



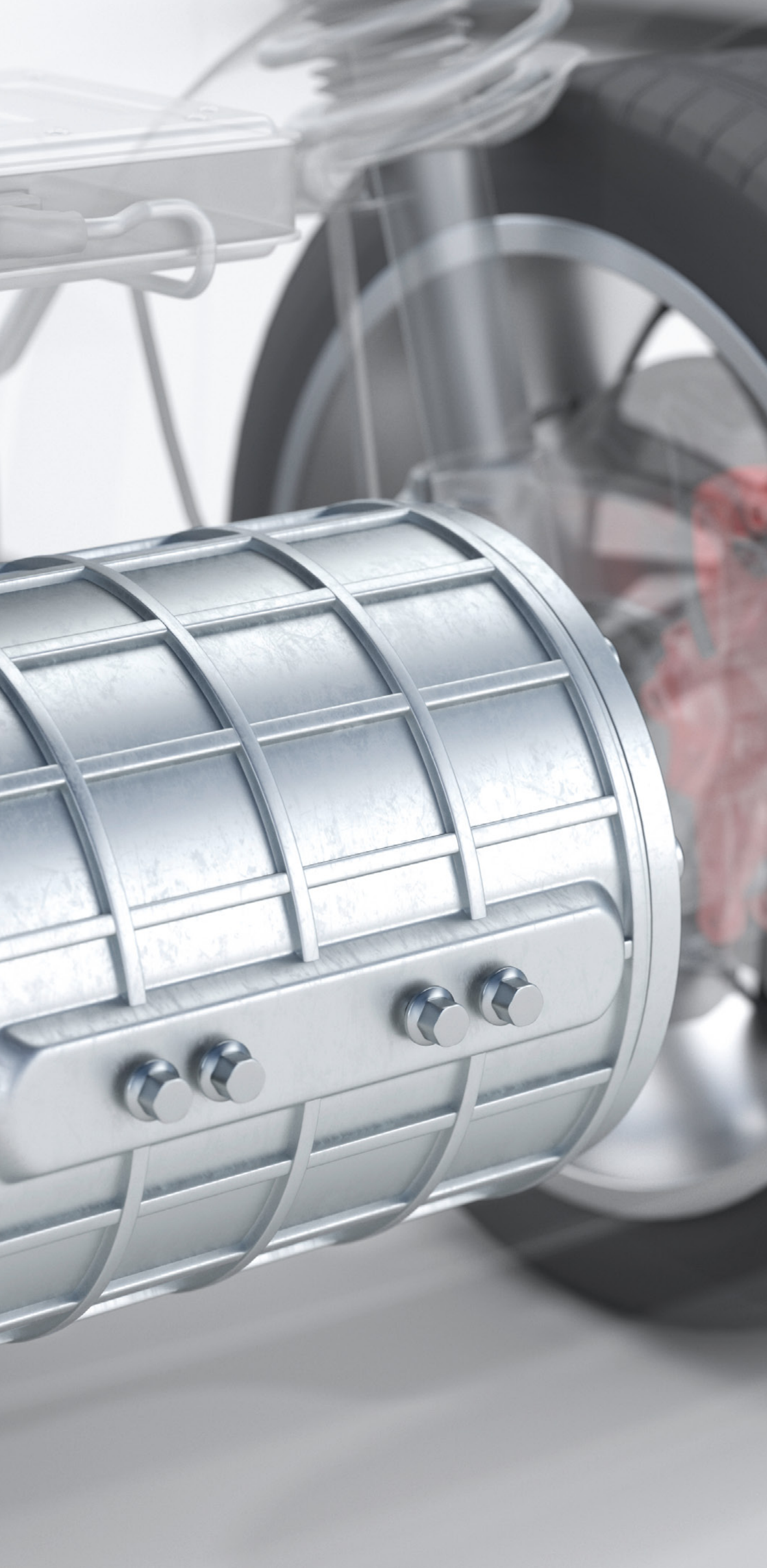
ZEISS eMobility Solutions

## Quality Assurance for high-performance Electric Motors

Inspection and quality data for reliable components



Seeing beyond



## Content

Find the right solution for  
your quality challenge

Quality control throughout the production of an

# Electric motor

Electric motors are the actual powerhouses of an electric vehicle – they combine high speed and enormous torque, all while being light and compact. In order to achieve maximum performance with little wear, all components must interlock precisely. The electric motor has many metrology challenges, like the precise bending process of the hairpin and their installation in the stator, and additional challenges in the production process of the stator and rotor.

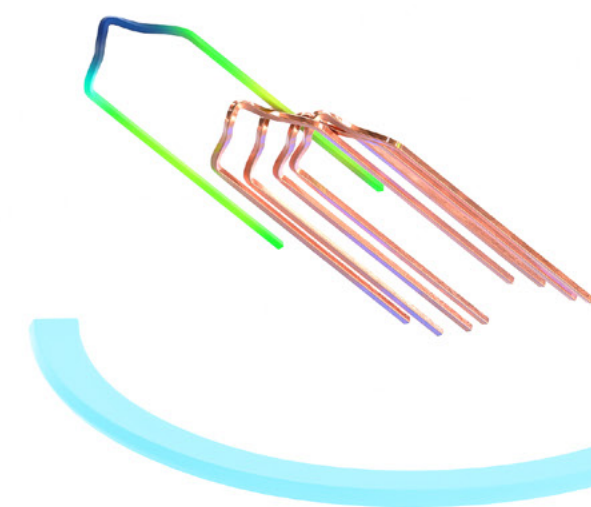
## Each step of the production process done right

Learn more about the extensive expertise of ZEISS in each phase of the e-motor production and assembly process:

