Transformational measurement and inspection for the fabrication shop floor and beyond

by Joel Martin, Hexagon Mfg. Intelligence, and Belinda Jones, HiTech Marketing LLC
Ten years ago in the sheet metal world, a precision shop conducted quality control (QC) with feeler gauges, micrometers, slide calipers, checking fixtures and, possibly, a few coordinate measuring machines (CMMs). Portable metrology solutions like articulating arms, laser trackers and scanners were making their debut in many Tier 1 and Tier 2 manufacturing facilities. But the sophisticated software and user interfaces required trained metrologists to perform dimensional control and inspection work. Smaller fabrication shops were reluctant to embrace technology that required a specialized workforce in high demand and short supply. Their tried and true measurement techniques were maintaining an acceptable level of part and product quality, so why change?

Metrology and those in the field who provide the software and hardware solutions have made significant progress in the past decade. A laser focus on usability and software customization has paid off in a big way to mainstream the use of high precision measurement for car bodies, aircraft, consumer products, electronic enclosures and other fabrication applications. Today, the worker who used feeler gauges to verify a part a decade ago is using portable metrology technologies without hesitation along with mechanics, technicians, tool builders and others who are not professional metrologists.

For a reasonable amount of money, metrology can be moved out onto the shop floor.

Transition or bust

At minimum, most fabrication shops have QC processes in place with fixture-based controls where stationary or portable CMMs are absent. There is an upfront investment to build the fixture, but the inspection process is quite simple. The QC process involves pulling a part and placing it into a fixture. The

† Hexagon’s Blaze 600M portable blue light measurement system is a non-contact optical 3-D scanning solution for rapid data acquisition on the fabrication shop floor.
The technician applies feeler gauges to the fixture to verify the part is good. A shim pack may be used to figure out the flush and gaps for the production part.

The downside of the process is its manual nature. The technician writes down a 2-mm shim in check point 32 on a piece of paper. The process could even be as basic as verifying the as-built part to a 2-D template with nothing but a visual inspection. The fab shop working in this way cannot provide any level of traceability for the customer, and there is a large potential for human error. In addition, if a Tier 1 manufacturer sends model change information to the shop, the fixture has be changed, which is an expensive proposition.

The move from a hard gauging concept to metrology-based methods results in an automated or semi-automated inspection process that details and archives digital, as opposed to hand written, information. This system provides traceability that is an accredited standard in the industry, and now an inspection report can be generated on the fly for better customer service. This transition from the manual archival world to the digital thread age introduces many advantages when defending the quality or state of fabricated parts.

**CAD and metrology**

The intersection between fabrication and metrology is a CAD model created in-house at a fab shop or supplied by a customer. This 3-D design is the starting point to ensure that parts are accurate, fit properly into a working assembly and align with other critical components and features. Specialized software has been developed for sheet metal design, simulation and feasibility as well as costing solutions. Fabricators must utilize a range of metals and materials at different price points – composites, carbon steels, stainless steels, aluminum, brass and copper. Before any material is cut or formed, the 3-D model is scrutinized for scale and manufacturability leading to more efficiencies gained in the process.

The 360° Smart Inline Measurement Solution from Hexagon is utilized for automated inline, near-line and offline inspection of an automotive body in white. The system uses robust white light measuring sensors with a large field of view and industrial robots as the positioning platform.
The CAD model lies at the heart of the “digital thread” that weaves together computer-aided engineering and computer-aided manufacturing technologies and metrology solutions. A 3-D model provides the basis for CAD-based inspection software operations. 3-D point data or scanned point clouds are acquired from the manufactured part associated with the digital model using a metrology device such as a portable arm and integrated scanner. Once the data is aligned to the CAD model using key reference points, the scan set and actual part are compared in the inspection program to verify if the part passes or fails.

**Making the move**

As a fabrication shop grows in size to produce multiple models of automotive parts or electronic enclosures and serves several customers with CAD-based product development, the advantage of implementing metrology solutions becomes apparent. Producing one part for a single customer using a checking fixture for quality assurance is workable and easy. But larger shops can have QC rooms filled with costly fixtures if there is no awareness of better methods. Fixtures also require recertification and are incredibly expensive to build and replace when there is a model change, or if the fixture goes bad or is damaged by a rogue forklift.

Three compelling factors will impact the industry’s move toward metrology-based measurement, starting with today’s aging workforce in manufacturing. Fab shops will inevitably have to increase training, as veteran employees retire in the coming decade. Will legacy operations move the company forward and attract new talent that cut their teeth on CAD and digital manufacturing?

As parts get bigger and processes more complex, process flow becomes more of a concern for fabricators – how long does it take from part build to part verification to shipping it out the door? Will manual practices and legacy operations deliver...
the efficiencies needed to remain competitive?

Lastly, traceability is an undeniable issue, as OEMs are implementing traceability programs to meet regulatory mandates and remain viable in a global market. A manual QC process cannot effectively serve the needs of today’s fabrication shop, when customers are requiring more visibility in the supply chain and want on-demand data to support process improvement and drive down costs.

