

Why measure cutting tools?

**Toyota's answer:
Product quality
and process
reliability**

Toyota Motor Manufacturing Kentucky (TMMK) churns out 2,200 engines and 4,400 axles per day...from scratch. From start to finish the engine line takes one hour. They build a four cylinder engine every 37 seconds and a V6 every 72 seconds. Keeping that production humming with minimal scrap requires precise cutting tools. *Getting* good tools relies on the ability to *measure* tool quality. And that led Toyota to the Walter Helicheck tool inspection machine.

The transition from trusting to verifying

Mike Johnson, the Assistant Engineering Manager for the Powertrain group explains: "Initially we bought

the Helicheck to measure tools coming in from our suppliers as an audit tool. But we took it further to what we call 'Tool Point Management,' in which we want to ensure that every critical tool is correct the first time it hits the line. Plus we wanted traceability of that tool, whether or not there's an issue. Is that tool performing consistently every time, and do we have data to show it? Or is there a problem one out of fifty times, or one out of twenty times? We needed a way to specifically measure critical features on selected tools that have a high impact in the line for tolerance, and to be able to measure those tools quickly and provide the data out to the line."



“We measure our tools to ensure the quality of the product and to increase reliability in the production line, so the first part is good, there is no scrap, and there is no downtime because a tool is incorrect.”

*– Mike Johnson,
Assistant Manager Engineering, Powertrain*

“Before, we were relying pretty much on the people in regrind. Let’s say a reamer has to have a 10 micron runout on the lip

height. Regrind setup and ran one piece. They’d check it manually with a V-block or an indicator or whatever. If it was OK they’d run the rest of them, put them in a box, and send them out to production. Now, after they’ve setup the tool, made sure it’s correct, and ground them all we bring them all into QC and every tool is measured on the Helicheck. The measurement data is automatically transferred to our database and we have an inspection report for each tool that goes into the box and out to the line. And because every tool has an ID mark engraved on the shank we can trace them all.”

Checking tools a lot better than 50 scrap blocks

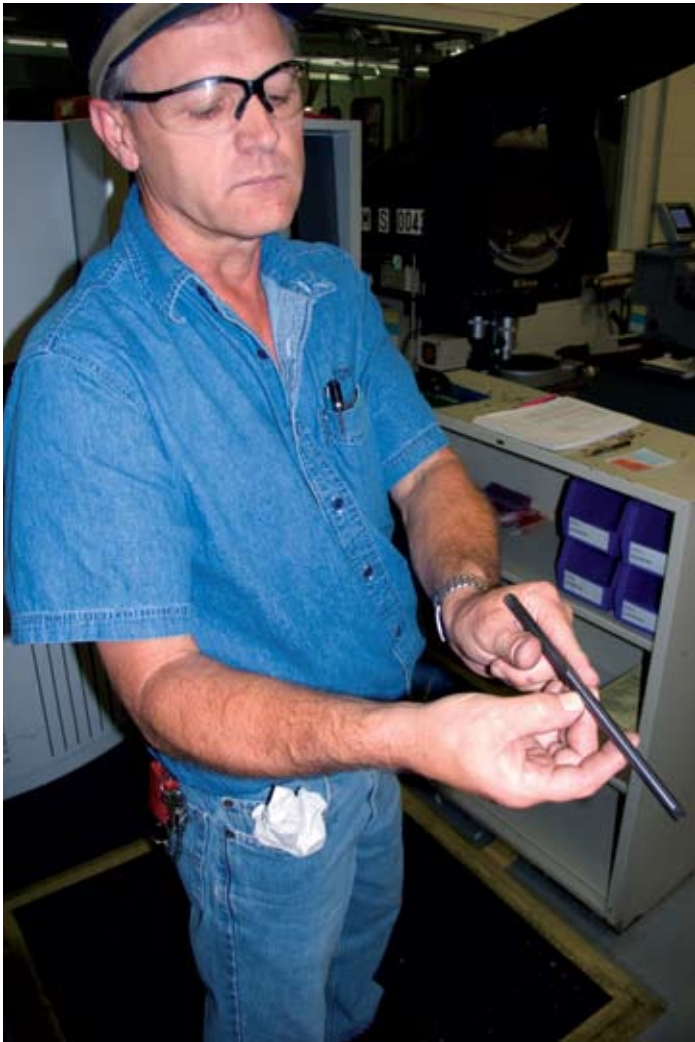
Toyota only recently began compiling the measurement data so it’s too early to quantify the impact in detail. But Mike can already see it: “We had several size problems with a power steering pump hole in the L4 block. When we instituted this program with the Helicheck we began to measure diameter on reamers to see if they were still holding spec and we found that because of the abrasiveness of that operation in aluminum, some reamers had become undersize through repeated use. Now we catch that before the tool goes out to the line, preventing a problem. Of course we had 'first piece' checks before, but if the first tool produced a part that was within tolerance, but close, it’s understandable that they’d run production and before you’d know it you’d have 50 scrap blocks. We’ve seen those kinds of impacts.”