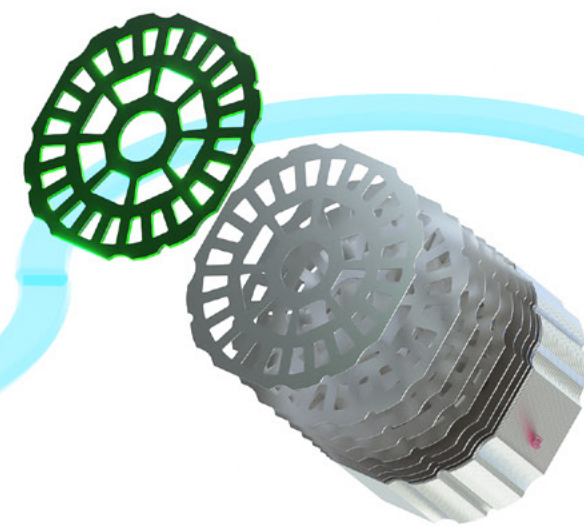
### Hairpin production

### Production of sheet stacks

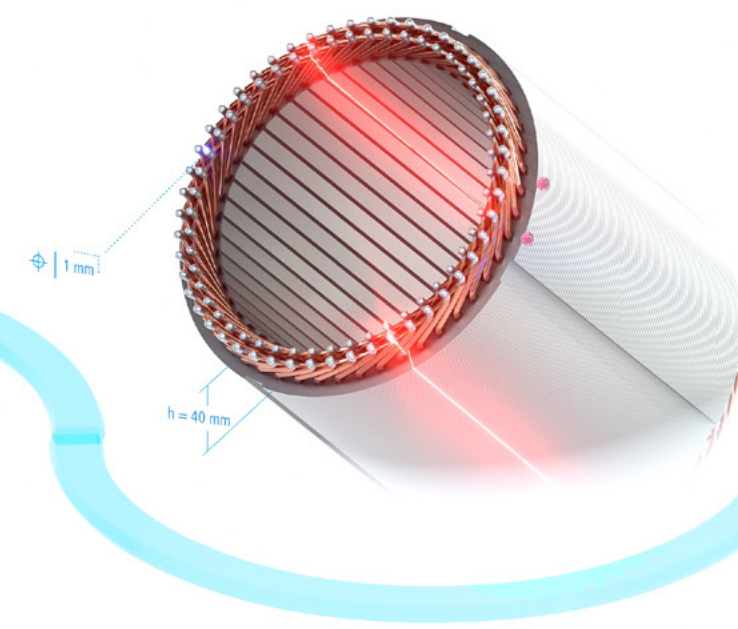
### Stator installation



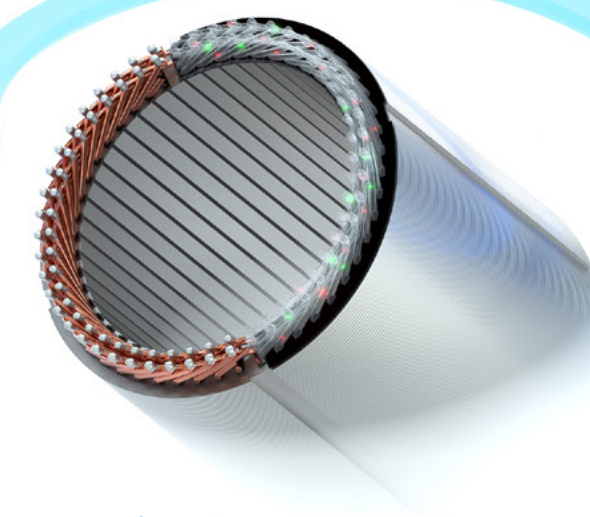
› Size, form and position



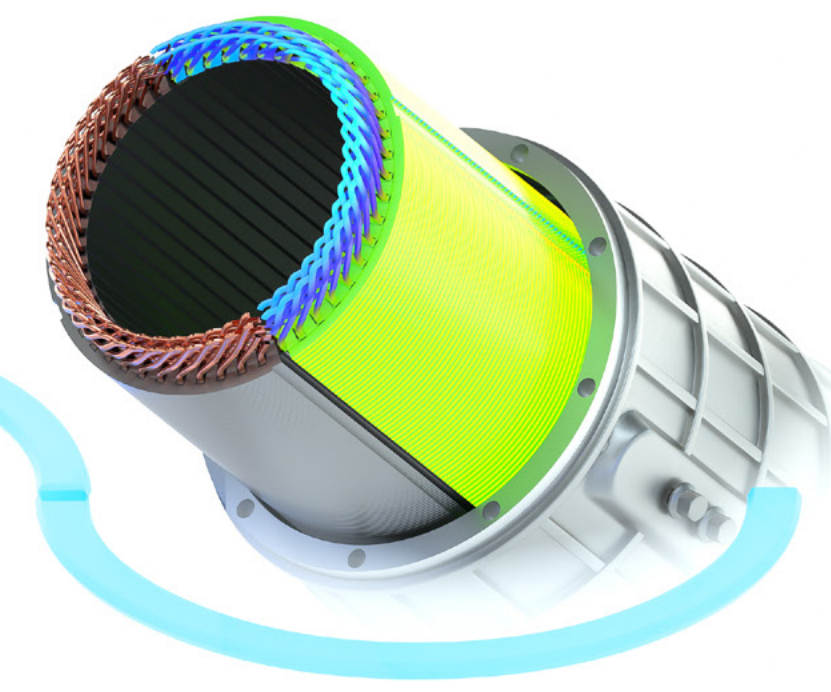
› Single sheet and sheet stack



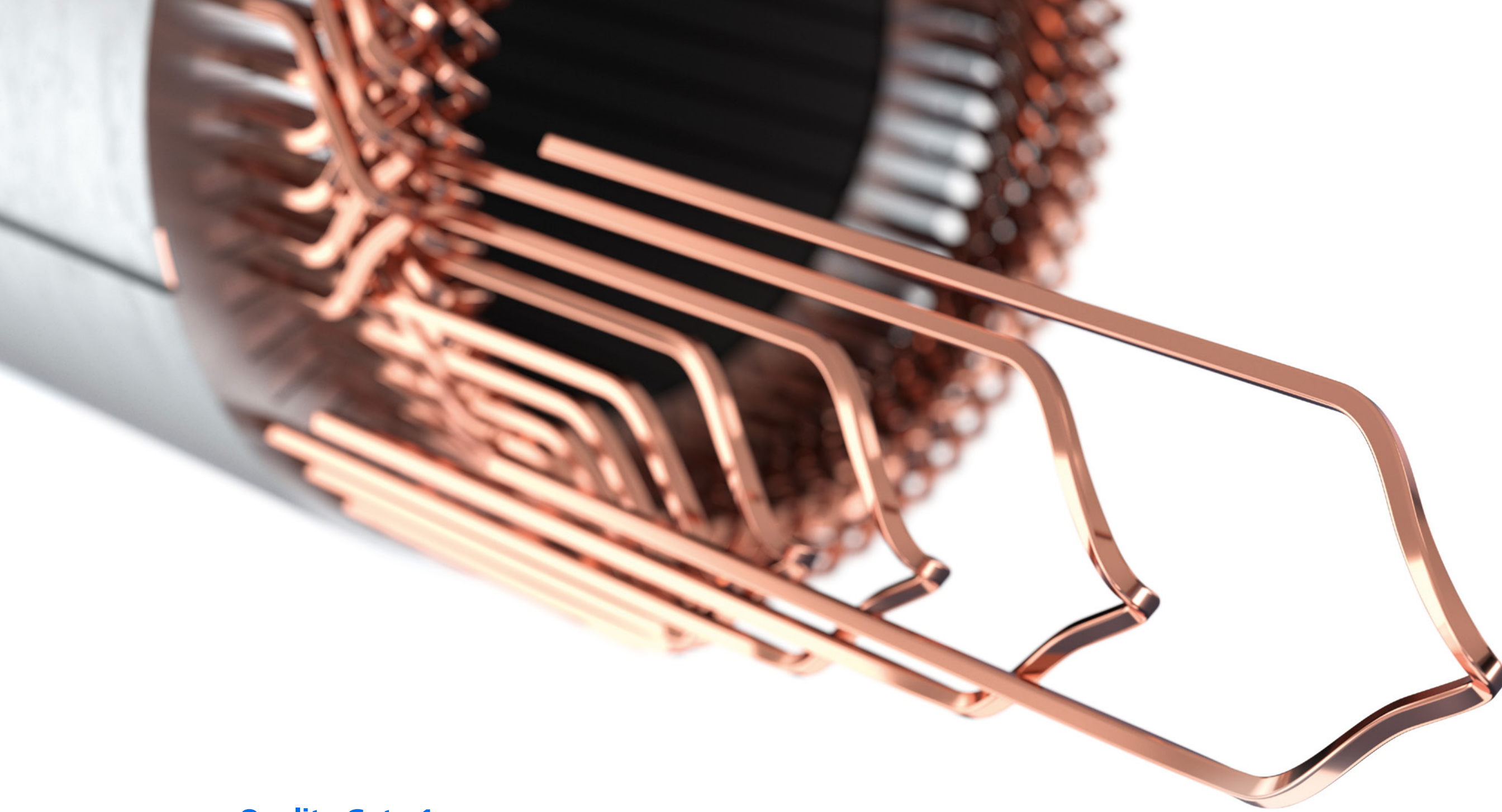
› Quality Gate 3



› Quality Gate 4



› Analysis of installation space dimensions



### Quality Gate 1

## Geometrical inspection: Size, form and position

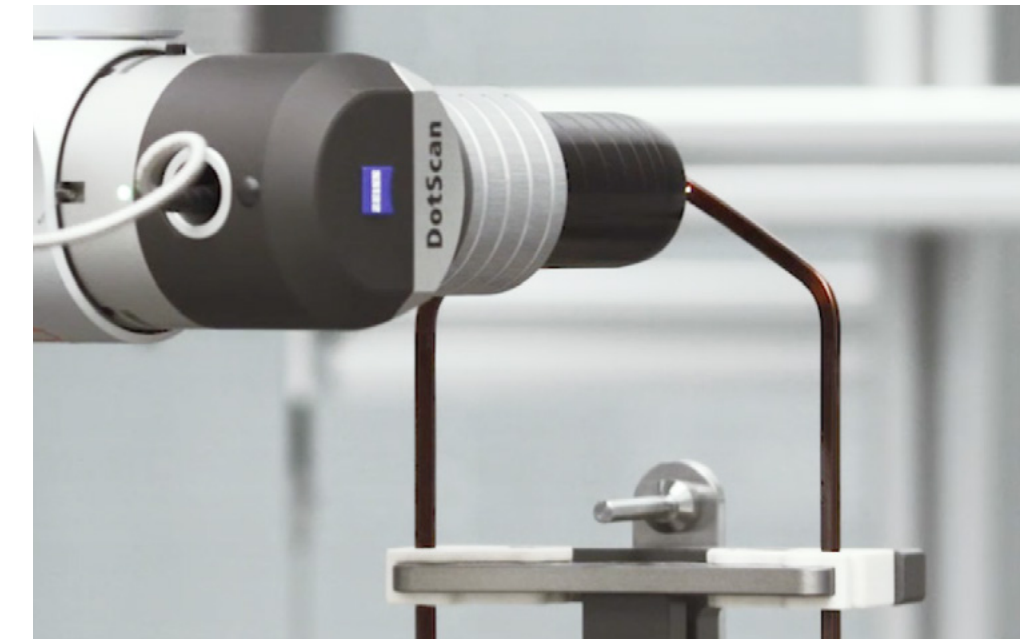
Hairpin production

### Challenges

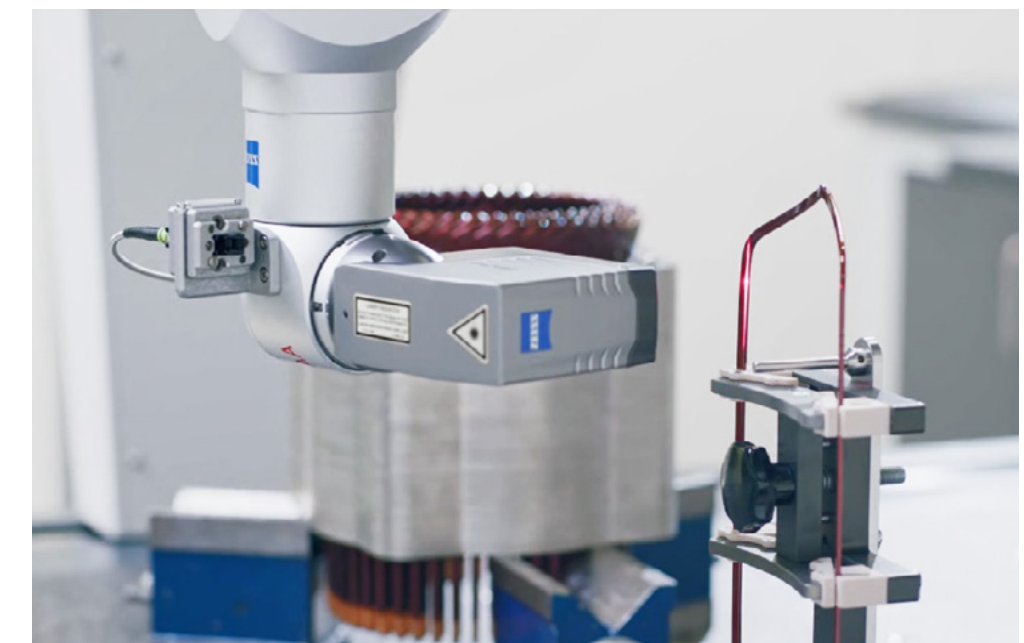
A large number of hairpins, which are bent from solid coated copper wire, are used as current-carrying conductors in electric motors. The flexible structures of the hairpins, as well as