Paul Köster
Medebach • Germany

THREE AUTOMATED PRODUCTION LINES IN ONE PLANT

ALL-INCLUSIVE: MACHINING, CLEANING, ASSEMBLING, LEAK TESTING & IMPREGNATING

Together with our customer Handtmann Kechnec s.r.o. we have taken on a very special challenge: Three different component types from the blank to the machined, assembled, tested and impregnated end product are produced in just one plant. So to speak, the “all-round carefree package” from a single source, with smooth interface coordination between the enormous number of suppliers and technology partners. Of course, always on board: State-of-the-art automation, part traceability, capacity-based part navigation and testing mechanisms with accurate data availability. The end result is three interconnected production lines full of intelligent control technology and lots of high-tech. Over a total of approx. 130 meters, the clutch and transmission housings pass through a large number of process steps with a cycle time of 43.5 seconds. Whether various machining operations, cleaning, high-pressure deburring, drying, measurements, assemblies, leak tests or the following impregnation, this special machine is individually adapted to the wishes of our customers. Personnel are only needed to load, monitor and maintain the production line - automation takes care of the rest.

Get an idea for yourself! On the following pages we have compiled detailed information about this project. In addition, you can find a video of the plant on our website:

SOME INDIVIDUAL OPERATIONS AT A GLANCE

Manual infeed of raw parts via circulation belt

Entry into the laser cabin

Laser marking

Result of the laser marking

Gantry solution for transport in machining centers

Machining in various machining centers

Possibility of SPC ejection

Further transport of the machined components into the washing cell

Transfer to the next cell

Secured access options

Component identification

High pressure deburring

SOME INDIVIDUAL OPERATIONS AT A GLANCE

Vacuum drying

Optional storage in buffer rack

Circulating workpiece carrier conveyor

Automated assembly of KVT expander plugs

Leak testing using mass flow and pressure difference procedure

In- & outward transfer options

Low-maintenance conveyor technology

Removal from conveyor belt

Loading of impregnation racks

Impregnation, cleaning and curing

Another option for storage in a buffer rack

Gripper transfer for capacity balancing between the production lines

SOME INDIVIDUAL OPERATIONS AT A GLANCE

Discharge of O.K. components

Discharge of N.O.K. components

Possibility of component reintegration

Rejection

Manual final inspection

Measuring cell from the inside

SPECIAL FEATURES IN THE PROJECT

"Capacity-oriented component navigation" - a term in the introductory text that is quite a task: Each component has its own individual production requirements, and all machines in the process flow are designed to meet them. Nevertheless, different parts can be flexibly produced together in certain areas of the plant and get “redirected” automatically. In this case, however, the different requirements go well beyond dimensions and machining. Different quality requirements for impermeability, impregnation rates, their repetition, cycle times, and resulting storage options are just some of them. All these special features must be taken into account when connecting the production lines and at the capacity-oriented component navigation. At the same time, there is a strict 0% error tolerance, because any confusion of OK, N.O.K. or rework parts due to incorrect navigation must be ruled out in any case. And our mechanical engineering experts have solved this problem in a clever way.

Facts

- Production of a total of 7 different component variants (3 component types)
- Leak testing using mass flow and pressure difference procedure
- Cycle time of 43.5 seconds
- 3 interconnected production lines
- Extensive data determination thanks to various measuring and testing systems

INDIVIDUAL OPERATIONS IMPLEMENTED

In this major project, a wide variety of technologies were combined, tailored to the requirements of our customer. As usual, the automation, assembly technology and leak testing machines were supplied by Köster. In the areas of machining, cleaning and impregnation, we have worked closely with well-known suppliers, entirely without interface discussions or time-consuming coordination problems for our customer.

Automation

- Intelligent conveyor technology with lift system & consistent component tracking
- Use of handling robots
- Gantry technology solutions
- Laser marking

Assembly technology

- Assembly of various KVT expander plugs

Leak testing

- Leak testing clutch housings
- Leak testing gearbox housings

Additional process steps

- Various machining steps in machining centers
- Cleaning & high pressure deburring
- Vacuum drying
- Impregnation

Christof Nölke, Sales
inquiry@paul-koester.de
+49 (2982) 92 11-866

CONTACT

ARE YOU FACING SIMILAR CHALLENGES?

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Paul Köster
Medebach • Germany

LEAK TESTING, ASSEMBLY TECHNOLOGY & AUTOMATION

4 DRIVE UNITS, 14 ROBOTS, 16 ASSEMBLIES & 8 LEAK TEST STATIONS

If you are wondering how the implementation of state-of-the-art leak testing and sophisticated assembly technology with highly complex automation can look in practice, this reference project with an extensive production plant for AUDI housings from the e-mobility sector will give you some answers.
In the production hall of our customer GF Casting Solutions Werdohl, topics such as "Industry 4.0" and "IoT" become tangible when an enormous dynamism within the production process lures our automation specialists out of their reserve.
What is it specifically about?
The housings for four different AUDI drive units pass through extremely different machining, cleaning, assembly and leak testing steps in a specific sequence, fully automated and intelligently coordinated by various control levels. At the same time, comprehensive process and production data is delivered, naturally including pinpoint component traceability.
And that's not all: within the six cells there are special technical features such as a gantry with 3 robots and – according to our partner ABB – a unique working range of 50 meters. Assembly technology has some impressive technologies, such as joining with inductive heating, the fully automated application of individual adhesive beads and state-of-the-art verification options such as data on position and temperature monitoring or volume measurements of applied sealant using a 3D camera.

