THIS MONTH: CORROSION IN THE OIL & GAS INDUSTRY

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MP MATERIALS PERFORMANCE

CORROSION PREVENTION AND CONTROL WORLDWIDE

Corrosion Assessment Using a Laser Scanner

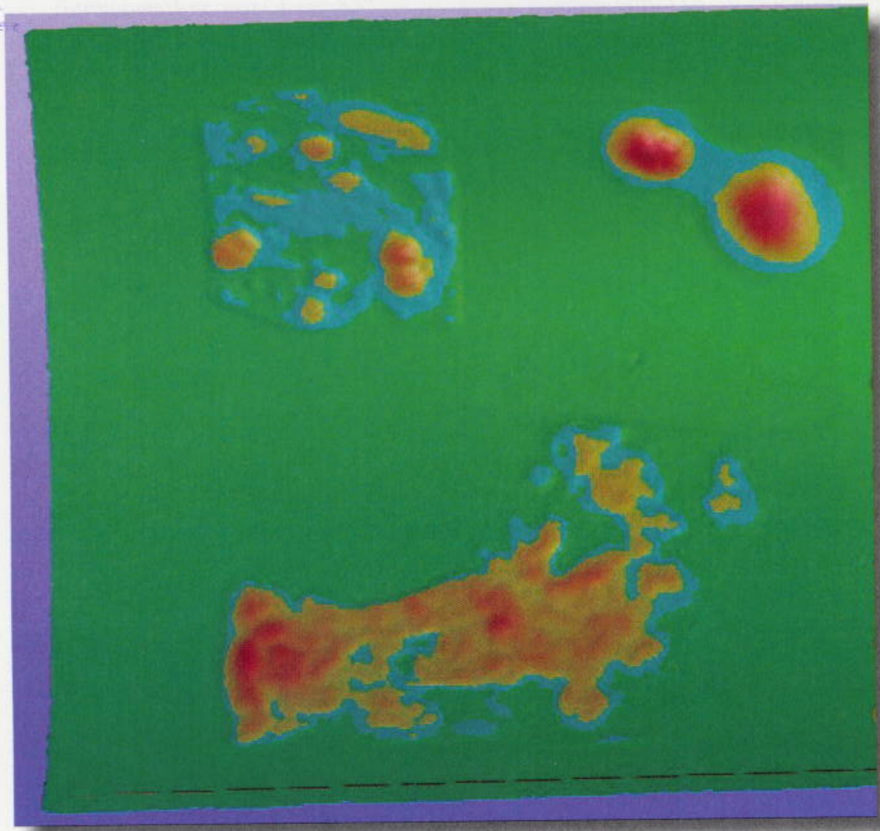
Corrosion Inhibitors for Top-of-the-Line Corrosion

Fiber-Reinforced Polymers for Pipeline Repairs

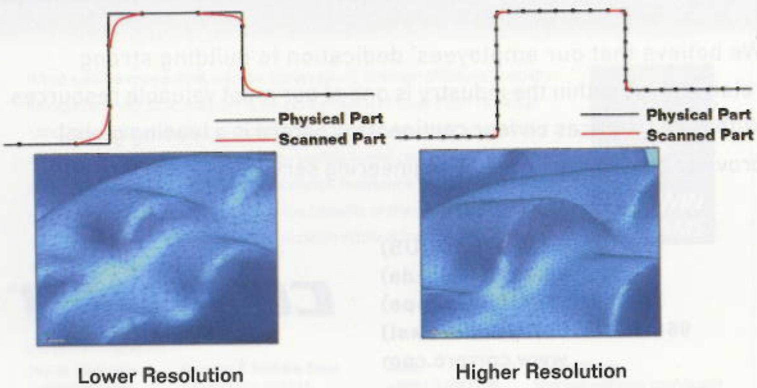
Evolution of the Corrosion Management Concept

NACE INTERNATIONAL

Handheld laser scanner generates computer images to assess external pipeline corrosion



A 3-D color image of the pipe surface is generated on a computer screen by the assessment software. All areas with wall depth above the critical factor are shown as green and features are shown in various colors, with the intensity of the color based on the severity of wall loss. The blue areas represent wall loss that is above the critical factor. Image courtesy of Creaform.



The 3-D mesh model of the pipe surface comprises more data points and a denser mesh grid as resolution increases, as shown by the higher-resolution illustration on the right. Image courtesy of Creaform.

To enhance gas pipeline safety in the field, Pacific Gas and Electric Co. (PG&E) (San Francisco, California), one of the largest combined natural gas and electric utilities in the United States, added a self-positioning handheld laser scanner to its collection of inspection equipment. This new tool, manufactured by Creaform (Lévis, Quebec, Canada), uses an accurate and efficient three-dimensional (3-D) surface mapping technology to assess internal and external corrosion and mechanical damage previously identified on a natural gas pipeline and help determine the pipeline's integrity and safety.

