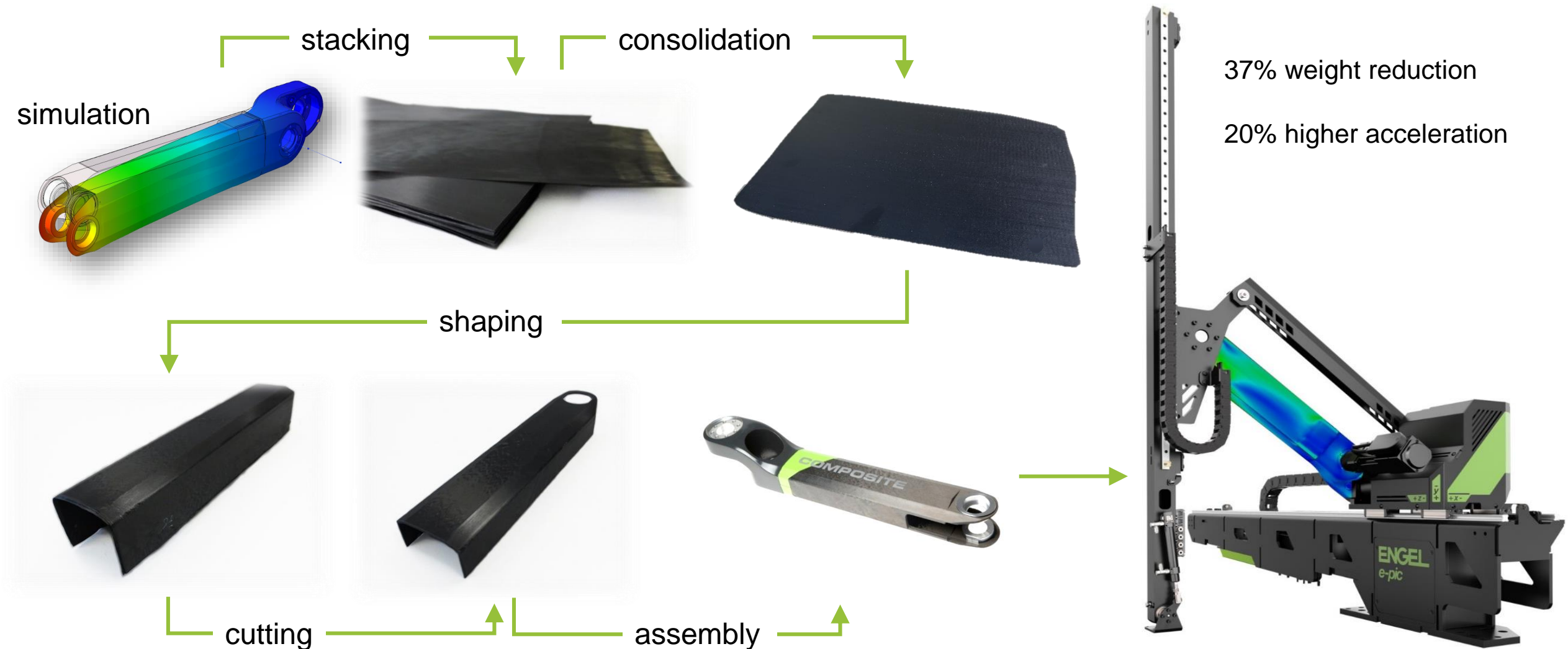


Processing of Tapes with unidirectional Fibers

Load optimized Composite Structures

Components from Thermoplastic Tapes

Robot Lever



Tape Processing

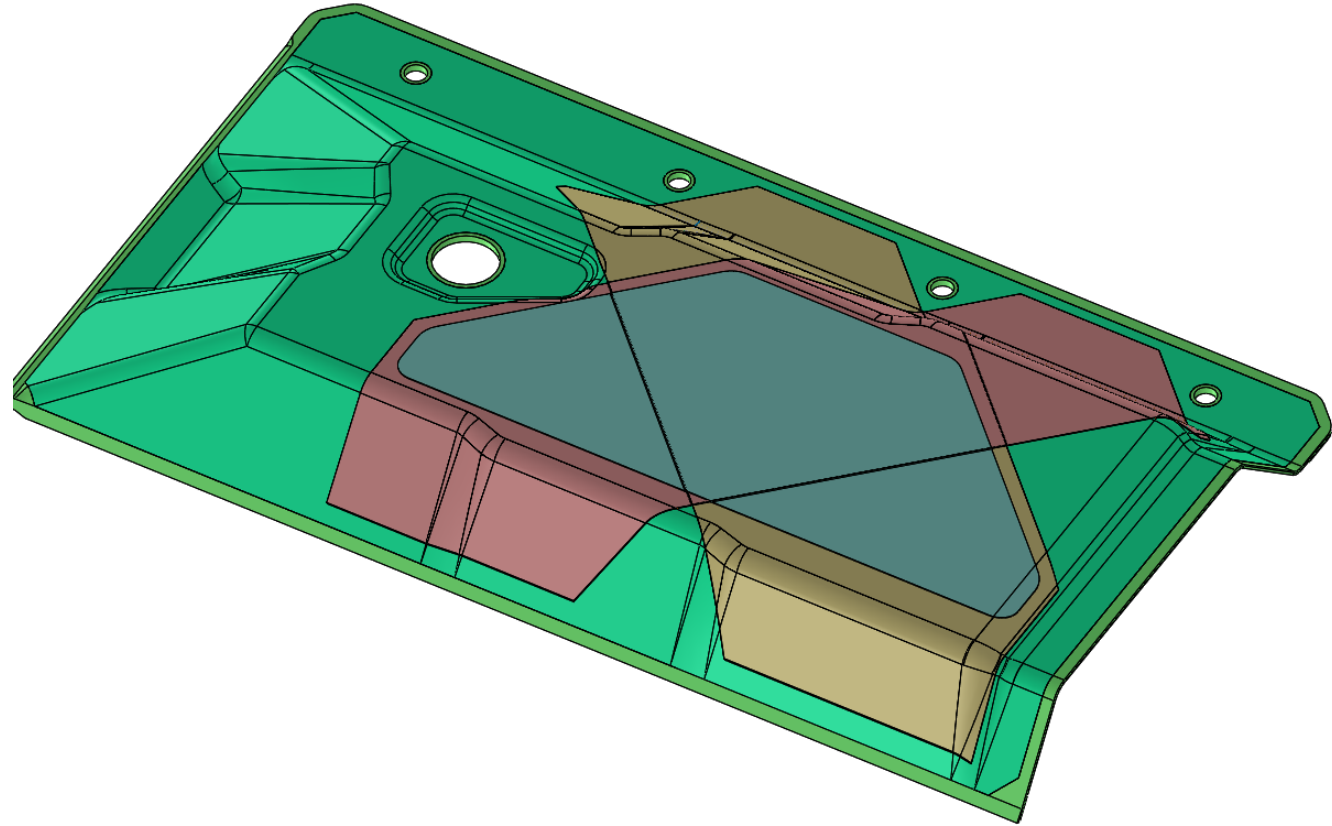
Modules of a Standard Manufacturing Sequence



