Measuring Left and Right

CMM Inspection vs. GMM Inspection

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Speed and accuracy is the name of the game in gear inspection. It's why a Wenzel customer recently purchased a WGT280 that can inspect gears in around eight minutes as opposed to around 18 with the CMM they were previously using. A number of customers are looking for similar results in 2017 regarding gear measurements.

Manufacturing is changing. Parts are getting smaller and smaller. Non-traditional job shops are starting to manufacture and develop gears which change the typical customer demographics. There has also been an increased need for worm gear inspection, presumably due to the addition of robotics in automation.

Utilizing both a coordinate measuring machine (CMM) and a gear measuring machine (GMM) gives the customer two machines that each are good at what they do. This is optimal rather than trying to adapt one to do the other's job. Naturally, two machines can relieve pressure if a large number of parts need to be inspected. It all depends on the types of parts that the customer makes and what they might be making in the future.

While it makes sense to utilize both a CMM and a GMM in the typical gear shop, there are significant differences that will be addressed in this article. We'll look at these differences, discuss quality and inspection trends and report on how gear inspection is evolving.

Durability and Longevity

Since their inception in 1956, CMMs have been a necessary tool in every quality department. Their development has been invaluable in the refinement of precision parts that make for long-lasting and more durable equipment.

When I entered this world, I had no idea that it previously existed, coming face-to-face with a myriad of different components of all different shapes and sizes from all corners of the United States. I then had the opportunity to dive into the unique realm of gear metrology with Wenzel America in 2016.

As CMMs became more sophisticated, gear inspection was also refined from needing three separate pieces of equipment to check profile, lead, and pitch, to becoming full CNC inspection equipment in the late 1970s. Two examples of earlier devices used for gear inspection are the Fellows Microdex for profile and two dial indicators to check pitch.

Wenzel has played a part in this development exhibiting our first gear measuring machine in 2003 to now having the ability to check virtually any gear as well as some cutting tools. Still, there are many differences between gear inspection with a GMM and 3D inspection with a CMM. I will outline three main differences I've experienced during my time using: types of parts measured, parameters that are extracted with each, and speed.

Compare and Contrast

One of the main features that you should see in all modern GMMs is the use of a 4th axis. This, of course, simplifies measurements greatly by minimizing the necessary measurement volume. It is also the best way to inspect a gear since this mimics the generative motion with which gears are made. It is natural, then, for a GMM to use a rotary table since almost all gear-related parts are rotationally symmetric. I've even found myself only locking five out of the six degrees of freedom when aligning these parts due to this characteristic. Racks would be an example of a part that I've measured where it makes no sense to use a rotary table. Of course, gear housings and other 3D parts can be simply fixtured to the rotary table and inspected without using the C-axis as well, but with other metrology software installed on the GMM. It is also worth noting the minor detail that, due to its size, a GMM is more forgiving when loading a part.

Furthermore, the parameters sought from typical parts measured in a CMM vs. those in a GMM could be best represented in a Venn diagram with the most common between both being Geometric Dimensioning and Tolerancing (GD&T) parameters. Profile, lead, pitch, runout, and even dimension over balls are the primary parameters that are not present in regular CMM inspection.

The more common GD&T parameters like flatness and roundness are secondary in a GMM. In this regard, it can be argued that GMMs are easier to program due to the simplicity of the necessary parameters that need to be input. This is not to say that gears are not complex geometries in the least! Nevertheless, it is fair to say that the characteristics that both a GMM and a CMM can evaluate are more common than different.

Finally, since a GMM's primary function is to check gears, it does it quite fast. The advantage in speed can be attributed to the 4th axis motion that practically all of today's GMMs equip. Additionally, if a CMM is not equipped with a rotary table, then a multi-probe stylus system would be necessary to check gear geom-

etries. This also results in added time not just for inspection but qualification as well. At times, these reductions in speed can amount to 50 percent. In the past, a CMM did not inspect gears using the generative method that CNC GMMs started with. However, nowadays, CMMs have made strides in measurement speed due to improved mechanics and integrated rotary tables.

Regardless of where your quality requirements lie, both types of machines are trying to achieve the same goal: to inspect parts accurately with the greatest precision. The way they do it is essentially the same. They are just two different flavors of the same type of tool.

