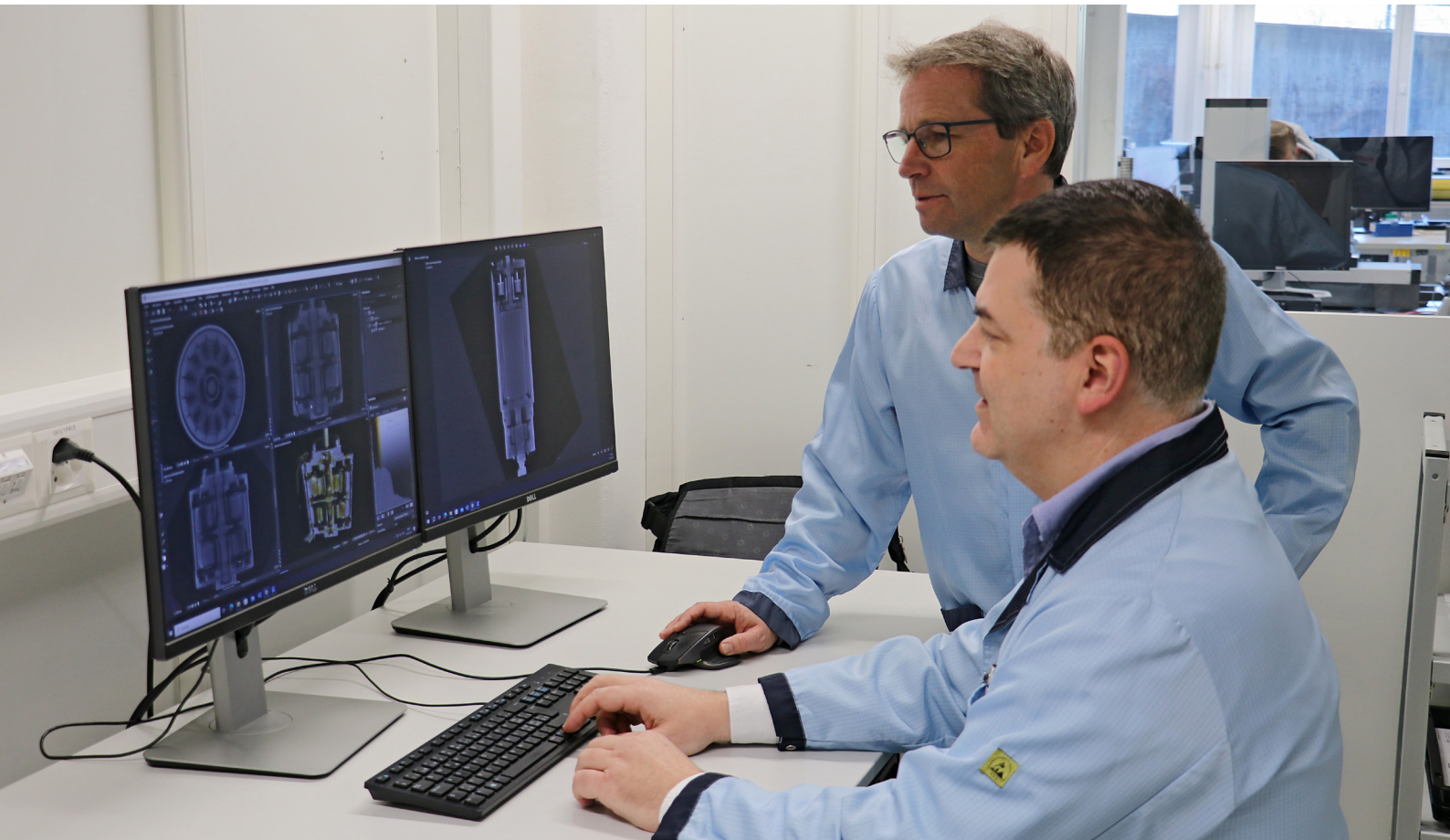


X-ray tomography enables non-destructive engine testing

Maxon drives set many things in motion that need to rotate precisely and reliably. To ensure their high quality, the Swiss company relies on metrology from Werth. A fully equipped multisensor coordinate measuring machine is capable of measuring even small gears in accordance with standards, and a CT machine allows a look inside the motors to detect any faults quickly and reliably.