For Mike, QC is serious business and tool measurement is easy to justify in a plant that pumps out 2,200 engines a day: “We can fill this entire engine assembly line with bad parts in an hour. How do you put a dollar amount on that? What’s the price tag on shutting a whole engine line down?”



Tolerances down to 10 microns required a measuring machine with better than one micron repeatability

TMMK's regrind shop sharpens 120 tools per man per day, or close to 40,000 tools per month. About 8% are critical tools requiring 100% inspection: All the reamers and some of the drills. Put another way, the critical tools are those with tolerances of 100 microns or less. Most of TMMK's reamers have a tolerance of 10 microns or less. Since the repeatability of the measuring method should be at least ten times better than the part tolerance, they needed a method with better than one micron repeatability.



Team Leader Mike Crouch indicates the etching on the shank that identifies this reamer and ties it to the inspection report

The Helicheck was their only option, as confirmed by Team Leader Mike Crouch, "We've got some reamers that we've tried to measure manually every now and again, like a three flute gun reamer. But we bring it here and the Helicheck measures consistently, much better



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And it's getting even harder


TMMK usually measures lip height, runout of the OD, relief angle, and diameter, and the tools are not always easy to measure: single flute PCD reamers; 6, 8, and odd flute reamers, and so on. And Mike Johnson reports that "the designs are becoming more complex and the tolerances are tighter. We have tools coming in the new engine we have never run before that are very complex and that will cost more than our typical operations but they save money in another place by being able to combine operations and reduce capital equipment."

People tend to see what they expect to see, but the machine remains neutral

There is a natural bias on the part of operators to measure a tool so that it meets the nominal value.

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Other perspectives on CNC tool measuring



Tool manufacturers and cutting tool users have different, but overlapping, views on the need for CNC tool inspection. A tool manufacturer wants to minimize scrap and maintain smooth and efficient tool production. He also wants to make sure his customers don't reject his tools. An end-user (e.g. an automotive manufacturer or an aerospace company) also wants to produce his goods efficiently and at high quality, but for him cutting tools are part of his process, not his end product. (For one user's perspective, see the article on Toyota on page 6.)

Preventing the pain of rejection

Recently, a major Midwest tool manufacturer had a large batch of reamers rejected by one of its biggest accounts (a big car manufacturer in the area). The tool had a very tight tolerance for concentricity and this batch didn't cut the mustard. At that point the auto plant was about to run out of tools due to the unexpected

The Walter Helicheck uses powerful software and high-tech cameras mounted on CNC axes to measure features that can not be inspected using manual equipment, like rake angle, clearance angle on the OD, or clearance at a step.

trouble, placing their production at risk. Needless to say the tool manufacturer was also at risk of losing a big account. The entire problem would have been avoided if the tool manufacturer had measured the tools properly before shipping them.

Some tool manufacturers include an inspection report along with their tools. This avoids any misunderstanding and builds trust. And it's easy with a Walter Helicheck, because the machine can automatically print certified reports. By the same token, end users should seriously consider either accepting only certified tools or inspecting the tools they purchase.

Predictability is the key to smooth production

A measuring machine can also contribute to Statistical Process Control (SPC), no less for a tool manufacturer than an end user. For example, another unnamed tool manufacturer lost a grinder due to a worn part during a particularly busy time of year. Besides the expense and hassle of an emergency overnight repair, he also



A measuring machine can eliminate the "chasing your tail" syndrome, in which you keep changing a design because you're not getting the result you expect but you never confirm that the part meets the spec in the first place because you can't measure it.

WALTER SCHLEIFEN						
Cyl. End Mill D12mm R1.5mm						
Tool No.	Inspector	Date/Time	Customer			
1	user	10/7/2005 2:28:28 PM	Walter Maschinenbau GmbH			
Order No.	Customer	Date				
4711	Walter	07.10.2005				
Criteria	Actual	Nominal	LSL	USL	State	
Diameter	20.003 mm	20.000 mm	-0.050 mm	0.050 mm	[Green bar]	
Rake Angle	8.05 *	8.00 *	0.00 *	0.20 *	[Green bar]	
Clearance Angle	10.07 *	10.00 *	0.00 *	0.10 *	[Green bar]	
Tool No.	Inspector	Date/Time	Customer			
2	user	10/7/2005 2:28:44 PM	Walter Maschinenbau GmbH			
Order No.	Customer	Date				
4711	Walter	07.10.2005				
Criteria	Actual	Nominal	LSL	USL	State	
Diameter	20.009 mm	20.000 mm	-0.050 mm	0.050 mm	[Green bar]	
Rake Angle	8.03 *	8.00 *	0.00 *	0.20 *	[Green bar]	
Clearance Angle	10.05 *	10.00 *	0.00 *	0.10 *	[Green bar]	
Tool No.	Inspector	Date/Time	Customer			
3	user	10/7/2005 2:28:58 PM	Walter Maschinenbau GmbH			

