ADDITIVE MANUFACTURING

GRENZEBACH

Automation Solutions
for Industrial 3D Printing

Content

Building Bridges

Connecting Places, and Breaking New Ground

Bridges create connections and open up new avenues. Anyone who has ever driven over the Golden Gate Bridge in America, the Beipanjian Bridge in China or the Viaduc de Millau in France has found the word "bridge" to have a deeper meaning. Sophisticated constructions, well thought-out designs, consummate engineering and at the same time always with the advantage of the users in mind. Courageously and energetically, the builders of these bridges have paved the way for others to advance in uncharted terrain, ascend to new heights and reach their goal with ease. Your expertise in 3D printing has opened up new avenues for numerous industries and ushered in the age of modern manufacturing. This inspires us, encouraging us to make even more progress in additive manufacturing with you by our side.

Build bridges. Break new ground. Connect people and innovations. This is done by experts from many disciplines, for whom the passionate use of additive manufacturing processes is quite simply part of the job. Designers are creating previously impossible designs using 3D printing. 3D printing manufacturers are producing components of unparalleled quality at an unprecedented speed—consequently achieving spectacular advances time and again. Developers, engineers and programmers, who get excited about additive manufacturing all over again every day, are behind these advances.

We love being involved here, contributing our experience and knowledge as well as driving forward innovations. With an optimistic yet critical view of things: As a partner and companion on your journey to becoming a 'lights-out factory'.

We at Grenzebach have also internalized and perfected this idea of "Think of what tomorrow will bring". Building on the knowledge of our founder and relying on the skill, ingenuity and innovative spirit of our employees, we have built our own bridges while paving the way for others, i.e. you, to achieve higher productivity and success.

Let's take the next step together and go into series production with your 3D printing expertise and our innovative automation solutions. Optimize your workflow for metal or plastic components by efficiently utilizing your 3D printing equipment. Take the pressure off your employees across the board. Create a working environment with the highest safety standards.

Take the path to a fully automated future. We will accompany you on this journey, and build bridges with you that fully satisfy your wishes and requirements.

Passion for Automation

Thinking Ahead and Opening Up Potential

Freedom. This is what 3D printing makes possible. In component design as well as in the development phase. Layer by layer, material is applied until the finished workpiece is finally held in your hands. However, the component goes through many manual intermediate steps before getting to this point. And this is where Grenzebach supports you.

As a reliable partner and companion, we put our experience in automation at your disposal. Grenzebach is one of the world's leading specialists in the automation of industrial processes. Thinking ahead when it comes to complex processes, designing them intelligently and unlocking potential—that is our passion.

- **1,600 employees worldwide**
- **Development and production sites in Germany, the USA, China, India, Greece and Romania**

1. CONSULTATION

We are your partnering consultant for automated additive manufacturing processes—from the project request, through detailed planning, right up to completion and beyond. Together with you, our experts work out holistic automation concepts that are tailored to your needs and budget.

2. PROCESS ANALYSIS

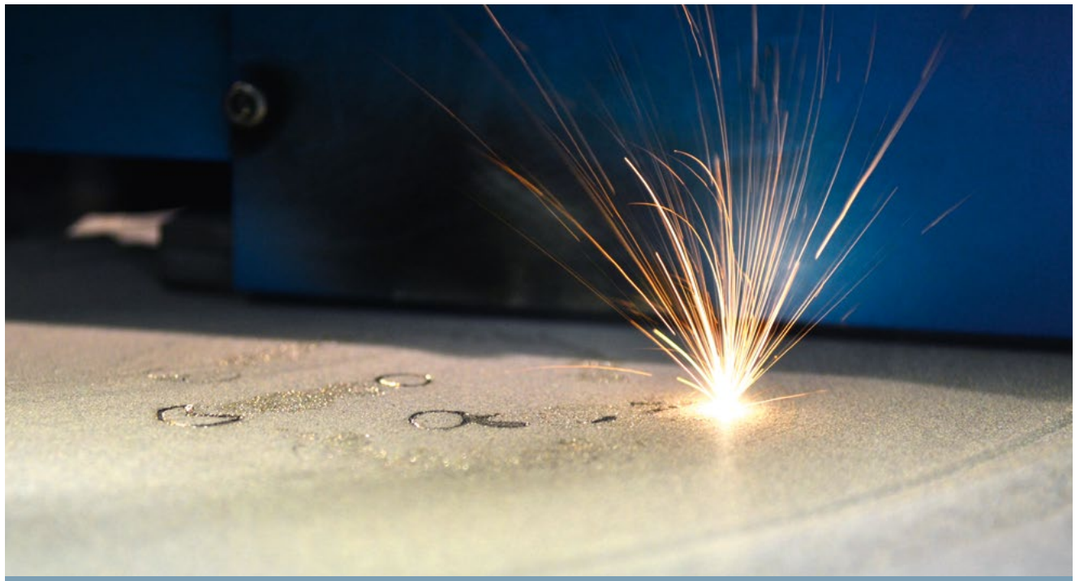
Based on a detailed analysis and the identification of potential for improvement, you will receive an individual solution package including hardware, software, and service—of a high quality, technologically innovative and digitally integrated.

