DETAILED CRACK DETECTION

Rogelio Guajardo, Head of Analysis UC, NDT Global, Germany, talks about detecting, sizing, and characterising challenging crack features.

For decades crack inline inspection (ILI) tools have been helping operators address most of the features in the pipelines. However, ILI technology has now reached a point where the conventional shear wave technique is no longer good enough to identify remaining features or because of the crack surroundings (i.e. weld geometry). Pushing the industry to evolve, NDT Global developed an innovative technology, PROTON™, a versatile phased

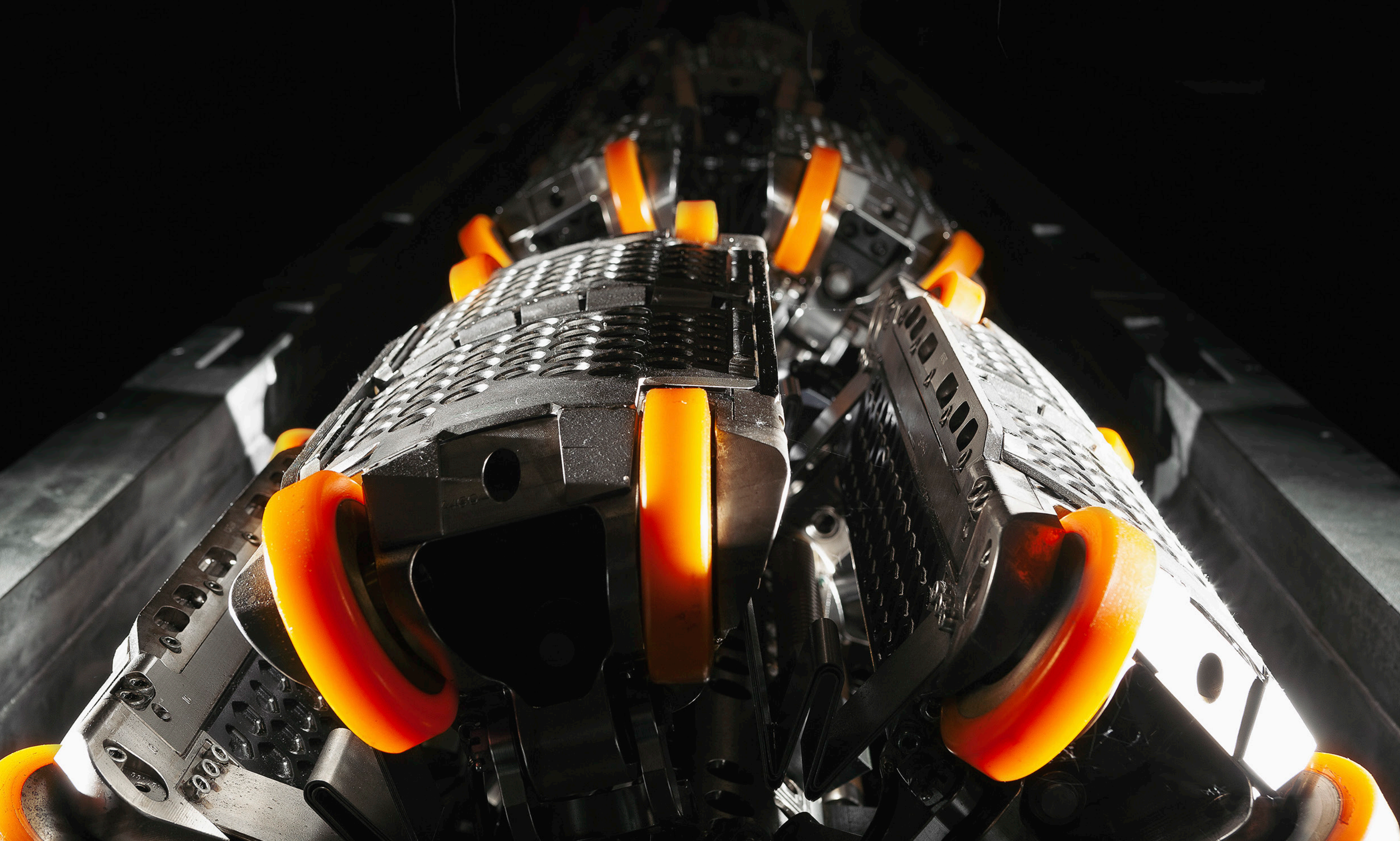

Table 1. Crack technology comparison based on key attributes

Attribute	Standard crack (UC)	High-resolution crack (UCx)	Pitch and catch crack (EVO Eclipse UCx)	Phased array crack (PROTON™)
High-resolution	No	Yes	Yes	Yes
Sampling scenario	1 PE angle	1 PE angle	1PE angle 1 P&C angle	2+ PE angle 2+ P&C angles 1 contour sample
Crack tip measurement	No	No	No	Yes
Tilted and skewed features depth sizing limits	10° & 5°	10° & 5°	45° & 10°	45° & 10°
Depth tool tolerance 1...<4 mm ≥ 4 mm	±1.0 mm N/A	±0.8 mm ±1.2 mm	±0.8 mm ±1.0 mm	±0.7 mm ±0.7 mm