Sounds exciting? For a deeper insight into the project, we have compiled detailed and in-depth information on the following pages.
You can also find videos of the plant on our website:

SOME INDIVIDUAL OPERATIONS AT A GLANCE (CELL 1 & 2)

Possibility of direct component infeed via circulation belt

Inlet incl. buffer storage via modular vertical lift

Three robots on one axis for intelligent component handling

Depending on the component type, various machining operations in 15 machining centers

Versatile interim storage options

Transfer of the processed components to cell 2

Pre-cleaning of parts contaminated with coolant (rear axle-HA)

HA: Manual loading of the feeder drawer for heat sinks and bearing bushings

HA: Inductive heating of the heat sink

HA: Joining the bearing bush

HA: Acclimatization in the rack system

HA: Provision of the assembly part at the manual workstation

SOME INDIVIDUAL OPERATIONS AT A GLANCE (CELL 1–3)

HA: Manual pre-assembly of the heat sinks, followed by automatic assembly

HA: Screw connection of the heat sink with parameter monitoring

HA: Handover of the component for further processing

Removing a component (front axle VA) from pre-cleaning

VA: Inductive heating of the component

VA: Automatic sealant application incl. control by means of 3D scanner

VA: Joining of the bearing bush incl. position and temperature monitoring

VA: Handover of the component for further processing

Removal of a component (rear axle, type Performance – HA-P)

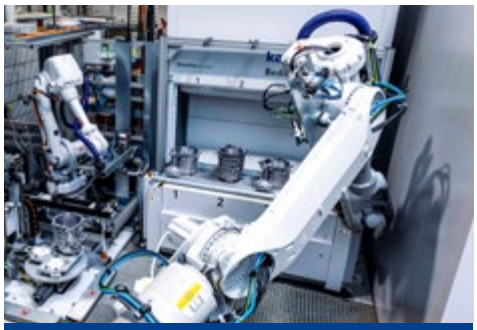
HA-P: Inductive heating and joining of the bearing bushing from below

HA-P: Dimensional control of the joining position, followed by transfer for further processing

After processing: Transfer component to cell 3 for cleaning and drying

SOME INDIVIDUAL OPERATIONS AT A GLANCE (CELL 3–5)

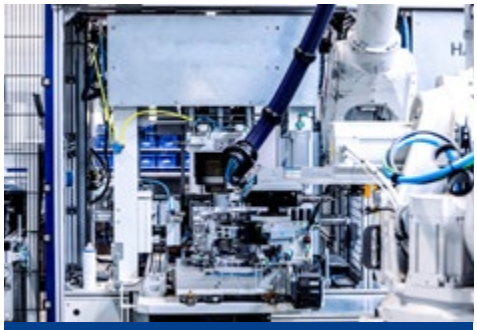
Removal of the component from the washing cell



Acclimatization in the rack system

Automatic plug assembly & screw-in of screw plugs

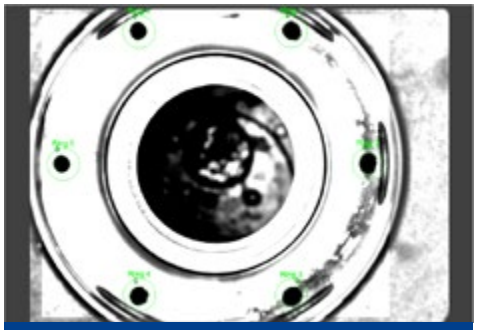
Transport to transfer rack cell 4



Leak testing of the unassembled housings

Clamping of the component as well as automatic pinning

Manual pre-assembly of cooling ring



Camera-based verification of pre-assembly

Automatic assembly cooling ring

Transfer to the cooling ring screw station

Positioning in transfer rack to Cell 5

Loading for assembly of sheet metal covers

SOME INDIVIDUAL OPERATIONS AT A GLANCE (CELL 5 & 6)

Automated removal of the sheet metal covers

Sealant application

Positioning and screwing the sheet metal covers

Deposit in rack system for curing of sealant and transfer to cell 6

Removal from shelf system

Leak testing of the fully assembled components

Rejection of the tested components

Manual final inspection

Manual work station for sheet metal ring assembly (rear axle, type Performance)

Quality control reassessment

Scanning and labeling of the finished parts

Packing for transport

SPECIAL FEATURES IN THE PROJECT

Now that the technical highlights of the machine have been described in detail, we would like to talk about a factor that should not be underestimated: The modularity of our machines. In this specific case, a capacity and type extension was carried out during the course of the project, and some of the housings were integrated into the plant only at a later date, which naturally necessitated sophisticated extensions. Thanks to good preparation and intensive coordination with our customer GF Casting Solutions, this was easy to implement thanks to the modularity of our concepts.

Facts

- Production in 1:1 mix of four different housing types with different processing times as well as assembly and test contents
- Leak testing using mass flow method
- Cycle time <106 seconds
- Intelligent raw part feeding via buffers and storage systems

CONCLUSION

Normally, in this section of the reference projects, we list an overview of the various process steps, divided into leak testing, assembly technology, and automation. For this major project, however, the space should rather be used for a small conclusion including an appeal:
With this exciting project, we would like to demonstrate the high performance that modern special mechanical engineering is capable of. Every manager knows how demanding it is to coordinate all employees in such a way that everyone works as efficiently as possible and is sufficiently supplied with work and the work materials. At the same time, the work must be checked and, ideally, errors should be detected even before they happen. The comparison may sound a bit lame, but the software of this plant faces a similar challenge – and is doing its job really well so far. Intelligent warning mechanisms report possible errors even before they occur or provide extensive data for tracing problems that have already occurred. In this way, state-of-the-art automation is implemented with a entirely new level of process reliability, fully adapted to the wishes and requirements of our customer. And this can also be transferred to other industries, because the still untapped potential with regard to Industry 4.0 is still rather great almost everywhere. So have the courage to think in a completely new way for your next project...