3. MANUFACTURING AND SERVICE

After engineering, we test the prototype together with you. After successful commissioning, we move on to series production of your solution for you. As your partner for additive manufacturing solutions, you can count on excellent, reliable Grenzebach service throughout the entire lifecycle of your system.

Ready for Series Production

A New Era Begins: More and More 3D-Manufactured Components Made of Metal and Plastic



Markets of our customers and partners

- AM systems and peripherals
- Automotive
- Defense
- Energy
- Consumer goods
- Aerospace
- Mechanical engineering
- Medical technology

While industrial 3D printing has so far been used primarily for prototypes or small series, industrial companies are increasingly making use of the advantages of additive manufacturing (AM) for series production:

- **Great design freedom for the production of complex components**
- **Independence from tools and molds**
- **Consolidation of entire assemblies into a single component, consequently saving installation costs**
- **Individualization of the components**
- **High flexibility and short lead times**
- **Increased resilience through shortening of the supply chain**

Nevertheless, there are still many challenges for additive manufacturing on its way to series production. Up to now, a high level of manual effort has been required for setup and unpacking operations as well as for servicing the AM systems. In addition, the upstream and downstream process steps have different cycle times than the production of an additively manufactured component in the 3D printer, resulting in longer downtimes along the process chain. The occupational safety of employees must also be ensured when handling metal and plastic powders as well as hot objects.

> **The more heavily additive manufacturing is used in industrial series production, the more important it is to intelligently network the process steps from start to finish—from the transport of build cylinders to the removal of finalized components—in order to maintain a consistent level of quality.**

Oliver Elbert
Head of Additive Manufacturing at the Grenzebach Group

Automation That Will Impress
Efficient, Economical, Safe

Advantages at a Glance

Increasing productivity
Reduce the downtimes for your industrial 3D printers caused by cooling, unpacking and setup, and consequently increase the utilization of your AM systems.

Reducing unit costs
Increased productivity and reduced manual effort can significantly reduce unit costs per component. As a result, the automation solutions pay off within a short time.

Increasing occupational safety
Dust exposure for employees and hazards from hot objects are minimized. This spares you elaborate technical protective measures and personal protective equipment.

