



FAPS

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Institute for Factory Automation
and Production Systems

Friedrich-Alexander-Universität Erlangen-Nürnberg



FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

Presentation of the Institute FAPS

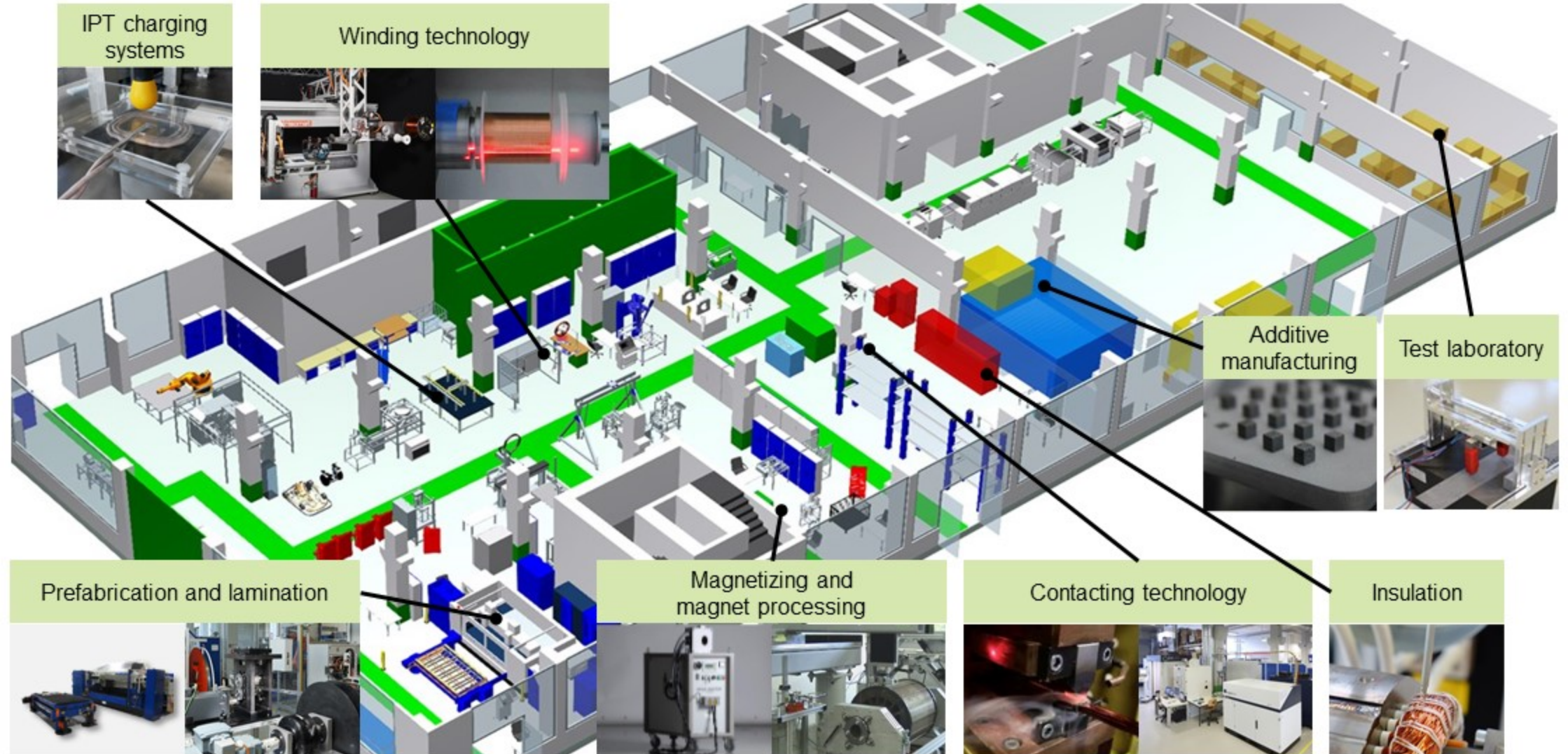
Research Group: Electromechanical Engineering



E|Drive-Center

Bayerisches Technologiezentrum
für elektrische Antriebstechnik

The laboratory of the E|Drive-Center in Nuremberg covers various processes for the production of electric drives.



The E|Drive-Center supports the industry with projects, seminars and patents.

Industry and research projects



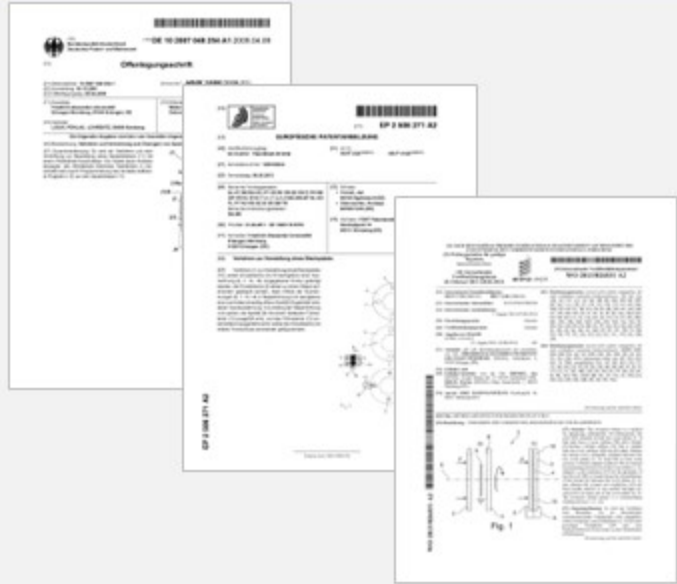
- A wide range of direct industrial projects
- Publicly funded research projects
- Successful research applications in the context of the electric mobility proposals of the federal government

Expert seminars, lectures, technology presentations



- April 2019: 8th Expert Seminar in Electromechanical Engineering: Production of Electric Drives
- December 3th – 4th, 2019: 9th International IEEE Electric Drives Production Conference (E|DPC)