Christof Nölke, Sales
inquiry@paul-koester.de
+49 (2982) 92 11-866

CONTACT

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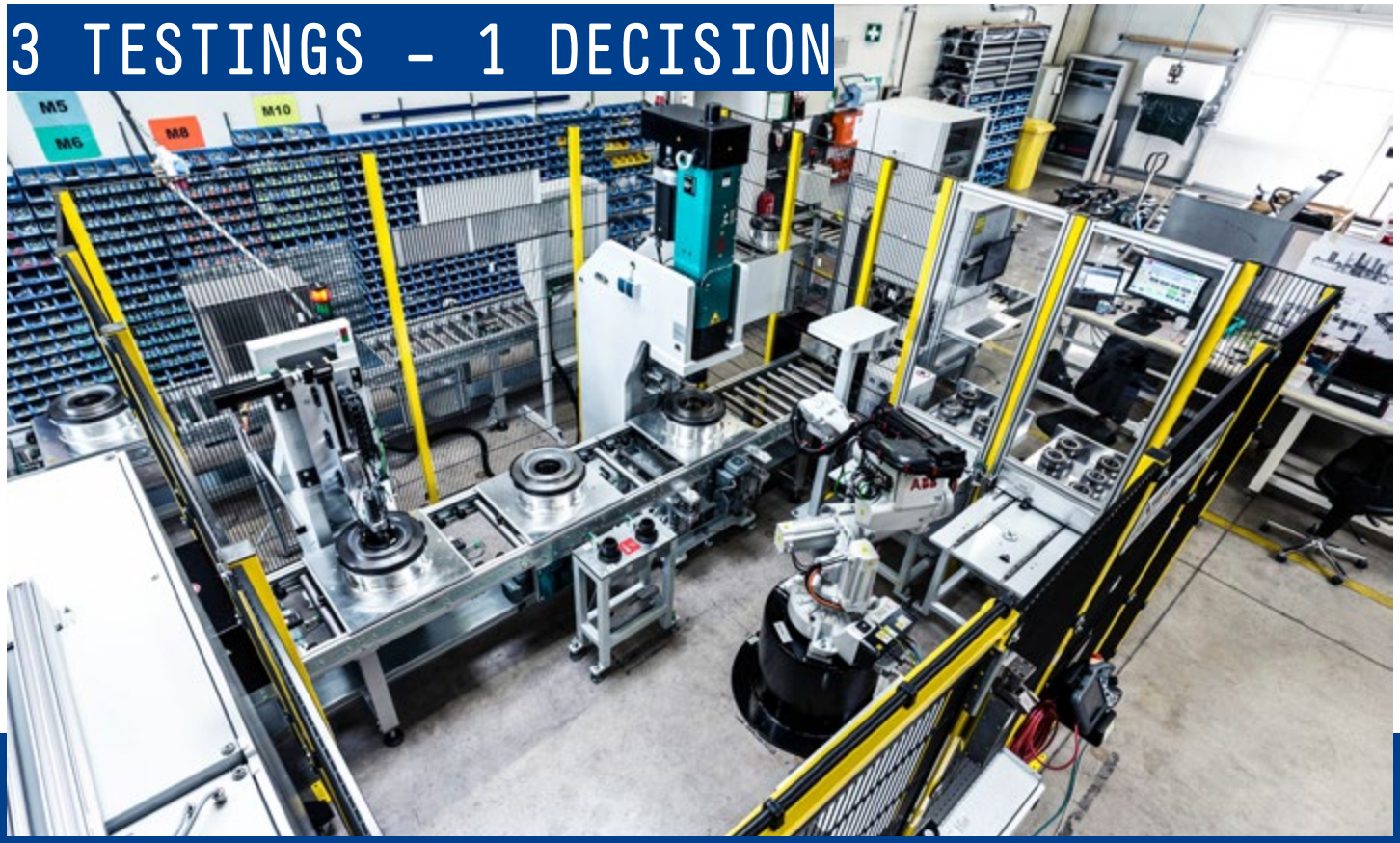
Paul Köster
Medebach • Germany

ASSEMBLY LINE FOR TRUCK AXLE HUBS

A DIFFERENT TYPE OF POWER STRUGGLE

3 TESTINGS – 1 DECISION



The question here is: OK or NOK?! The customer, a manufacturer of trucks and buses, attaches great importance to quality. Not every component reaches the end of the machine for withdrawal. Prior to this, they need to pass three different testings within the assembly process. If only one of the criteria doesn‘t fulfill the requirements, there is no possibility to pass the red light and NOK stopper. Sounds like an interesting story? Not really, the quality control is part of our customers‘ daily business and for us as a special mechanical engineering company it is one of our core competences.

So why is this machine so impressive? In the end the overall concept and the invested know-how of our designers and engineers make the difference: Various process steps have been combined time- and space-savingly, even though the component weighs around 30 kg and is anything but easy to handle. The assembly line seems to be small and without attracting attention, but who expects forces up to 150 kN behind this pressing unit?! Also, the detailed data, which is stored and visualized throughout the entire process, enables a completely new level of live information supply.

Maybe after all this is turning into an exciting story...you decide!