the sensitive coating with insulating lacquer, make geometrical inspection of the individual dimensions a serious challenge.

### Our solution

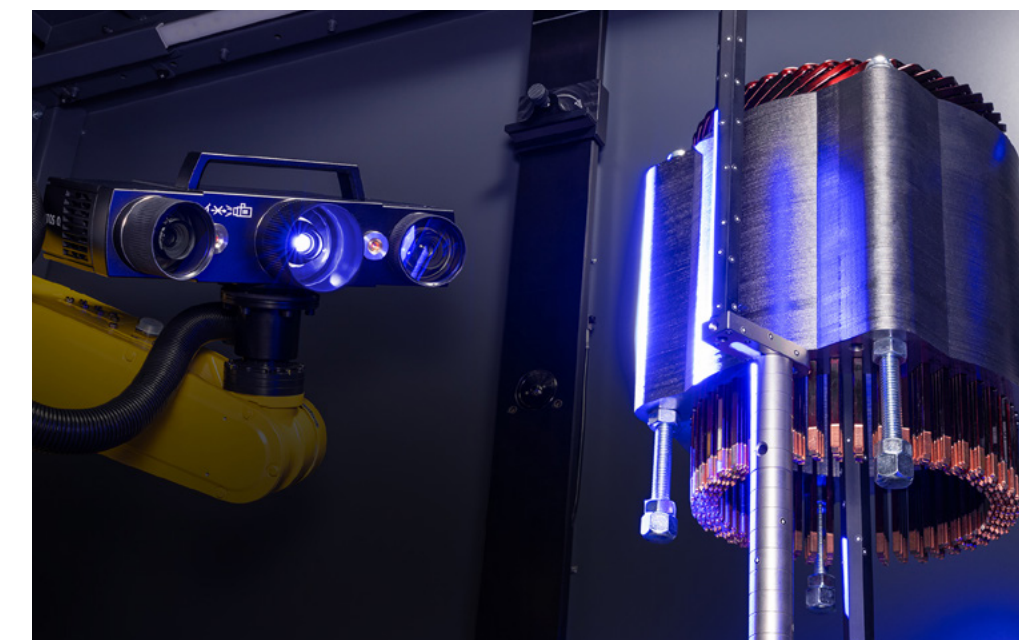
Contact-free measurement using optical probes on coordinate measuring machines overcomes the challenges posed by the hairpins' structural properties. These optical sensors are also capable of precisely measuring the form, lacquer coat thickness, and additional geometric characteristics.



The hairpins can be measured with high precision using the confocal white light technology of the ZEISS DotScan



ZEISS LineScan uses laser triangulation to enable fast, full-field digitization of the hairpins without pretreatment.



ZEISS ScanBox for eMotors enables non-contact and fully automatic digitization of sensitive structures.