Table 2. Input parameters for the assessment

Yield strength (psi)	52 000	CVN (ft-lb)	5
Ultimate strength (psi)	66 000	Diameter (in.)	24
Elastic modulus (ksi)	29 500	Wall thickness (in.)	0.281
MOP (psi)	1011	Flaw shape	Elliptical

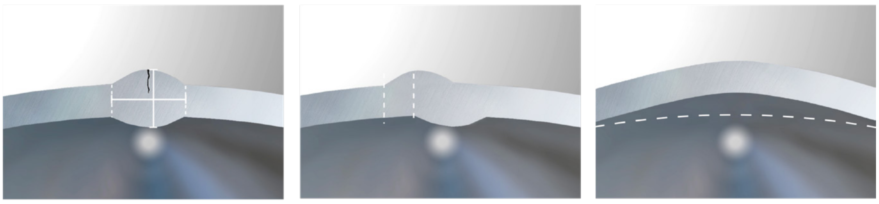

Figure 1. **Weld characteristics obtained from the contour sampling.**

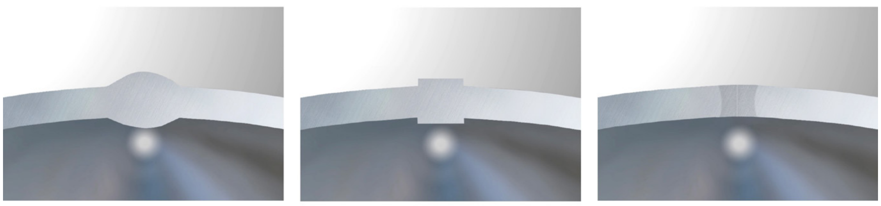

Figure 2. **Weld type geometries obtained from the contour sampling.**

array platform providing operators complementary information to efficiently address and manage their crack programme. When evaluating a crack feature, it is important to look beyond the feature length and depth, and pay attention to the crack location and any other variables. This provides a unique perspective to the assessment. To better understand the context, the analyst must increase the assessment accuracy.

Should we assess a crack with the same dimensions that is in a perfectly smooth trimmed ERW, compared to a DSAW where the wall thickness (WT) in the weld is 150% of the nominal WT? Probably not! Would we treat the crack in the same way if it were in a misaligned long seam or one with a peaking?

By putting features in context to the surroundings at the time of the assessment, we can run an efficient integrity management programme (IMP) where we can intelligently allocate our resources (i.e. economical and personnel) addressing the features based on need.

Current ILI crack tools report feature length and depth, referencing a WT measured across the entire pipe joint – so how can we obtain a holistic view? This is where PROTON comes into play.

Detecting, sizing, and characterising challenging crack features

PROTON is an ultrasonic inspection platform that uses phased array sensors. These are the same type of phased array sensors used by NDE technicians in the field, but in an ILI tool recording 360° and travelling at 1.4 m/sec. Phased array makes the inspection platform versatile, as it can have the same mechanical design, multiple refracting angles or samples, allowing it to be configured for specific applications by just updating the firmware.

This platform combines all the knowledge and technological advancements that NDT Global has made in the field of crack detection over the past 20 years and more. Pulse echo (PE) is still the 'battle horse' used for detection, the difference is that now there might be multiple refracting PE angles and not only one, the conventional 45° shear wave. PROTON also includes one or more pitch and catch (P&C) angles overcoming the tilted and skewed limitations from PE, like NDT Global's EVO Eclipse UCx. The selection of the angle and techniques used (PE and P&C) is based on the application and the type of features that need to be addressed.

As standard, PROTON will record at least four data sets (2 PE and 2 P&C) for crack detection, identification, and sizing. The technology has conventional indirect measurement capabilities (PE and P&C) for multiple angles for every crack feature, but also has the possibility to provide the direct crack depth based on the tip. This technology has previously been seen in field verifications, but PROTON is enabling this capability for an ILI tool. Table 1 provides a simple comparison between available crack tools.