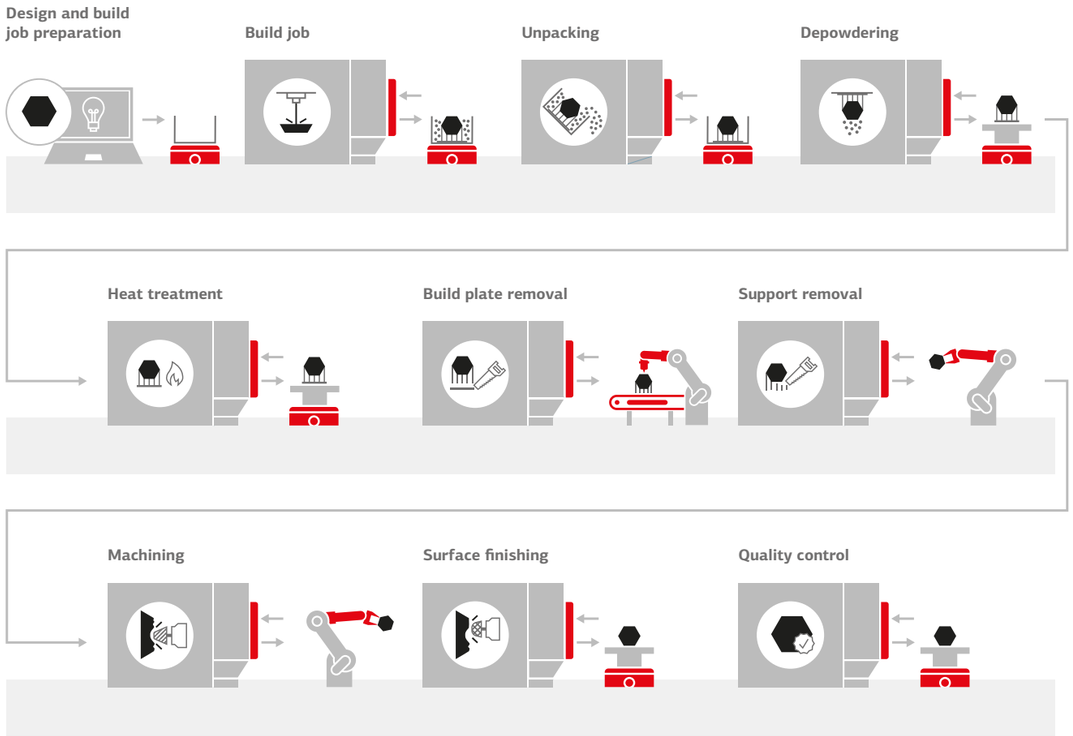
Reducing manual effort
Do not transport heavy or hot components, and carry out open powder handling. The physical strain for the machine operator is significantly reduced, and their work is focused on important and demanding operating steps.

Enabling reproducibility
The consistent and fully controlled execution of individual process steps minimizes the unwanted influence on the manufacturing process, which is often still sensitive.

Synchronizing the process chain
Unequal process durations can lead to downtime. Intelligent synchronization of various process steps increases system utilization and makes optimum use of investments.

Gaining independence from the shift model
Automation allows machines to be used in three-shift operation even though only one or two shifts are staffed with employees. This makes it possible to optimize production times and machine utilization (OEE). This is associated with a reduction in unit costs.

Automation Along the Process Chain



Thanks to the latest developments in artificial intelligence, hardware and software, it is now possible to intelligently automate almost every step of the process chain. However, especially in post-processing, many processing steps are still carried out manually compared with the preparation and printing phase.

Grenzebach's **automation equipment** can also be tailored to individual requirements and implemented for new as well as existing systems along the process chain. It includes:

» **Driverless transport systems and goods carriers**
Automated guided vehicles (AGV) can make processes more flexible in the long term. Suitable goods carriers are used open or closed (with/without inert gas) as required.

» **Machine fitting**
Locks or attachments connect the printers with post-process equipment and ensure an efficient and securely automated process.

» **Robot cells**
In the robot cells, different work steps such as gripping, removal and inspection are performed as standalone solutions or amalgamated up to the seventh axis. Robots from different manufacturers can be integrated.

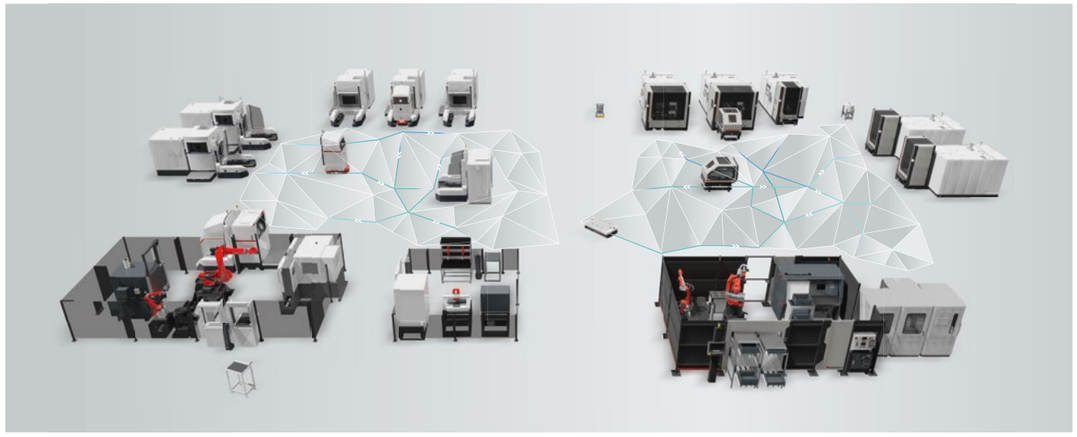
» **Transport and handling technology**
Permanently installed conveyor lines supplement driverless transport systems (DTS) as required. Material is delivered just in time, components are transported individually or on the build platform.

