Arm-Wrestling Unique Measurement Problems

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Multi-axis, arm-type measure ment systems are neither conventional hand measurement tools nor coordinate measuring machines (CMMs). But they are being used to solve a large assortment of measurement problems that defy conventional solutions.

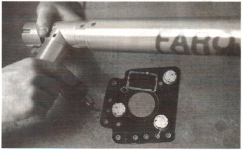
Because of their unique characteristics, such as six axes of movement, broad measurement span, ease-of-use, and portability, new applications for arm-type measurement systems seem to arise regularly.

Applications that might favor this tool include:

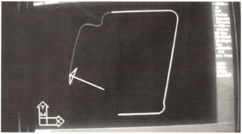
- parts with obstructed lines of sight,
- parts or tooling that cannot or should not be moved during the manufacturing process,
- situations where it might be useful to have CMM capabilities in the field,
- reverse engineering applications for manufacturing operations that can't justify having a CMM,
- large contoured edges or three-dimensional surfaces that need to be digitized for analysis.

One such system came about when a group of engineers at Martin Marietta Corporation (currently, Lockheed Martin) teamed with Faro Technologies Inc. of Lake Mary, Florida to adapt the company's FaroArm® to industrial measurement applications. Originally designed for medical applications, the FaroArm measuring device has articulating links and rotating joints to provide a full range of motion similar to the human arm.

The FaroArm enables users to accurately digitize simple points or complex surfaces in three dimensions to within ±0.003 inch. Through direct serial port interface and customized drivers, these three-dimensional data are immediately available in the user's preferred computer software for analysis. Current users include job shops, aero-



As this template is scanned with the FaroArm, the drawing is simultaneously created within the computer. The computer is use to drive NC equipment for manufacturing the templates.



space manufacturers, metal stampers, casting operations, and even structural engineers to verify stability of a massive sculpture. However, many other potential users are at a loss to figure out where this new class of measurement system might fit into their operations.

DIRECT dimensions, Inc. of Baltimore, Maryland is able to provide some answers to that dilemma. This unique device is one of the tools DIRECT dimensions uses to help manufacturers solve unique measurement problems.

Digitizing Sheet Metal Templates

DIRECT dimensions is helping a number of sheet metal shops convert their conventional cutting templates to programs for operating new laser and water-jet cutting machines as well as automatic punching machines.

The conversion process involves scanning the contours of the pattern and sending the digitized data as a .dxf file to a post-processor, which automatically converts the information into an NC cutting program. What would have required as much as a man-day of programming takes a fraction of the time.

Updating Old CAD Drawings

After the sheet metal cutting program has been created, the digitized data are also used to create an updated part drawing in AutoCAD software. Very frequently, these templates have undergone a series of modifications on the shop floor to improve manufacturability, without being recorded in the software file. The result is that no accurate drawing exists. Updating the drawing with the digitized data ensures that it matches the actual template.

This approach also works well to update drawings of tooling and fixtures, which are often frequently modified during pre-production. Measuring the production setup and feeding the data back to the computer aided design system to update drawings can save hours of trial and error work years later when the tooling needs to be repaired. The articulating measurement device is ideal for this because the tooling can be measured without having to disassemble it.

Measuring Very Large Parts On Machine

The arm-type measurement system packs in a suitcase and can easily be carried to the measurement site. This portability is especially useful if a part is very large.

The 30-foot diameter gear assembly for an aerospace manufacturing system was so massive that it had to be fabricated in 12 sections. An in-pro-

FARO ARM

cess inspection would have required breaking down the set-up and transporting the part to a large gantry-style CMM.

Instead, a FaroArm was set up on the bed of the machine so that the part could be measured in place, saving enormous time, labor, and costs.

Making the Perfect Parabola

The performance of an eight-foot diameter, molded satellite dish depends on how closely its contours approximate a perfect parabola.

