Real-Time Measurement Opportunities

Matthew Jaster, Senior Editor

Shop floor inspection and gaging equipment is putting advanced metrology systems right on the factory floor. Here's a collection of articles on shop floor inspection and gages from companies like Gleason, Mahr, Comtorgage, United Tool Supply and Frenco.

Changing the Paradigm for Shop Floor Inspection with Gleason

For today's gear manufacturers, nothing is more frustrating, or costly, than a shop floor 'bottleneck'. Waiting for inspection results from the lab can bring production to a standstill. Yet, growing low noise requirements, increased power density, greater reliability, and other demands have made gears more complex and inspection requirements more critical than ever. Here's how two new Gleason inspection technologies are meeting these challenges and adding significant value to shop floor inspection.

GMSP: Bringing the Lab to the Shop Floor

The Gleason 300GMSP Analytical Gear Inspection System operates just as reliably in most shop floor environments as it would in a tightly controlled lab environment. Manufacturers can now put this advanced metrology system in close proximity to their production machines, and finally eliminate both the wasted time needed to transport finished gears to the lab and the additional time needed for parts to work their way through the queue.

While the GMSP delivers all the same capabilities and functionality as the other systems in Gleason's GMS series, it features a completely new 'shop hardened' design that makes it impervious to the significant temperature, vibration and contamination variations common to the factory floor. A proprietary machine base material is used that's better suited than the typical granite for the sustained higher temperatures of the shop floor. The use of this new base material, coupled with a completely new patented 'H' base design with active leveling system, has proven to be an excellent solution. The new base design consists of a bottom base with four air springs mounted on risers, which support the machine work platform. These air springs detect, and automatically compensate for, vibratory forces on the fly, such that the machine work platform (axes, table and workpiece) is both isolated from and immune to vibration seen in typical gear production environments.

The high precision guidance systems used to position linear and rotary axes on most inspection systems are inherently susceptible to even minor temperature changes. The use of enclosed glass scales ensures exceptional accuracies, but also come with a thermal co-efficient. The GMSP addresses this as well, with a new type of scale made from a material that has essentially zero thermal expansion within the typical shop floor temperature range. While scales of this material type must be left open rather than enclosed, they are exceptionally resistant to dirt. In addition, the GMSP's new design helps mitigate the collection of particulates that can build up on scale surfaces and reduce accuracy and reliability.

The GMSP also incorporates a system of new software and sensors that work in combination to detect, and compensate for, typical thermal fluctuations found on the shop floor. This ability to identify and apply compensation for factory floor temperature influences in real-time contributes greatly to GMSP's exceptional accuracies in an uncontrolled temperature environment.

Like all the GMS series products, the GMSP features *GAMA 3*, Gleason's object-oriented Windows 10 compatible operating software that puts a host of features right at the operator's fingertips, creating a simple, intuitive human/machine interface. With *GAMA 3*, creating a new program is as easy as point and click, and can be done in a few easy steps regardless of experience level, language requirements or the gear or application type.

Most importantly, *GAMA* supports multiple analysis tools to help identify the root cause of gear noise, including Fourier analysis of bearing surfaces, tooth contact analysis, surface finish analysis and easy interface with *KTEPS* software.

With *GAMA 3*, VDI/VDE 2610 GDE (Gear Data Exchange) capability is standard, reducing the need for redundant programming and allowing gear data/parameters to be easily transportable between different machines. The GMSP is easily networked with Gleason

GMSP models deliver lab-level inspection right on the production floor, saving the time usually required for part transport and lab room queues.

production machines in a Closed Loop, so program corrections can be made at the machine tool real time.