» **Inspection solutions**
The produced components can be sorted and checked for quality using inline or offline inspection solutions.

» **Software integration**
Digital interfaces enable data exchange between the machines and the higher-level control systems.

Intelligently Networked

Automation Solutions for Industrial Additive Manufacturing



Grenzebach's automation technologies are used to network systems such as 3D printers, depowdering or post-processing systems—mechanically, electrically, and digitally. Your process steps are intelligently interlinked in such a way that your systems are efficiently utilized, a safe working environment is created and an optimal production flow is achieved. If solutions are missing in the process chain, we can develop them for you.

CUSTOMIZING THE PROCESS CHAIN

The following steps can be integrated and networked:

Additive manufacturing processes

- Selective laser melting/ powder-bed-based melting of metal
- Selective laser sintering/ powder-bed-based melting of polymers
- Binder jetting
- Electron beam melting

Loading and unloading

- Replacement of empty and full build cylinders at AM systems and downstream process steps
- Removal of the interchangeable frames/build cylinders from a 3D printer

Depowdering

- Emptying the build cylinder
- Depowdering the build job
- Component cleaning

Processing

- Heat treatment
- Removal of support structures
- Separating from the build platform

Surface treatment

- Blasting
- Polishing
- Coloring

Testing and quality assurance

- Component sorting
- Component geometry
- Surface quality

Research Projects

Actively Shaping the Future

What does the future of the industry look like? How can additive manufacturing processes be intelligently networked? We regularly answer these and other questions as part of research projects. In doing so, we not only think outside the box, but also deliberately break away from familiar avenues. Because we are convinced that only those who question what currently exists, try things out and break new ground will change the future in a sustainable way.

Funded by the European Union
NextGenerationEU

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

nexAMo

Learn more about the project here

nexAMo: The nexAMo research project aims to develop modular, highly flexible matrix production for next-generation mobility products. Grenzebach is supporting the project, which is funded by the BMWE (Federal Ministry for Economic Affairs and Energy), in the areas of unpacking, exchanging and transport.

POLYLINE

POLYLINE: The POLYLINE lighthouse project, funded by the BMBF (German Federal Ministry of Education and Research), focused on the development of automated and efficient additive manufacturing of plastic components for series production in the automotive industry. Handling and bin-picking robots, exchange and transport solutions as well as automated guided vehicles were used and integrated into the overall concept by Grenzebach.

Learn more about the project here

SPONSORED BY THE
Federal Ministry of Education and Research

NEXT GENERATION AM

Learn more about the project here

NextGenAM: The series production of quality metal components via industrial 3D printing was the goal of the NextGenAM (Next Generation Additive Manufacturing) innovation project. Aerospace supplier Premium AEROTEC, automotive manufacturer Daimler and technology provider EOS developed an integrated and automated process chain for this. Grenzebach contributed to the success of the project as a solution supplier to EOS.

Selective Laser Melting
Automation for Metal Components

Selective laser melting (SLM), also known as powder bed based metal melting, uses a computer model to create a metal component. By adding Grenzebach automation technologies to the printing process, you take your production flow to a new level and make your additive manufacturing even more efficient, safe, and cost-effective.

SLM ON COURSE FOR GROWTH

The market for SLM is growing. Due to the increasing standardization of this additive manufacturing process in industry, more and more companies are venturing toward the factory of the future, especially in the aerospace, automotive, medical, toolmaking and turbomachinery industries. However, the biggest challenge is still the long production time of a component in the AM system, while upstream and downstream production steps have significantly shorter processing times.