## Quality Gate 2

# Geometrical inspection: Single sheet and sheet stack

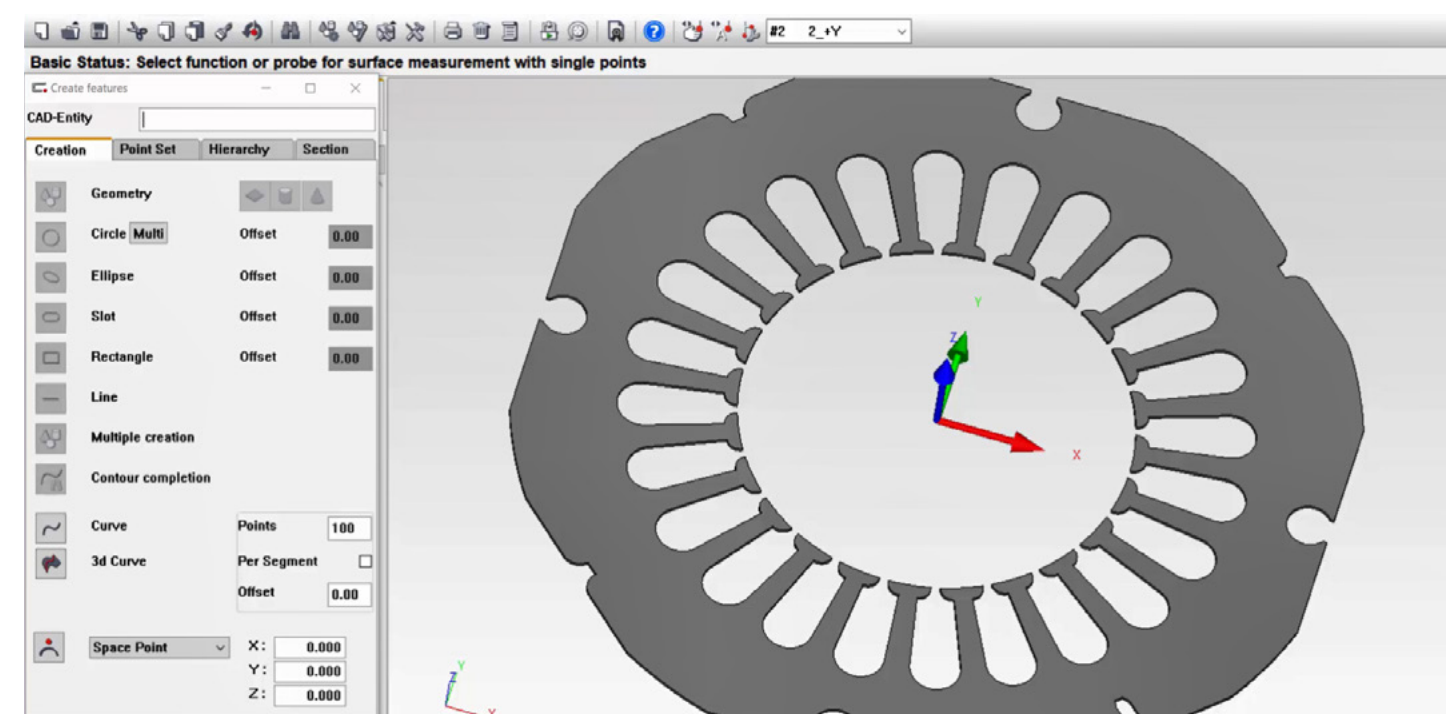
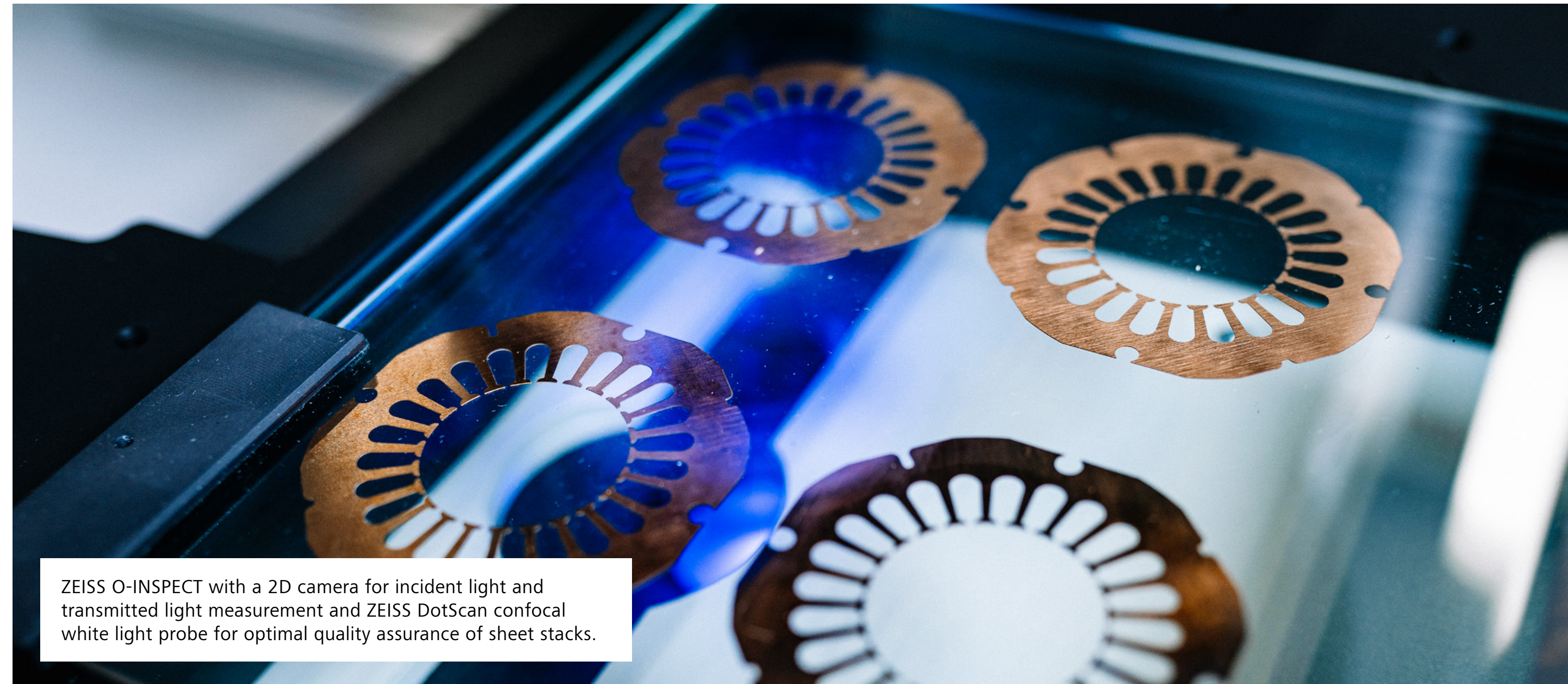
Production of sheet stacks

## Challenges

A sheet stack consists of multiple single sheets just a few millimeters thick. The 2D geometry, flatness, and absence of burr of the single sheets, as well as the positioning and dimensions of the grooves in the sheet stack, have a large impact on the fit of the hairpins and permanent magnets, and consequently on the performance of the electric motor. These highly precise assemblies require quality assurance with tolerances precise to the micrometer.

## Our solution

Multisensory ZEISS coordinate measuring machines provide a large number of contact and optical probes on a single system. The system is capable of inspecting pallets of components without operator involvement, resulting in increased machine utilization and decreased inspection cycle time. With X-ray solutions, internal defects can be detected quickly and effectively.



ZEISS CALYPSO enables simple programming for a large number of recurrent inspection characteristics.



ZEISS PRISMO for the complete 3D geometrical inspection of the stator and rotor sheet stacks.