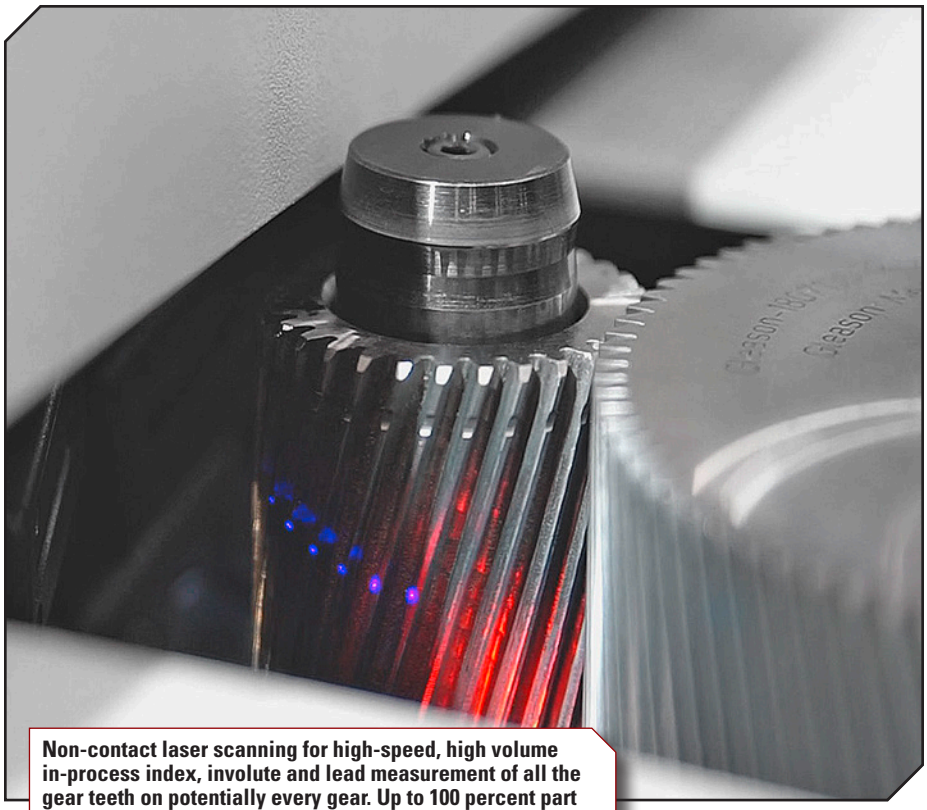
GRSL: In-Process Gear Inspection at Light Speeds

On the other end of the production spectrum, where transmission gears are being produced in high volumes and inspection of every gear in-process is increasingly desirable, Gleason offers its new GRSL Gear Rolling System with non-contact laser inspection. GRSL combines the latest non-contact gear analytical measurement innovation with the tried-and-true double flank roll test gear inspection process used today in most high-volume gear production where 100% inspection is required. This new product follows the strategy of the recently introduced multi-purpose GMSL non-contact inspection system from Gleason. Where the GMSL was developed to exceed the requirements of today's most stringent gear processing research, development and reverse engineering needs, the GRSL brings high accuracy, high speed, non-contact measurement of gears in-process to the high-volume production environment, where performance expectations have never been higher.

The new GRSL product stays true to the strategy Gleason's partner customers continue to ask for. It adds value by adding measuring capability with multiple sensors on a common platform to reduce cost of ownership, the number of operators required and the footprint. In addition, it adds throughput by measuring both the composite, functional error and the individual part characteristics of involute, index and lead, simultaneously during the same revolution of the gear during the test cycle.

Single Platform, Exciting Possibilities

This patent pending, dual purpose inspection system provides additional value by offering the versatile GRSL platform in three different configurations for use as a stand-alone manual gage, a semi-automatic gage or even as a fully automated gage where high volume throughput is the priority. Tests for full analytical results of both involute and index are performed on all teeth for most external, cylindrical gears up to 250 mm diameter in a matter of seconds along with the composite double flank roll test, again, with both tests taking place simultaneously.



Non-contact laser scanning for high-speed, high volume in-process index, involute and lead measurement of all the gear teeth on potentially every gear. Up to 100 percent part analysis and validation can take place in seconds.

With the new GRSL, the power of high-speed involute, index and lead measurements also comes with the ability to integrate with Gleason's *GAMA* gear analysis and charting output. This means options for AGMA, DIN, ISO as well as OEM specific analysis are available for the measurements, with common charting typical of the entire GMS line of analytical machines.

Consider the process control possibilities of full, high speed involute, index and lead measurement in process, inline. Add to that the ability to network this data in a Closed Loop directly to the machine tool using Gleason Connect to communicate results that can assist in determining necessary changes to the machine tool, the cutting tool, part setup, etc.