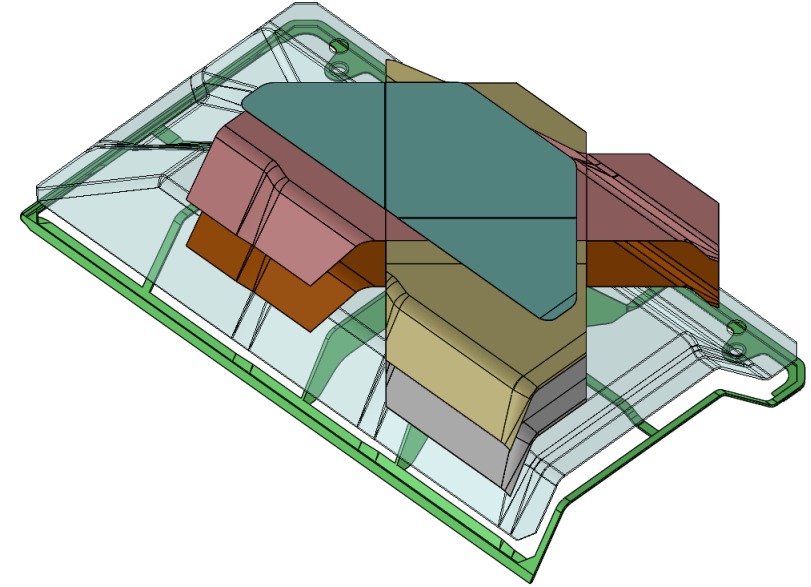
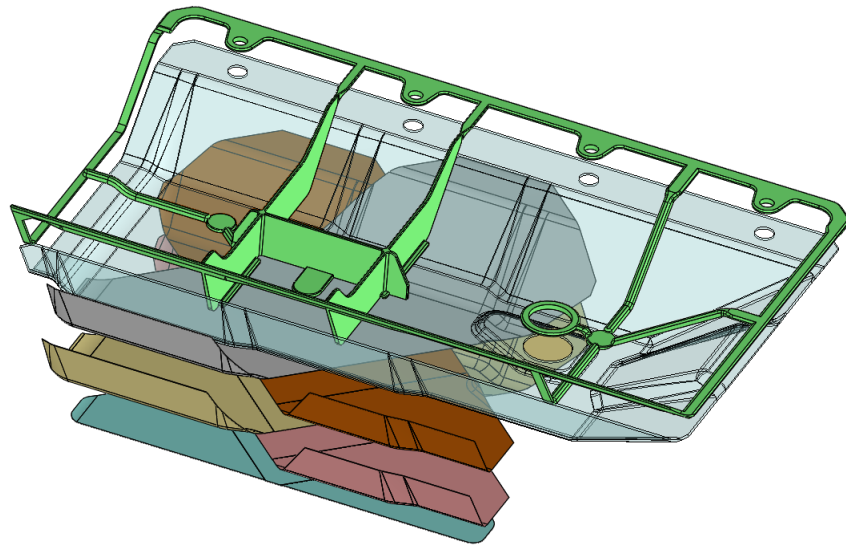
roll	cutout	stack	blank	heated blank	composite part
					

Pick-&-Place Approach for Tape Processing

- Net-shape stacking
- Flat stack
- Position and gap control
- Materials mix
- No specific tape width