### Quality Gate 3

## Insulation paper and hairpin position

Stator installation

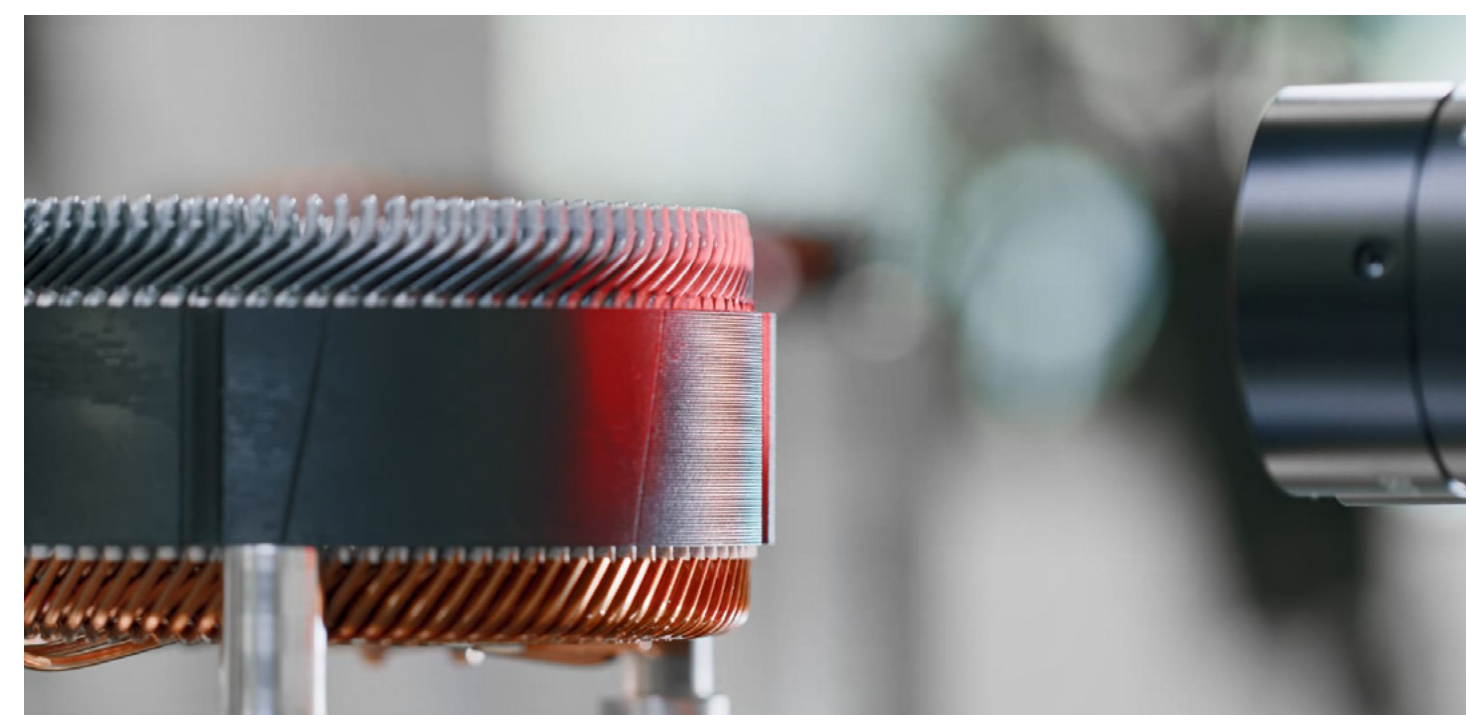
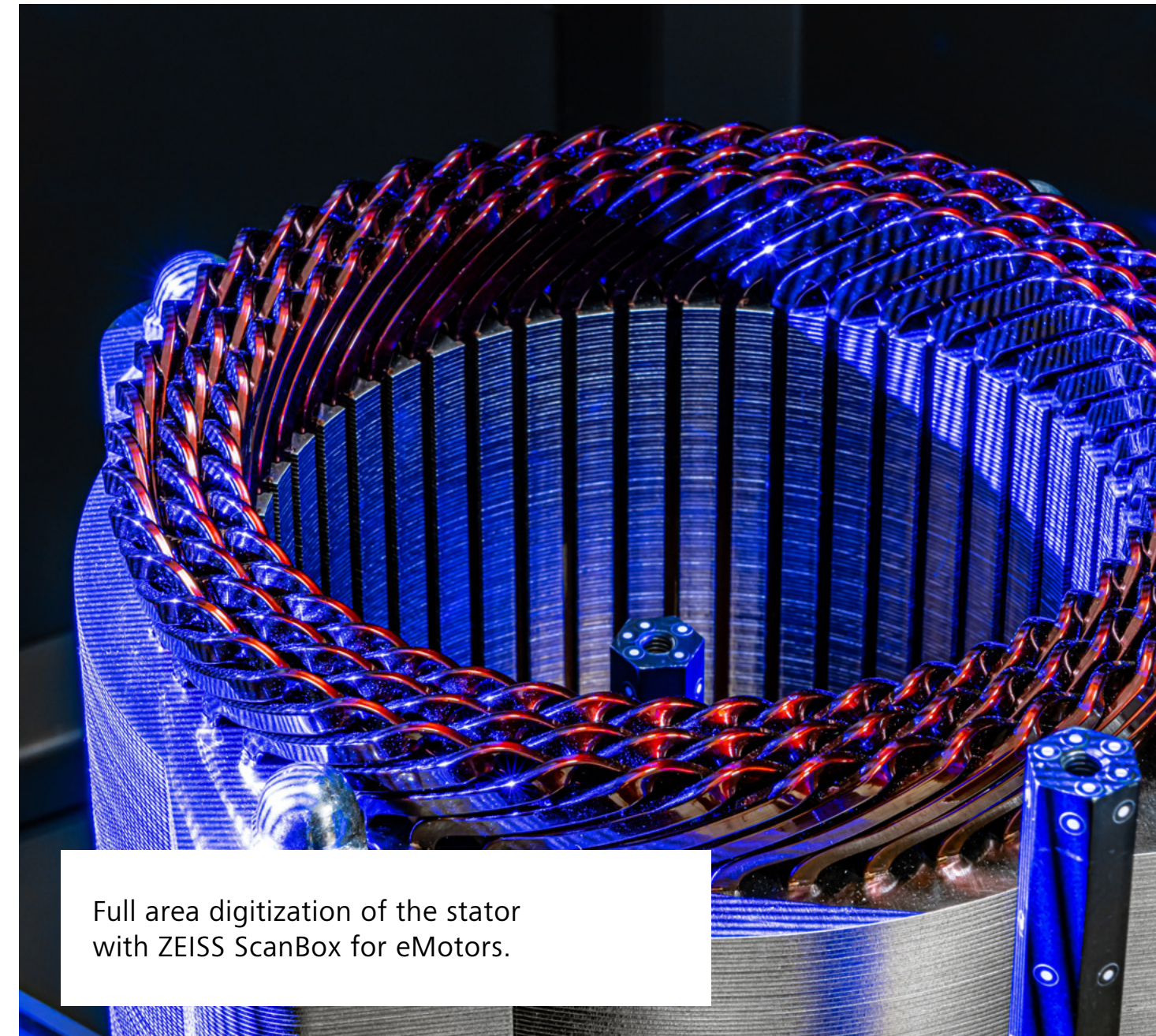
### Challenges

Inspection of the positioning and excess length of the insulation paper between the hairpin and stator sheet stack is crucial to prevent dangerous short circuits in the stator.

