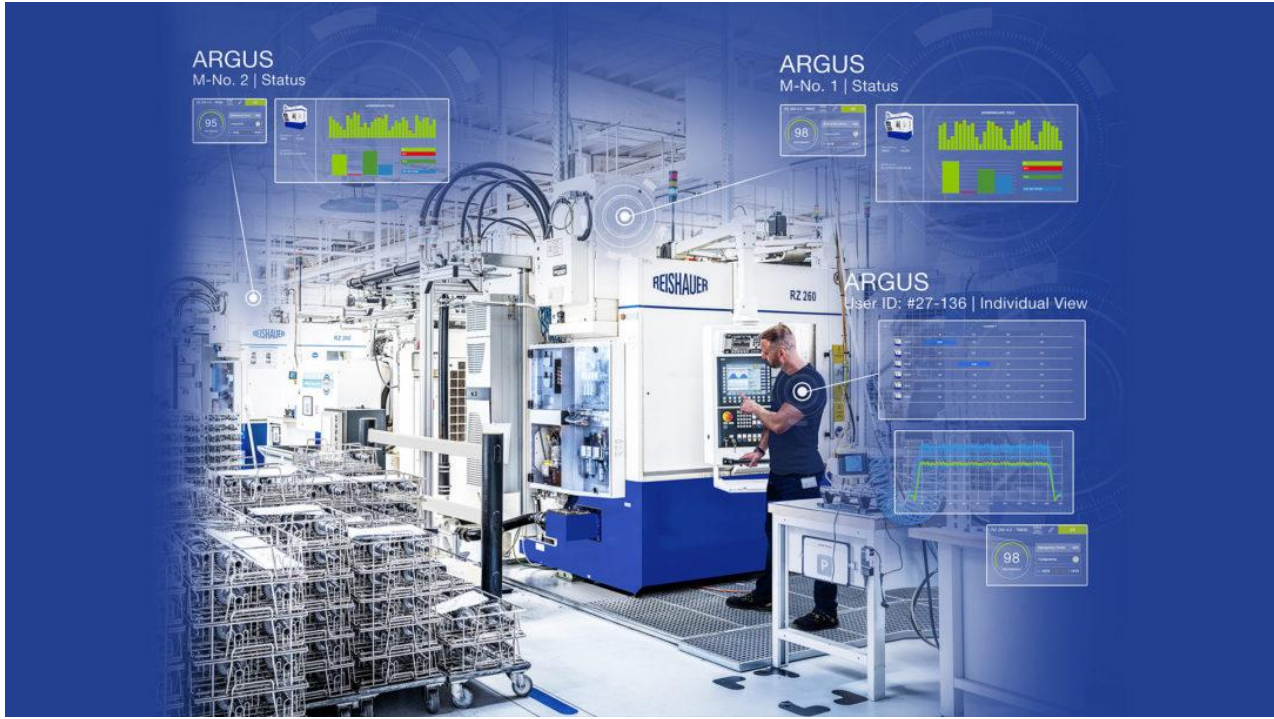


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Digitization of Hard Fine Machining of Gears in a Production Environment

The goal is to optimize processes further and extend tool life to meet increasingly higher quality standards while reducing production costs

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A view of the ZF production environment.

ZF-Brandenburg exemplifies modern manufacturing processes utilizing digital technologies. Integrating machines and production technologies into the digital world, where machines connect to the cloud and algorithms assist in assessing machine statuses, is already standard practice here. Operators, planners, and managers are always networked with all

systems in real time, making ZF-Brandenburg a pioneer in digitalization best practices. Among other innovations, ZF employs the Argus Monitoring System from Reishauer to digitalize its machine tools in the hard fine machining of gears. This article by Reishauer AG summarizes the insights gained from digitization in the machine tool sector, highlighting the long-term collaboration between the two companies. ZF Getriebe Brandenburg GmbH, distinguished by a team of over 1,500 specialists, leads in producing exclusive manual and dual-clutch passenger car transmissions used in high-end German sports cars for maximum precision and performance. A crucial factor in the quality of these transmissions is the precise ground gears manufactured on machines from Reishauer AG, a Swiss pioneer in gear grinding machines.

Reishauer's ARGUS system is a groundbreaking innovation for monitoring processes and workpieces produced at ZF. This system enables the evaluation and optimization of the grinding process quality and the precise monitoring of machine components and grinding tool wear. The collaboration aims to leverage joint synergies by combining specialist production knowledge with the innovative power of digital solutions. Both companies are deeply committed to continuous optimization, resulting in a mutually beneficial partnership. ZF utilizes the ARGUS system to meticulously monitor processes and machine components in gear production, achieving significant advancements in its manufacturing technology.

What Will Gear Production Look Like in the Digital Age of 2024?

ZF Brandenburg revolutionized gear production by comprehensively implementing the ARGUS monitoring system. Today, almost 100 percent of all components are monitored directly, permanently, and seamlessly in real-time. This continuous monitoring guarantees an unprecedented level of safety in modern gear production. The ARGUS system monitors components and ejects potentially defective workpieces during the machining cycle, preventing quality issues in subsequent assembly stages. This proactive approach enhances process reliability and significantly reduces costs in later process steps. Process planners can react immediately to unexpected issues, such as frequency excitations. With 100 percent control provided by the ARGUS system, they can see exactly how each component is or was ground, recognize machine conditions, and identify problems in real-time. This allows them to eject faulty components from the machine or block critically identified parts in the process flow before installation in gearboxes, thus preventing faults that previously led to costly dismantling measures. The ARGUS system enables efficient detection of grinding worm breakages caused by local overloads during pre-machining fluctuations and easily detects rare large breakages due to collisions. One of the primary reasons ZF acquired the ARGUS system was to address challenging vibration problems. Shortly after implementation, with the expertise of Reishauer, ZF developed the ability to detect potential sources of vibration in specific working areas of the grinding worms.