SOME INDIVIDUAL OPERATIONS AT A GLANCE

manual part loading into special workpiece carriers

inward transfer via separating stops

entering the measuring station including DMC-reader and DIATEST measuring system

testing diameters regarding different drill depths

manual loading of storage cabinets

withdrawal of the bearing via robot and automatic DMC-reading of each part

positioning of the bearing for temperature measuring

temperature difference >2°C between housing and bearing: positioning on the NOK-storage

temperature difference <2°C: pressing in with forces up to 150 kN

in case the measured force/stroke curve is NOK: transport to the NOK stopper, no laser marking takes place

measured curve is OK: transport to the laser cabin for DMC-reading and laser marking with the collected data

quality of the DMC is OK: transport of the assembled component to the unloading stopper

THE PROJECT IN FIGURES

3 decisions are crucial in this project:
- Is the prior mechanical processing alright?
- Is the temperature difference between the bearing and the housing within the rated range?
- Is the force/stroke curve of the pressing-in process as specified?

In case only one of these questions is rated negatively by the system, the outward transfer takes place at the NOK stopper with indication of the error data.

Facts

- component weight of ca. 30 kg
- 3 testings with DIATEST measuring system
- maximum pressing-in force of 150 kN
- collected data: geometric measured values, temperature data of housing and bearing, force/stroke values of the pressing-in unit & timestamp of the laser marking

INDIVIDUAL OPERATIONS IMPLEMENTED

This assembly line is not only an intelligent system which decides with the aid of modern techniques autonomously whether the component part is OK or NOK but also bundles information to keep the reason for the decision transparent. At the same time, it offers possibilities for interaction whereby it was paid attention to visualize only the most important parameters at different positions via IPC & touch panels.

Automation

- conveyor technology including inward transfer & constant traceability of the components
- integrated control of the prior mechanical processing quality via DIATEST measuring system
- handling of the bearings via robot including DMC-reading as well as positioning for temperature measuring with subsequent NOK outward transfer or handover for further processing

Assembly technology

- servo-motor-driven pressing-in of temperature tested bearings into the components
- laser marking of the assembled OK parts

Christof Nölke, Sales
inquiry@paul-koester.de
+49 (2982) 92 11-866

CONTACT

ARE YOU FACING SIMILAR CHALLENGES?

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Paul Köster
Medebach • Germany

PRODUCTION FACILITY BATTERY HOUSING

LEAK TEST XXL

WITH E-MOBILITY COMPONENTS

It was predictable that the massive changes due to the demanded mobility transformation will also affect the industry's conventional leak testing. Together with our customer we did the next step heading towards future mobility in different projects. The task was to integrate a leak testing facility into the existing manufacturing process. The leak test was carried out by using the mass flow procedure (air testing) and the leak detection in the case of NOK-parts via helium sniffing method (gas testing).
The characteristic of these projects was not only the timeliness of the topic, but also in the dimension of the component parts: With corresponding size these battery housings demanded a completely new mindset in all process steps and challenged our engineers consistently in the course of the project: How is it possible to reliably seal such a massive component part if the seal production can't set up rubber seals with a length of ca. 6.5 m in one part?
The solution of this challenge lay in the development of a special connection system for the realization of very long, closed seals. Also, the component handling via vacuum gripper system by robot and the in- and outward transfer of the XXL part needed a detailed coordination which led to conclusive general concepts.

SOME INDIVIDUAL OPERATIONS AT A GLANCE

part loading with special rack

application of a handling-robot with vacuum gripper system

air leak test with small test pressures

integrated maintenance mode for changing the upper sealing plate

loading rework-part on special handcart

handing over the OK-part for the next operation

outward transfer of NOK-parts via shuttle

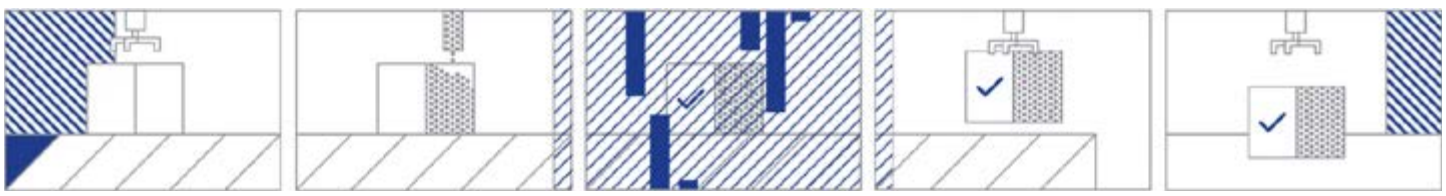
leak detection using helium

THE PROJECT IN FIGURES

Because of the huge component volume, the mass flow testing method was selected in this project. Though the high sensitivity for temperature influences played a decisive role, too. In addition, the difficulty of accurate sealing, which was solved by the development of a special connection system, made this project exceptional.

Facts

- component size analog vehicle platform
- longest sealing contour with a length of ca. 6.5 m, consisting of 11 single pieces
- integrated maintenance mode for changing the upper sealing plate



INDIVIDUAL OPERATIONS IMPLEMENTED

At first glance, the list of the individual operations implemented in the core areas of leak testing and automation appears very short, compared to other projects. However, if you look at them with the size of the component and the corresponding challenges in your mind, the intensive development work of this project quickly becomes apparent. At the same time, our project gives an idea of how far-reaching and exciting the effects of the new drive technologies will be on the future work of an entire industry.

Automation

- automatic removal of components from transport racks
- use of handling robots with vacuum gripper system
- outward transfer of NOK-parts via shuttle
- interlayer handling

Leak testing

- leak testing by air using the mass flow procedure including an integrated maintenance mode for changing the upper sealing plate
- manual leak detection via helium sniffing method

Christof Nölke, Sales
inquiry@paul-koester.de
+49 (2982) 92 11-866

CONTACT

ARE YOU FACING SIMILAR CHALLENGES?