Inventions and patents



- 7 invention disclosures in the range of electromechanical engineering and inductive charging technology
- 2 patent workshops in cooperation with the "Bayerische Patentallianz"

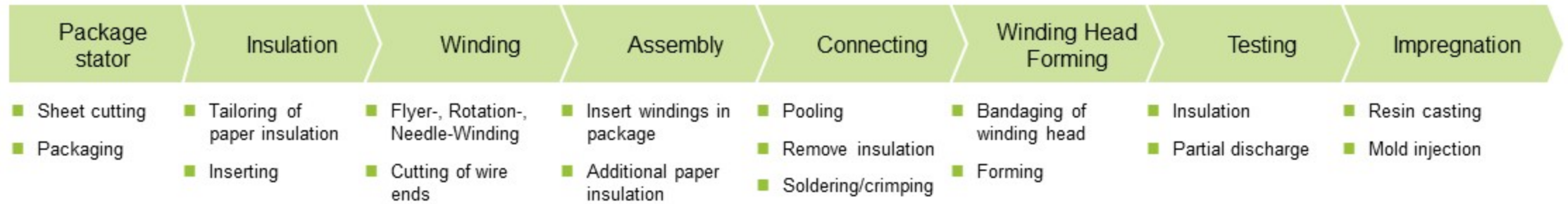
The institute FAPS offers diverse cooperation possibilities with the industry and further institutions.

	Funded research projects	Industry promotion	Direct cooperation	Student cooperation
Specific characteristics	<ul style="list-style-type: none"> Funded research activities Joint application 	<ul style="list-style-type: none"> Direct cooperation through shared staff 	<ul style="list-style-type: none"> Direct knowledge and technology transfer 	<ul style="list-style-type: none"> Supervision of final papers
Special benefit	<ul style="list-style-type: none"> Funding quota for industry partner normally at 40%*, for Institutes till 100%* 	<ul style="list-style-type: none"> Long-term research in direct cooperation 	<ul style="list-style-type: none"> Service relationship with confidentiality agreement 	<ul style="list-style-type: none"> Ideal Kick-off for a future research cooperation
Specialty	<ul style="list-style-type: none"> Dependency on donors Small projects realizable with or without focus on the region Special programs for small and medium-sized companies, association members or big companies 	<ul style="list-style-type: none"> Definition for Cooperation projects, topic and focus Employee of the university with a workplace inside the company and inside the institute for an ideal exchange 	<ul style="list-style-type: none"> Abstract and joint academic publication of the results Possibly joint patent application 	<ul style="list-style-type: none"> Thesis with focus on the topic area of the E Drive-Center
Project start and duration	<ul style="list-style-type: none"> Application ca. 12 months* Duration for 2-3 Years* 	<ul style="list-style-type: none"> Start with suitable doctoral candidate Promotion in 3 years* 	<ul style="list-style-type: none"> Capacity-dependent start Variable duration 	<ul style="list-style-type: none"> Starts with suitable students (April & October) Usually 6 months*
Service portfolio	<ul style="list-style-type: none"> Network development Joint research and development activities Capacity and machine use 			

*figures are based on average values; this information is supplied without liability

The E|Drive-Center strives to resemble all relevant production steps regarding electric drives.

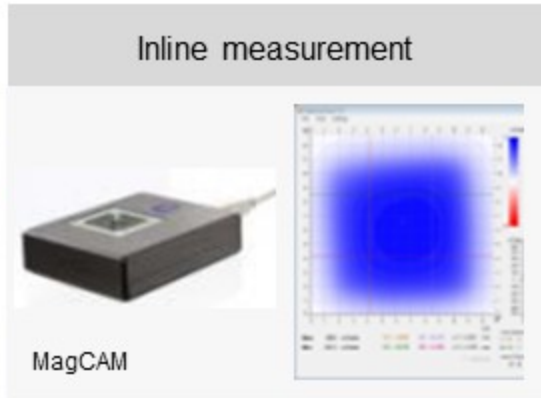
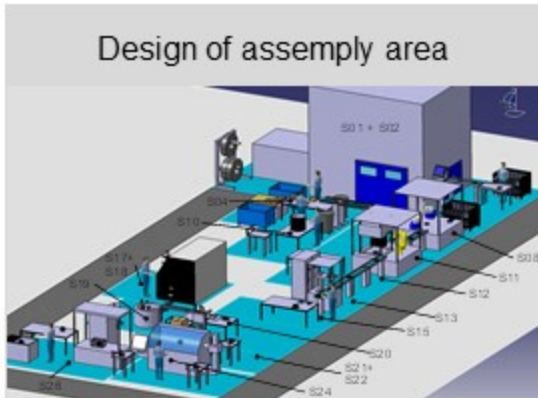
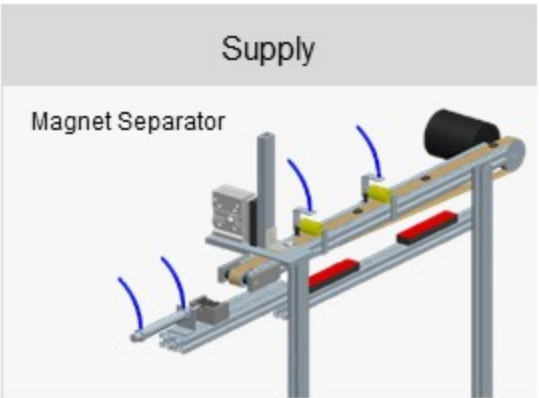
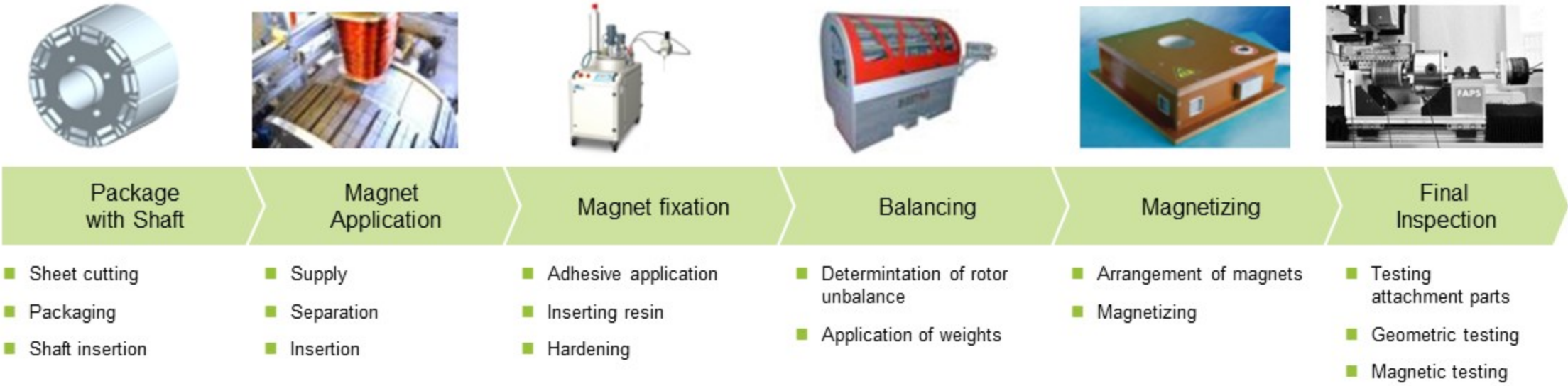
Example: Production process of a stator with distributed winding