Maxon, headquartered in Sachseln in the Swiss canton of Obwalden, has been developing and manufacturing high-precision drive systems since 1961. These systems enjoy a worldwide reputation and are used wherever requirements are demanding and engineers refuse to compromise. Maxon motors power NASA's Mars rovers and are installed in insulin pumps and surgical hand tools. They can be found in humanoid robots and high-precision industrial systems as well as in tattoo machines, e-bikes, passenger aircraft, camera lenses, racing cars, and heart pumps. The Giessen-based manufacturer Werth Messtechnik has also been relying on Maxon motors for its coordinate measuring machines for many years.

Maxon's success is based on experienced employees who are constantly working on innovations and have

a deep understanding of quality. The drive technology manufacturer was certified according to ISO 9001 back in 1988 and has long been compliant with other quality standards such as EN 9100. It is designed for companies that develop and produce components for the aerospace industry. The Medical division is certified according to the ISO 13485 medical standard, which confirms that all processes and procedures are documented and traceability is guaranteed.

Adrian Burch, Head of QA Metrology at Maxon, is responsible for the metrology used in the company, among other things. He has been relying on Werth products for particularly demanding measuring tasks since the 2010s: „Back then, we invested in the Videocheck HA 3D CNC coordinate measuring machine and, in 2019, in the Tomoscope S computed tomography coordinate measuring

system. Both are, in a sense, the heart of our metrology department. In different areas of application, they enable us to capture and visualize complex geometries, which ultimately contributes to improved production processes, higher quality, and greater cost-effectiveness."

The premier class of 3D metrology

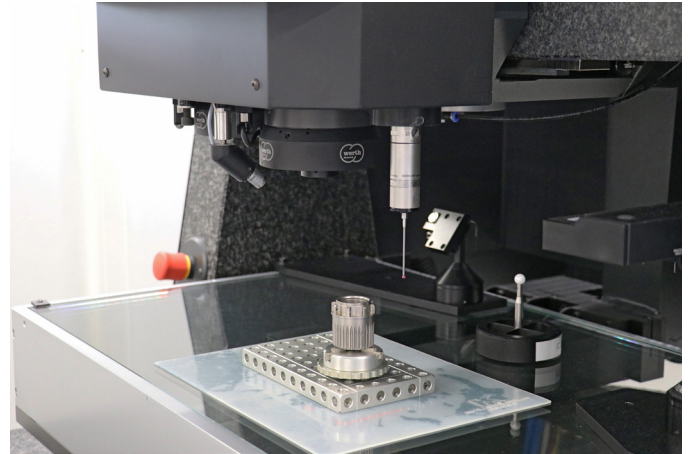
The high-end Werth Videocheck HA multisensor coordinate measuring machine is optimized for precision applications. It has a robust granite construction with a fixed bridge and decoupled main measuring axes. In combination with the air bearing guideways, the machine achieves minimum length measurement errors of MPE Euni up to $(0.25 + L/900) \mu\text{m}$.

The metrologists at Maxon chose a telecentric tenfold lens, the TP200 trigger probe, the Werth zoom optics, the patented WFP fiber probe (Werth Fiber Probe), and the WinWerth GearMeasure software. „A key reason for this choice was the ability to measure our micro-gears in accordance with standards using the fiber probe," explains Adrian Burch. „Conventional testing methods reached their limits with our small plastic gears with a module of 0.12, which are used in miniature motors measuring 6 mm. Even the slightest pressure caused the teeth of the tiny gears to deform, resulting in incorrect results."

This cannot happen with the Werth fiber probe because it works on a tactile-optical principle. This means that it consists of a glass fiber with a stylus tip with a diameter of up to $20 \mu\text{m}$ attached to the end. The stylus shaft merely positions the stylus tip, whose position is captured optically via the telecentric lens.

„The Werth VideoCheck HA with the fiber probe has taken us a big step forward," says Adrian Burch. „It has enabled us to minimize correction loops in toolmaking and reduce the testing effort during series production thanks to first article inspection and process evaluation." The Werth Videocheck HA is used at Maxon Motor – then as now – not only for micro-gears, but also for

a wide range of measuring tasks across the entire spectrum of engine parts, whether for incoming goods inspection, development projects or customer service.



The Werth Videocheck HA is not only used at Maxon for measuring micro-gears, but also for a wide range of measurement tasks on the entire spectrum of engine parts, whether for incoming goods inspection, development projects or customer service. © Werth Messtechnik

For Christian Pfeffer, who is primarily responsible for the Werth measuring machines within the three-person metrology team, the VideoCheck HA is „a measuring machine in a class of its own." He also mentions the good cooperation with Werth: „Of course, our demanding measurement tasks always raise questions and problems, which we discuss with the Werth measurement technology experts. They have a wealth of knowledge that they are happy to share with us."