Taken a step further, GRSL can now be fully integrated into Gleason's new Hard Finishing Cell (HFC), the Closed Loop manufacturing system to produce precision gears in medium and high volumes. The system includes revolutionary in-line gear checking with real-time analysis and automatic feedback of corrections to a Gleason 260GX Threaded Wheel Grinding Machine, as well as integration of modules for auxiliary processes such as part washing and marking. Parts handling throughout the process is fully automated using high-speed robot and pallet system.

All of this is now available, fully integrated with the traditional double flank roll, composite testing still called out on most part prints today in high volume gear production.

Noise Analysis: In-Process, On the Shop Floor

The possibilities are exciting to think about and the capabilities continue to grow. Along with analytical measurements of gear parameters being measured in process in a matter of seconds, the same data acquired during the all teeth measurement can be analyzed using Gleason's analysis for noise characteristics seen in gears before they are assembled with a mating gear into a gearbox. Tolerances tied to these values can be monitored and controlled in more advanced, quantifiable methods than just go/no-go audio measurements shown in traditional single flank and end of line testers used today. The

value in predicting noise characteristics before the gear is ever assembled with a mating gear, a master gear or worse case in the gearbox itself is significant. It reduces the need for hard masters, a perishable component that needs certified and replaced regularly. It eliminates the need to tear down a finished gearbox to replace or rework gears tied to the noise. The new GRSL technology when added with Gleason's noise analysis reduces both gear lab space requirements and the use of analytical gear inspection machines, since GRSL operates on the shop floor and can do the work of multiple inspection systems by measuring in process. It minimizes the need for single flank testers and other end-of-line testers with the noise analysis data it provides. It also reduces gearbox teardown and gear rework chasing gear noise. The GRSL also offers the flexibility of operating the analytical and composite, double flank tests independent of one another if desired. This can offer advantages such as extending the life of the master gear if, for example, it is determined that not all parts require double flank composite testing. The power and flexibility of this new technology continues to grow.

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Gear Gages Go Integrated Wireless

George Schuetz, Mahr Inc.

Gears are an important element of mechanical designs. However, they are often taken for granted despite their many life and death implications. In fact, gears are used in so many applications and with so many different performance requirements that one can get lost in the principle design functions - including how a gear is assembled to a matching part, how it performs under different conditions, and the strength of its components.

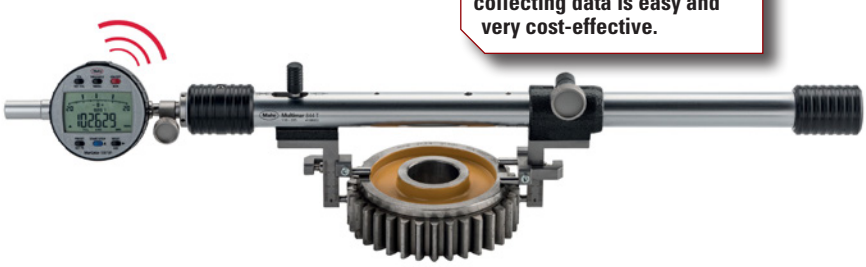
There is a very complex science behind gears and equally complex measuring systems available to discover virtually every imaginable piece of information about them. However, most gaging used for interim gear qualification on a shop floor is based on the gear being made from a basic cylindrical shaft or hole. From this, verification usually comes down to a few critical dimensions that can be measured and certified by measuring a related inside or outside diameter.

Thus, on a straight gear, the two common checks that need to be inspected are the parts' major diameter and diameter over balls/wires. Historically, basic inside diameter (ID) and outside diameter (OD) gages have been modified with special contacts to allow inspection of these important gear parameters. For example, the basic snap gage with dial indicator has become a diameter over ball gage using custom contacts. Since dial indicators and gages were developed some 100 years ago, basic dial indicator gages have been used to control important gear parameters.