Pictures: Schuler, rm-Prüftechnik, Castech, Lehner, Risomat, Remy, Spectrumtech

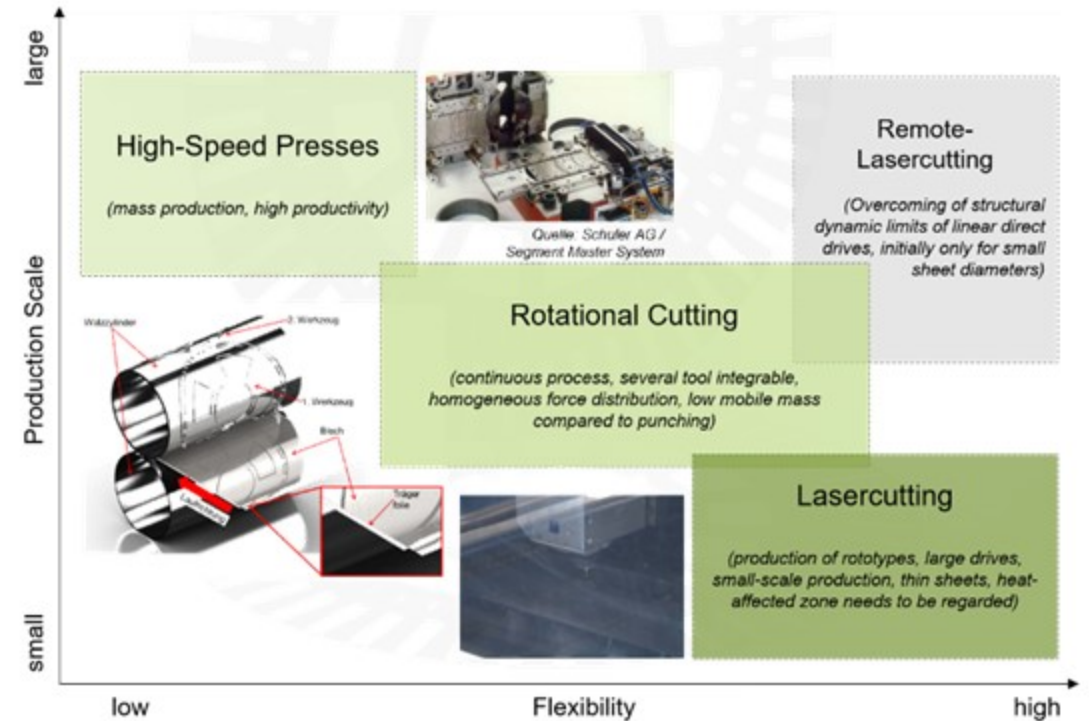
The large-scale assembly of permanent magnets requires efficient processes and testing technology.

