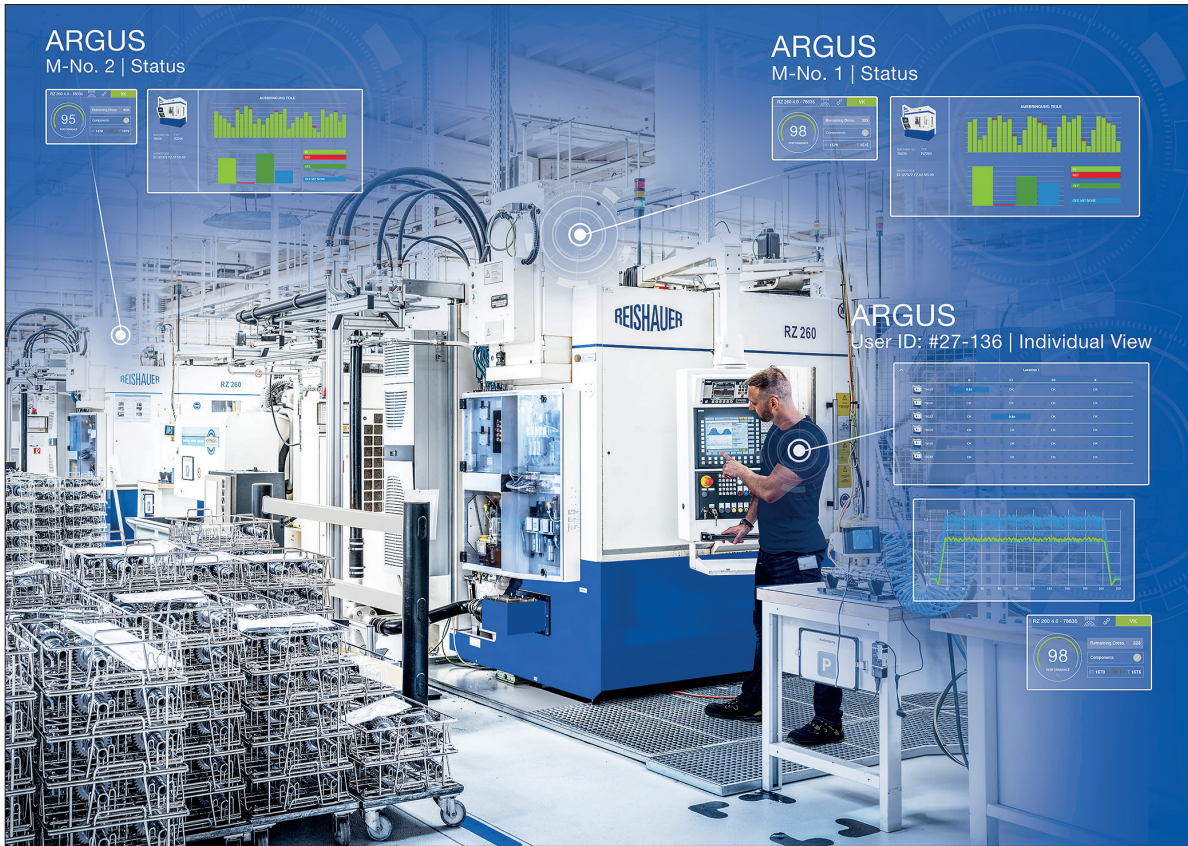


Tooling, a key part of the overall generating gear grinding process

written by Walter Graf

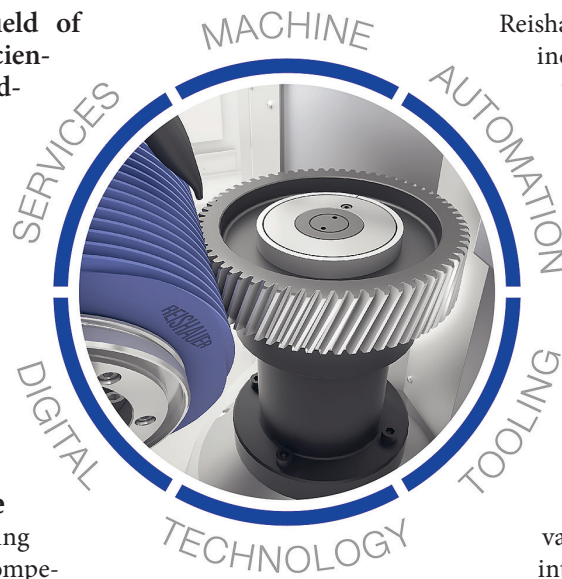


Shopfloor environment with ARGUS monitoring of process and tooling

■ In the precision-driven field of gear manufacturing, the efficiency and reliability of gear grinding machines are crucial. This article examines the characteristics of Reishauer gear grinding machines and their integrated system approach. While all system components are important, this article focuses on the tooling, with other elements addressed in less detail.

The Reishauer Circle of Competence

At the core of Reishauer's grinding philosophy lies the "Circle of Competence", a holistic system encompassing every aspect of the gear grinding process. Instead of concentrating solely on building machine tools,



Circle of Competence

Reishauer offers an integrated system that includes machines, automation systems, tooling, technology, digital solutions, and support services. This comprehensive approach ensures that all elements function together effectively, enhancing efficiency and precision in gear grinding.

Machines: precision and reliability

Reishauer gear grinding machines are engineered for precision, reliability, and high performance. Equipped with advanced CNC controls and modern interface concepts, they maintain consistent quality and machine availability. This consistency is crucial for manufacturers requiring high-volume production with repeatable accuracy.

Automation: integrated efficiency

The company builds automation systems that integrate with the gear grinding machines to meet modern production demands. These modular and customizable systems allow manufacturers to tailor automation to their specific needs. By synchronizing automation with machine operations, idle times are minimized, and throughput is maximized.