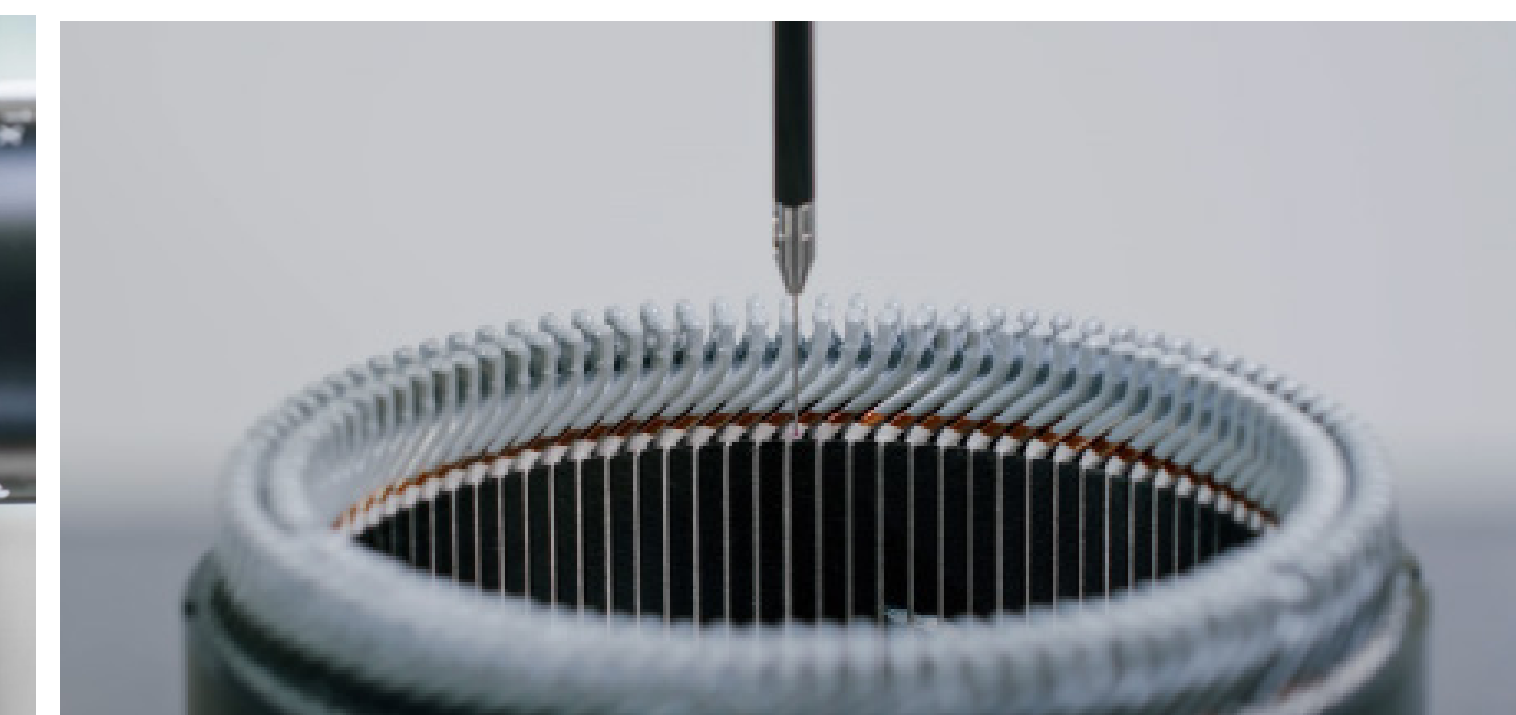
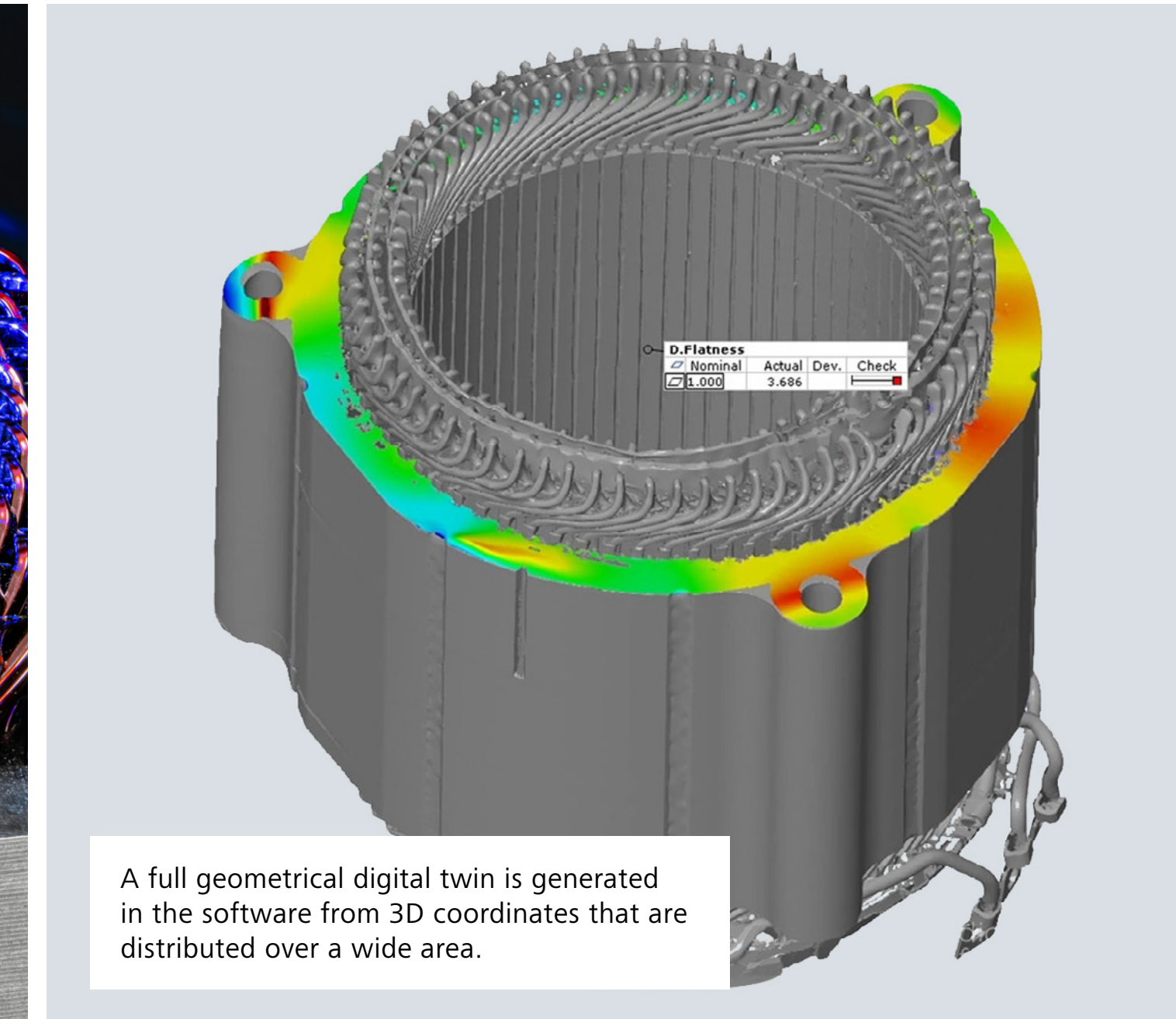
Furthermore, inspecting the position of the hairpin ends is critical in the process, both before and after welding, in order to ensure the required safety, reliability, and performance of the e-motor.

### Our solution

- Positioning of the insulation paper can be performed by means of optical 3D scanning with ATOS optical sensor as well as tactile and optical measurement with ZEISS coordinate measuring machines.
- Optimum process control and merging of the different measurement results is provided by the reporting and statistics software ZEISS PiWeb.



Both optical camera-based measurement with ZEISS ViScan and a tactile solution with ZEISS RDS XXT are suitable here.



ZEISS PRISMO with tactile styli is the ideal solution for determining the position of the hairpin welds tips.

## Quality Gate 4

# Weld seam inspection

Stator installation

## Challenge

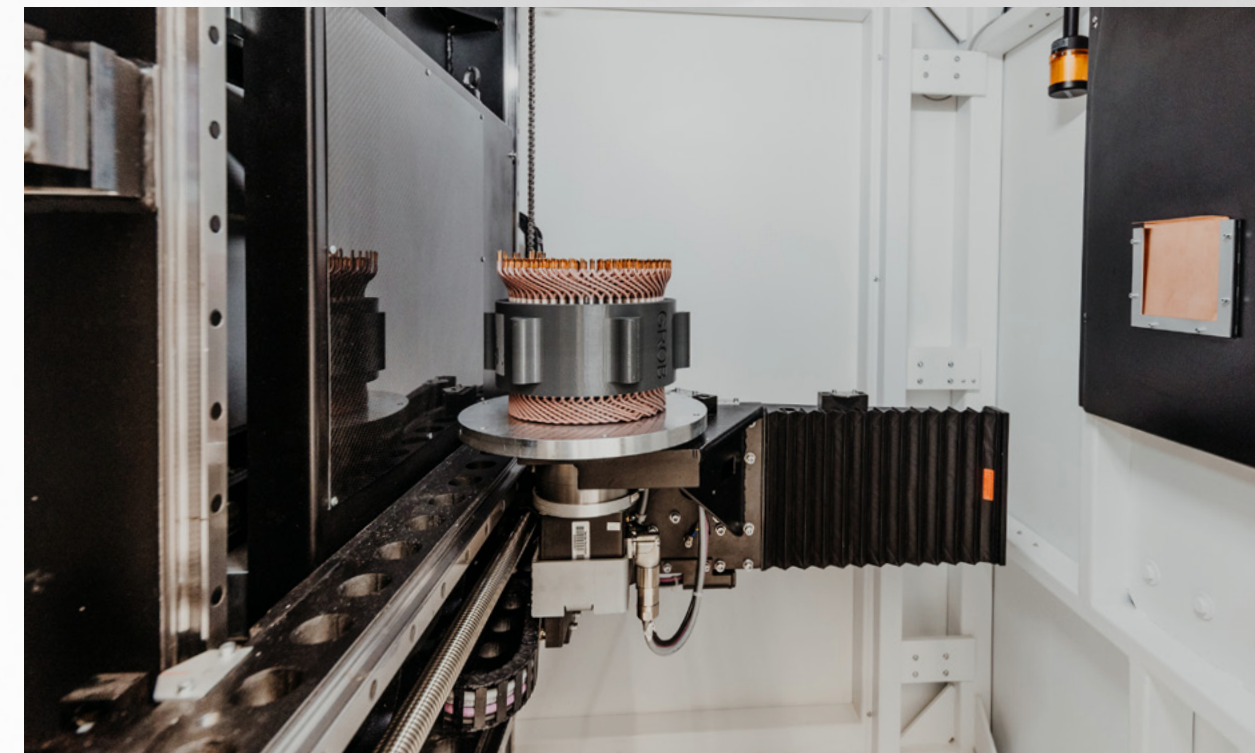
When welding the hairpin ends, lacquer residue at the stripped ends or fluctuating weld parameters can result in porosities in the weld seams – and thus lower performance or cause total failure of the e-motor. Inspecting of these weld seams for possible defects is critical for the performance of the e-motor.