Example: Production process of a rotor with permanent magnet on the inner side



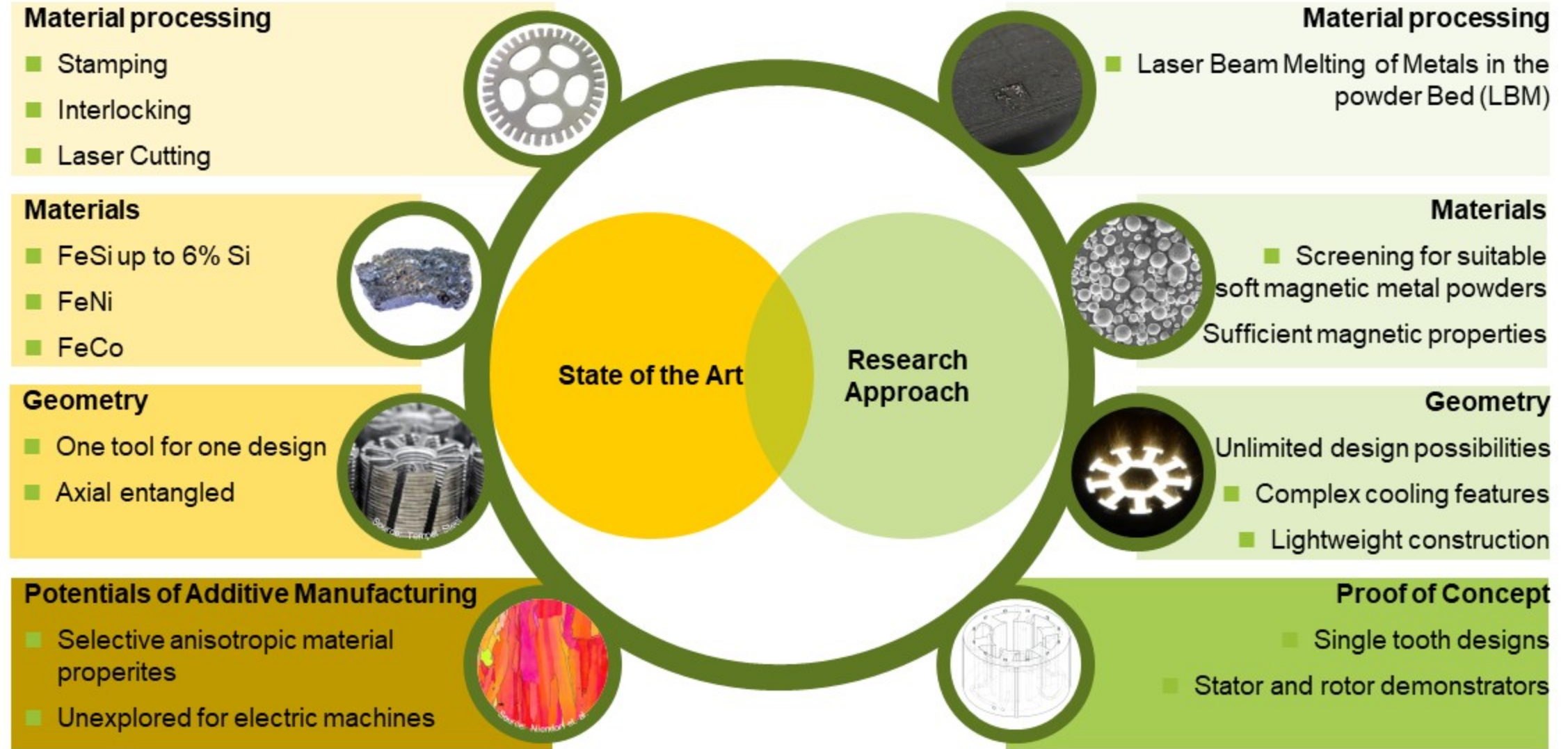
In the ZIM-Project E|RoCut an alternative production process is developed for thin electrical steel laminations.

ZIM-Project E RoCut	
Technical functionalities	Relevant parameters
<ul style="list-style-type: none"> Continuous process Low mobile mass Fast supply and removal of the electrical sheets Reusability of the components/modules Robust in application 	<ul style="list-style-type: none"> High cutting speeds High cutting precision (tolerances of 50 µm) Low, homogeneous cutting force distribution Thin sheet thickness 0,05 - 0,35 mm Sheet metal band speed >10 m/min (>30 pieces/min)
Economic aspects	Potentials
<ul style="list-style-type: none"> Low investment costs Low tooling costs Low life cycle costs Long tool life 	<ul style="list-style-type: none"> Very high output at a sheet metal band feed >400 m/min (already achieved in the paper industry)



- AP 1** Analyzation of the requirements of the process, tooling and product
- AP2** Concept development and validation
- AP 3** Development of the core process of rotational cutting of electric sheet
- AP 4** Development of a rotational cutting machine for electric sheet

Additive Manufacturing of soft magnetic alloys enables great potentials for bionic and lightweight design of electric drives for aerospace applications.



Electrical machines need electrical insulation in various parts in order to function.