Digital systems: industry 4.0 integration

Furthermore, Reishauer provides digital solutions that are aligned with Industry 4.0 standards. The digital portfolio includes:

- predictive maintenance: uses data analytics to anticipate maintenance needs, aiming to reduce downtime
- advanced analytics: offers insights into machine and tooling performance and process optimization
- process monitoring: tracks key parameters throughout the grinding operation to ensure consistent quality

Integrating these digital systems enhances the performance and output of the machines and the tooling, enabling manufacturers to improve efficiency and productivity.

Tooling: an integral component supported by digital technology

A key feature of Reishauer's system is the in-house production of tooling components such as grinding wheels, diamond dressing tools, 3D-printed coolant nozzles, and clamping fixtures. By manufacturing these tools internally and using a digital process monitoring system, the company ensures they are precisely matched to their machines and grinding processes. This synergy between tooling and machinery enhances performance, consistency and reliability, highlighting that tooling is not merely an accessory but an essential part of the entire system.

Reishauer employs the ARGUS process monitoring system to evaluate and continuously improve tooling. This system leverages data and analytics to optimize tooling processes, improving production efficiency.

Evaluation of grinding worm behavior

By highlighting the synergy between ARGUS and tooling, *figure 1* illustrates the grinding intensities across the shifting axis covering the full width of a grinding worm for producing over 5,000 workpieces. The upper blue point cloud represents roughing strokes, while the lower green point cloud represents finishing strokes. The roughing strokes show a decreasing grinding intensity from right to left,