OUR AUTOMATION SOLUTIONS: FULLY AUTOMATED

What if the 3D printer could be automatically loaded, the metal powder could be extracted, and the build platform could be gripped and transported open or closed (with/without inert gas) from workstation to workstation? Grenzebach automation solutions allow you to do precisely this ... and even more.
Driverless transport systems (DTS) and goods carriers network your individual workstations. Locks or attachments enable an efficient and safe automated process. Robot cells grip components or containers, pick up carrier plates or inspect the produced parts inline or on a standalone robot-guided inspection system. Permanently installed conveyor lines supplement the DTS as required. Components are transported individually or on the build platform. The entire 3D printing process, including upstream and downstream areas, can therefore be digitally mapped and controlled.

AUTOMATION SOLUTIONS FOR METAL PRINTERS

Depowdering Solutions
Automatic powder removal and return, as well as ergonomic setup, become child's play with Grenzebach unpacking stations. You benefit from increased productivity and reduced downtimes.

Transport Solutions
Transport solutions from Grenzebach introduce movement into your process chain. Open or closed, hot or cold, with or without inert gas: Our docking stations and transport containers offer full transparency, traceability, and safety.

Customized Solutions
Do you have an unconventional production environment or have to cope with particular working conditions such as heavy parts? We develop AM solutions for your specific requirements, tailored to exactly fit your existing equipment.

EXAMPLE APPLICATIONS

- **Prototype and development components**
- **Pilot series and small series**
- **Spare parts e.g. in mechanical engineering**
- **Devices and equipment**
- **Toolmaking**
- **Automation of handling systems**
- **Development of novel components**

WOULD YOU LIKE TO LEARN MORE?

Visit our website and discover our current range of metal components.

Selective Laser Sintering
Automation for Plastic Components

Selective laser sintering (SLS), also known as powder bed based polymer melting, creates a plastic component based directly on a computer model. By adding Grenzebach automation technologies to the printing process, you take your production flow to a new level and make your additive manufacturing even more efficient, safe, and cost-effective.

MOST ADVANCED AND MOST RELIABLE 3D PRINTING TECHNOLOGY FOR PLASTIC

SLS is one of the most modern and reliable 3D printing technologies in the field of additive manufacturing for plastic. Until the 3D-printed component meets all quality requirements, it undergoes further—often still manual—post-processing steps after production.

OUR AUTOMATION SOLUTIONS: FULLY AUTOMATED

What if the build cylinder could be removed from the printer, an empty build cylinder could be loaded automatically, the build job could be transported open or closed from workstation to workstation, and individual components could be gripped and sorted depending on the order? Grenzebach automation solutions allow you to do precisely this ... and even more.
Driverless transport systems and goods carriers network the individual workstations. Locks or attachments enable an efficient and safe automated process. Robot cells grip components or containers, and inspect the produced parts inline or on a standalone robot-guided inspection system. Permanently installed conveyor lines supplement the DTS as required. This means that the entire 3D printing process, including upstream and downstream processes, can be digitally mapped and controlled.

AUTOMATION SOLUTIONS FOR PLASTIC PRINTERS

Exchange Solutions
Buffering, loading, and storing: All this and even more is possible with our exchange solutions for serial laser sintering.

Transport Solutions
Everything in flux. With our automation solutions for laser sintering process chains, we provide safe transport as well as efficient loading and unloading of interchangeable frames between different processing stations, e.g. furnaces, unpacking, or depowdering stations simply and quickly.

Bin-picking Solutions
Not all bin-picking is the same. No matter whether you're looking for a modular solution or complete solution, our bin-picking solutions separate your components using the latest hardware and visionary 3D sensor technology.

Customized Solutions
Off-the-shelf solutions not for you? No problem. We develop AM solutions for your specific requirements, tailored to exactly fit your existing equipment.

EXAMPLE APPLICATIONS

- **Prototyping and mass production**
- **Robotics component and gripping systems**
- **Plastic housing**
- **High-performance components**

WOULD YOU LIKE TO LEARN MORE?

Visit our website and discover our current range of metal components.

Tailor-Made Fits Best

For Your Process Chain With Particular Requirements

Do you have special requirements? We have the solution. As an experienced partner, we work with you to develop solutions that are precisely tailored to your needs for an efficient and industrialized process chain.