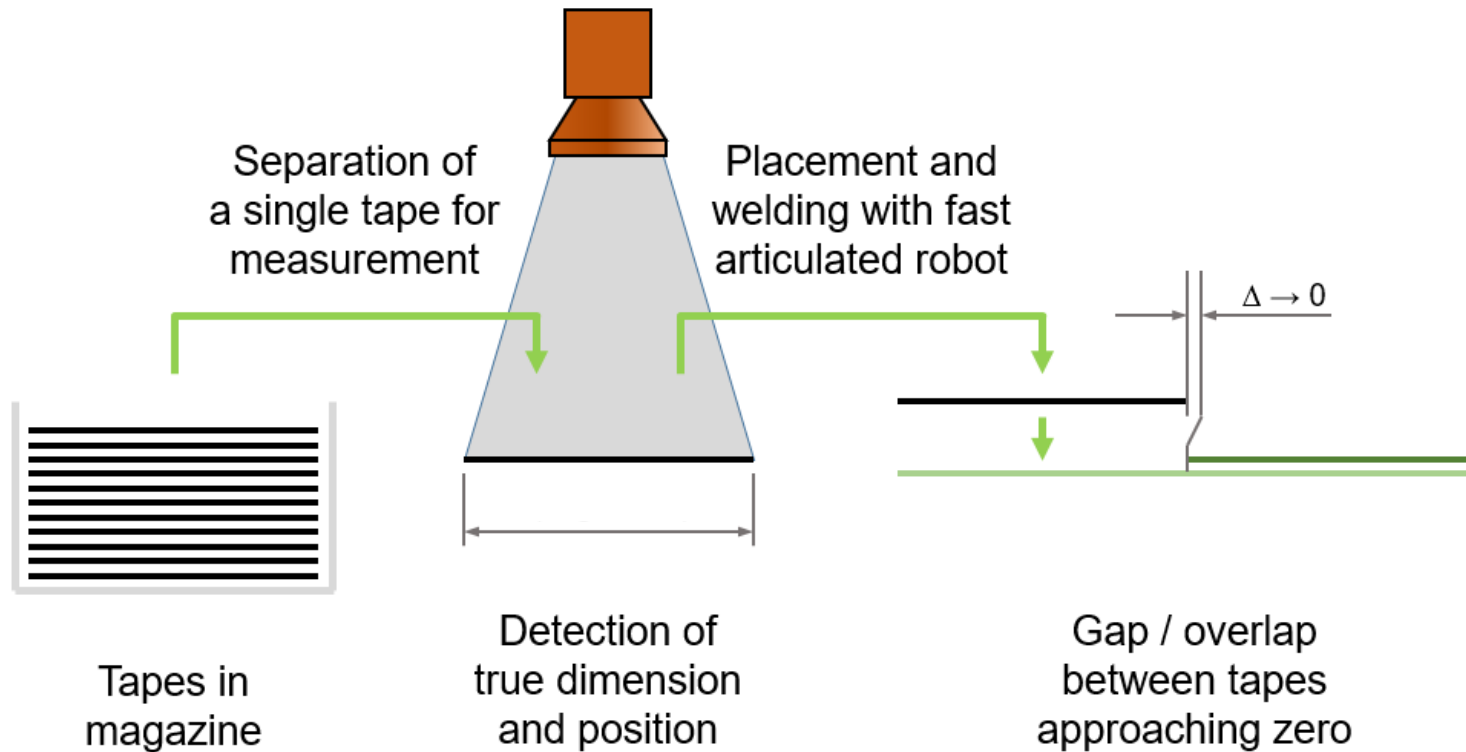
Pick-&-Place Approach



Net-shape tape stacks bevorhand of consolidation

Position an Gap Control

Efficient and precise Pick-&-Place Technology



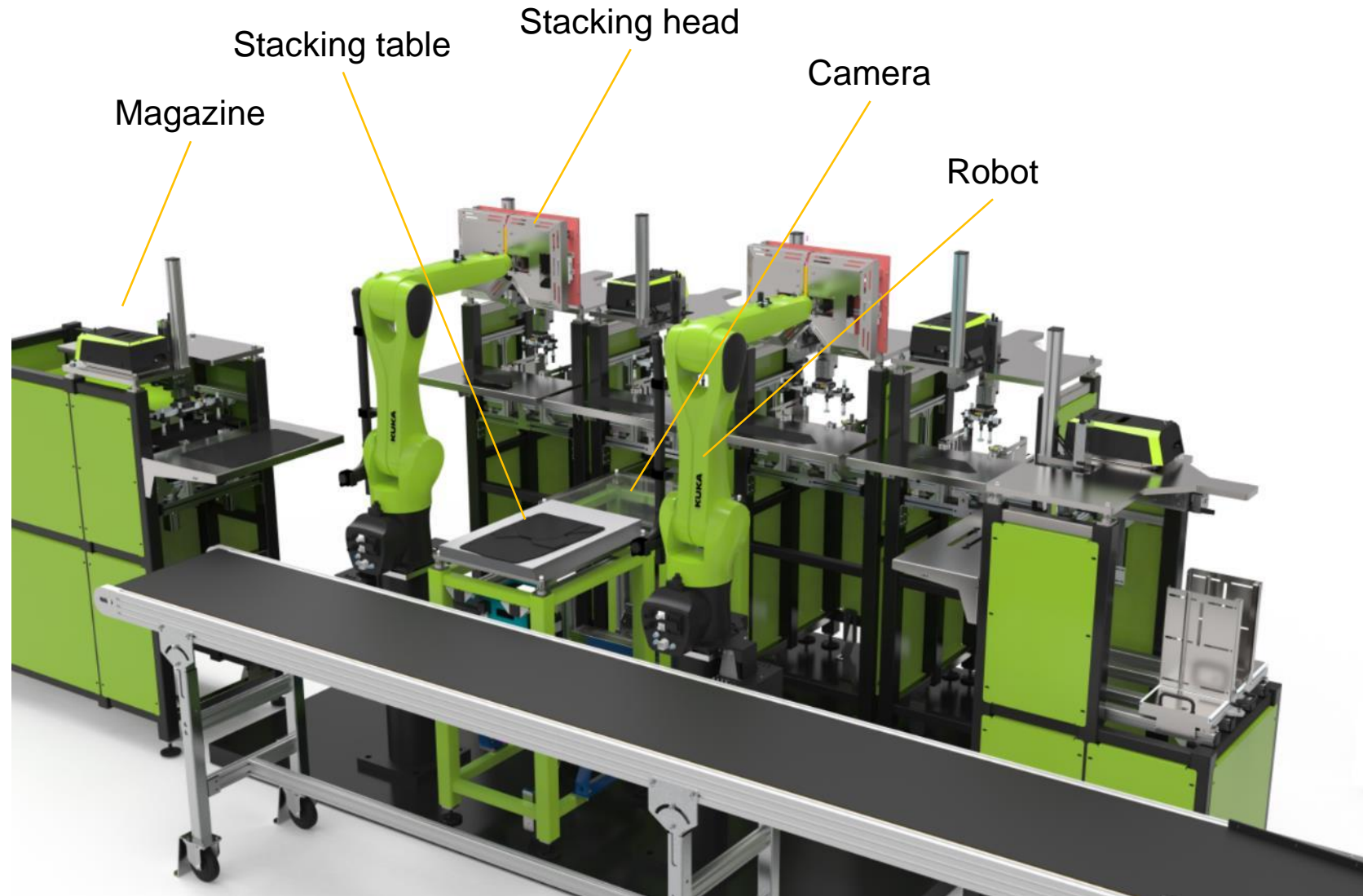
- High stacking rate
- High stacking precision



Utilization of an optical measurement system

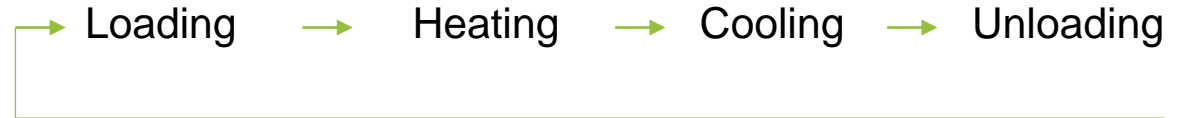
Tape Stacking Unit

- Pick-&-place approach
- Net-shape stacking
- Optical measuring device
