// by Robert Farrell, president, Farrell MarCom Services //

CRACKING THE CODE

Weld crack inspection isn't rocket science, but the two have plenty of common threads

Recently, Mark Koehler, Professional NDE (PNDE) Services Group's business development manager, and Neil Coleman, Signalysis Inc.'s founder and president, discussed non-destructive testing (NDT) methods and how it applies to weld inspection. During the conversation, they offered a host of information regarding the various types of NDT as well as the information about the products and services their companies provide in that regard. They also explained how some of the roots behind NDT can be traced to the rocket era – a stellar discussion, indeed.

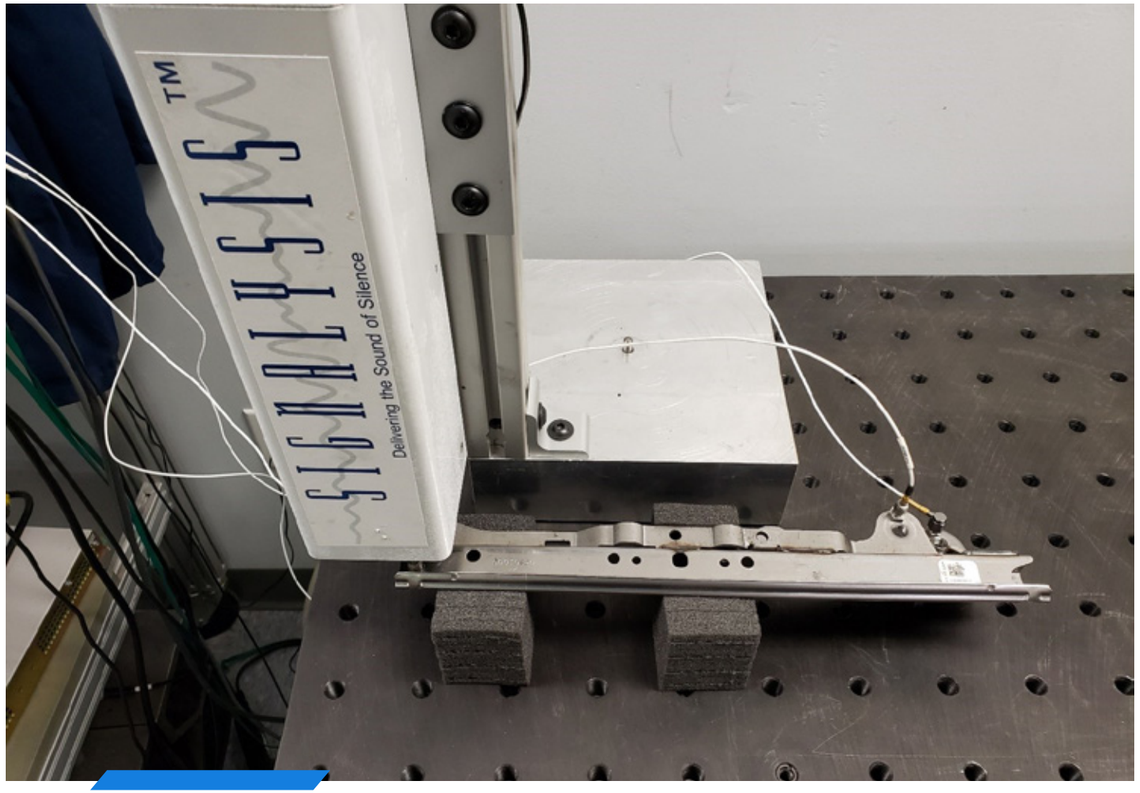
Robert Farrell: Let's kick things off with the businesses you represent.

Koehler: PNDE offers third-party assistance for all NDT methods. Our emphasis is on responsive, reliable and professional customer service, and our services include Level 3 services, training, audits and best practice implementation. In addition to general field services, our expertise is typically applied to aerospace, automotive, industrial manufacturing, petro-chemical and power generation applications.

Coleman: Signalysis provides quality inspection test systems to suppliers serving a variety of industries, including automotive, medical, appliance and more. Our solutions range from turnkey quality control systems to highly technical consulting engagements. Our space is on the manufacturing floor where our end-of-production inspection test systems verify that a part meets quality standards or customer specifications before it leaves the facility.

Am I right that there's a common thread between NDT, NASA and Signalysis?

Coleman: You're right. The company was founded in 1987, but our roots can be traced back decades earlier. My father, "NASA Bob" Coleman, was a physical test engineer for the Polaris rocket program and later for NASA. In fact, he was even offered an opportunity to work with Wernher von Braun, the father of rocket science, but that's a story in itself. (Learn more by listening to a podcast on the Signalysis website.)