Your requirements and wishes come first. We therefore work with you to analyze the necessary automation requirements so that you can make optimum use of your equipment and sustainably increase your productivity. In doing so, we integrate existing and new machines into the optimized manufacturing process. We will then provide you with a tailor-made concept, with recommendations on how you can quickly and easily integrate automation solutions into your standard production processes.

Our services for you:

- **Consulting and needs analysis**
- **Simulation and software development**
- **Project management and training**
- **Installation and commissioning worldwide**
- **Flexible worldwide service and support**

Developments and Partners

Reaching the Goal Together: From Concept Development to Series Production

EOS

EFFICIENT AND SAFE

In order to further advance the additive manufacturing of metal and plastic components, EOS and Grenzebach are jointly developing a range of peripheral equipment. The focus here is on the highest possible utilization of the industrial 3D printer and the associated peripherals, efficient and robust production processes, and the best possible occupational health and safety in production. The collaboration began with the automated interlinking of EOS Shared Modules for components in metal 3D printing. The partners then developed the Exchange P500 and Transport P500 automation solution for polymer printing. This was followed by further equipment such as the Dual Setup Station unpacking solution for the metal sector. The range is constantly growing and is opening up further avenues to industrial series production for EOS customers.

Nikon SLM Solutions AG

FAST AND RELIABLE

SLM Solutions wanted to expand its range with a depowdering solution for its NXG XII 600 printer that can process build cylinders weighing up to 2.3 tons while keeping manual operations to a minimum. Grenzebach developed an initial concept design together with SLM. The design phase then began, and Grenzebach produced a prototype. Due to their high level of expertise in the development and production of additive manufacturing solutions, the first prototype was delivered and put into operation in less than twelve months.
The depowdering solution developed is a versatile and cost-effective solution that helps customers streamline their operations and increase safety for employees. The Reclaim 600 can be operated with several printers in parallel. In addition, the depowdering solution can be integrated seamlessly into existing SLM hardware such as the universal powder tanks and the NXG XII 600 build cylinder, simplifying the workflow and eliminating the need for additional tanks or storage solutions.

> **We chose Grenzebach because they have many years of experience in the development, automation and handling of heavy components. We are very satisfied with the project and the resulting solution, which we have already delivered to customers all over the world. We will also continue to work together to develop technologies that meet the growing requirements of our customers.**

Sebastian Feist
Product Manager Factory Integration & Periphery, SLM Solutions

You Can Trust Us
The Grenzebach Service Promise

With our solutions, you not only master the challenges of additive series production, but also benefit from our comprehensive service offerings. We make sure that the technology you've invested in delivers on its promise. Count on Grenzebach for added value and durability – because we live and breathe service and automation. Around the clock. Around the globe.

THE GRENZEBACH SERVICE MODULES FOR ADDITIVE MANUFACTURING. EVERYTHING FROM A SINGLE SOURCE.

EXCELLENT SERVICES
Optimizing the availability of technology, keeping output consistently high, designing usage to be sustainable:

- **Remote support**
- **Health checks**
- **Preventive maintenance**
- **Customer training**
- **On-site service call-outs**
- **Flexible service contracts**
- **Warranty extension**

ORIGINAL PARTS
Securing maximum performance, value retention thanks to long service life, reducing downtimes:

- **Excellent quality**
- **One-stop shopping**
- **Maximum production reliability**
- **Maximum availability**
- **Optimal customer service**
- **Long service life**
- **Worldwide delivery**
- **Electronic parts catalog**

ROLLING UPGRADES
Increasing output, increasing the productivity of the system and extending service life:

- **Process optimization**
- **System overhaul**
- **Hardware and software modifications**
- **Technical consulting**

FUTURE SERVICES
Using Grenzebach's software landscape SERICY, benefiting from smart, robust processes:

- **Predictive maintenance**
- **Online documentation**
- **Reporting**
- **Statistics**
- **Analyses**

WE SERVICE | **WE LIVE SERVICE**
– ADDED LIFETIME AND ADDED VALUE

A Strong Partner by Your Side
Mastering Series Production Together

By choosing Grenzebach, you are entering into a trusting partnership with a reliable partner throughout the lifecycle of your additive manufacturing solutions. As an expert journey partner, we are by your side with advice and assistance during the planning and implementation of systems.

Our Service department responds flexibly to individual challenges with customized services and products. During the utilization phase, the after-sales team supports you in using the system optimally for as long as possible or adapting it to new requirements through modernizations.