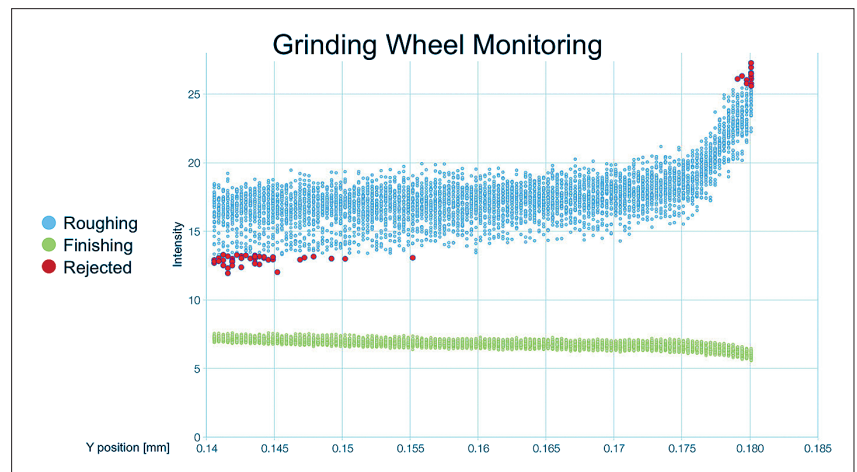


figure 1 – Grinding wheel monitoring

whereas the finishing strokes display an increasing intensity in the same direction. The decrease in grinding intensities during roughing indicates process-induced wear of the threaded grinding wheel. Ideally, a calibrated force model would maintain almost constant grinding intensities across the full grinding wheel width. The observed drop in intensity during roughing is attributed to continuous microscopic deterioration of the bond-grain matrix of the threaded wheel, leading to gradually reduced material removal from the workpieces. The increase in grinding intensity during finishing strokes compensates for the reduced material removal from the preceding roughing strokes. This wear effect on the threaded wheel results in an unstable process and causes rejected workpieces, depicted as dark red dots on the lower left side of the roughing stroke point cloud. In this case, the user had to change the grinding wheel specification to stabilize the process.

Evaluation of the performance of clamping devices

As with the grinding wheels, the ARGUS can also assess the effectiveness of the clamping tools. Monitoring the grinding intensity, for example, provides information on concentricity deviations that indicate faulty clamping devices or deviations in pre-machined workpieces. In the example shown in *figure 2*, roundness differences between the two workpiece spindles, C1 and C2, can be seen. ARGUS uses complex algorithms to simplify the interpretation of the dynamic effects on grinding intensity and to enable process analysis without requiring the user to have specific expertise. In this case the C2 spindle was misaligned, increasing intensities due to out-of-roundness. After aligning the workpiece spindle C2 on reaching 4,000 workpieces, both spindles showed an identical range of grinding intensities, as shown in *figure 2* on the right side of the diagram.

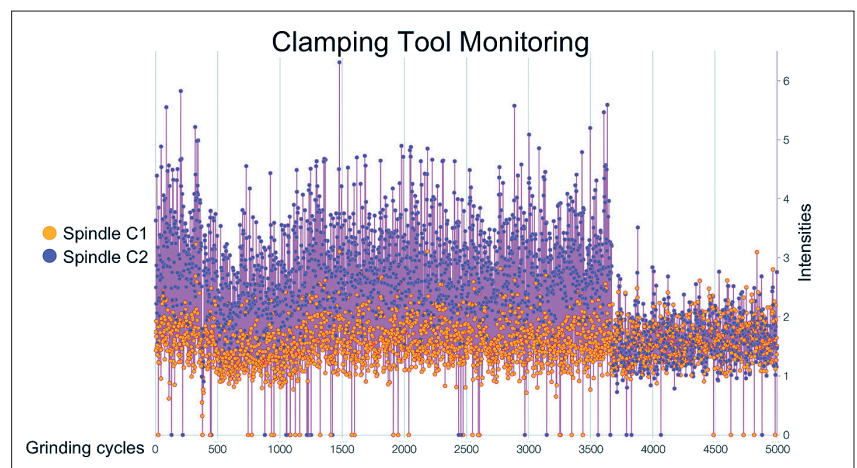
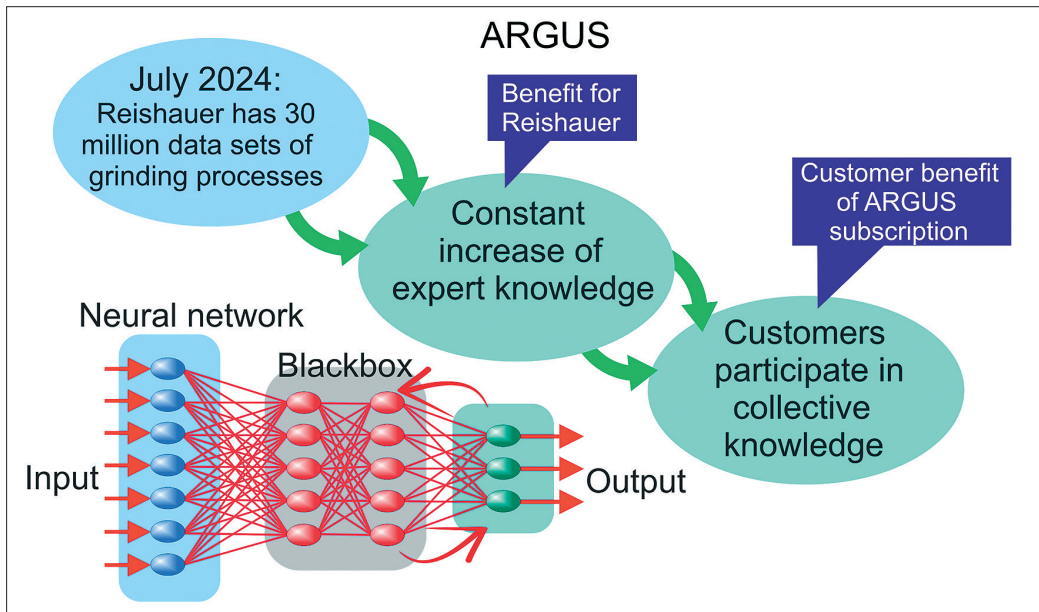