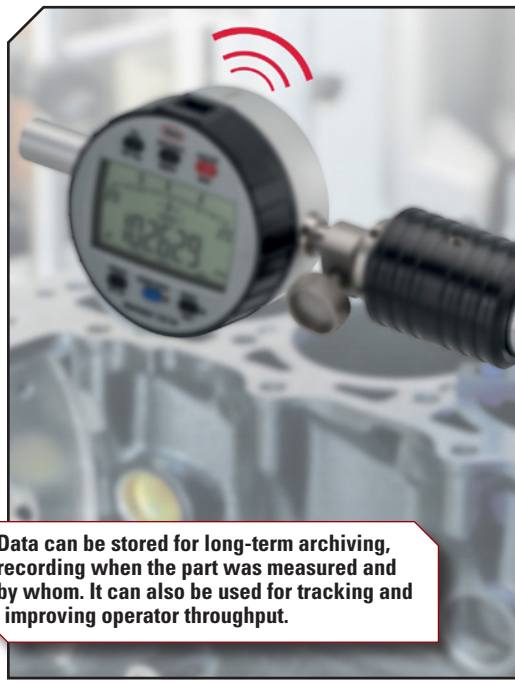
Around 50 years ago, the manufacturing world began collecting measurement data. Through tables, charts and graphs, measurements were made and used to help document quality or used as process control to help prevent bad parts from being used.

About 30 years ago, data collection for process control took a major leap forward. This happened as a combination of electronic technology and economics enabled digital gaging. With a digital signal available, it became possible to transfer information via cable directly from a gage or digital indicator to the data collector. This made it much more practical to make process control decisions based on statistical analysis.

Electronic data collection also ushered in a major improvement in data quality.



Today's digital indicators have data output built in, and collecting data is easy and very cost-effective.



Data can be stored for long-term archiving, recording when the part was measured and by whom. It can also be used for tracking and improving operator throughput.

Previously, data was either handwritten on a sheet of paper and then logged into a computer, or it was logged into the computer directly at the point of gaging. One can easily understand how an operator, sitting at a bench measuring hundreds of parts, could transpose numbers, skip digits, or simply enter incorrect numbers. These problems were virtually eliminated by importing data directly to data analysis software. In fact, when electronic data collection strategies were first implemented, it was not unusual to see ten-fold improvements in collection efficiencies and error reductions compared with manual collection methods.

These days, checking gear parts at a gaging station with a dedicated fixture gage connected to a computer via a cable for data collection is the norm. Today's digital indicators have data output built in, and collecting data is easy and very cost-effective. It is also fast and reliable and provides a great solution for many process or quality control applications.

But whether using just one digital indicator or multiple digital indicators on one gaging fixture, cable clutter soon became an issue. Each digital indicator would typically have its own cable, and since there are so many, some type of interface box was required to handle the multiplexing of the signals to the computer. With the integration of the transmitter in the digital indicator, both the cabling and the multiplexers are eliminated — not to mention a cleaner

looking gaging station. The PC running the data collection software can be triggered by the operator to gather the data from multiple digital indicators.

Eliminating cables is great, but probably the best application for this technology is right at the machine tool. Rather than store the data only to document that the part was measured and whether it was good or bad, the information can be better utilized. By transmitting wirelessly into the machine tool's controller, the data can be used in the calculation for offsetting. Thus, as the operator measures the parts, the data is used to assign the proper offsets, greatly improving the quality and throughput of the machine tool. Out-of-spec parts are virtually eliminated, and the machine's ability to make parts to the desired dimension is greatly improved.

At the same time, the data can be stored for long-term archiving, recording when the part was measured and by whom. It can also be used for tracking and improving operator throughput.

Today the combination of digital gaging for accurate shop floor measurement, unrestricted wireless transmission of reliable data, and statistics for process control allow for truly effective use of measurement data.

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Comtorgage Offers Gages for Specific Gear Applications

Comtorgage Corporation is a manufacturer of handheld, indicating gages for the measurement of bores, grooves, keyways, recesses, threads and a variety of gages specifically designed for the gear and spline industry. The gages are rugged enough for use on the shop floor, at the machine, or in the gage lab.

Monitoring a gear generating or spline cutting operation, whether it be shaped, broached, milled, hobbed, or rolled, requires periodic measurements of various characteristics of the part. In addition to an analytical check, a good way to keep track of the process is to periodically check the 'Measurement Between/Over Pins'. Maintaining this dimension within allowed tolerance will provide a certain amount of confidence in the process (except for index, lead, and profile errors).