Gear Inspection Then & Now

The pages of this magazine have explored gear inspection for many, many years, highlighting the tighter and tighter tolerance requirements, increased quality demands, and the evolution of gear standards.

Software is one area, in particular, that continues to change the inspection game. Inspection software is becoming easier to use since a more intuitive and logical programming interface is being adapted. Also, the most up-to-date gear standards are being implemented right into the inspection software.

The ability to check virtually any gearing component is now possible. For example, Wenzel just made available a new broaching module to check broaching tools as well as an updated enveloping worm module. We are also able to take advantage of Gear Data Exchange.

Taking this a step farther, I would say that the Industrial Internet of Things (IIoT) will also reveal areas of growth and new developments in gear inspection. Monitoring inspection equipment is something that is underrated and the ability to capture more information never hurts.

There is plenty of information that an inspection machine's controller can provide us, and Wenzel is taking steps to unearth this information for customers so that they understand the health, if you will, of their inspection equipment.

We've developed an Intelligent Machine Interface (IMI) that can collect environmental data like temperature and humidity using integrated sensors as well as the performance of the machine using information from the controller. In this way, using information about actively running programs, warnings, and status reports can be collected and analyzed, by Wenzel as well, with the customer's consent.

This will allow for preventive measures by letting service technicians detect any possible problems with wear or fatigue, for example, to critical parts in the machine before it happens. This means that the customer will have less downtime and interruptions in their production and inspection processes.

Gear Data Exchange

I've written about GDE for our Wenzel America blog (*www.wenzelamerica.com/one-gear-rule/*). It is similar in practice to Part Manufacturing Information (PMI) where GD&T information is built into CAD in order to make programming easier and less error-prone. GDE is a universal format that describes all geometric parameters for cylindrical gears

which can then be easily transferred between design, manufacturing, and quality departments.

The format is based on Extensible Markup Language (XML) Version 1.0 which is easily able to be implemented to already existing database applications. The .xml files themselves are so well structured and organized with ASCII text that even novice users can identify mistakes easily. This feature is available in most modern gear software today. It is able to both import and export GDE files.

The *Verein Deutscher Ingenieure* (VDI, Association of German Engineers) has standardized this format in VDI 2610. They also regularly update the GDE format that the .xml files should follow in order to create your own GDE files as you see fit to describe your gear. You can download the latest files at *www.vdi.de/xml/2610/* and you can open them in a simple text editor like Notepad. The benefit of this type of structure is that it makes for fewer errors by the operator streamlining programs and inspection.

Changing Inspection Demands

Whether the customer is interested in CMMs or GMMs it's fair to say that gear inspection is always advancing. The gear industry (as a whole) still suffers when it comes to finding skilled labor. There remains a noticeable amount of the workforce that will be retiring in the next five years. These positions will eventually need to be replaced with qualified candidates that can keep up with the changing demands of our industry. As long as apprenticeship programs remain out there, there is no reason the next wave of workers should miss out on the vast amount of knowledge that workers with decades of experience are actively trying to pass down.

This is why various companies, Wenzel included, participated in Manufacturing Day (*www.mfgday.com*) where local high school students were able to experience what the world of metrology had to offer. The students that came to visit us were actually from a technical school so they were familiar with basic metrology concepts like calipers and a micron! This is an annual nationwide event that benefits every community so make sure to check out a

nearby event near you. We are participating in this event once again this year (*www.mfgday.com/events/2017/wenzel-america-2*) and urge our colleagues in the industry to do the same.

And while the demands of the gear industry change, so too, will the opportunities. Big gears will come back once the mining and energy sectors develop more. A 2017 January/February *Gear Technology* article as well as AGMA supports this increasing trend in manufacturing investments in the United States for the gear industry.

On the flip side, I also see gears becoming smaller and more accurate as the need for light components and automation increases. This includes our customer, Forest City Gear's, tiny gears that will go on the Mars 2020 rover. Finally, I believe smaller shops will focus more on the quality of their products since, as I mentioned earlier, more non-traditional job shops are starting to explore gear manufacturing.

It's an exciting time in the gear shop as data-driven manufacturing takes our industry and our equipment into the future. Here lies an opportunity to examine your inspection needs, plan for future projects and determine what technologies you'll require moving forward.

(Editor's Note: Some information from this article was retrieved from the *International Journal of Emerging Technologies and Innovative Research* here: *www.jetir.org*)

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