Phase separation



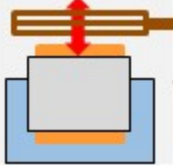
insulation washer



Impregnation of the winding



Inductive curing



Base insulation



Powder coating



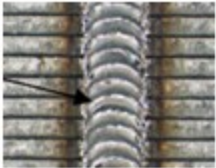
Cover slide



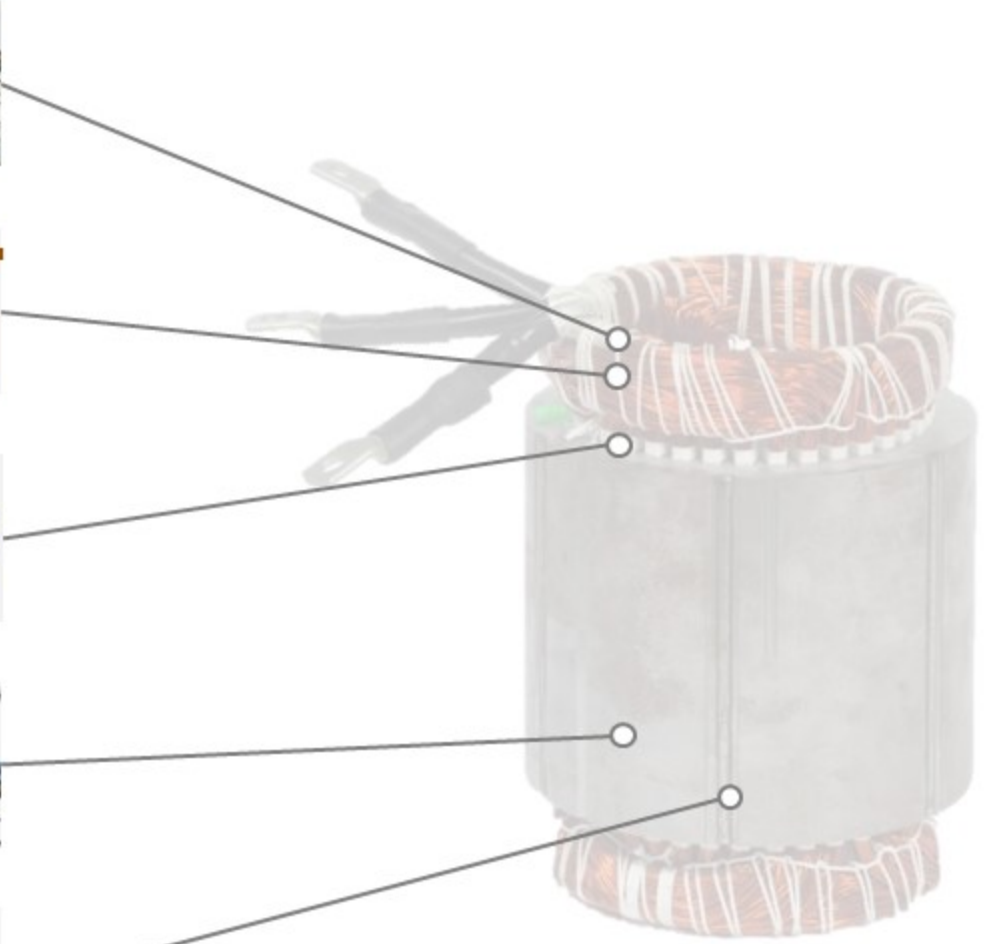
Automatic attaching of groove seal



Insulation of the individual sheets

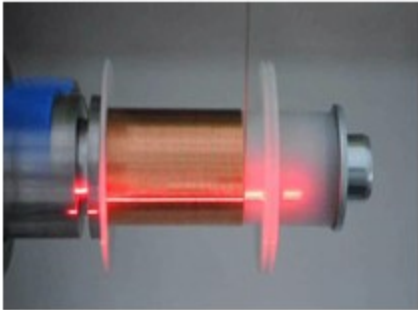


Electric sheet plastic clip



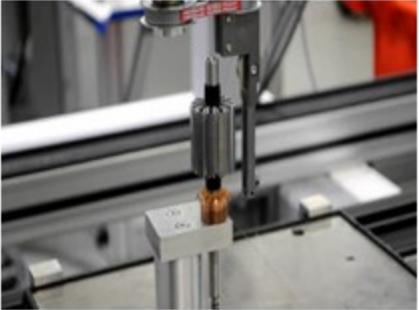
Innovative process chains can be realized by using industrial robots for winding technologies.

Linear winding



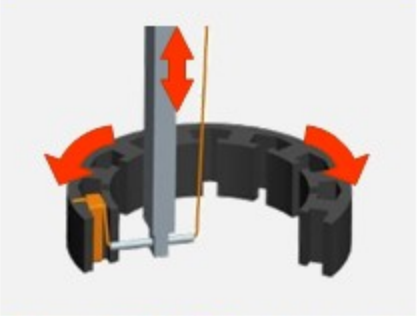
Winding systems with integrated process control loop for automated manufacturing of accurately positioned windings

Flyer winding



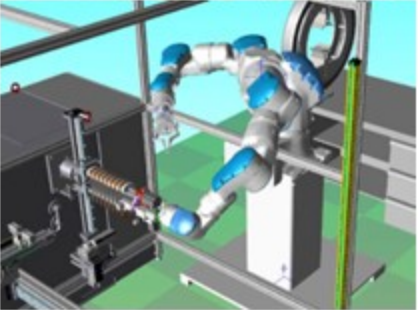
No wire guiding due to the robot based wire guide rotation

Needle winding



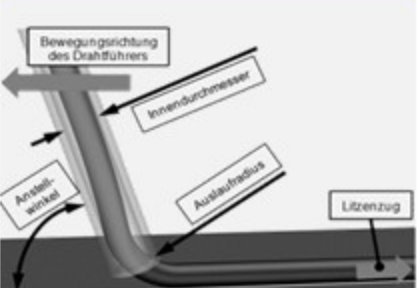
Robo-supported winding techniques with programmable flying path

Winding assembly



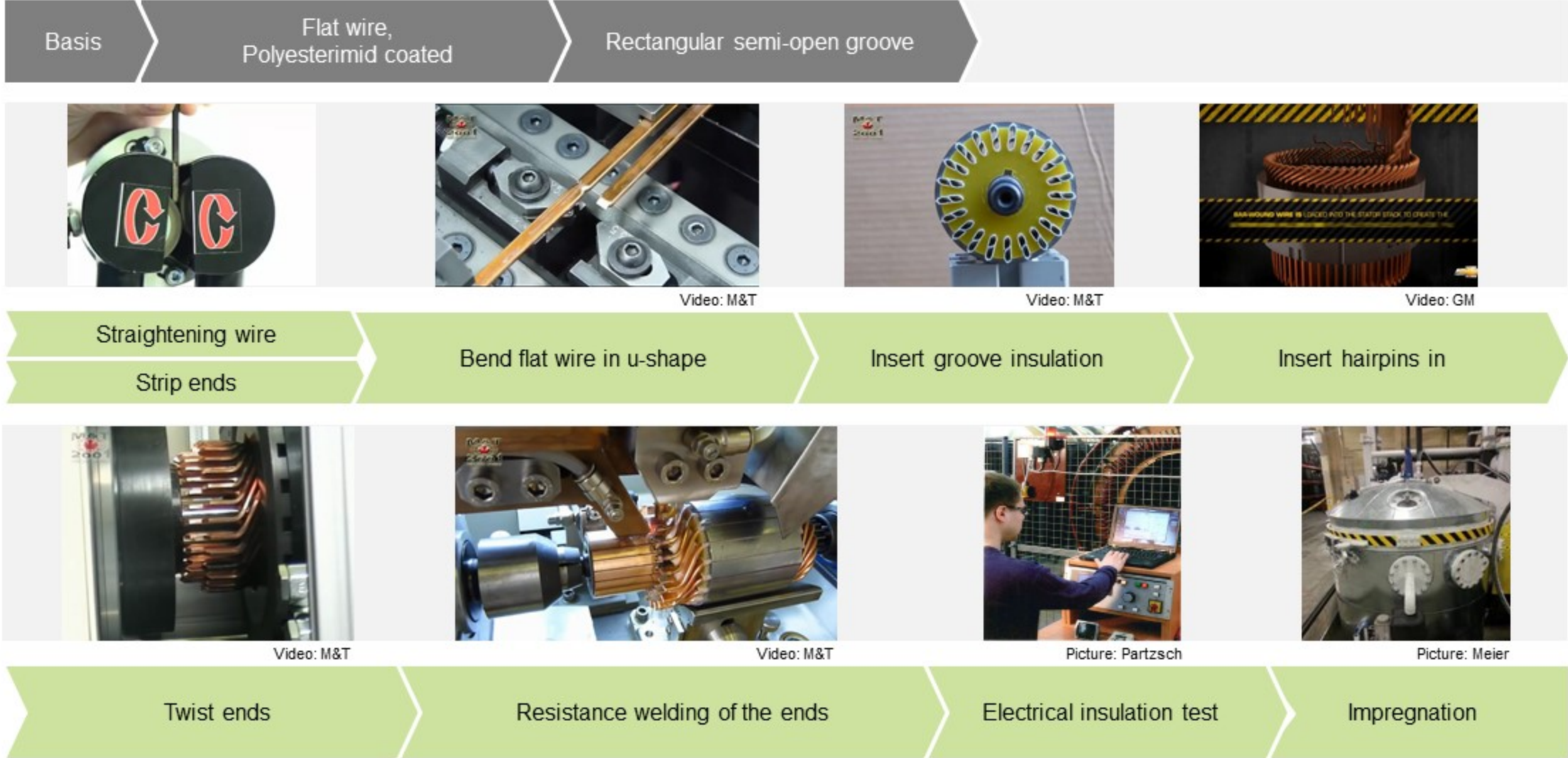
Substitution of complex insertion tools by flexible robot-guided winding assembly

