Screw threads may be one of the most important of industrial fasteners. Found practically everywhere, smooth operating threads that connect parts under intense stress and strain are vital to most industrial pieces of equipment. They are getting more critical in certain applications where failure equals catastrophe. Leads, pitches, diameters, tapers, and angles must be uniform with tight tolerances as well as free of occlusions or defects. Manufacturers need to prove they meet quality requirements, and that the need to ensure quality is just as important upstream with the cutting tool itself.

Checks and Balances
A convenient and common means of checking the threads of critical parts is to use a simple thread gage, a profile piece that measures the thread form accuracy, the profile in axial plane of one pitch. “This ensures the functionality of the thread by their attributes alone,” explained Bruce Morey - Contributing Editor

Automotive, aerospace, and other industries find inspecting threads of vital importance. Oil & gas may be the most particular, given the intense operating conditions and consequences of a threaded pipe failure. The Gulf Oil Spill of 2010 continues to have ramifications all the way down to pipe thread inspections.

The Ins and Outs of Inspecting Threads
Bobby Kirkwood, application engineer for Mitutoyo (Aurora, IL). “It is a go/no-go check and it is the most common practice in industry.” Moving beyond a simple go/no-go check would include using dial indicators set into convenient holders. Dial indicators measure pitch diameters, pitch (the distance between threads), as well as taper and thread height. Strong connections require precisely matched parameters to ensure a snug fit in critical applications, like piping connections used in the oil & gas industry.

To define the tolerances in these measurements, Kirkwood said that it is common practice in the oil & gas industry to refer to a Golden Part, a First Article Inspection piece that was precisely manufactured and measured with standard metrology devices. Shop personnel will zero indicators on the Golden Part, and then measure variations to it on production parts to ensure they stay within tolerances. “It acts like a transfer gage,” said Kirkwood. Mitutoyo also offers thread and ball-point micrometers for measuring pitch diameters, for use to a print against a Golden Part. Pitch diameter is a significant measurement because it often determines the quality of the mating and connection. Companies like Gagemaker (Houston, TX), a reseller of equipment from Mitutoyo, offer complete kits of gages and special-purpose dial indicators for industries like oil and gas, mining, and water wells.

High Accuracy, High Tech

Hand-held devices introduce the variable of operator consistency. Kirkwood notes two devices from Mitutoyo that capture measurements with far less operator variability—Three Wire Thread and Contracer measurements. The common 3-wire measuring system puts wires of known thickness into the screw threads, so that a micrometer measures the wires that protrude. This displacement method is far more accurate and consistent. It can be used to calibrate gages or used directly in measuring production parts, according
to Kirkwood. Measuring pitch diameter is particularly tricky since it is the diameter of an imaginary cylinder where the thread is as thick as the groove.

Perhaps the ultimate device is a contour tracer, or contracer, that creates a trace of the profile of the thread, creating a 2D trace over a defined distance. One example is the Mitutoyo Contracer CV-2100 which provides measuring resolutions of up to 2.5 microns. “This provides data now that can be interrogated for angles, radii, or pitch—all specific and variable qualities of a thread profile,” said Kirkwood. This would allow a much deeper analysis of critical threads. In his 30 years of professional experience, Kirkwood has worked mostly in energy extraction, and he has seen a profound change since 2010. “Since the 2010 Gulf Oil Spill, customers like Shell and Chevron, are demanding more traceability with higher quality metrology,” according to Kirkwood.

Automotive Quality and Speed

At the high end of the metrology spectrum is using an optical comparator or a general-purpose CMM, such as a Zeiss Micura equipped with a VAST-XT-Gold sensor for thread measuring. There are times when a CMM is called for, according to David Wick, manager for product management for Zeiss Industrial Metrology (Maple Grove, MN). “In general, measuring threads and taps is important to industries such as automotive or aerospace, where our customers manufacture a cast part with flat machined surfaces that contain tapped bolt holes in it,” said Wick. “Think of a water pump for your car—it’s cast, has flat surfaces where the gaskets go, and tapped bolt holes. Ensuring the tapped holes are the
right size, have the right thread pitch, are tapped at the proper angle to the flat surface of the casting, are all critical measures to ensure the water pump is manufactured correctly.” While not appropriate for production work, measuring these qualities as part of an automotive PPAP or First Article Inspection is most important, and calls for the best methods possible in mission-critical situations.

Even in high-volume production, using simple thread inserts that physically chase around a tapped hole may not be sufficiently fast, especially at automotive production speeds. That is when high tech comes to the aid of high speed, such as with the Marposs E70T eddy current nondestructive testing, or NDT, device from Marposs (Auburn Hills, MI). “We developed our eddy current NDT for material integrity and verification, but we also found it useful for thread detection,” said Roger Zeoli, product manager for Marposs.

In its pure form, the E70T is essentially a pass/fail type of test, according to Zeoli. “We use a probe that goes inside of a tapped hole, and we’re looking for the presence of the thread.”

The tap may not have gotten deep enough even if the drill did, or the tool may have broken or been chipped. He describes initial applications were to use the E70T as a forensic tool. Used with an automotive SPC process with a thread gage to periodically check a few samples, if a problem were detected,
then operators would use the E70T to quickly determine if a suspect lot had any other issues. “What we’re seeing more with customers now is automating that process using the probe on a slide that is advanced into a hole to check the presence of the thread,” said Zeoli.