- Correction of position and angular orientation
- Fixation with heated pins



Consolidation Unit – in Cooperation with FILL

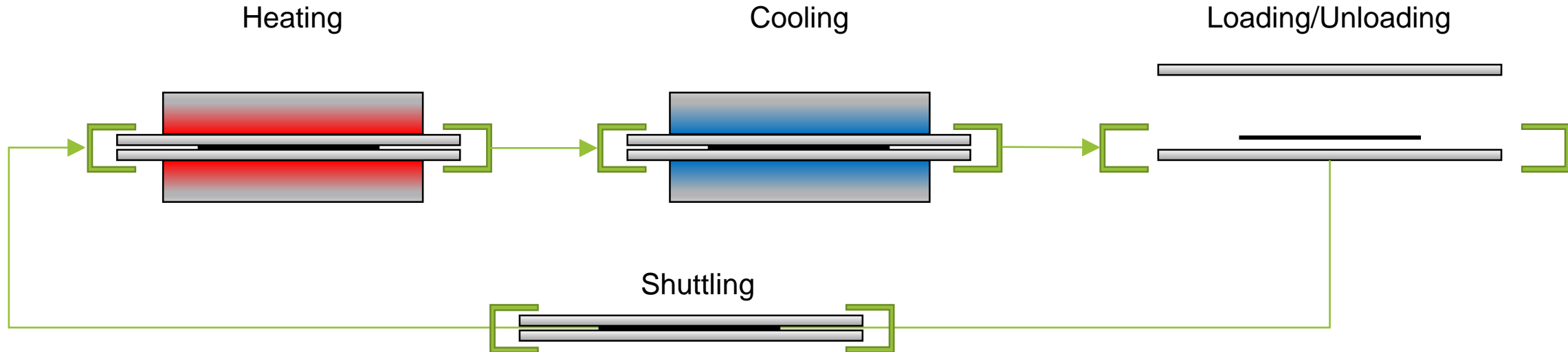
- Consolidation (heating and cooling) between thin steel platens exposing the blank's outer shape
- Separate stations for loading/unloading, heating and cooling
- Equipment for manufacturing of a finished blank per one minute
- Net-shape consolidation
- Different thickness area possible