↑ *Signalysis Inc. provides quality inspection test systems to a variety of industries, including automotive and medical, and offers a range of solutions from turnkey quality control systems to technical consulting engagements.*

While vibration is present to some extent in any structure, excessive levels can introduce cracking and other flaws. At best, this means unwanted noise or compromised structural integrity, and at worst, we're talking about total failure. In the case of rockets, space shuttles, aircraft and so on, even minute cracking can be catastrophic. Like my father, I took an interest in testing, vibration and problem solving, and when I started Signalysis, he came on board to leverage his technical experience and expertise to help solve real-world manufacturing issues. ›

So, in a way, quality testing really is rocket science.

Coleman: Well, it's not that complex. From a vibration perspective, its roots and application to detect structural flaws can certainly be traced to the rocket era. But it's important to note that you don't have to be an expert these days to leverage advanced technology.

Let's talk about NDT. Can *FAB Shop* readers get a quick explanation?

Koehler: We can verify that a part, product or structure meets quality standards or customer specifications in many ways. For example, we've all seen car crash tests. That's an example of a testing method where what is being tested is destroyed. This is fine for testing a prototype, but not so good for in-service equipment or parts that come off a manufacturing line.

Non-destructive testing, also known as non-destructive evaluation (NDE) or inspection, includes a variety of analysis techniques used to evaluate the properties of material, parts or systems without causing damage. NDT is widely used in maintenance, certification, safety or verification scenarios, or in a manufacturing environment to verify that a part meets quality standards before being shipped to the OEM or customer.

What are some forms of NDT?

Koehler: There are several including eddy current, liquid penetrant, magnetic particle, radiographic, ultrasonic and vibrational testing. Visual inspection is another form of NDT. A number of variations and special techniques for some of these methods exist that can apply to certain applications.

Is it risky to rely on visual inspection for safety or quality?

Coleman: From a manufacturing perspective, you pretty much hit the nail on the head. Visual inspection can be subjective or interpretive. When guesswork is involved, the results are often high scrap rates, excessive warranty claims, lost contracts or even litigation in some cases.

When it comes to quality, testing must be objective and based in physics. This is especially true where flaws are often ›

Watch this short podcast to hear another conversation between Robert Farrell and Mark Koehler on the topic of NDT.

minute and nearly impossible to detect visually.

Regarding Signalysis systems, how much is automated and how much is manual?

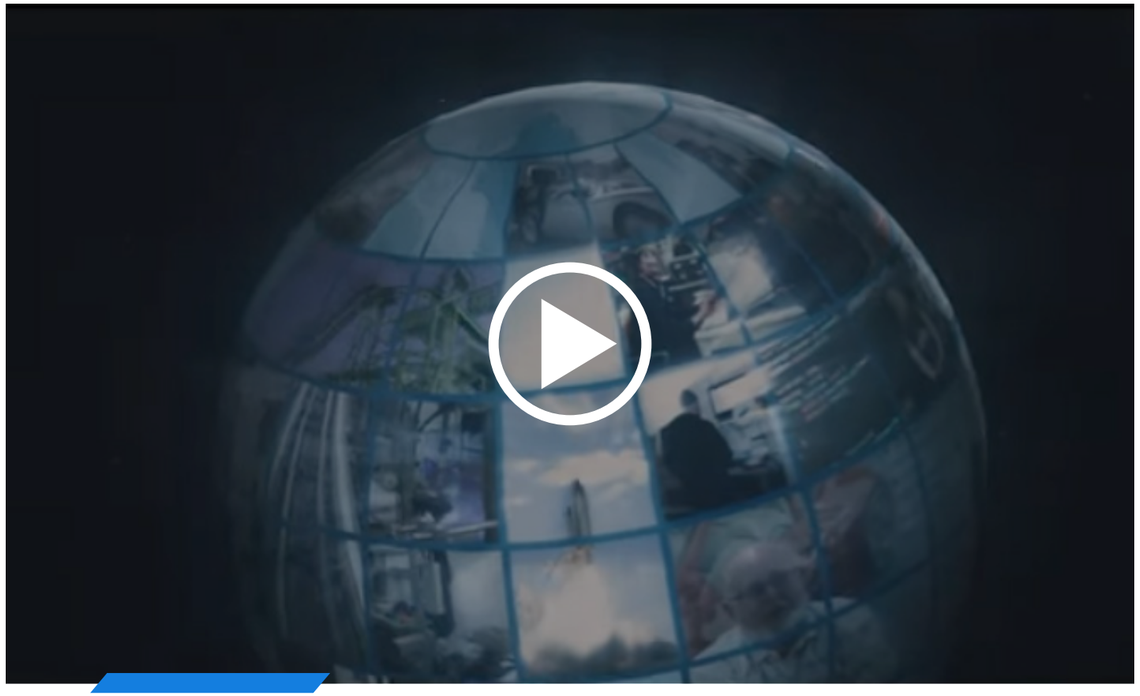
Coleman: We create custom turnkey systems designed to automate and accelerate quality inspection. Depending on the customer requirements, our solutions range from manual load to automated hands-free test systems. All the calculations are transparent to the user. The underlying physics and software simplify the process to a push of a button, and quality control receives a quick Pass/Fail from the system.