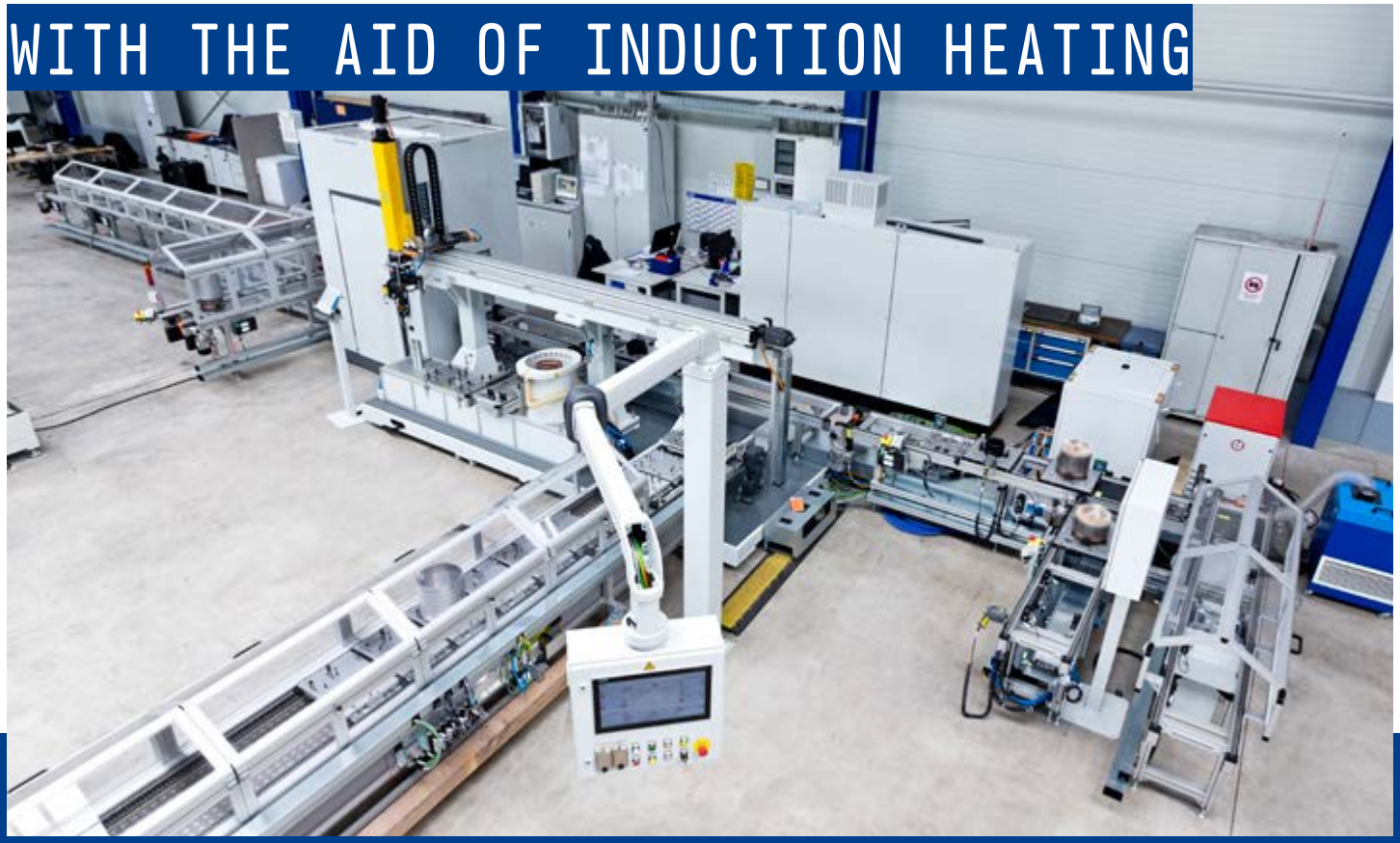
We would be happy to advise you on comparable projects and answer any questions regarding our reference cases.

Kolpingstraße 1
59964 Medebach
Germany
Tel: +49 (0) 2982 9211–0
info@paul-koester.de

Paul Köster
Medebach • Germany

ASSEMBLY LINE FOR ELECTRIC MOTOR PRODUCTION FACILITY

AN ETERNAL CONNECTION: JOINING WITH THE AID OF INDUCTION HEATING



At first sight the project task of our well-known customer who operates in the field of Hybrid- and Electromobility seemed to be unspectacular: An assembly machine to automatically assemble a stator into a housing to supplement an assembly line for electric motors at the customer‘s facility.
Our challenge: The stator has to be joined permanently with the component but the clearance was extremely small.
At this point our know-how in special mechanical engineering was demanded and we worked out an individual concept.
The keyword in this project was induction heating. Thus the housing was heated up to more than 200°C, then joined to the stator and afterwards cooled off. The resulting connection between the assembled part and the stator is not only technically highly interesting but also guaranteed to be durable.
Of course, the whole concept included further functions and details which were linked by state-of-the-art automation. Whether laser marking, an automated counter measuring device for the joining axis, side track for NOK-parts or special, antistatic conveyor technology - every detail was individually coordinated to meet the customer‘s requirements.