Laying techniques



Realization of complex winding patterns for litz-wires with varying winding gaps

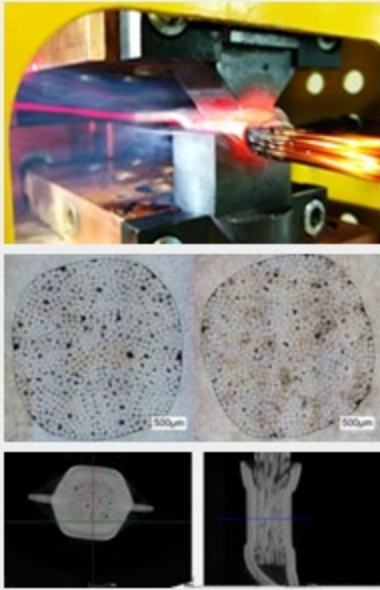
Due to the increased significance of the assembly of preformed coils, current research projects focusing on hairpin-technology.



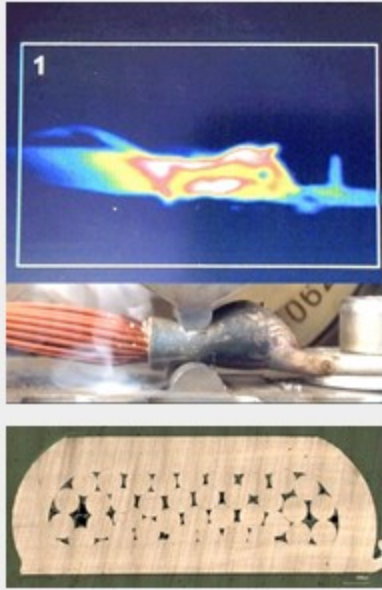
For contacting there is a multitude of technologies used in electromechanical engineering with different advantages and disadvantages.

Contacting Technologies

Hot Crimping



Ultrasonic crimping



Insulation stripping and crimping




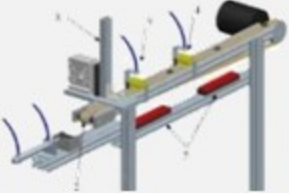






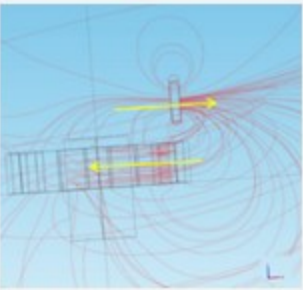

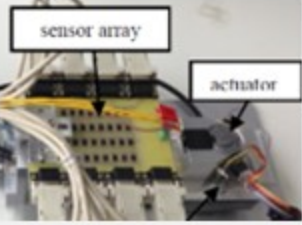
Ultrasonic splicing



Laser welding



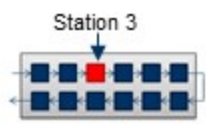
The assembly of permanent magnet synchronous drives comes with integrated evaluation technologies.

Assembly shaft / sheet package	Logistics (magnet, rotor)	Magnet assembly	Magnet fixation	Magnetization	Magnet measurement
<ul style="list-style-type: none"> Alternative joining process for shaft / sheet package 	<ul style="list-style-type: none"> Stack provisioning and separating  <ul style="list-style-type: none"> Workpiece carrier concepts for rotors 	<ul style="list-style-type: none"> Gripper technologies for SPM  <ul style="list-style-type: none"> Insertion tools for IPM 	<ul style="list-style-type: none"> Bonding (SPM)  <ul style="list-style-type: none"> Bonding (IPM)  <ul style="list-style-type: none"> Caulking (IPM) 	<ul style="list-style-type: none"> Optimization of magnetizing quality and cycle time  	<ul style="list-style-type: none"> In-Line measurement strategies for checking of geometrical and magnetic characteristics  

Requirements due to higher power density and quality of traction drives calls for development of efficient in-line testing technology.

State-of-the-art technology

complex manufacturing processes were not entirely evaluated – just single processes and stations



The relevant process data is not available in a direct evaluable format – a manual processing is not practical.



Dependencies of process parameters are unknown. Correlation with quality features are only partly possible.

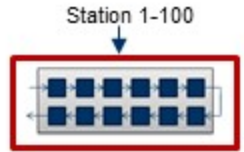


Avoidable mistakes and reject costs threaten the production location Germany.