What are some of the most common reasons for weld failure?

Koehler: That's a difficult question to answer because it all comes down to a variety of potential questions, such as what the weld is designed to do and whether the weld is being subjected to more stress than what it was designed for.

For example, if you're putting together a lawn mower, you're talking about a structural weld that you're hoping holds up against a lot of vibration. But, with a weld that's on a bridge structure, you're dealing with many more critical components. Usually, it's a moment connection, which is a joint that transfers bending forces between a column and beam, for example. You have to be sure that the weld can handle tremendous loads and move without cracking.

There are a variety of reasons why a weld might fail. These often include over-cycling or over-stressing or it might be simply under-designed and ›



Watch the video to learn more about Signalysis Inc.

the engineering wasn't correct on the front end. Improper weld technique can also cause failure, such as if the weld hasn't properly fused to the base material. Obviously, any inherent defects that are present in the weld can propagate and cause the weld to crack or otherwise fail. To sum it up, weld failure can be traced to any number of areas from engineering, design and materials to processes, conditions or workmanship.

Which NDT methods are applicable to weld inspection?

Koehler: The answer depends on whether or not you're looking for a defect that would be on the surface or contained within the weld. In the case of surface inspection, typically you would use magnetic particle inspection and/or liquid penetrant inspection. And that would be driven by the type of material. For example, with aluminum, you would use penetrant inspection. Most stainless steels and other alloys that cannot be considered ferritic, in other words have ferrous properties that can't be magnetized, are candidates for liquid penetrant inspection.

If you're looking for something internal to the weld structure or a portion of the weld that does not have an accessible surface, then your two common inspection methods are radiography and/or ultrasonic.

How do you determine the best inspection method?

Koehler: A lot of what we do is driven by codes and standards. Geometry of the weld also plays a role, such as whether it's a fillet or groove weld.

If someone is looking for advice, we ask them a series of questions about what they are looking for and their concerns. And if we identify that it can be a fatigue-related issue from stresses or something on the outside that we have access to, then we would probably recommend magnetic particle or liquid penetrant.

But if it's a new weld and they're not sure if the weld has been done correctly, then we would most likely perform a volumetric test – and that would typically be radiography or ultrasonic inspection, essentially looking through the part. ›

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> *// Mark Koehler, business development manager, Professional NDE Services Group //*

What is the Signalysis approach to identifying weldment flaws?

Coleman: Many of the parts and products Signalysis works with contain welds. Our quality test solutions employ vibrational analysis to the entire part to detect hidden, microscopic flaws, such as weld cracks. Our crack inspection algorithms are built on a foundation of FEM, physics, structural dynamics and strength of materials.

Without diving too deep into the physics of it all, how is this done?

Coleman: Our quality inspection test systems are custom-built to the specifications and requirements of each customer. While the form and function of our test systems may vary greatly, the common thread is the technology that powers them.

Every structure, part or weld has a distinct set of mode shapes with deformation patterns known as eigenvalues or resonance frequencies. The input to our advanced quality inspection algorithm begins with identifying these mode shapes that are most sensitive to cracks.

The measurement process uses a force response method. Impacting each part with a high frequency hammer generates a modal response that is measured by a laser vibrometer. This data is used to compute a frequency response function.

What software is driving the process?

Coleman: Over the years, we've developed and continually enhanced our SigQC software. SigQC combines sophisticated algorithms, mathematical and statistical techniques along with vibration and acoustics methodology.

What does a typical PNDE customer engagement look like?

Koehler: Most of the time, we're engaged by a client who is manufacturing something that is going to be driven according to industry standards such as ASME, API or AWS. They would contact us to perform NDE on specific part, weld or weldments.

Occasionally, we'll get calls where we're engaged by a customer to help ›

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>
> *// Neil Coleman, founder and president, Signalysis Inc. //*

solve a problem with a particular product, weld or welded assembly. At that point, we conduct an interview to understand their concerns and objectives. We then perform the testing and report the results.

And Signalysis? How does it work with its customers?

Coleman: As I mentioned earlier, our job is to solve problems, and we do this by combining our expertise and experience with knock-your-socks-off service. We meet with customers to fully understand the specifications and challenges of each. Some may need a way to identify parts with flaws while others are looking to ensure that parts meet tight customer specifications. In this way, we can develop a system that is tailored to the specifications and budget of each manufacturer. Of course, we perform installation and provide training and support.

How does weld inspection differ from quality testing a brake rotor, for example?

Coleman: The underlying physics and technology are consistent across the board. For the most part, the difference lies in the configuration and packaging of the system. This includes hardware components, configuration, customized software and so on. ■

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