Inspecting Metrology Options

Gary Hobart

Ensuring that the quality and accuracy of a finished product meets its CAD design is of paramount importance for the medical device manufacturing industry. However, how to facilitate that is not nearly as clear. This article provides valuable insights on how engineers can be certain they are employing the most appropriate inspection technologies for their specific applications.

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Engineers and designers in the medical industry are often tasked with formidable assignments to create incredibly small and intricate parts. The road from design to manufacturing to quality assurance is now fully digital thanks to the use of CAD. Choosing the correct parameters—tolerancing and methodology for manufacturing—is tough enough, but ensuring that the design intent matches the real-world capabilities of available metrology equipment can be tougher. There is a dizzying array of measurement devices and techniques that can be employed to acquire data. Each can be used to one degree or another to understand if the "as-made" product conforms to the original design intent. But which to choose? Unfortunately, the answer isn't always clear-cut.

Where CAD and Metrology Meet

Today, engineers use 3D CAD files in their daily production processes, from design to machine tools to the inspection room. Inspection software now bridges 3D CAD to 3D inspection. Why is this so important? Precision inspection enables engineers to ensure they're producing nearly perfect parts, and industries, such as medical part manufacturing, depend on this capability. Organic forms, such as artificial joints, are being manufactured based on very complex forms, parabolas, and surfaces that require advanced inspection techniques. A patient's outcome depends more than ever on manufacturers ensuring that mission critical parts are made as close as possible to the design.

The Right Device

Engineers often accept the results without question when a measurement device proclaims the part "passed." It's only when the instrument announces a failure that the legitimacy of the measurement or even the machine's accuracy is questioned. However, engineers should be equally skeptical of passing and failing results, at least until they're confident that their measuring methodology is valid. Frequently, the wrong methodology can be employed to assess the feature, which can just as easily result in a false positive as a failure. An exaggerated example would be using a standard retractable tape measure with a resolution of a tenth of an inch to measure something with a tolerance of 0.004 of an inch. The tape measure is incapable of a resolution to achieve confidence in the result. Therefore, the real answer is masked by the limitation of the measuring device (or technique). Of course, this is an over-simplification but is the heart of the issue—a perfectly valid device can be used and perfectly invalid results can be obtained.

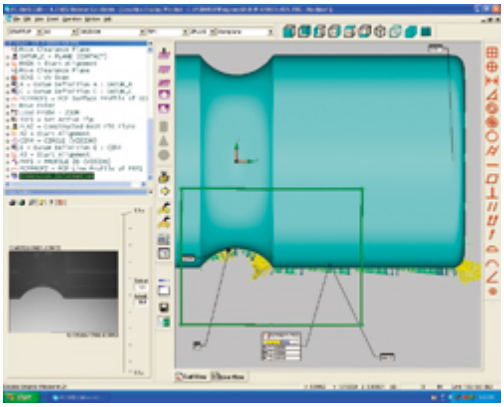
In the realm of metrology, there are many different ways to acquire dimensional surface data. Different sensors come with strengths and weaknesses for different measuring applications. Sometimes design engineers find it difficult to accept that

the tolerance they specified in a product design is incapable of being achieved in the "real world" by the quality assurance department's available equipment, but this situation occurs relatively often. A CAD environment is a virtual world, and as such, always produces the utopian "perfectly designed" product. The reality of design for manufacturability is really, by extension, design for inspectabilty—anything can be made; verifying that it is what the designer wanted in the first place is the tricky part. The task is seldom as obvious as knowing not to select a caliper (returns only two data points) to verify form deviation (requires lots of points), but, whatever the situation, the designer or manufacturer must assess the overall specification of the proposed measuring machine to be used for the job at hand. In essence, that person must ask the simple question, "Can the available measuring system return results with a greater accuracy than the part's original design specification?"

Tools to Measure By

To better understand how metrology sensors add capability of measuring the original design intent of a CAD model, the following overview will illustrate the fundamentals of how different technologies can measure. Vision (camera-based) machines are useless if incorrect lighting or magnification is employed. Environmental conditions, such as a change in temperature, can sometimes impact the effective accuracy of a CMM. These circumstances, coupled with misapplication of a tool to the job, can be contributing factors to wrong results. However, with assistance from an OEM and proper product education, uninterrupted effective measurement can be achieved. Oftentimes, the misapplication of the tool to the circumstance can be influenced by the metrologist's particular experience with one or another type of platform, another advertisement for the value of ongoing education for metrology professionals. First, typical platforms for measuring medical parts will be reviewed, and then specific sensors used with these platforms.