SOME INDIVIDUAL OPERATIONS AT A GLANCE

transfer of the component from premachine, if necessary merge of rework parts via DMC hand scanner

manual assembly station for cable clips

position control of the stator via camera

supply of the housings via circulating pallet conveyor

induction heating of the housing

following joining process including force/ stroke monitoring

side track for NOK-parts including withdrawal possibility after cooling time

cooling tunnel with covers including access facilities

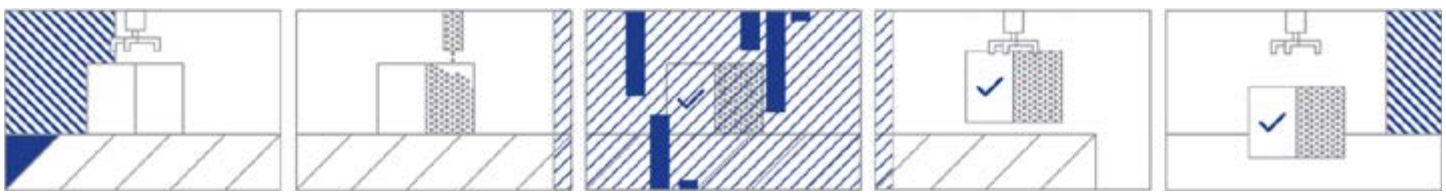
automated counter measuring device for the joining axis

THE PROJECT IN FIGURES

Not only the seamless integration of the assembly machine into the customer‘s existing production line required a perfect coordination but also the special demands of the component and the related safety aspects for the operators while working with strongly heated components were particularly considered.

Facts

- inductive heating up to more than 200°C
- antistatic conveyor technology
- multitude of components in “Clean Design“
- complete traceability of process steps in the Manufacturing Execution System (MES)



INDIVIDUAL OPERATIONS IMPLEMENTED

Inductive heating was the determining factor in the process of this manifold project by occupying the major part of the cycle time.
Additionally both heating and dilatation had to take place smoothly and the small clearance between stator and housing made this order especially exciting, too. Another important keyword was the implementation of the whole project in „Clean Design“ whereby the high cleanliness requirements for the stator were achieved.

Automation

- conveyor technology stator: Bosch transfer system
- conveyor technology housing: Circulating pallet conveyor
- additional conveyor merge of rework parts
- automatic position control via camera system
- use of X-/Z-handling system
- automated counter measuring device for the joining axis
- extraction point for NOK-parts

Assembly technology

- manual assembly station for cable clips
- joining in an inductively heated component
- force/stroke monitoring of the joining process
- laser marking

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+49 (2982) 92 11-866

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59964 Medebach
Germany
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info@paul-koester.de

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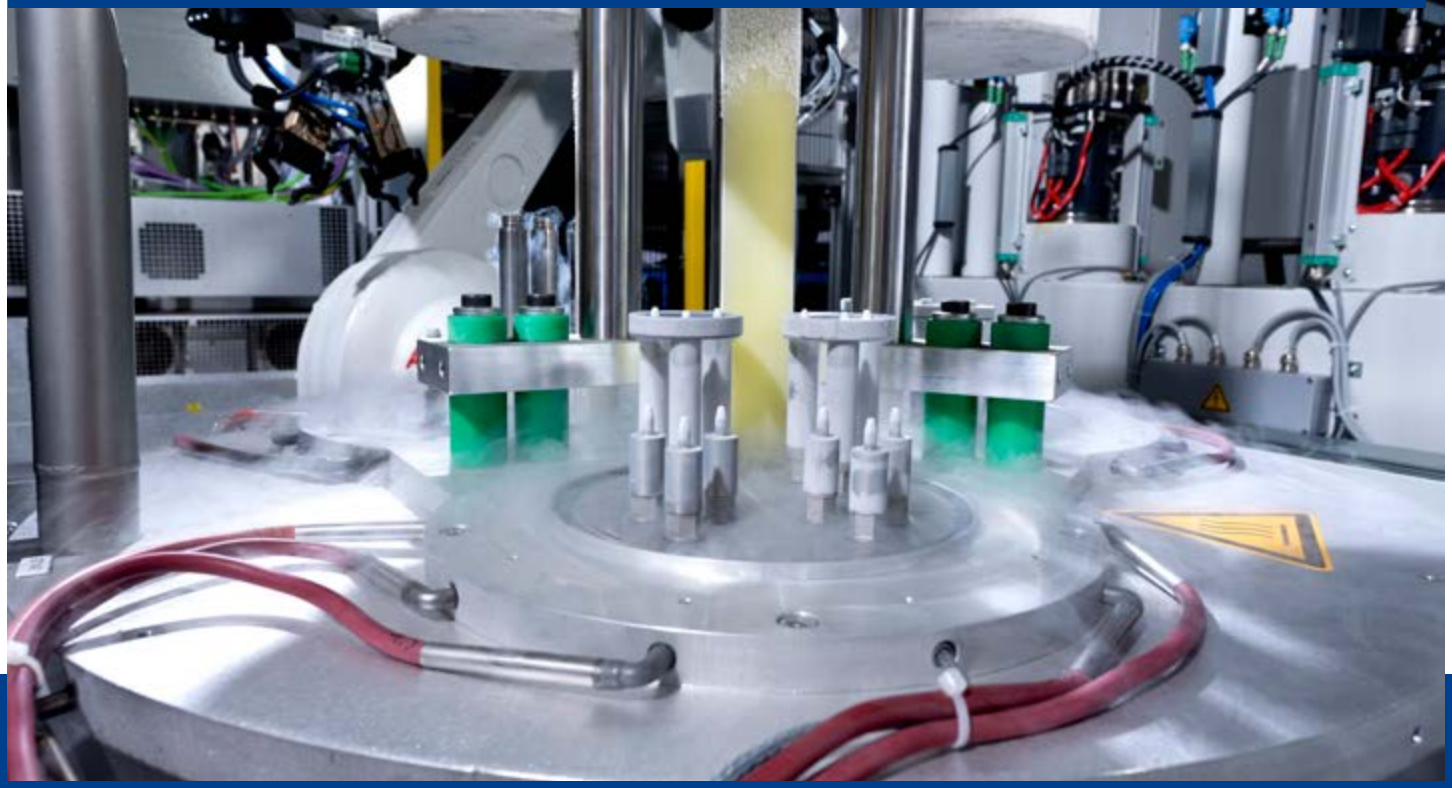
Medebach • Germany