“That is becoming important where suppliers have to show all holes have been 100% inspected.” While developed for automotive, he notes there is no reason the device could not be adapted to other industries, such as oil & gas.

Thread quality can also be examined using the company’s E59N material integrity probe by rotating the probe 360 degrees to capture a complete scan of the surface for surface porosity or inclusions. This is typically done by rotating the part.

**Starting at the Cutting Tool**

Seco Tools (Troy, MI) is a company that provides tooling inserts for cutting precision threads. “Quality threads for both aerospace and oil and gas are particularly critical,” explained Don Halas of Seco Tools. Drill pipe and casings must perform two to three miles underground, or under the seabed, in extremely high temperatures and pressures. He agrees that the Gulf Oil Spill of 2010 has caused increased scrutiny and concern over liability issues. “If a pipe breaks, the major oil companies want to know who was at fault anywhere in the process,” he said. That means keeping track of the entire value chain, ensuring high-quality processes in every element of the manufacturing chain, including the threading inserts.

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**Zoller’s “genius” inspection machine is applied to thread mills and taps as well as general-purpose cutting tools.**

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“What the customer requires from Seco tools is knowledge of how the thread forms are cut and checked, right down to documenting the operator who ground them,” said Halas, which Seco does as part of its ISO 9000 certification. “One advantage we have at Seco tools is we can go back to documenting the mix of the metal powders used to make the insert, since we make our own blanks prior to grinding.” He also notes that Seco provides to its customers the Mylar overlays they themselves use in optical comparators to check the cutting tools. “We make a template of the thread form and lay a contour of the cutting tool over it to ensure it will make the right cut,” he said.

Both types of cutting inserts that Seco provides, snap taps and chasers, are checked. “In our system we check basic metallurgy, dimensions after sintering, dimensions after grinding, edge measuring or edge prep, coating thickness and adhesion, and a final visual inspection,” he said.

There are a number of standard thread forms, one of the most important defined by the American Petroleum Institute, or API. “In addition to that, many manufacturers have their own proprietary thread forms, which we refer to in the industry as premium thread forms,” said Mike Campbell, machining specialist for Sandvik Coromant (Fair Lawn, NJ). “Premium thread forms are usually slight modifications to the API standard, with tighter tolerances. The demands are increasing because the materials are changing due to the deeper depths of the well.” He also notes that because of the criticality of the threads, Sandvik also inspects their threading inserts prior to shipping to the customer. One of the most critical of measurements is the edge prep. “If the hone is not correct, then the performance deteriorates very quickly,” he explained.

Quality tools need to respond to tougher materials. “In the oil & gas industry there has been a lot of focus in stronger and more demanding materials. We have been concentrating on machining materials such as Inconel. This heat-resistant superalloy requires a very, very precise process to thread,” explained Campbell. It would take two, sometimes three separate index cuts to produce a single thread, roughing then finish cuts. “Because of the cost of the materials and the machining to that point, scrapping a part because of a poor cutting tool becomes expensive.”

**Tool Metrology**

Philip May, insert design engineer for Sandvik Coromant said that his company is using video and multisensory metrology systems for thread tool inspection. “These systems automatically measure key features of the threading tool,” he said. “We partner with our customers to develop high-frequency, tight-tolerance inspection processes. The speed and accuracy of these automated processes allow us to meet and often exceed the customer’s requirements.”

A specialty company that provides advanced noncontact CNC measurement of tooling is Zoller (Ann Arbor, MI). Zoller provides a series of dedicated metrology systems for measuring, inspection, and management of metalcutting tools. Cutting tools like thread mills are subject to the same wear constraints as any other cutting tool and could be measured with a general-purpose machine. But measuring them with dedicated measuring machines like Zoller’s thread-Check provides efficiency as well as accuracy. Using a 2D imaging camera inside a cabinet with six CNC-driven axes, automatic measuring programs scan tools for threading specific defects. It provides for complex measuring of threaded tool geometries, threaded taps, cutters and forms according to the company.

Zoller includes its pilot 3.0 software to help operators program the measurement as well as record the results. Operators can select the type of tool from a graphical menu and

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**The VAST sensor allows self-centering scanning, which keeps the stylus in constant contact with a thread surface as it scans and traverses a helical measurement strategy. The utilization of a rotary table makes this job much easier, as only one orientation of the stylus is required as the part is turned by the rotary table.**

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Photo courtesy Zeiss
the software and machine combination sets up the parameters for the measurement to proceed.

Werner Lueken, product manager, also noted that their genius line of universal measuring machines, including the genius 3s, 3m, and 4 are also often used for thread mills and taps as well. These machines collect data with a five-axis, CNC-guided motion. Chip spaces, circumference and tool face are measured. The groove and chip space contour is scanned automatically from the data and can be exported as DXF or XML data files. “Everyone is moving towards higher accuracy,” explained Lueken, “An inexpensive cutting tool can produce a lot of expensive junk, depending on the material, application, and where it is used in the value chain. It is important that it is inspected first before use because, today, you do not have the luxury of trial and error.”

The expectation is the first part manufactured will be good enough to be used. “The only way to do that is checking through the entire value chain, starting with the tool, then the part, the assembly, and the final product.”

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