When we look at Table 1, it appears that there are not too many differences between EVO Eclipse UCx and PROTON. There is, however, one key element in the sampling scenario that makes all the difference and provides the context we started talking about – the 'contour sample'.

What is this 'contour sampling'? This is a high-resolution 0° measurement – a high circumferentially speaking redundant WT measurement sampling. Because of its characteristics, it is possible to extract additional data points that surround the crack and provide a unique perspective on how to address it.

Some key data points that can be extracted from this sample are related to the weld characteristics such as the weld height (local WT), weld width, weld misalignment, and/or weld peaking (Figure 1). This information not only identifies the presence of a weld misalignment, for example, but the actual measurement of it. However, that is not all; the sample allows analysts to confirm the weld type based on its geometry (i.e. rounded = DSAW) using artificial intelligence algorithms (Figure 2). This information is invaluable during analysis as it will improve feature identification and discrimination between weld 'hi-low' and true features, and while performing the assessment of the feature (as the toughness levels for the DSAW may not be the same as in an ERW). With this contour sampling, PROTON can provide at least five additional data points associated to the crack that provide context.

The input data for the assessment in Table 2 depicts the advantages of contour sampling.

Scenario 1

Safety Factor (SF) is calculated using the nominal WT, referencing the information in Table 2 for a sample of 142 crack-like features with depths and lengths oscillating between 0.040 - 0.160 in. and 1.0 - 9.0 in. respectively, there will be a total of 111 features (78%) that need to be verified within a year. From the 111 features, 49 (1 critical and 48 immediate) require prompt attention. Figure 3 summarises the results.

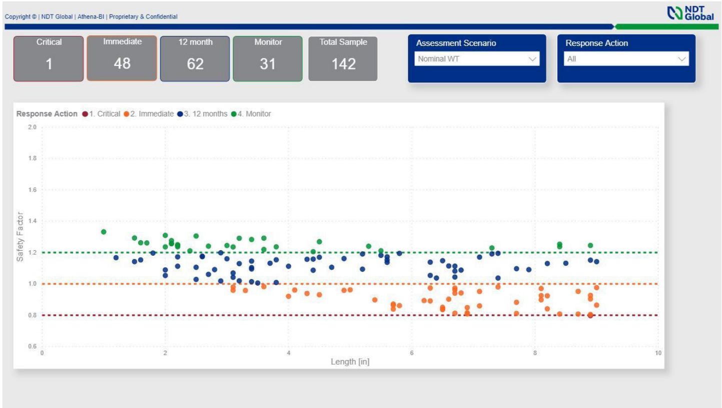

Figure 3. **SF calculation based on nominal wall thickness (WT).**

Figure 4. **SF calculation based on the local WT.**

Figure 5. **SF calculation using local WT and peaking tool tolerances.**

Figure 6. **PROTON Phased Array inline inspection service allows wide adjustments to achieve optimal performance in pipeline operators' assets.**

Scenario 2

PROTON provides the local WT (Figure 1) for each crack.

Table 3. Example of IMP response action	
Safety factor	**Response action**
SF ≤ 0.8	**Critical = shut down the line**
0.8 < SF ≤ 1.0	**Immediate, reduce pressure and verify within 15 days**
1.0 < SF ≤ 1.2	**12 months, verify within 12 months. No action on pressure**
SF > 1.2	**Monitor, no action planned only feature monitoring**

This information is used to calculate the SF. Because of the ID and OD weld caps, the local WT is higher than the nominal WT reducing conservatism from the calculation.

In this scenario (Figure 4), the number of required verifications within 12 months has reduced from 111 to 26, two of which are the most critical. This reduction of over 70% brings efficiencies to the IMP.

Scenario 2.1 Peaking

For certain features, PROTON flagged features in areas where peaking is present. For those features, the tool tolerance is different, knowing this, the features can be re-evaluated, and the SF updated. After the evaluation (Figure 5), one additional feature was added to the immediate category and two were identified as requiring verification within 12 months. Still this represents 82 digs less in one year compared to Scenario 1. This additional peaking information provided context to the features and changed the way we assess them.

PROTON provides a holistic view of the crack features and its surroundings, allowing pipeline engineers to manage their assets efficiently. Who doesn't want to reduce 82 digs, as in our example? We'll let you to do the math on the savings. PROTON is one of a kind; there is no other tool in the market that can acquire that level of detail from its data that results in high accuracy of the delivered results. This platform is pushing boundaries and challenging the industry to move forward, changing the way crack programmes are managed.

References

1. GUAJARDO, R.(2019), 'High-Resolution Inspections for Crack Detection: The Next Level of Accuracy', Pipeline Pigging and Integrity Management Conference. Houston: Clarion Technical Conferences & Great Southern Press.