ENGEL Tape Processing Technology

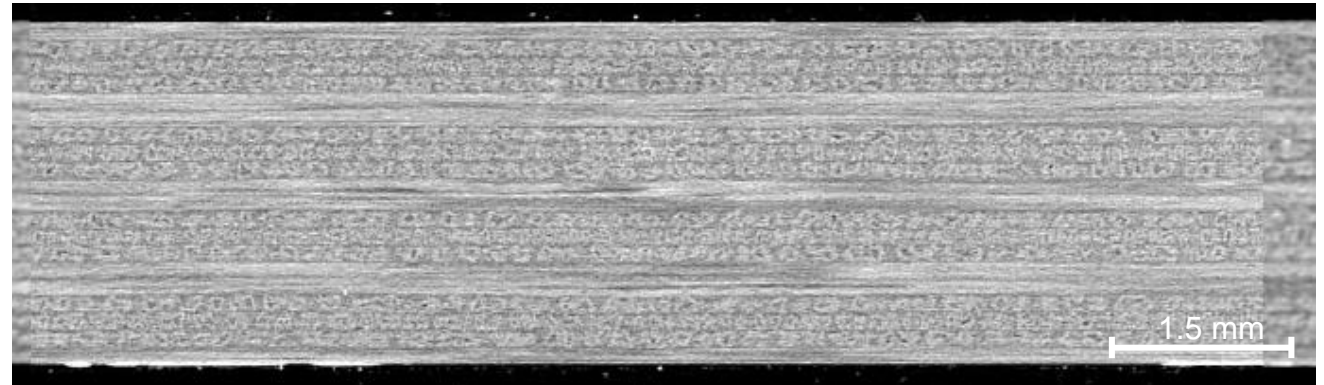
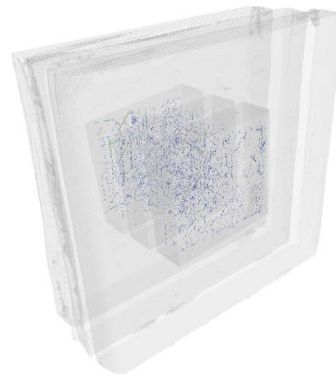
Consolidation Unit