Platform: Vision Machines



Most medical device manufacturing companies are familiar with vision (camera) based inspection systems. Many of these vision systems now can also be equipped with a variety of additional fully-functional measuring probes—touch, laser, or white

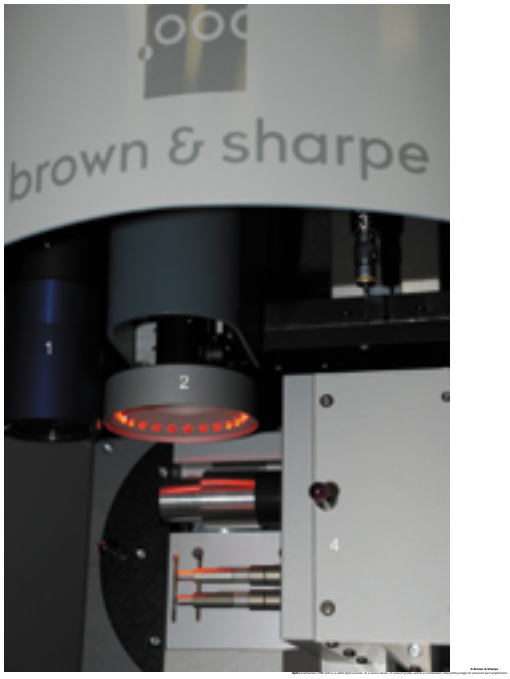
light sensors (WLS)earning these systems the designation of "multi-sensor." Each sensor (touch, laser, WLS) can serve many purposes, but the vision (camera) probe is fastest and most accurate for two-dimensional measurement in the XY field of view. Although capable of Z (height) measurement, the vision sensor's accuracy is impeded by the depth of field of the lens, and therefore its accuracy is governed primarily by magnification.

As these systems are camera based, the measuring methodology is actually governed by the live image. The system is literally measuring the image it "sees," pixel by pixel. With interpretation algorithms analyzing the image, this means in practice that the smallest portion of a feature on a medical part that could be viewed (and measured) by a vision system would be equal to 1/10 of a pixel. If one were using a very high magnification lens, the equivalent accuracy would be in the sub micron range for a vision probe. When used in combination with a white light sensor, the effective resolution could be nano-metrology capable.

Part data is generally collected in seconds of time and can be supported by pick-and-place trays, which minimize operator handling. Both feature location and feature form can be measured from the data acquired. The price range of these systems is based on capacity, speed, sensor types, and accuracy to support a wide spectrum of budgets.

Ideal candidates for a vision based system include typical small parts with medium to extreme accuracy requirements that are molded, extruded, or machined, such as fasteners, drug delivery systems, catheters, and in some cases, prosthetics. The main limitation will be the size of the unit's table to accommodate the part.

Platform: CMM



An alterative methodology to the vision based machine is a "traditional" coordinate

measuring machine (CMM). Where once these devices were most appropriate for prismatic parts with limited form measuring requirements, the variety of sensors now available can transform the traditional bridge CMM into a true multisensor platform as well. A combination of tactile, laser, and video sensors allow complicated parts with a variety of feature types and characteristics to be measured on the same machine. Many of these sensor types are similar to, if not the same as, those available on a vision platform. The advantages of a CMM include the ability to handle potentially larger, longer, or greater simultaneous quantities of parts than many vision machines, and the ability to handle greater part weight.

Platform: Articulated Arm

Articulated arm machines are light, portable, and easily moved anywhere. With a laser scanner attached, they are an invaluable resource for quick digitization or one-off inspections. This is especially useful for larger assemblies, parts, or even machinery, where an operator can use the arm to reach above, under, around, or inside the object. It's even possible to use one to scan a live patient.

Tube geometry is a difficult metrology problem to solve without the right tool for the job. Articulated arms can be specially equipped with probes and software for measurement of tubes of all sizes and materials, including direct communication to tube bending machines for bend correction.