Before it acquired the handheld scanner, PG&E used a conventional industry practice for measuring external pipeline corrosion, which typically involves drawing an extensive grid of 1-in (25-mm) squares on the surface of an excavated pipe and then measuring the wall loss, square by square, with a manual tool. The handheld 3-D scanning technology allows PG&E to capture the same information from the entire pipeline section with more precision than the manual method, and assess within minutes whether the pipe is fit for service. "When it comes to finding the nooks and crannies of pipeline dents

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surface and the scanner's position is determined at the same time the surface features are scanned, ground or pipe vibrations will not affect the measurements, which greatly enhances the accuracy of the scan, Lavoie explains.

With a scanning data acquisition rate of ~25,000 points per second, the cameras record the shape of the surface and calculate the data to create a high-resolution, 3-D mesh model of the surface as a stereolithography (stl) file, a file format used by computer-aided design (CAD) software. Resolution can be as high as 50 µm (0.05 mm). Resolution refers to the level of surface detail that the sensor acquires, with the 3-D mesh model comprising more data points and a denser mesh grid as resolution increases. Lavoie comments that flat surfaces typically require lower resolution, which facilitates faster data acquisition, while surfaces with more complex geometries require higher resolution. Usually, resolution of 1.25 mm is recommended for corroded pipes, and it typically takes less than 10 min to scan a 1-m^2 area at this resolution.

The accompanying software makes it possible to view an exact rendering of the pipe's surface geometry on a computer screen as it is being scanned. Any holes in a scanned image of the pipe surface can be seen immediately on the computerized rendering and the pipe surface can be rescanned until the image is complete.

Lavoie notes that once the data are acquired, various analyses can be run depending on the parameters set by the user. When a pipe is scanned for corrosion, the software evaluates the pipe surface based on analysis criteria that include parameters for material loss and burst pressure—the maximum pressure a damaged area can withstand without failing. One key parameter is called the critical factor, where wall loss below a certain depth is considered critical. After data acquisition, the depth reading is calculated for each data point on the 3-D mesh model that represents the pipe segment. Areas that are at least one data point deeper than the critical factor are called features. The user also defines rules for feature interaction, which is the distance between features on the pipe surface. If the distance between two or more features is smaller than the interaction rules, then the features are joined into one larger feature.

On a computer screen, the software then displays a color image of the pipe surface. All areas with wall depth above the critical factor are shown as green and features are shown in various colors, with the intensity of the color based on the severity of wall loss. Redefining the critical factor can result in an image map that shows either more or fewer areas on the pipe surface that are considered features.

The software uses a grid system similar to the manual pit gauge method to analyze each feature's position on the pipe surface, its maximum depth, and its burst pressure. Using the maximum depth measurement in one grid square, the software calculates the burst pressure according to ASME B31G.[1] The burst pressure calculation will be more accurate as the grid size is reduced (e.g., from a 1-in to a 0.05-in [13-mm] grid), and the software can make calculations for any grid size. Lavoie explains that it may be necessary to reduce the grid size and refine the burst pressure calculations when the burst pressure is critical compared to a pipe's operating pressure.

PG&E says the handheld laser scanning technology will work in conjunction with other pipeline safety tools to help it test, repair, and replace segments of pipeline as needed throughout PG&E's service area, as set forth in PG&E's Pipeline Safety Enhancement Plan (PSEP).

Sources: PG&E, www.pge.com, and Creaform, www.creaform3d.com. Contact Jérôme-Alexandre Lavoie, Creaform—e-mail: jerome-alexandre.lavoie@creaform3d.com.

Reference

1 ASME B31G-2012, "Manual for Determining the Remaining Strength of Corroded Pipelines" (New York, NY: ASME, 2012). MP

Information on corrosion control and prevention

An inspector at a refinery uses the handheld 3-D scanner on a pipe segment to conduct a direct assessment of external corrosion. Photo courtesy of Creaform.

or external corrosion, the EXAscan† provides speed and detail far and above the mechanical way of doing things," says Alex Gutierrez, a supervisor with PG&E's Applied Technology Services division.

The handheld scanner simultaneously uses lasers and triangulation to collect data about the geometry of the pipe surface, which are transmitted to a nearby computer with an associated software program developed specifically by Creaform that analyzes the data and generates a 3-D image of the surface being scanned, explains Jérôme-Alexandre Lavoie, product manager with Creaform. The scanner's positioning system uses multiple retro-reflective positioning targets—6-mm diameter round reflective dots—that are attached to the pipe surface in a random pattern with ~10 dots in a 12- by 12-in (305- by 305-mm) area. The spacing between dots can vary depending on the pipe diameter. The scanner is held ~10 in (254 mm) above a section of the pipe and pulling its trigger initiates data acquisition. Two cameras on each side of the scanner capture the dot pattern and use triangulation of the dots to determine the position of the scanner in relation to the pipe surface.

Simultaneously, two Class II (eye-safe) laser beams are projected on the pipe surface to form a red laser cross. The laser beams projected on the pipe are deformed according to the shape of the pipe surface. The surface then reflects an image of the deformed laser cross back to the scanner's cameras. Because the scanner's reference system (the reflective markers) is affixed directly to the pipe

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†Trade name.