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Cross-sectional Scanning:
New Possibilities for the Inspection
of Injection-molded First Articles

Cross-Sectional Scanning:

Rapid First Article Inspection of Complex Molded Parts

Cross-Sectional Scanning's unique qualities and approach leads to faster, less expensive and more complete inspection of injection-molded first articles.

3D SCANNING IS USED FOR DIVERSE APPLICATIONS in design, manufacturing and inspection. While it is commonly used for, and linked to, reverse engineering, the biggest application is in the area of inspection for quality control. In this application, conventional tools such as CMMs are prevalent, but 3D scanning technologies have emerged and are gaining the interest of manufacturing companies due to their ability to dramatically reduce labor costs.

Laser and white light systems are frequently associated with 3D scanning. However, there are many other technologies that facilitate the capture of 3D shape information. These include scanning CMM's, computed tomography (CT) and articulated arm touch probes.

Another alternative is cross-sectional scanning. Although it shares some commonality with other 3D scanning systems, it has a unique approach with characteristics that make it ideal for first article inspection of, and process qualification related to, small, highly complex, injection-molded parts. This uniqueness is derived from the basic process, which is analogous to rapid prototyping working in reverse. Like rapid prototyping, cross-sectional scanning is insensitive to complexity and has no difficulty in defining internal geometry. It also shares the advantages of simultaneous processing of multiple parts, no required fixturing and being capable of fully automated, unattended operation. This translates to faster, less expensive and more complete inspection of injection-molded first articles.

The Process

Cross-sectional scanning delivers a digital definition of a physical object by generating an ultra-dense 3D point cloud. As with laser and white light systems, the point data is captured using a CCD digital camera and stored as a point cloud. But the similarities end there. Cross-sectional scanning has more in common with rapid prototyping and optical comparators than it does with other 3D scanning technology.

Like rapid prototyping, cross-sectional scanning is a layer-based process and like optical comparators, it creates an image of a 2D profile. Blending the two technologies, cross-sectional scanning generates 3D data that completely defines the physical object. On a layer-by-layer basis, the process automates the capture of the 2D profile images and assembles them into a 3D representation.

As with rapid prototyping technology, cross-sectional scanning is able to process the most complex molded parts. Intricate, feature laden parts are processed in the same time as simple shapes. Most notably, the layer-by-layer operations delivers data capture of internal geometry, which makes it one of the few technologies to do so. The ability to process multiple parts in a single operation, the elimination of fixturing and automated, unattended operations are other traits shared with rapid prototyping. These advantages expedite the process and minimize labor demands.

For first article inspection, accuracy—referred to as uncertainty by NIST (National Institute of Standards and Technology)—is of the utmost importance. Accordingly, cross-sectional scanning yields an average error of just 6 micron (0.00025 in.) and an overall error range of 18 micron (0.0007 in.).

Following the scanning operation, the point cloud data is ready for export as point data (in ASCII or IGES format), STL or OBJ file. For quality control applications, it is immediately ready for inspection reporting. Unlike other scanning methods, the operation of the cross-sectional scanning process eliminates the need for scan

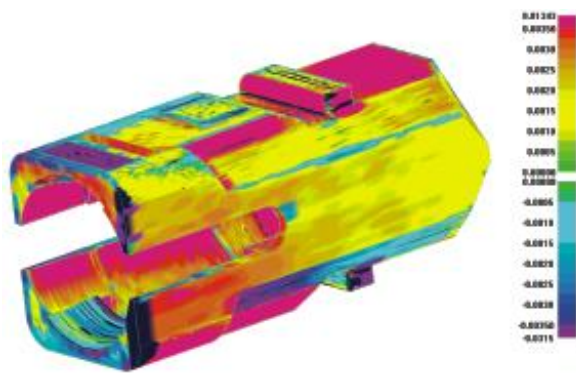
CGI's CSS-300 machine.





Images courtesy of CGI.

CSS can even scan small, detailed, clear parts like this telephone connector.



The different colors in this computer generated color map show the deviation of a part from the original design.

alignment, hole filling and surface smoothing. This means that inspection can begin within moments of the completion of the scan.

For quality control applications, cross-sectional scanning uses both a proprietary, patented software called Spec.Check™ and commercially available scanning software such as Geomagic, RapidForm and PolyWorks. Spec.Check is used for feature-by-feature inspection and go/nogo reporting while Geomagic, RapidForm and PolyWorks are used for color mapping and reporting of the deviation of all points from the original design. The combination of these tools offers a quick, yet thorough, analysis of part quality.

For additional time savings, the inspection from a part may be saved as a template within Spec.Check. The template can then be applied to other instances of the same part—from a multi-cavity injection mold—for inspection reporting that can be completed in just a few moments. Contrary to traditional CMM reporting, Spec. Check produces both tabular data and a 3D image of the point cloud with inspection data graphical presented. This visual format provides a quick reference—green for pass and red for fail. Also, unlike conventional inspection processes that require development of a thorough inspection plan before the work is done, the point cloud allows interrogation of any features of the part at any time.

Distinctions

The process and imaging methodology allow cross-sectional

scanning to offer some unique advantages for first article inspection, as well as reverse engineering. The core differences center around automation, completeness of the data set and the materials that can be scanned.