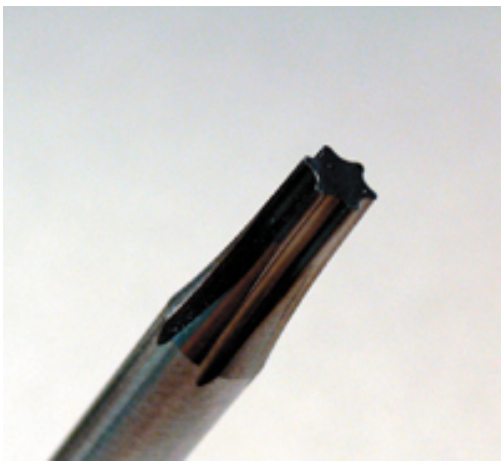
Probing Technologies

Tactile Probes

Tactile probes work by physically touching the part to inspect it. They fall into two main categories the so-called "touch probe" and the "analog scanning probe." These types of probes are normally found on CMMs, but increasingly, on multisensor vision systems as well. The touch probe returns a single measured point for each time it touches the part. The touch probe's accuracy is very good, and is generally related to the length of the styli and styli diameter used. Overall accuracy can be improved by utilizing a motorized probe head instead of a star-shaped styli, and orientating the probe head to the perpendicular to the surface of the feature being measured. This technology is particularly useful in measuring products with 3D prismatic features that can be characterized with relatively few points.

If one needs more form data to characterize a flowing 3D surface, an analog scanning probe is more appropriate. The probe moves along a surface and returns thousands of points of high quality data in a relatively short time. Analog scanning probes are generally among the most accurate of the scanning probes, although if one requires exceptionally large amounts of dense data, collection with analog scanning can be somewhat slow.

Lasers



Lasers fall into many categories and break down into two types—triangulation or through the lens (TTL). Both types return dense, high quality data quickly.

The triangulation type, normally found on devices such as articulated arms or fixed CMMs, have a fixed working distance and stripe size, and are normally used to "paint" the part to collect the data. The drawback is that the reflection of the transmitted light (laser) to the receiver is needed, so there is a limitation to the angle of measurement (thus the need to "paint" from various angles). Additionally, the surface finish of the inspected part can have an impact on results. Overall results of this type of laser inspection tend to be somewhat less accurate than analog scanning inspection or video inspection, but there's no better way to capture large amounts of form data quickly; these types of probes will produce millions of points in seconds. Large parts and assemblies can be measured with systems of this type, particularly lasers mounted on portable arms.

TTL lasers, used most often with vision-based machines, combine the transmission and reception of the laser through the same lens. Functionally, this means that the system needs to be much closer to the part for measurement, but the depth of field of the lens can influence (or improve) accuracy. Since a camera-based laser is typically mounted above the part, measuring features on the sides or bottom of the part requires the part to be rotated. This type of laser system limits part size to the size of the measuring stage, so it's best for smaller parts.

White Light Sensors

The white light sensor (WLS) is like a TTL laser; it is a through-the-lens type of sensor and it is also used for smaller parts to collect form data. Additionally, it is often on a vision-based machine. Unlike today's lasers, however, white light sensors just measure light in excess of 26,000 color levels. A single color is chosen and checked for the return value of the projected light. The strength of the reflected light is not a factor, and this method can easily accommodate parts with extreme angles, up to 88° offset to the probe. This technology is ideal for parts with numerous small, complex surfaces with extreme surface variation.

The Right Stuff

Get it right by getting to know the machines available to measure a design. Talk to the OEM about product specs, and discuss the inspection needs for today and down the road. For those considering buying a metrology solution, take the time to look at add-on technologies for the CMM, vision system, or other device that will fulfill new requirements and give greater flexibility to the system. With a variety of metrology solutions all linked to CAD inspection, complete dimensional inspection can be achieved in medical design, down to the tiniest part. With correct metrology methodology, producing high quality parts that conform exactly to design intent is not only possible, it's a reality.

Online

For additional information on the technologies and products discussed in this article, see *MDT* online at www.mdtmag.com [2] or Hexagon Metrology Inc. at www.hexagonmetrology.us [3].

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