Each Comtor-Spline Gage is made for a specific application. The gage incorporates two AGD gage pins of the same size as specified on the part print. The pins are allowed to "float" to compensate for minor misalignment or variations in tooth spacing. Mastering of the gage can be accomplished with a simple Cylindrical Master Ring or with a Sector master, if required. Measurement results can be monitored via Analog Amplifier (as shown in photo #1) or with a Digital Indicator (as shown in photo#2). Where required, the gage can be equipped with flatted pins to insure no interference with the Major Diameter. To ensure that the gage is designed correctly for the application, complete spline data is required, along with a part print showing where the spline is in the part.

Measurements can be monitored via a Digital Indicator.

Figure 1 shows three different gages, each for the 'Measurement Between Pins' dimension (based on Spline Data shown on the part prints) provided by the end users. One of the smaller gages includes a depth stop to allow the measurement to take place at a specific location within the spline. The measurement is not a 'line contact' with the entire pin locating in the tooth space. Actual contact takes place at the very tip of the gage pins, which allows for detection of any taper that may be present.

The example in the Figure 2 shows the Snap Spline design used for measurement of external splines and spur gears. In this case, the AGD gage pins are held between brackets and again allowed to float. The lower arm retracts to allow the positioning of the gage into the spline or gear teeth spaces. Mastering of the gage can be accomplished with a simple Master Block or with a Sector master, if required.

Measurements can be monitored via an Analog Amplifier.

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Frenco Examines International Spline Interface Standard for Ebike Manufacturing

The inspection method described in the International Spline Interface Standard (ISIS), uses a ring gage with two steps on the front side. This ring gage shows Go and Nogo situations in one gage. The decisive factor is the position of the shoulder on the ISIS shaft. The location of this shoulder must be within a range of 1.70 mm after the gage stops on the shaft. Thus, the Go situation is achieved (Go Range).

If the male shoulder on the spindle touches the lowest surface No Go (minimum surface on the ring gage), the spindle is too small (undersize). If the male shoulder on the spindle is above the top surface No Go (maximum surface of the ring gage), the spindle is out of tolerance (oversize).

ISIS Difficulty

If a dimension over balls is too small in section A-A for example, it will not be recognized with the ISIS gage concept. Unknown scrapped parts could be

in circulation. The decisive factor is the position of the shoulder (male shoulder). Obviously, there are shafts manufactured without shoulders. In this case, the ISIS concept cannot be used anyway.

Frenco ISIS Inspection Concept

The limits minimum and maximum will be checked separately in this concept. This means as already known in the machining element splines, that a full composite profiled Go ring gage for max. effective and a sector profiled Nogo gage for min actual will be used. This Nogo gage can figure out shafts which are too small.

A shaft with a male shoulder must fit in the Go ring gage so far, that the shoulder touches the front side of the ring gage. Shafts without this shoulder will be considered to the front surface of the shaft. The front side of the shaft must be in contact with the internal located stop in the Go ring gage. If the shaft reaches this stop, it can be clearly recognized with a sound.

The sector profiled Nogo gage is designed accordingly, so that it can be set on the shaft, and the front side of the shaft must not exceed the end surface of the Nogo ring gage.

As an alternative inspection method instead of the Nogo ring gage, a Frenco indicating inspection device type AVMF 1x1 can be used. With this, a dimension over two balls can be inspected in level A-A or B-B, too. During production, a range of different sizes can be observed and controlled. The smallest dimension over balls is the min limit which is not allowed to fall below. A setting master right on this min limit is available and the dial indicator can be adjusted to zero with this setting master. By inspection of a shaft, it is not allowed to fall below this min limit. Therefore, the handling is very easy with this indicating gage.

For more information:
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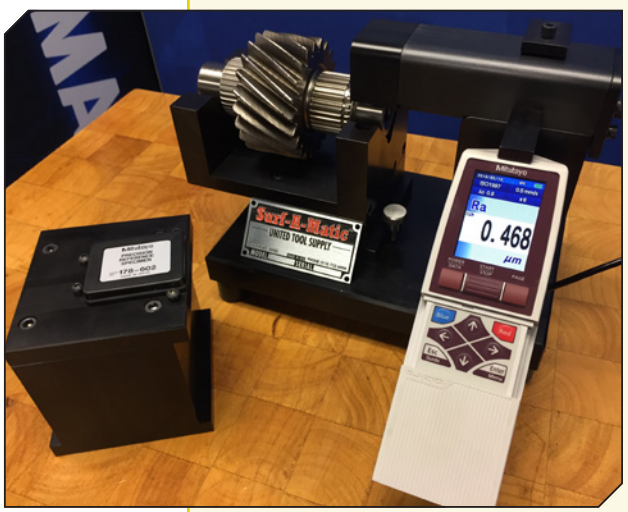
United Tool Supply Offers Diverse Range of Gear Inspection Equipment

United Tool Supply developed a bench top gage for 20 mm–75 mm internal spline inspection, called the Unite-A-Matic Model 2020.