The Walter Helicheck is repeatable under one micron and (unlike manual operators) isn't swayed by knowing the nominal value. It also prints out a certified inspection report.

risked losing an important order. But after this incident, the tool manufacturer invested in a tool inspection machine and SPC software. They networked both systems so that the slightest problems on any of their tool grinders will be reflected in the tool measurements and shown in the SPC software. Now most problems due to machine wear can be predicted

and fixed before a failure. In-process inspection and monitoring also helps eliminate scrap.

"Measuring" can also mean "diagnosing problems"

In another example, a world-wide automotive parts supplier designed a new cutting tool to improve production of a certain part. They then had the tool made by one of their suppliers. But the cutting tool didn't live up to their expectations, so they changed the design. However, this also didn't produce the desired results. With time running out and project costs soaring, it occurred to them that perhaps the tool wasn't being made according to the specs. Neither they nor their supplier had inspection equipment with the capability to check the tools. They were chasing their tail! A measuring machine capable of measuring unique geometries is essential for avoiding such situations.

New geometries and tighter tolerances driving need for better inspection

The demand for higher performance has driven tool design into strange new worlds: micro tools; tolerances in the microns; tools with helixes that vary from front to back, or helixes that differ from flute to flute; tools



A measuring machine is like a life preserver: A small investment that prevents a catastrophe

with variable core diameters; and tools that combine complex geometries for multiple operations. As CNC tool grinding has risen to these challenges, the question remains: How can we measure these new tools? Many of the new features and tolerances simply cannot be measured manually. Keep in mind that the measuring

method should be ten times as accurate as the required tolerances for your measurements. So if your tool tolerance is 10 microns the measuring machine must be repeatable within 1 micron. This requires CNC measuring technology like the Walter Helicheck.

Spend a little to save a lot

The quality of a product starts with the control and quality built into the tools used for production. Bad cutting tools put production quality at risk and add huge extra costs. But you can avoid these costs with proper tool measurement.

Or use the analogy of white-water kayaking. Like kayaking, you can expect challenges in business and you'll probably get wet. But you won't drown if you invest in a life preserver. That small investment today can save you later! ■

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The Daruma doll in the lobby symbolizes the success of the 2AZ (four cylinder) engine line. The doll arrived with white eyes. Following Japanese tradition, at the start of the engine project the TMMK leadership blackened one eye while wishing for success and the team members signed the doll. When the production line was up and running they blackened the second eye in another ceremony. The Daruma's low center of gravity and self-righting shape also symbolizes the team's belief that although they may stumble, they will persevere and prevail in the end.

So TMMK sometimes uses the Helicheck to verify a manual measurement. Mike says “We use it to check parts from our suppliers that have been measured manually, especially if they say it’s borderline. We’ve had cases in which the manual measurement says the tool is right on the borderline, and the Helicheck proves it’s actually 2 microns undersized, yet the supplier denies it.”

Helicheck helps troubleshooting

Tooling Specialist Abhijit Kardekar says TMMK also uses the Helicheck for troubleshooting. “For example, we can check a reamer in its holder to see if the holder introduces any runout.” He also likes the fact he can check his indexable tools, some of which have features that cannot be checked on a V-block. “You can put it on a Helicheck and check run-out on those tools also...Long drills, standard indexable drills, and endmills too...We can see whether or not the insert was mounted properly and although they don’t have the highest runout tolerances, when a part comes out badly we can at least do some troubleshooting and eliminate tool runout as the problem.”

Kentucky plant leads the way

Every tool used within Toyota is designed for a specific purpose by the home office. And Toyota also mandates company-wide Quality Assurance programs. But TMMK’s tool measuring program goes farther and the rest of the company is beginning to catch on. Mike explains that in Japan “They have a slightly different philosophy on how to use the Helicheck. They’re looking only at runout but we didn’t think that was good enough.”

“We presented our Tool Point Management program to the Global Engine Committee back in May – that’s representatives from all the Toyota engine plants – and it was very well received. TPM is being implemented at all Toyota engine plants, but whether they will all implement our particular method remains to be seen. But they see the value of it and we’ve had their guys from regrind here and they all agree it’s great.” ■



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