Non-destructive inspection of all weld seams for possible defects poses a special challenge.

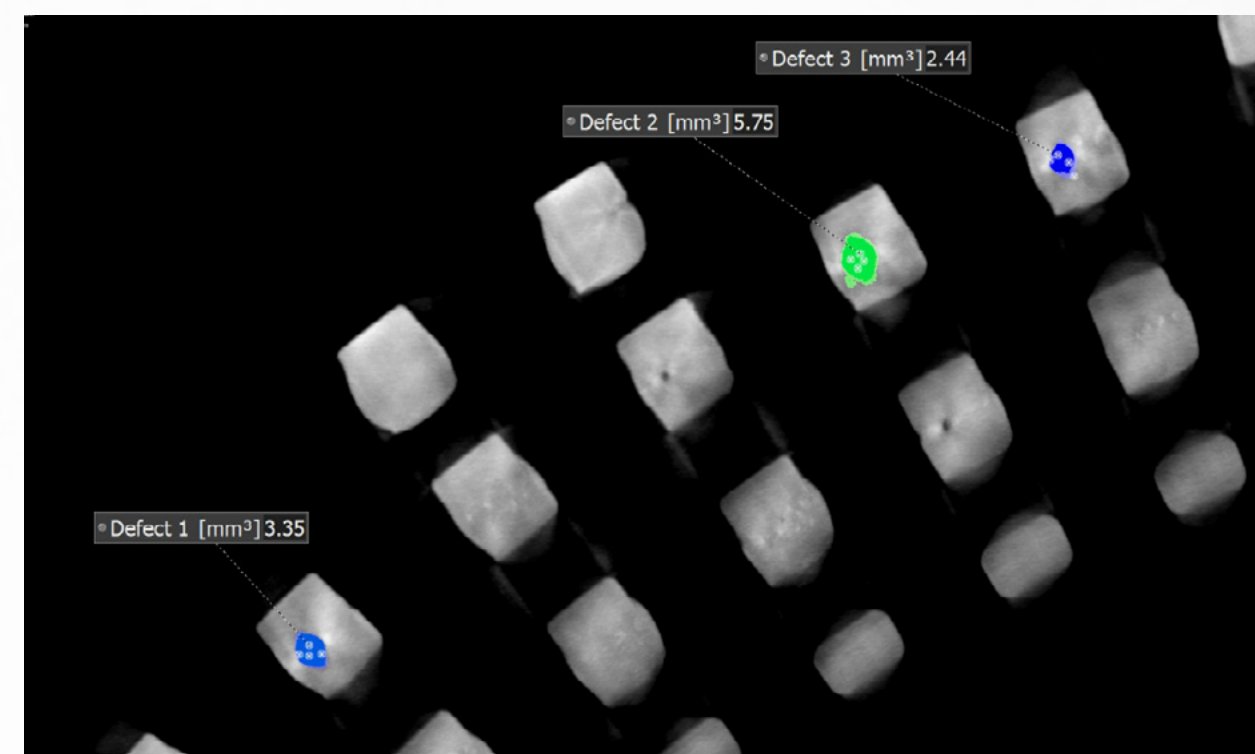
## Our solution

Using industrial computed tomography, such as with ZEISS VoluMax 9 titan or ZEISS METROTOM can be used to non-destructively identify pores and defects inside the weld seams of hairpins.

Depending on the choice of system, the solutions offer short scanning times of 10–15 minutes and a wide range of options for metrological evaluation and classification of defects.



Identification of porosities in the weld seams of hairpins with ZEISS VoluMax 9 titan.



Evaluation and classification of defects with ZEISS METROTOM



AI-supported, automated defect detection in the hairpins with ZEISS Automated Defect Detection (ZADD)

## Quality Gate 5

# Analysis of installation space dimensions

Stator installation

## Challenges

The external dimensions of the stator are crucial for its installation into the electric motor housing. If the stator exceeds the installation space, the assembly of the motor is not possible.

Additionally, the complex geometries and mixed material (plastic, steel and copper) of the stator also create challenging characteristics for the component's overall quality assurance



ZEISS LineScan for fast and reliable data collection.



ZEISS VAST series for highly precise inspection of critical external dimensions.

## Our solution

ZEISS coordinate measuring machines equipped with mass technology enables automated swapping between different sensor technologies. The combination of laser triangulation probes and tactile stylus systems enables full quality assurance for the pre-assembled stator. ZEISS Integration Series enables automated inspection of larger quantities.



ZEISS eMobility Solutions

## Coordinate measuring machines

Reliable and high-quality coordinate measuring technology

The broad portfolio of [coordinate measuring machines from ZEISS](#) combines very precise tactile and optical measurement with high measuring speed.

Due to increasing demands on the inspection of components with ever smaller tolerances, coordinate measuring machines are becoming more and more important. For this, ZEISS provides solutions such as:



### ZEISS bridge-type CMMs

Bridge coordinate measuring machines from ZEISS are equipped with a precise probing system featuring impressively high measuring speeds. The various solutions and systems can be tailored precisely to individual requirements.



### ZEISS Optical Series

Every measuring task has its own challenges, but if the components are fragile, very small, easily malleable, or easy to scratch, contact-free quality assurance is crucial. ZEISS Optical Series has a solution for all these challenges.

ZEISS eMobility Solutions

## Optical 3D measuring machines

Fast automated measurements with highest precision

For efficient quality assurance of electric mobility's various components, the ZEISS Metrology Portfolio includes standardized optical measurement system. These systems cover each process step, from programming to automated digitization, inspection and reporting.

For fully automated analysis of full-field deviations between actual 3D coordinates and CAD data, the portfolio offers the following solution, amongst others:



### ZEISS ScanBox for eMotors

ZEISS ScanBox for eMotors enables the automated inspection and digitization of hairpins and stators.

## ZEISS eMobility Solutions

# X-Ray Solutions

Reveal the hidden secrets of your part

[ZEISS X-Ray Series](#) is a non-destructive inspection solution that reveals what would otherwise remain hidden from even the keenest eyes. Inspecting and analyzing internal and external component structures is crucial in overcoming e-mobility related challenges, such as safety and performance requirements.

To solve these challenges, ZEISS provides the following X-ray solutions, amongst others:



## ZEISS BOSELLO

Fast and precise 2D X-ray technology for non-destructive testing of electric motors brings cost and time benefits. The ZEISS BOSELLO MAX X-ray system visualizes internal structures and can reliably detect inclusions and irregularities quickly.