"This was a natural fit for us as it fell within our Unite-A-Matic product line. Knowing what else the industry was asking for, we continued to explore other opportunities for growth. With a new mindset to "own the gage bench" we set off to develop a product line for a shop hardened surface finish gage and a shop hardened PD runout gage. This led to the birth of our Surf-A-Matic surface finish gage and our Roll-A-Matic PD runout gage," said Curtis Criswell, director of operations, United Tool Supply.

The Unite-A-Matic Model 2020 features ±.001 mm repeatability, a sealed digital readout system with inch/metric capabilities, cushioned gage head for consistent gaging between operators, roller bearing platen locator, interchangeable 2020 O.D. ball, pin or specialty anvils, interchangeable 2020 platen locators and a setting master can be provided. Options include output port for data collection, wireless data collection, and a stand on roller bearing wheels with storage drawer.



The Roll-A-Matic Model 8800 offers a flexible design to accommodate multiple parts, it's able to use existing masters, SPC capable, simple to use design, manual and servo-driven models, stand with roller bearing wheel and storage drawer and custom builds are also available.

The Surf-A-Matic Model 1000 features protective stylus housing, a universal design to accommodate multiple parts, interchangeable tooling, SPC capability, an accessible and removable controller, vibration dampening feet and custom builds are also available.

For more information:
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A Change in Processes and Positions at United Tool Supply

United Tool Supply started as an industrial supply business and transformed seemingly overnight in the mid-80s to a manufacturing company with the birth of the Unite-A-Matic PD inspection gage. The original Unite-A-Matic OD DOB gage evolved into an ID model and a bench top model for OD gear inspection. These three models sustained the business from the mid-80s through the first decade and a half of the 2000s.

By 2015, the company was down to four employees, and had lost touch with many engineers and key contacts as restructuring took place over the years. The customer base was shrinking, and the company was not selling the amount of new product it had in the past.

"The odds were stacked against us day in and day out, but day in and day out, we showed up and we worked hard," said Curtis Criswell, director of operations, United Tool Supply.

At its height, United Tool Supply was selling over 100+ new gages a year and touted dozens of employees. It was seemingly unfathomable to imagine how a company went from sustaining a livelihood for so many families turn into a shell of what it once was.

"Our conference room had the same blood red carpet from the '70s when our facility was built. The conference room turned into an oversized storage closet. Our manufacturing shop was cluttered, full of antiquated machines, and memories of what use to be," Criswell added.

They took on the painstaking process of a cosmetic overhaul. The blood red carpet was replaced with a neutral blue. Down came the storage shelves that had archived the company's history for decades. The old drafting tables were replaced with new computers and software.

"This was a difficult time. A company so proud of its roots. At times, too proud to make a change. As the saying goes, 'if it isn't broke, don't fix it.' Truth is, the business model was broken, and it was left for us to fix," Criswell said.

United Tool Supply began to sort and separate good vs bad inventory, reorganizing the organization in ways that made more sense. Machine component inventory was labeled and stored accordingly, a workflow process was created, and efficiencies were gained. In came new CNC equipment, out went multiple machines with each replacement.

"Not only did we bring in new equipment, but we now keep work in-house that was contracted out in the past. What took weeks now takes days," Criswell added.

Product innovation has been key for the company's success. While the Unite-A-Matic PD gage built the business, it is now other products that will grow the business now and in the future.

"We are creating strategic partnerships to support our customers in any way possible, including prototype gears and technical staffing," Criswell said. "Those reading this may think 'United Tool is doing what now?' And to that question I want to remind the reader to call back to the story presented before them. United Tool Supply is a company that was never meant to be, building a product that had never existed previously, in an environment originally meant to store inventory. The odds continue to stack against us, but who doesn't love an underdog story?"