The manufacturer could not afford a CMM costing several hundred thousand dollars to measure their molds. Instead, they tested the product functionally by placing a microphone at the focal point of the dish and analyzing the noise level of captured sound. Based on the results, the mold would be modified and a new dish molded and tested until, after many iterations, the cleanest range of sounds was captured. This was a painfully long and arduous process.

Today, a FaroArm is used to scan the mold. The surface contours generated by the measurement system are superimposed over a perfect parabola in computer aided design software. The disparity between the two images indicates where the mold is either too deep or too shallow, and by how much.

To correct the problem, the FaroArm is used again to find and mark areas on the mold that need to be reworked.

Scanning Contoured Edges

Most CMMs only collect discrete points at predetermined intervals. A major advantage of the FaroArm is that it can be used to manually scan continuous surfaces.

A recently developed application of the FaroArm for an aerospace manufacturer involves measuring parts trimmed by a large robotic router machine. Most of the laminated composite parts within the final assembly need to be trimmed to very exact dimensions.

The robotic cutting program for the part is modeled in CATIA software. Inspection of the first piece verifies the accuracy of the cutting program. The conventional process called for inspectors to use templates cut to shape to verify the trim. This process could take as much as a man-day. Today, it is possible to set-up the FaroArm, scan over a thousand points along the entire periphery of the complex three-dimensional part, and analyze the data in CATIA within about two hours. Accuracy is improved, and the NC-programmer gets feedback on his part the same day.

Re-engineering Existing Parts

An aerospace manufacturer is currently involved in a number of projects that require the re-engineering of existing parts into computer aided design software. This work involves modifications to long-standing parts that currently meet customer specification.

Originally designed 'on the board', perhaps more than a decade ago, these parts have a history of design and tooling modifications not necessarily noted on the drawings. The FaroArm rapidly scans the parts and digitizes their data, which are sent to the computer system in a format that is readily converted into a three-dimensional computer design of the part.

Measuring Distortion of Large Surfaces

The thrust reverser is part of a housing that surrounds a jet engine. It is used to redirect engine thrust forward, helping to slowdown an aircraft after landing. Large thrust reversers can span a twelve-foot diameter envelope and contain numerous complex surfaces.

One type of thrust reverser Lockheed Martin produces contains complex shaped bondments made with a high-temperature, high-strength composite material. Similar to plastics, when the bondments' internal stresses are relieved during the cooling cycle, distortion may occur.

The degree of distortion is highly predictable under simple conditions. However, the highly complex curvature of large aero structure bondments can make the ultimate distortion difficult to predict and control. The bondments are designed with very tight tolerances, but Lockheed Martin has found that some areas of the complex structure exceed surface profile tolerances. Accurate measurement of the surface profile is required to adjust the design to the manufacturing process.

The distortions cause extra work in the final assembly of the thrust reverser. Parts installed on the bondment surface can interfere with mating parts either on the engine, other nacelle components, or within the reverser itself. Adjustments, such as shimming or removing material, are required to compensate for deviations even down to 0.010 inch. Minimizing the distortion reduces the extra work and associated costs.

Using electronic theodolites, it sometimes took three times longer to measure complex bondments than it did to manufacture them. Similar to surveying equipment, a theodolite system uses optical sights and a computer to triangulate the three-dimensional coordinate of a target. Operators manually align the sights to each target point—one at a time. An experienced crew can capture about two data points per minute.

Thousands of data points, however, are needed to characterize three dimensional surface deviations. Placed in the center of the semi-circular bondment, the FaroArm operator traces the spherical probe tip steadily along the surface. At data collection intervals of one-eighth inch, 2000 data points are collected in 10 to 15 minutes. What could take a week to do, is now accomplished in a few hours.

Does The Arm Fit?

If you still can't decide whether your shop has a good application for a measurement arm, you might consider trying the services of a contract measurement consultant to see how well the arm fits.

Direct dimensions is a full-service measurement consulting firm offering computerized, three dimensional measuring, quality assurance and control, rapid reverse engineering, and manufacturing assistance.

For more information about DIRECT dimensions or the FaroArm (dirdim@erols.com), **circle RF550.** JST