Calibration of the process monitoring was optimized to remove components that could potentially cause unwanted noise (NVH) in transmissions from the process chain. This optimization resulted from analyzing large amounts of data in the ARGUS web application, ensuring a higher quality of the final product and enhancing overall production efficiency.



Production planner Denny Macholdt showing pride in his achievement.

The Impact of the ARGUS System on Gear Production at ZF Brandenburg

The ARGUS web application is accessible through any web browser, and its user-friendly interface is a standout feature. Even an inexperienced user can identify problems in the production environment with just a few clicks. However, resolving quality-relevant issues requires expert knowledge. ZF Brandenburg employs quality engineers specifically for this purpose, which has greatly simplified and accelerated the implementation of ARGUS. Reishauer AG consistently provides its customers with qualified, long-term support for digital applications and technological tasks.

Production Before ARGUS

Before the introduction of ARGUS, quality problems were often identified only at the end of the production during the end-of-line (EOL) testing. Statistical process control within a low percentage range could only detect static or slow changes. This meant faulty gears were often installed in gearboxes before defects were discovered. To determine the source of a fault, gears from the defective gearbox had to be measured using tactile methods in the measuring room. For example, if a component fault was linked to a grinding worm breakage, all components ground on that particular day had to be identified. In such cases, the affected production lot had to be blocked, and all components might need to be checked 100%. The resulting high follow-up costs were significant. Although such events were relatively rare, anomalies detected during EOL testing led to dismantling costs that were substantially higher than if the grinding machine had already sorted out potentially faulty parts. After hard finishing, the process steps become significantly more cost-intensive. Considering the unnecessary number of process steps, the working time, and the material costs due to components that were not ejected, it becomes clear how cost-effective and productive the grinding process with ARGUS is.

With the help of the ARGUS process monitoring system, every user can access all relevant data on their machines at any time and from anywhere, allowing them to make informed decisions.

Data Evaluation, Analysis, and Operability

Today, the ARGUS web application enables planners to view the production process in real-time from a PC on the shop floor, in the office, or on a mobile tablet, regardless of location. One production planner commented, “The system allows us to think more deeply about the process and make more targeted decisions. With ARGUS, we can identify harmful frequencies and determine the speeds that should be avoided to ensure the process’s safety and quality.” Data analysis can identify error patterns and eliminate these potential problems directly on the machine. Once this step is taken, process optimization usually begins. In ARGUS, technology parameters can be easily linked to measurement data. This approach often reveals simple opportunities where small changes can quickly lead to greater effectiveness. Of course, this is always subject to the system’s inherently high process reliability.

“The ARGUS system enables us to gain deeper insights into the process and make more precise decisions.”—Denny Macholdt, ZF process planner.

Enhanced Machine Condition Monitoring

In addition to analyzing the grinding process, ARGUS excels in machine condition monitoring. With automatic component diagnostics (ACD), machine signals are constantly monitored and automatically evaluated to identify potential component failures. Autonomous test cycles take only a few minutes and record extensive data daily. These test cycles are designed with sensors to detect machine faults quickly. Cloud algorithms then display the collected data as a simple traffic light signal. A red light indicates that immediate action is required.

Before implementing ARGUS, ZF had to conduct complex measurement series and grinding tests to identify problems, such as profile form errors caused by a worn shift axis. This process required two to three employees and incurred significant costs. With ARGUS and ACD, it is now possible to immediately determine if a machine component is the cause of a problem, significantly reducing labor and downtime. ZF's planning department rated the usability of the ARGUS system as very user-friendly. Two to three hours of training is sufficient for a machine operator to use the ARGUS system effectively and take data-based actions.



Reishauer's inventor of ARGUS, Dr Christian Dietz and ZF's Denny Macholdt.

Expertise and Collaboration in Gear Production

However, more detailed analyses, particularly the frequency analysis offered by ARGUS, require significantly more experience. ZF has gained this expert knowledge through its collaboration with Reishauer and by developing its internal expertise in process planning. This increase in in-house know-how includes appointing an NVH expert who exclusively handles machine vibrations. Since the digitalization of gear production at ZF, a division of tasks and collaboration between machine operators and process planners has been established. Planners focus on data analysis of large production batches, derive evaluation limits, assess trends, and take appropriate action. This division has led to considerable improvements in production.

Conclusion

ZF emphasizes that production has significantly improved with the use of ARGUS. The system's precise definition of limit values has increased the quality of manufactured parts. Defective parts are effectively identified and sorted out for subsequent processing, reducing the number of rejected parts and wasted production time. Additionally, the cost reduction due to the significant decrease in end-of-line (EOL) returns is quantifiable, as the number of returns has fallen markedly since the introduction of ARGUS. ARGUS also helps minimize tool costs by providing detailed insights into the condition of the tools. This insight allows using tools to their performance limits without prematurely removing them from the production process based on the potentially incorrect assumption that their service life is nearly exhausted after a predefined number of usage cycles.

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