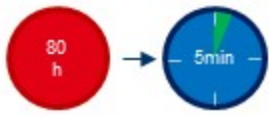


Potentials because of in-line testing

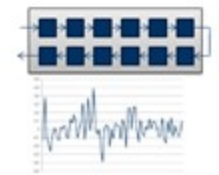
Integrated analysis of production facilities in the industrial series production, instead of individual units.



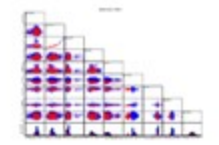
Huge datasets should be available in short time – the quality of the ongoing value chain should be improved.









Opportunity of an improved influence on value added quality. Growth of the competitive advantages through extended process understanding.









Development of efficient analysis concepts for highly automated manufacturing plants. → No fault finding but prevention.









The magnetic field measurement laboratory is equipped with magnetic field testing probes and testing systems for error detection and characterization of magnetic circuits.

- Competences in magnetic field measurement technology 
- Support with the selection/application of suitable magnet field sensors 
- Test bench development for magnetically soft and hard materials 
- Development of test systems for quality control accompanying production 
- Measurement data processing 
- Software development 

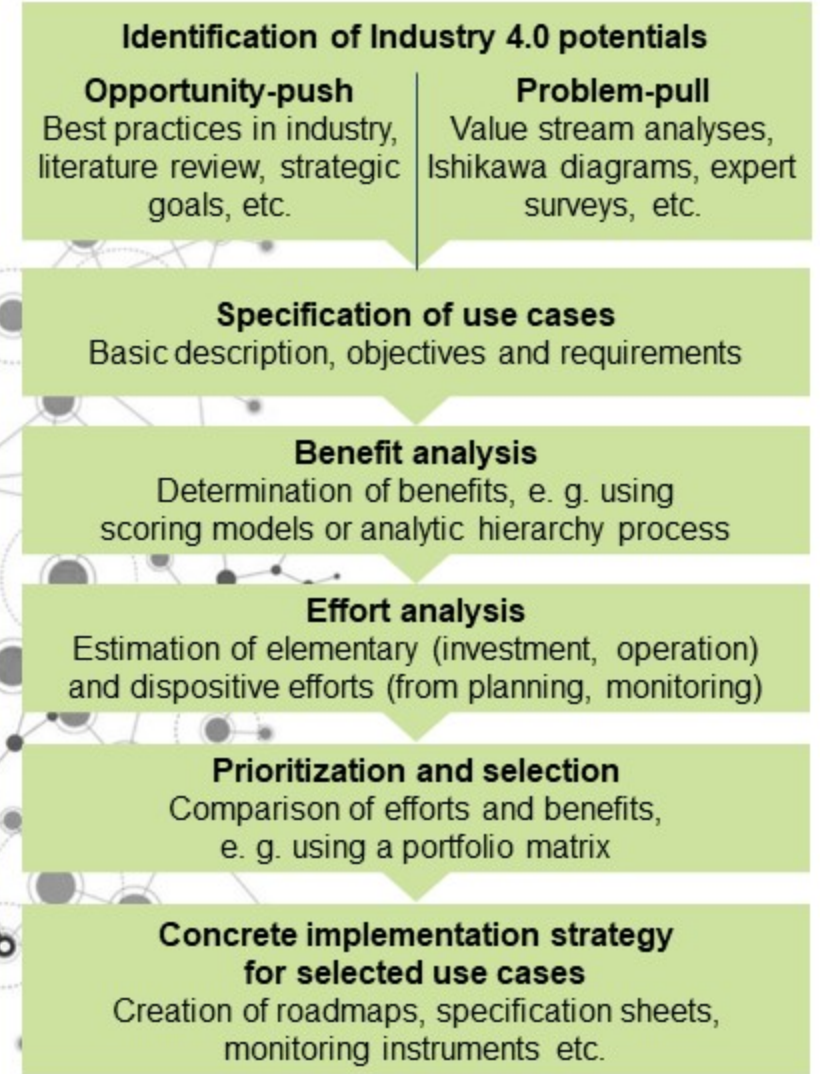
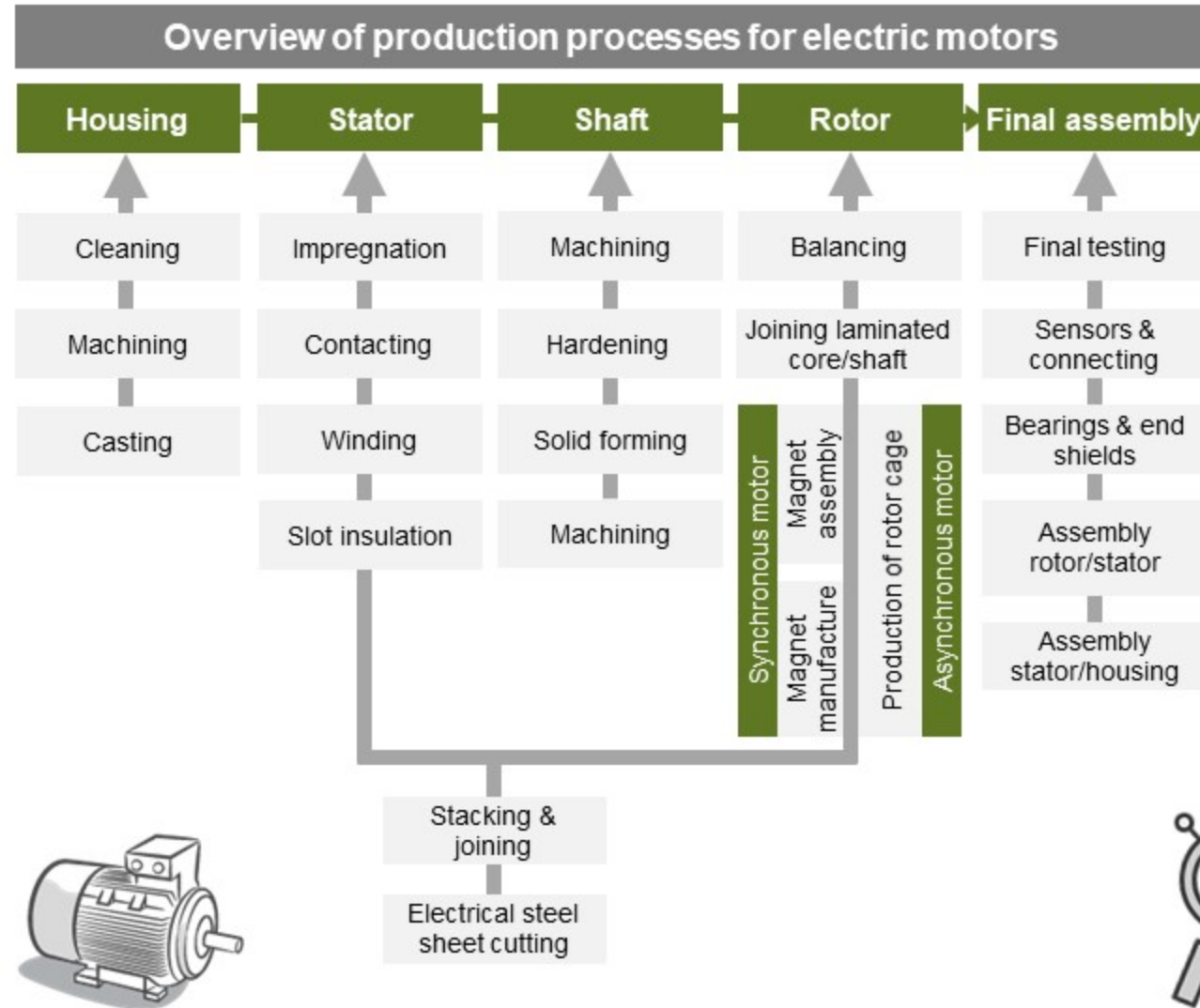
Magnetically soft