Working principle



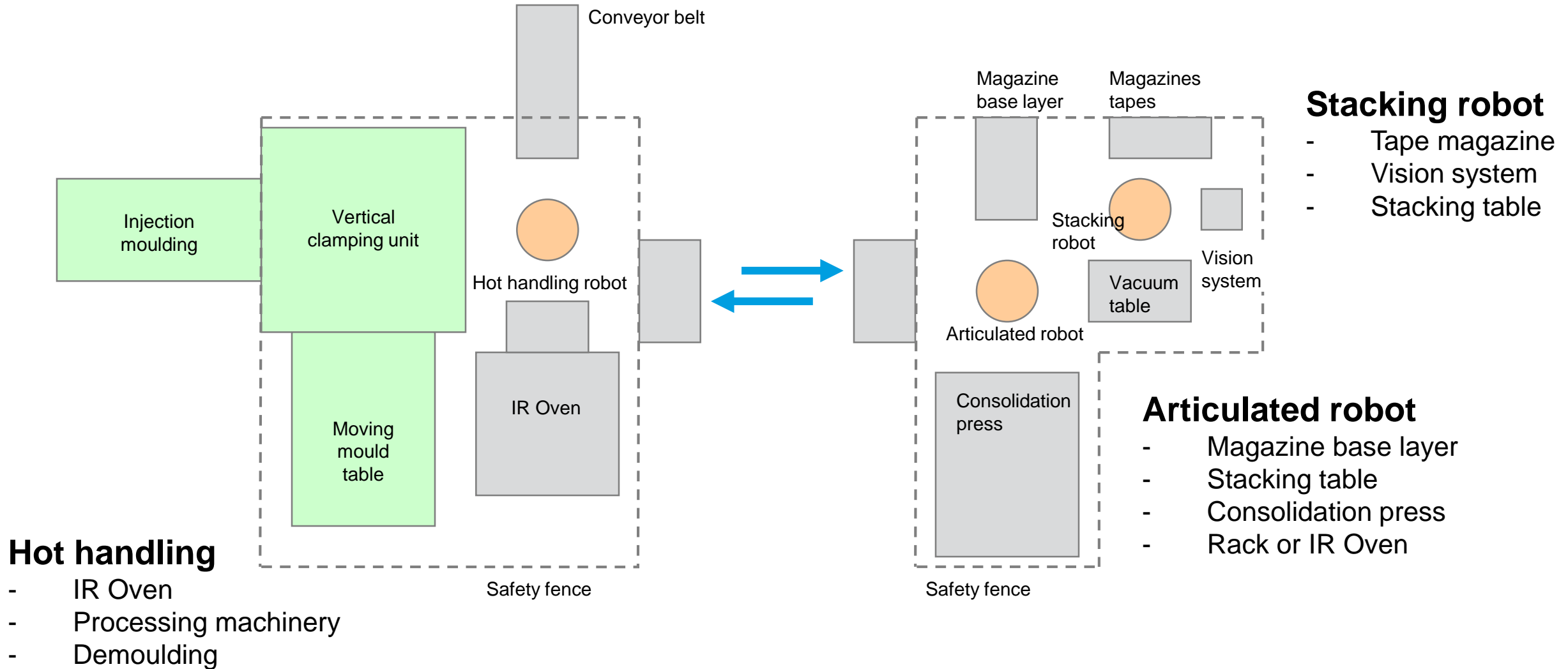
Consolidation quality

porosity analysis with CT
→ Porosity $\ll 1\%$



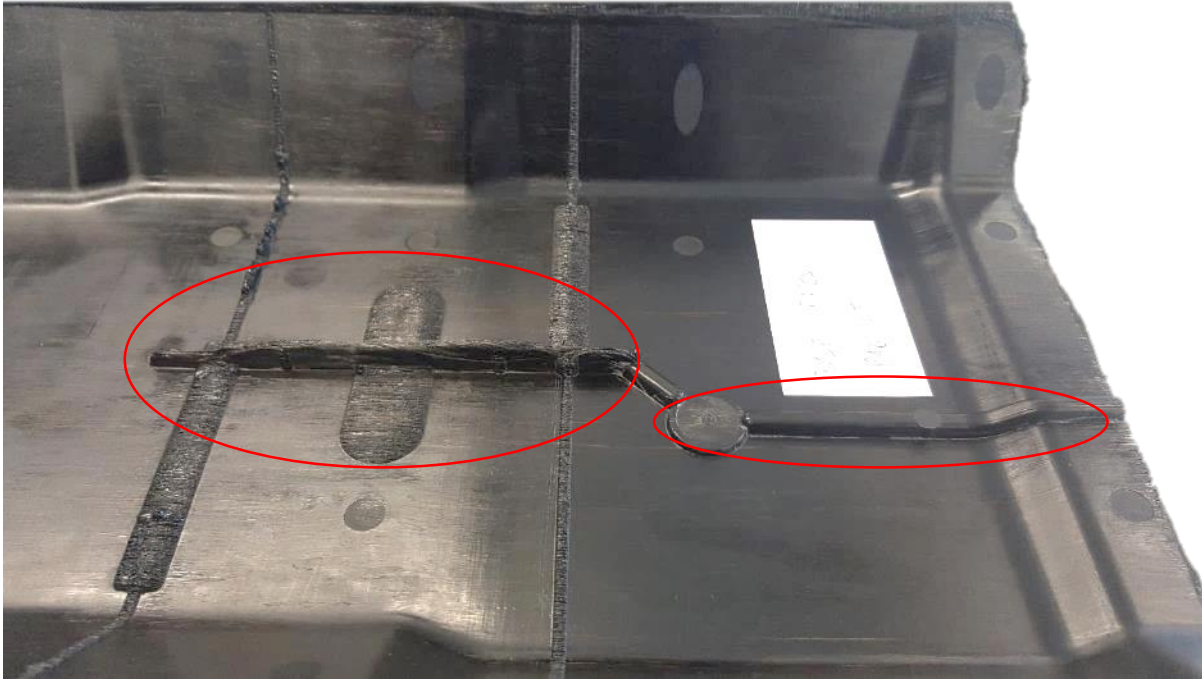
Tape Processing

From Tape to Thermoplastic Composite Part



One-step vs. Two-step

Possible Issues with Tape Processing