CYLINDER HEAD ASSEMBLY PRODUCTION LINE

EXTREME SUPERCOOLING: PRESS-IN OPERATIONS AT APPROX. 200°C BELOW ZERO



Siberian conditions: We built a system for the assembly and leak testing of cylinder heads for a large manufacturer of trucks, buses and diesel engines from Russia. This even includes a liquid nitrogen container in which the components are super cooled for pressing in.

Precise assembly under extreme conditions is crucial for components that have been precision-machined down to the micrometer, such as valve guides or valve seat rings. Due to the extreme supercooling of the components using nitrogen, these are shrunk together to make it possible to press them into the openings provided. This is a high-precision process that has to be implemented in a very short time.

CELL 1: ASSEMBLY OF NITROGEN-COOLED COMPONENTS

Cell 1 general overview

Automatic supply of valve seat rings

Automatic fitting of the liquid nitrogen tank with valve seat rings and valve guides

Transfer of the cylinder head from the intake roller conveyor

Pressing in of nitrogen-cooled valve seat rings

Pressing in of nitrogen-cooled valve guides

CELL 2: ASSEMBLY OF CLOSURE ELEMENTS AND INJECTOR SLEEVES AS WELL AS LEAK TESTING

Transfer of the cylinder head from the intake roller conveyor

Loctite wetting and pressing in of threaded bushings and closure caps

Fully automated O-ring assembly

Loctite wetting of injector sleeves

Assembly of KVT expander plugs

Leak test of oil chamber using the pressure difference procedure

Horizontal visual inspection

THE PROJECT IN FIGURES

Precision and speed are equally important when working with extremely supercooled components.

Precise cycle times and accurate matching of processes present special challenges here.

Facts

- Cycle time of <78 sec. per cylinder head
- 10 process steps divided into two cells
- 5 Robots
- Supercooling of the components to be pressed in to -195.8 °C

INDIVIDUAL OPERATIONS IMPLEMENTED

The integration of manual processes with semi-automated and fully-automated procedures in assembly and material flow requires perfectly coordinated timing, which satisfies not just the needs of the manual work, but also the requirements of the special assembly conditions. In this project, we coordinated all steps down to the last detail.

Automation

- Component feed by roller conveyor
- Visual inspection by vertical and horizontal axes
- Use of handling robots

Assembly

- Pressing in of nitrogen-cooled valve seat rings and valve guides
- Pressing in of closure caps, including Loctite wetting
- Pressing in of threaded bushings
- Fully automated O-ring assembly
- Screwing in of Loctite-wetted injector sleeves
- Manual placement of a KVT expander plug

Leak testing

- Leak testing of the oil chamber using the pressure difference procedure

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inquiry@paul-koester.de
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Germany
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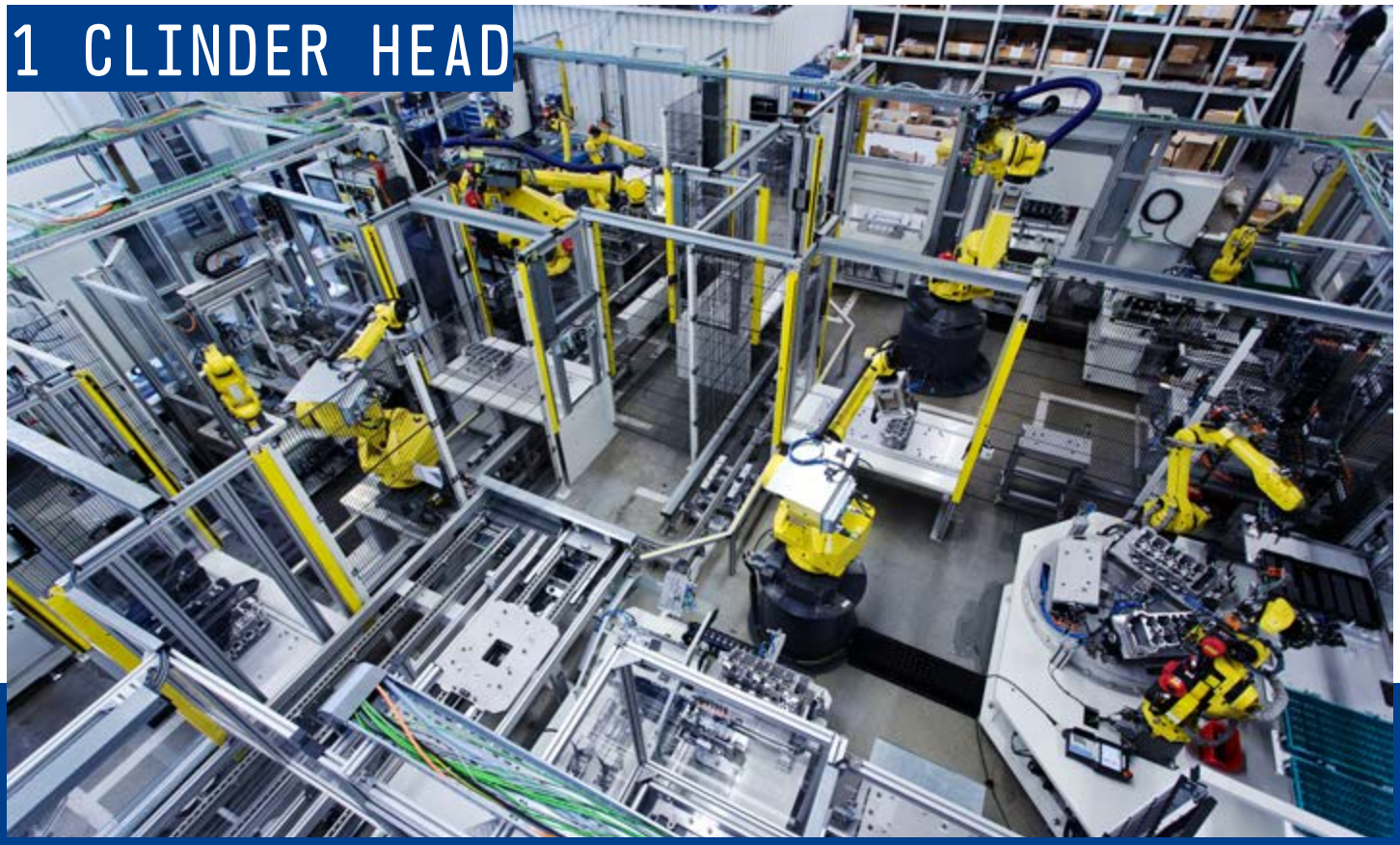
CYLINDER HEAD ASSEMBLY PRODUCTION LINE