When compared to all data acquisition technologies, cross-sectional scanning combines many of the benefits of contact and non-contact systems and extends the value by delivering complete part definitions in an automated process. With batch processing and templates, the process is extremely fast when performing inspection on multiple parts. With the exception of more expensive and more complex CT scanners, cross-sectional scanning is the only process that generates 3D data from internal geometry or inaccessible features. While many companies have devised practices that avoid the need to do so, the technology opens the door to full inspection of a component to provide a thorough analysis of the quality of the part, both inside and out.

When compared to CMMs, cross-sectional scanning offers some unique benefits in the areas of preparation and supplemental quality inquiries. To prepare for a CMM inspection, a thorough inspection plan is required. In effect, all features of interest and potential trouble spots must be defined prior to measurement of the object since it is not a trivial matter to re-inspect a part. Building the inspection plan takes time and careful consideration. It also demands that the organization is able to foresee or predict the elements that may affect part quality and performance.

Prior to inspection, the part must also be fixtured to position it for the CMM and to minimize variables that may corrupt the measurements. Also, the CMM must be programmed to capture each point of interest. This consumes a lot of employee time. With cross-sectional scanning, a rough inspection plan is appropriate, since the dense point cloud allows unlimited quality interrogations without the need to rescan the part and the process does not require fixturing or programming. This expedites the process and reduces the time demands on the inspection staff—with some users reporting 10:1 labor savings.

Unlike laser and white light scanners, cross-sectional scanning does not use triangulation to calculate spatial data. This overcomes many of the limitations of these technologies. Cross-sectional scanning can handle a wide range of materials, including opaque and transparent, and has little limitation of part color. Cross-sectional scanning can also inspect parts with either glossy or matte surface finishes.

Considerations

Cross-sectional scanning is a powerful tool for generation 3D data, but it is not the ideal solution for every part in every application. When considering the technology, it is best applied to feature rich, complex parts and those with internal geometry. Additionally, since scanning time is a function of part size, not complexity, ideal applications are those with tiny to medium sized parts that range from small connectors to objects the size of a softball.

Another consideration is the number of data points desired. If only a few points are of interest, contact systems like CMMs are the best option. However, when the data points swell into the hundreds, or even the thousands, or if the same measurements are needed over multiple parts, cross-sectional scanning is likely to be the most efficient process for data acquisition.



Above: This electrical socket is the same part as in the picture to the left. This shows CSS's ability to scan complex, inaccessible features.

Left: This image shows CSS in process. The part is encased and the fly cutter is on the right.

Another aspect that promotes the use of cross-sectional scanning is the base material of the part. In many cases, the technology can capture data from parts that are not well suited for contact or optical systems. For example, soft, elastomeric parts are difficult for contact systems since they often deform under the pressure of the probe. On the other hand, clear parts are not suited for optical systems since the light passes through without returning to the scanner sensor. Neither soft nor clear materials are problematic for cross-sectional scanning.

A final, but important, consideration is that cross-sectional scanning consumes the part. Therefore, good applications are those where the part is not one-of-a-kind and the cost of the part is low. This rules out many prototyping applications but promotes the use of cross-sectional scanning for inspection of injection molded parts that cost, on the margin, only pennies each.

Conclusion

Cross-sectional scanning is just one of many alternatives for the acquisition of 3D data from physical objects. As such, it is a tool that complements both conventional processes like CMMs and the growing application of 3D scanning technologies like laser and white light. As with any technology, consider the application, goals and requirements and use this information to select the process that meets the requirements while minimizing time and cost.

While cross-sectional scanning, and 3D scanning in general, offers major advantages in first article inspection, adoption of the technology has been slow. The methodology and the data set are proven, but they are radical departures from the time-tested tools common in the quality lab. The catalysts to change will be the continuing necessity of greater inspection capability for less cost, the accelerating convergence of factory process capabilities with engineering design requirements and the drive of innovative companies and their people. Change is not easy. But as it happens, companies will discover that they gain a more complete quality picture, flexibility in quality procedures, reduced inspection costs and faster approval cycles so that products can be launched sooner. **TCT**

Craig Crump is the CEO of CGI (Minneapolis, MN). Craig is a co-founder of the company, along with his wife Ellen, since its inception. Craig holds three patents in the CGI 3D scanning technology. In the early 1990s, Craig was employed by Stratasys, Inc., a developer and manufacturer of rapid prototyping systems, as a development engineer. Craig has a degree in Mechanical Engineering from the University of Southern California and an M.B.A. degree from U.C.L.A. He can be reached at (952) 937-2005 or ccrump@CGIinspection.com. For more information, visit www.CGIinspection.com.

CGI's Cross-Sectional Scanning Process

The CGI 3D scanning process begins with the encasing of a part in a slow curing material called Encase-It™. Once cured, the encased part is mounted on the platform of a CGI Cross-Sectional Scanning machine. Using an industrial fly cutter, an ultra-thin layer is carefully milled away, and the CGI scanning system accurately captures each newly exposed 2D profile. The milling and imaging process is repeated until the encased part is fully consumed and the collection of 2D images are post processed to generate a cloud of points that fully describes the 3D shape of the entire part.

What separates CGI from other 3D scanning technologies is the completeness of the 3D data sets. Contrary to laser and white light technologies, the CGI technology captures sharp corners, deep pockets and internal geometry in a single scan. Use of CGI eliminates the time consuming efforts in post process assembling of the data to create a complete data set.