- Fibers and matrix might be pushed in flow channels during shaping of the blank
 - Reduction of flow channel crosssection
 - Complete filling of the flow channels
- Incomplete filling during injection

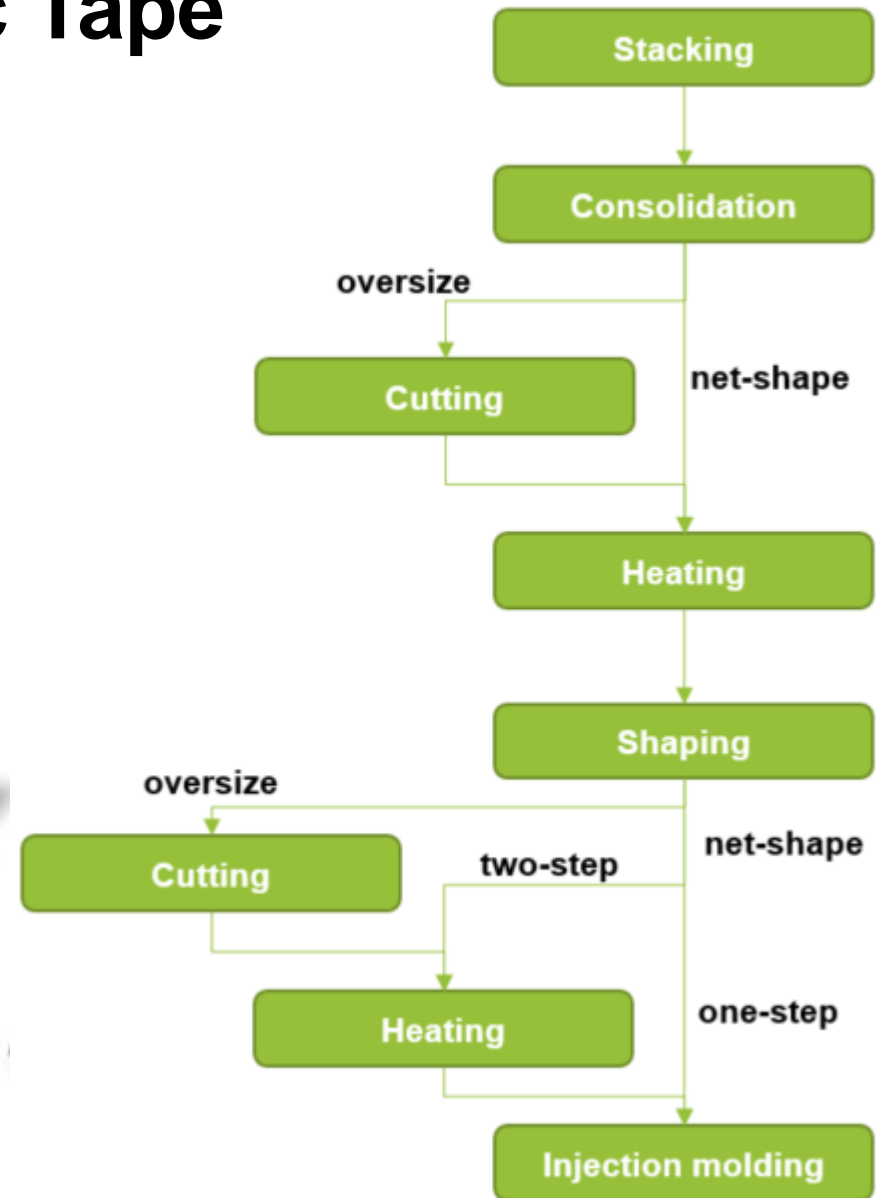
Processing Routes for thermoplastic Tape