## ZEISS VoluMax

ZEISS VoluMax 9 titan is an excellent complete solution for porosity detection of welding areas in the quality assurance process of stators. Users benefit from fast scan times of 10 to 15 minutes, low noise and reduced artifacts.



## ZEISS METROTOM

The ZEISS METROTOM is a 3D X-ray system which provides fast and detailed scans for all measurement and inspection jobs. The standard acceptance test, precision engineering, and the sophisticated calibration process ensure the traceability of the system.

## ZEISS eMobility Solutions

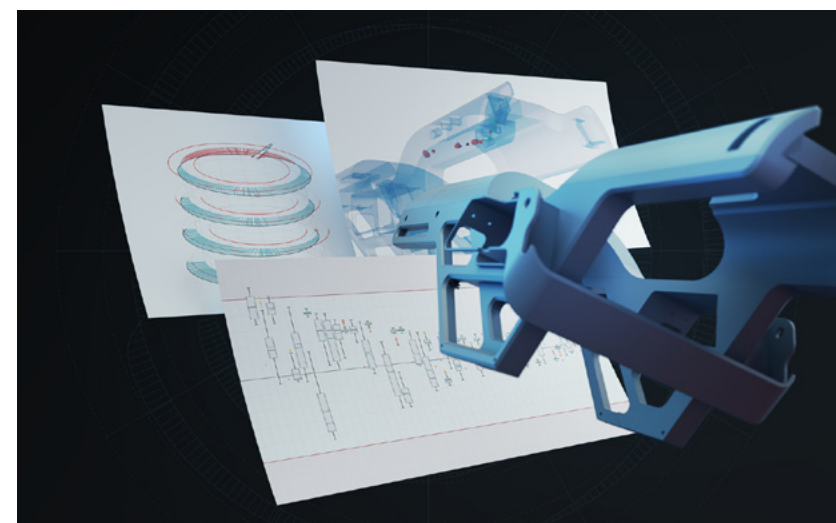
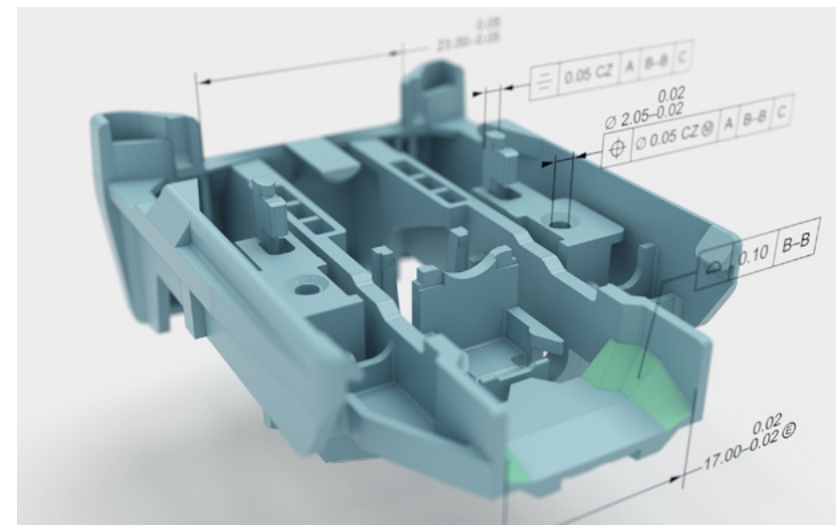
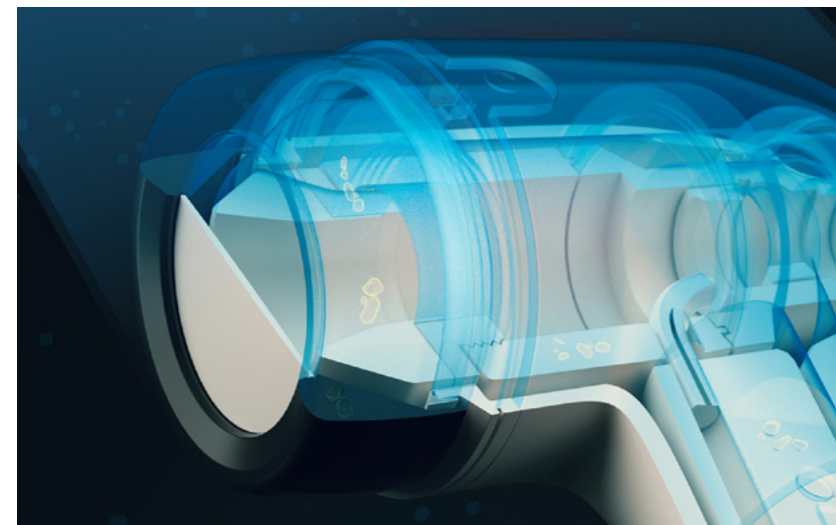
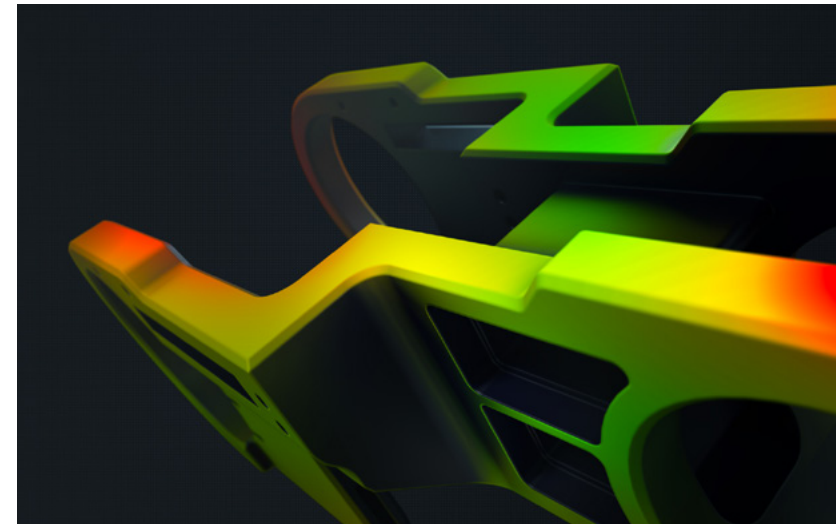
# Software Solutions

Customer challenges in focus

[ZEISS Quality Software](#) delivers high flexibility combined with high-precision analyses. Depending on your requirements, you create data evaluations, analyses and reports across technologies and systems.

With the digital ecosystem for ZEISS Quality Software, the [ZEISS Quality Suite](#), you have access to the various software solutions via one central platform and can access all services with just a few clicks.

To solve different challenges ZEISS offers software solutions such as:



## ZEISS INSPECT

Discover the versatility of ZEISS INSPECT. With the software, you analyze optical 3D surface data and volume data – regardless of which system you use. Numerous powerful features allow you to customize the software according to your needs. Data import via drag & drop and many user-friendly templates as well as the always up-to-date integration of inspection standards ensures efficient workflows and precise results.

## ZEISS INSPECT X-Ray

Visualize and analyze your parts down to the inner core using CT data. No matter which CT hardware you use, the powerful ZEISS INSPECT software will help you visualize and analyze the data. Evaluate defects, structures, and assembly situations, and bundle your results in easy-to-understand reports – even with video. [ZEISS Automated Defect Detection \(ZADD\)](#) software detects even small and fuzzy defects in components reliably and quickly.

## ZEISS CALYPSO

ZEISS CALYPSO is your universal metrology software for the dimensional inspection of standard geometries. In combination with our coordinate measuring machines, you get a high-performance system from a single source. Expand the software with additional functions for special requirements such as the inspection of curves, freeform surfaces and gears.

## ZEISS PiWeb

ZEISS PiWeb supports decision making on the shopfloor with measurement results from different measurement technologies. This allows you to efficiently track your production quality across all measuring machines. ZEISS PiWeb can capture and analyze results from tactile, optical, manual or CT measurements.



ZEISS eMobility Solutions

## From energy to eMotion

We are happy to provide you with more information about our products and services for your battery tray application.