figure 2 – Monitoring clamping devices



Advantages of large database model

Evaluation of the performance of diamond dressing rolls

Diamond dressing tools are also monitored within the process. Measured dressing intensities objectively evaluate a dresser’s useful service life, often exceeding the indicated or guaranteed dressing cycles. To be on the safe side users traditionally perform eight roughing strokes and two finishing strokes during dressing. With ARGUS dressing monitoring, the number of dressing strokes can be reduced, as the monitoring system indicates after how many strokes the grinding worm is properly dressed.

As of September 2024, Reishauer had accumulated around 30 million grinding cycles and all associated data points, each cycle comprising approximately one million data points, stored anonymously in a dedicated cloud. This substantial data pool allows for applying data science and AI for pattern recognition and algorithm optimization. Insights gained from data analysis are continually incorporated into updates for the benefit of all subscribers. In terms of tooling the data analysis leads to an objective evaluation of the performance of tools, whether being grinding wheels, diamond dressers, or clamping fixtures. These valuable insights are used to improve tool performance continuously.

ARGUS minimizes tooling 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.

Technology: addressing modern challenges

The advent of electric drives (e-drives) has introduced new challenges in gear manufacturing, including higher rotational speeds, increased torque, and stringent requirements to minimize noise, vibration and harshness (NVH). Reishauer addresses these challenges with advanced technologies such as,

for example:

- twist-control grinding: manages the distribution of twist along the gear flank to meet specific performance criteria
- polish grinding: enhances surface finish to improve gear performance and longevity; moreover, polish grinding reduces gear noise (NVH) in transmission, which is particularly important in electric drives

These technological innovations enable manufacturers to produce gears that meet the demanding specifications of modern applications.

Services: ensuring maximum availability

A global network of service engineers and decentralized spare parts stores ensures that Reishauer machines maintain maximum availability. Their support services minimize downtime and provide customers with prompt assistance, contributing to the reliability of the entire system.

Proven performance and global adoption

With over 1,000 modern RZx60 machines operating worldwide around the clock, Reishauer’s gear grinding machines have demonstrated reliability and effectiveness on a global scale. Leading automotive manufacturers and suppliers rely on these machines to produce gear sets that meet the most demanding standards.

Conclusion

Reishauer’s gear grinding machines stand out due to their integrated system approach, where each element – from tooling to digital systems – is designed to support the others. This philosophy ensures high precision, reliability, and efficiency, meeting the evolving demands of gear manufacturing. By recognizing tooling as an essential part of a cohesive system, the company exemplifies how integration and innovation drive performance in engineering. ■

further information: www.reishauer.com