First metrology steps

Many small to mid-size fab shops have implemented CMMs as an end-of-line inspection process. The gauging process is used for daily work, and when there is a problem, the CMM is used to troubleshoot the part. The advantages of stationary CMMs are particularly apparent when inspecting automotive parts or other high-volume parts in the aerospace, ship, defense, appliance, machinery and railway industries. Their open structure permits direct access to the workpiece and makes for easy loading and unloading.

However, the CMM can become a bottleneck during heavy production cycles causing throughput issues. This is where a portable articulating arm starts to make dollars and sense. For a reasonable amount of money, metrology can be moved out onto the shop floor. The instrument does not change the gauging concept, but the gauge is replaced with a fast, flexible and precise measurement solution that can provide single point measurement and scanning capabilities.

Portable metrology change

The transition to the digital world has been paved with dramatic changes in technology, software and user interfaces, resulting in workable solutions for shop floor workers. In the beginning, fabrication shops may have perceived the value of portable CMMs, but did not have the talent to leverage the technology. Today, instead of using a 2-D print to perform a feeler gauge check, the technician can utilize a portable articulating arm with laser scanning capabilities for 3-D surface inspection.

The combination of Hexagon’s Leica T-Scan 5 and Leica Absolute Tracker AT960 can ensure hundreds of millions of accurate points on fabricated surfaces.

September 2016
of a sheet metal part. Powerful, intuitive inspection routines can be customized to capture, align and analyze scanned data, then generate a 3-D color map with various degrees of point deviation on the computer screen. The shop floor worker can visualize and verify the results for themselves during the QC process, and make a fail or pass decision.

The arm’s integrated scanner acquires thousands of points per second for detailed inspection of geometric and surface features. The portable CMM setup also allows for point data capture with contact probes when needed. The arm comes in various measurement volumes up to 15 ft. for different part sizes and typically sits on a solid granite plate atop a rolling cart that can be transported all over the factory. Integrated wireless communication used in touch probing mode adds another element of free movement. The mobile system is also practical when larger parts on the shop floor need to be inspected or reverse engineered.

While sheet metal tolerances vary, the inspection system provides accuracies of 0.002 in. to 0.004 in., well in range of most target accuracies. The accuracy specification of a laser scanner is 50 microns. The accuracy of an articulated arm with probe weighs in at 25 microns, with the entire solution spec accumulating at approximately 75 microns.

**Script-driven processes**

Working with a knowledgeable technology provider or an in-house programmer, metrology software programs allow script customization to provide step-by-step, easy-to-execute inspection routines for shop floor workers. This development presents some compelling choices for fabrication shops. Is the shop going to build a $100,000 checking fixture that it uses once and throws away with a model line change? Or does it spend two days of programming to build a part program script that does the exact same thing?

The operative word in this scenario is “change” when moving from gauging to part programming for inspection. When a customer has a model year change or a design change or a vendor change, the fab shop spends a few hours upgrading a software script to follow along with the workflow, as opposed to throwing away a pricey tool and starting over. When a shop goes from working on a left door to a right door, or moves from Ford to GM, or receives a mid-cycle update, the digital inspection process is updated instead of eliminating the fixture. The return on investment is mind bending, and the metrology equipment will be viable for many years.

**Game changers**

Small fabrication shops will clearly make productivity gains as they move from hard gauging to use of
metrology in the realm of portable arms and CMMs. With ultra-fast, flexible scanning systems arriving on the scene, fabrication shops will make another leap to point cloud-based systems with streamlined operations for inspection, measurement, manufacturing and reverse engineering.

The big picture for Tier 1 and Tier 2 manufacturers is the use of inline metrology, so producers get away from inspecting cars and building the product correctly the first time. The integrated process will reduce cycle times and also generate 100 percent of the data for every car built before it rolls off the line. In the auto world, inspection is looked at as “cost.” The new value strategy lies in removing metrology from an end-of-line process and integrating it upstream to modify the production process so a manufacturer does not have to scrap parts.

Advanced manufacturers are realizing metrology data feedback is valuable throughout production, so manufacturers can modify the process, and not spend time verifying parts. The technology used to enable these concepts – robots, laser trackers, sensors, software and hardware – is all available today. At the OEM level, manufacturers are putting metrology processes right next to part production on the shop floor. Automated cell systems combining metrology and robotics can take a part, load it into a scan cell, hit go and have a report at the end of the cycle.

Integrators are working closely with manufacturers to advance their operations with an eye on smart factory trends that are reshaping the way things are built around the world.

With data-driven manufacturing trending high these days, fabricators may find themselves giving metrology technologies a serious second look. Syncing automation and data exchange during production is closing the manufacturing feedback loop and putting Industry 4.0 concepts to work. Front and center of all of this innovation is 3-D data – data captured by metrology solutions such as articulating arms, laser trackers, scanners and more.

Globally competitive enterprises are also on the hook to generate more manufacturing efficiencies by replacing legacy technologies and processes with new ones. Streamlining the design and manufacturing of sheet metal parts with a closed feedback loop will ultimately reduce product development time and material costs of sheet metal parts for those producing ships, car bodies, aircraft, consumer products and more. ■