16 ROBOTS, 2.88 MINUTES, 1 CLINDER HEAD



It takes less than three minutes for a complex cylinder head to be assembled from a series of sometimes very delicate individual parts and to leave the line. This system, built by Paul Köster GmbH, makes it possible to perform multi-step assembly operations in no time flat and check components for leaks in six different test cavities in a total of seven individual tests.

The nearly 25-meter long system for a well-known supplier of a leading car manufacturer in southern German was built and commissioned for the customer after detailed planning, design and production in Medebach. The highest precision, intensive coordination and deep process know-how ensure a reliable process for 18 individual operations.

Everything is provided by Paul Köster GmbH in this turnkey project, from the initial system designs to the overall comprehensive system.

SOME INDIVIDUAL OPERATIONS AT A GLANCE

Component feed transport system

Cylinder head cover leak testing

Cylinder head leak testing

Spring plate assembly below

Valve assembly

Valve key assembly

Hammering in valves and leak testing

HVA element and roller cam followers assembly

Spring and spring plate assembly

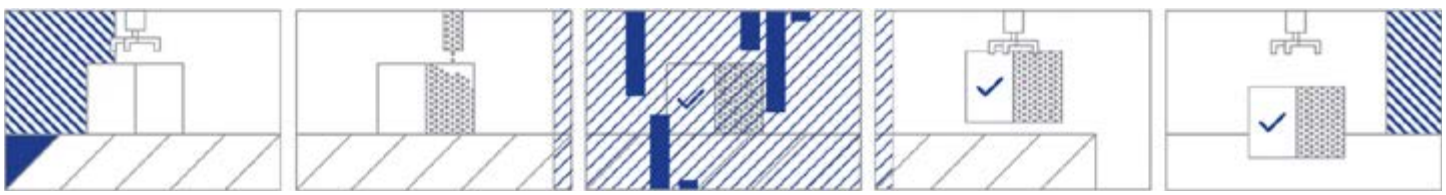
THE PROJECT IN FIGURES

Numerous interfaces were optimally coordinated for a smooth flow and consistent cooperation of the individual cells.

The complexity and multi-faceted nature was reflected not only in the individual assembly and testing operations, but also in the coordination and timing of all related processes.

Facts

- System approx. 25 m long
- 7 process steps
- 18 individual operations
- 16 robots
- Cycle time of <2.88 min per cylinder head



INDIVIDUAL OPERATIONS IMPLEMENTED

This project required all our core areas in order to ensure a functioning and well-tested component assembly.

The transport and provision of parts and individual components holds all individual processes together. The assembly stages were coordinated with the interspersed leak tests of the various test cavities so that, in the end, all essential steps run into each other rationally.

Automation

- Component feed transport system
- Visual inspection of cylinder head and cover
- Use of handling robots

Assembly

- Ball assembly
- Screw plugs, spacer screws, check valve
- Valve stem seal and spring plate below
- Valve assembly
- Spring and spring plate assembly
- Valve key assembly
- Assembly of spark plugs with type recognition
- Hammering in of valves
- HVA element and roller cam followers assembly
- Assembly stud bolts
- Camshaft manual pre-assembly
- Laser marking
- Manual unloading and packaging

Leak testing

- Cylinder head cover leak testing
- Cylinder head leak testing (water chambers, pressure oil channels, pressure-free oil chamber, air ducts)
- Leak test (combustion chambers, spark plug chambers)

Christof Nölke, Sales
inquiry@paul-koester.de
+49 (2982) 92 11-866

CONTACT

ARE YOU FACING SIMILAR CHALLENGES?

We would be happy to advise you on comparable projects and answer any questions regarding our reference cases.

Kolpingstraße 1
59964 Medebach
Germany
Tel: +49 (0) 2982 9211–0
info@paul-koester.de