- Sheet package examination

- Low-Field sensors

- Domain recognition

- Robot-based

- Level recognition

- Image data processing


Magnetically hard

- Microcrack recognition

- Broadband sensors

- Testing of field distribution

- Automated test bench

- Crack recognition

- Control / Analysis


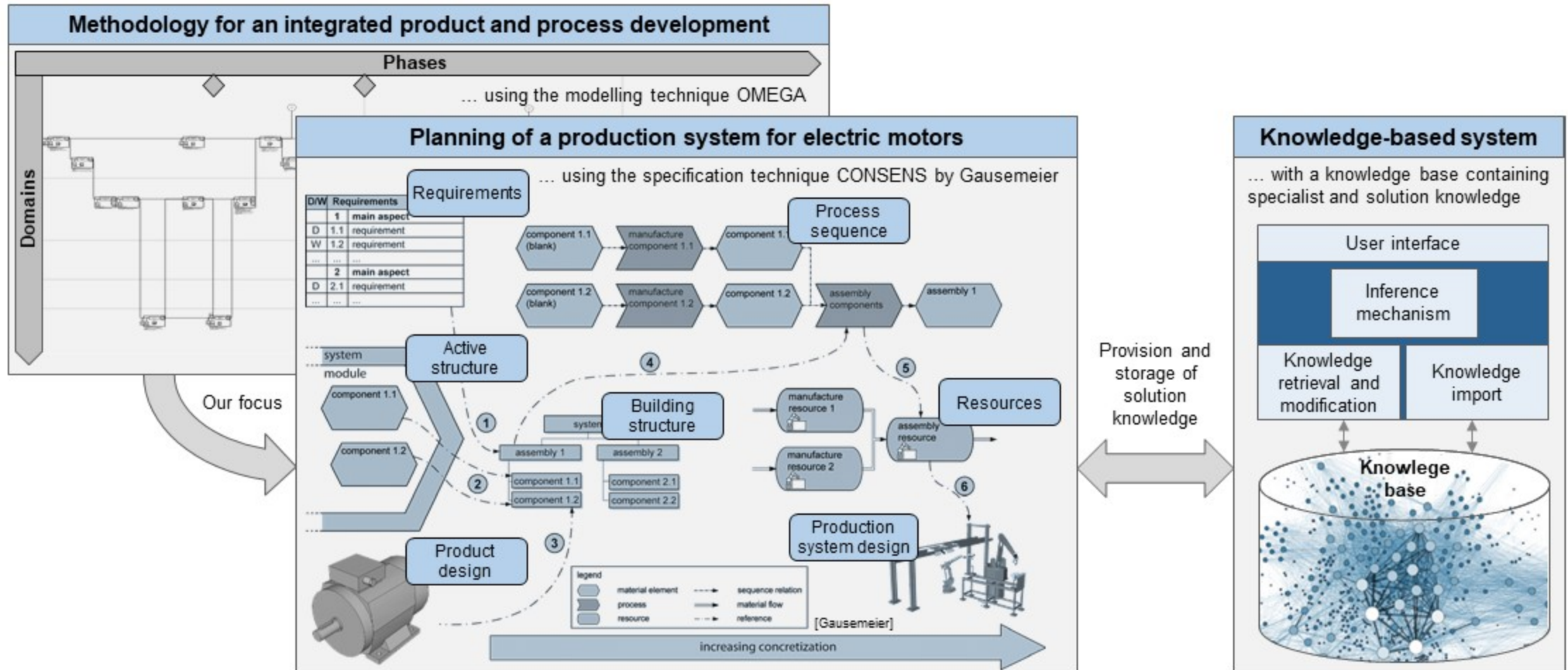
For the identification, evaluation and selection of application scenarios for Industry 4.0 technologies in electric motor production, a suitable methodology is required.



A knowledge-based system could support the conceptual design of an electric motor production system by provisioning existing expert and proven solution knowledge.



Knowledge-based planning tool for the conceptual design of electric motor production systems





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Thank you