New measurement and testing technology

Maxon not only stands for innovative products, the equipment used in the company must also be innovative. That is why the metrologists had their eye on industrial computed tomography early on. „Above all, the ability to test components and assemblies quickly and non-destructively provides time and economic benefits," says Adrian Burch. „In addition, even complex, difficult-to-access contours can be measured using the data model generated. This convinced us that computed tomography is a measurement and testing technology worth investing in."

There were several reasons why Burch and his team chose the Werth Tomoscope S CT machine. One important factor was the machine's high performance, as Christian Pfeffer explains: „The Tomoscope machines offer technical features that are ideal for visualization and highly accurate measurement of a wide variety of materials. Even dimensional measurement with minimal measurement uncertainties, similar to conventional sensors, is possible."



The Werth Tomoscope S is suitable for visualizing and highly accurate measurement of workpieces and assemblies made of different materials. © Werth Messtechnik

Of course, the experience gained in the partnership also played an important role. „We were confident that Werth was a reliable partner in the field of computed tomography, enabling us to make optimum use of this new metrology technology," adds Adrian Burch.

Expectations confirmed in practice

Since Maxon's metrology engineers had intended from the outset to measure and test not only individual components but also complete drives, they chose the Tomoscope S series. The machine is suitable for workpieces up to approximately 200 mm in diameter and 400 mm in length, although the current Plus models are even suitable for workpieces up to approximately 500 mm in diameter and 700 mm in length. With regard to the transmission X-ray tube, which is available with X-ray voltages from 130 kV to 240 kV, they opted for the 225 kV version. „An X-ray tube with a transmission target like this ensures a very small focal spot even at high tube power,“ explains metrology engineer Pfeffer. „This enables us to achieve maximum resolution down to the μm range at high measuring speeds.“ The built-in X-ray detector with a large number of pixels and detector area is also responsible for the high resolution and large measuring range.



Maxon uses the Tomoscope S, among other things, to X-ray complete motors and visualize all internal components. © Werth Messtechnik

The Tomoscope S has been in operation at Maxon since 2019. It spends around 60 percent of its time performing visualization tasks, primarily on complete motors. Christian Pfeffer explains: „Developers or customer service employees usually come to us with a machine that has a problem – it's not working properly, is too loud, or something similar. We then place the motor in a simple holder and examine it with the Tomoscope. We often look at the images together with our client and start troubleshooting. If there are foreign particles in the housing, the magnet is cracked, or contacts are missing, this can be quickly and easily identified.“

In the past, the motor had to be dismantled for such investigations, which was time-consuming and not possible in a non-destructive manner with welded products. Alternatively, Maxon used CT services from external providers, which was an expensive and time-consuming undertaking. Having the Tomoscope S in-house has made metrology much more flexible, faster, and cheaper. For example, if a loose cable or a missing brush contact is detected in a motor, it is even worth testing an entire small series to ensure that the other motors are fault-free.

Pfeffer and his colleagues use the remaining 40 percent of the Tomoscope's operating time for measuring tasks on engine components made of plastic, aluminum, steel, and even titanium. The more complex the workpiece, the more useful the measurement with the CT machine. This is because, on the one hand, there is no need to produce a complex measuring device and, on the other hand, contours that are difficult to access with a probe or optically can be captured in a single measurement process. „We often use the nominal-actual comparison for plastic parts,“ says metrology engineer Pfeffer. „The color-coded deviation plot allows us to see immediately where the actual workpiece deviates from the 3D CAD model. This is valuable information for our tool shop, which knows exactly where to make adjustments to the injection mold.“ A quick nominal-actual comparison is not only helpful for toolmaking, but also for detailed measurements on components made of steel or titanium. „The color-coded deviation plot quickly shows us the problem areas where we need to perform detailed measurements with the Videocheck HA or other measuring machines,“ says Christian Pfeffer. „This saves us the effort of testing the entire component on the 3D coordinate measuring machine.“

The Werth Tomoscope S is programmed with the same WinWerth measurement software as the Videocheck HA multi-sensor coordinate measuring machine at the connected workstation. To achieve the highest possible utilization, Maxon invested in an additional offline workstation. This allows the data to be evaluated in parallel with the next measurement, saving time.



The heart of Maxon's metrology department: the Video-Check HA 3D CNC multisensor coordinate measuring machine (left) and the Tomoscope S computed tomography coordinate measuring machine (right). An additional offline workstation allows CT data to be evaluated in parallel with measurements taking place at the same time. © Werth Messtechnik