Aspects

- Surface appearance
- Degree of draping and shaping
- Precision of outer contour
- Demands on fiber orientation
- Definite transition from composite fraction to injection molding fraction



Component from organic sheet
cut after shaping



Automotive Composite Applications

Medium to large volume Production

- Door modules
- Rear walls
- Center tunnel
- Seat pan
- Instrument panel carrier
- Engine hood
- Trunk cover
- Trunk door
- Composite roof
- Roof beam
- Brake pedal
- B-pillar inner
- ..

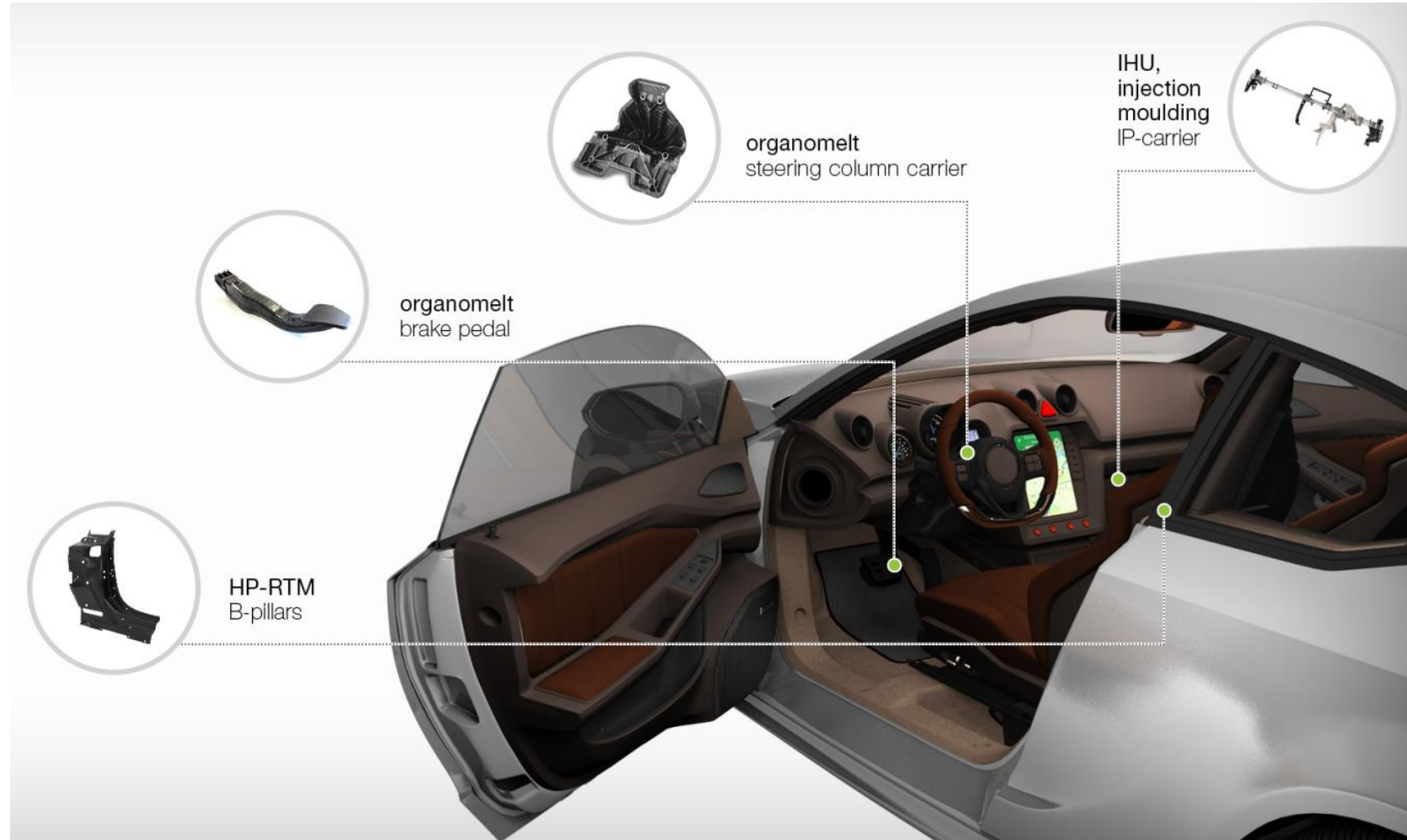


Test geometry for organic sheet components and tape-based components

Automotive Composite Applications

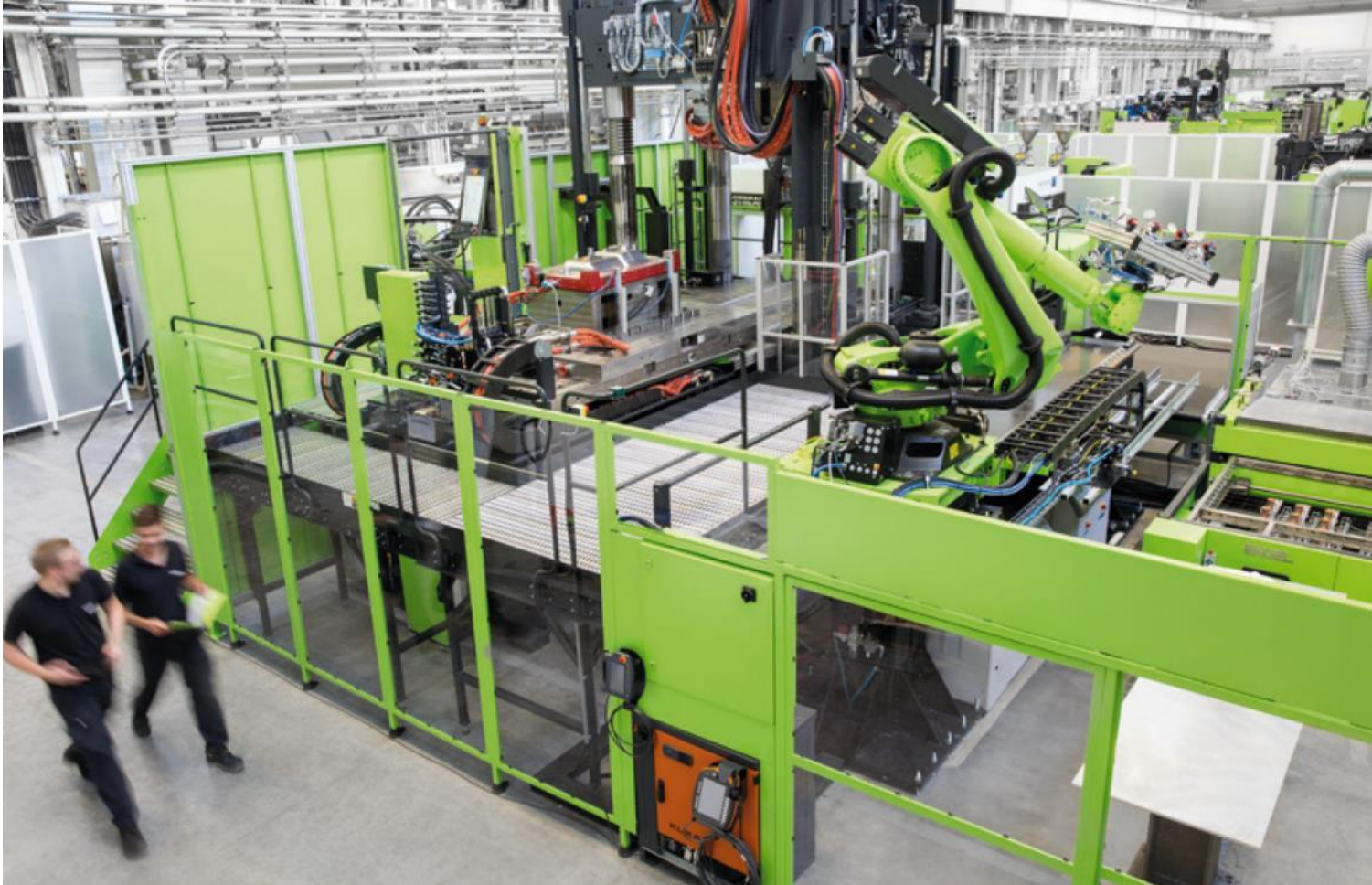
Medium to large volume Production

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- ..



Laboratory Equipment

Center for Lightweight Composite Technologies - Linz



Laboratory machine, ENGEL v-duo 3550/1700

in situ reactive unit

processing machine for caprolactam

ENGEL v-duo 3550/1700

Clamping force 17,000 kN

max. clamping surface 1,750 x 2,170 mm

incl. injection unit

incl. articulated-arm robot (7 axes)

ENGEL v-duo 1560/700

Clamping force 7,000 kN

max. clamping surface 1,000 x 1,440 mm

incl. injection unit

incl. articulated-arm robot (6 axes)

Summary

- Utilization of thermoplastic tapes manufacturing for load optimized composite parts
- Net-shape stacking
 - Minimization of scrap rate
 - No cutting operation after consolidation
- Reasonable Limitation of stacking operation
 - Stacking and consolidation in the cycle time of the injection molding machine
- Consideration of multi-step approach for shaping and functionalization



Tape stacking unit – laboratory setup

Thank you!

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Center for Lightweight Composite Technologies

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