Automation solutions are the key to a lights-out factory. Our additive manufacturing solutions form a highly efficient unit here. Our goal is to relieve the burden on your employees in the best possible way and to sustainably increase your productivity. That's why we're consistently thinking about tomorrow as early as today.

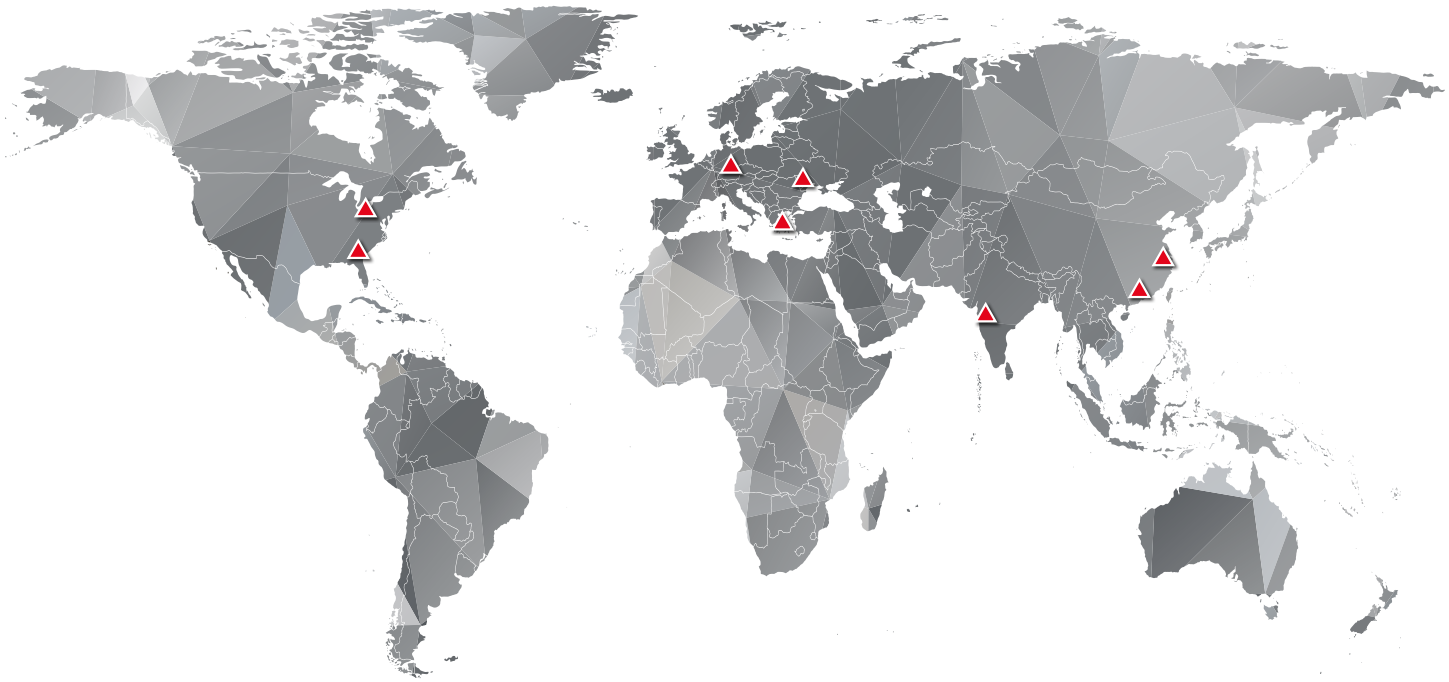
Christian Herfert
Head of Special Technologies at the Grenzebach Group

Rely on over 60 years of experience in the automation of industrial processes. With Grenzebach's expertise, gained through projects with numerous well-known customers from all over the world, suitable solutions can be found for every customer—quickly, reliably, and at a high quality.

Stay on the safe side with Grenzebach

- **An independent family business with great financial strength and its own financial reserves**
- **Complete solutions provider**
- **Rapid prototyping and fast updates**
- **Worldwide manufacturing and service with local contacts**
- **Certified partner (TISAX, ISO 9001, etc.)**
- **Durability of systems and vehicles**

WORLDWIDE



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