Paul Cooper, Halfwave AS, Norway, shares developments that have been made for internal and external pipeline inspection.

Acoustic resonance technology (ART) uses a series of broadband acoustical sensors to perform an integrity inspection of pipelines for metal loss and damage. Wall thickness is measured by analysis of the resonant signal that is emitted from the target, which allows for a direct and accurate measurement of the target thickness. ART can be applied for both inline inspection (ILI) and advanced subsea inspection in the oil and gas pipeline industry.

Generally, a raw signal consists of a reflected signal, which represents the time of flight measurement, and a tail section, which represents the thickness measurement of the inspected object. A frequency analysis of the tail section is performed so that the structural thickness can be directly measured. ART utilizes a wideband ultrasound to detect resonating frequencies. This allows for direct and early identification of wall thickness loss. Both external and internal metal loss has a depth detection level of 0.5 mm, measured to an accuracy of ±0.2 mm.

With ART, wall thickness is derived from resonance frequency bands, as
shown in Figure 3. Therefore, measurement specifications do not degrade as wall thickness increases or as the speed of an ILI tool changes.

**ILI of thick walled pipelines**

The first application of ART was for ILI operations. Supported by leading offshore pipeline operators, Halfwave developed ART Scan™ with the primary goal of creating an ILI tool that could obtain reliable and accurate inspection results in gas pipelines.

**The challenge**

The design premise when developing ART Scan was to give operators the ability to inspect large multiple diameter pipelines (ranging between 28 - 42 in. dia.) that may have varying gas pressure and flowrate in the same section. Another key goal was to provide high resolution wall thickness measurement of thicknesses of up to 3 in. (75 mm) during inspection lengths of up to 800 miles (1100 km) in a single ILI run.

**The development**

The first ART Scan tool was developed with the ability to use natural gas as a coupling medium for ultrasound and the capability of performing inspections in pipe diameters of 28 - 42 in. It has a total of 192 transducers and can typically inspect at speeds of 0.1 - 6 m/sec. The ART Scan’s sensors are engineered to work with a stand-off to the pipe wall. The only contact points of the tool are the discs or wheels that drive the ART Scan tool and maintain centralisation through the pipeline. The sensors operate at a relatively high stand-off from the pipe wall to avoid any risk of scouring the internal pipeline flow coating.

**The result**

Subsequent to the development of ART Scan, the tool completed several qualification runs. In total, the qualification runs totalled more than 1000 miles of pipeline, covering wall thicknesses of 0.5 - 2 in. and pressures of up to 3500 psi. The longest completed single section of pipeline during the qualification period was over 400 miles in length. Several sections were inspected multiple times to prove the repeatability of results.

**Measurements through wax**

Another common challenge that operators face is the cleanliness of a pipeline’s internal surface. If a pipeline is found to have wax deposits, it can significantly affect the quality of the inspection results. When this challenge was highlighted to Halfwave by an operator, the company agreed to develop a solution using ART.

**The challenge**

In this case, Halfwave was commissioned to perform a pipeline inspection on a crude oil pipeline that had a very low flowrate. The flow in this specific pipeline was less than 10,000 bpd, equating to a velocity of 0.04 - 0.08 m/sec. The 18 in. pipeline, in which the inspection was to be performed ran, using a 16 - 26 in. ART Scan from platform to platform, requiring low flow wye passing capability. Despite an attempt to clean the pipeline of wax before the ART inspection, an estimated 7 - 30 mm of wax still remained on the pipeline’s internal surface.

**The development**

Through engineering moduling and extensive laboratory testing, ART has proven its ability to both assess wax thickness and provide reliable wall thickness measurement throughout the pipeline. With 128 transducers, ART Scan was configured to traverse the wye while running at speeds of 0.04 m/sec. The representative pipeline test loop with wye was fabricated and the ART Scan met the requirements without any complication.

**The result**

The inspection run was executed within 40 hrs by two field engineers at the end of last year. ART Scan recorded the pipeline’s wall thickness through up to 50 mm of wax to full measurement specification. Since the first test, several runs have been completed in crude oil to full satisfaction of the operator.

**External pipeline inspection**

Another industry-driven inspection application based on the ART inspection platform is the ART External Measurement Inspection Subsea (ARTEMIS™). The development of this ART-based inspection method was supported by a major oil and gas operator and was subject to a nine level application development programme. The overriding goal for this application was to provide a cost-effective solution that could
be deployed via a remotely operated vehicle (ROV) for non-intrusive inspection of unpiggable subsea pipelines and risers.

The challenge
All subsea pipelines are coated, and there are a limited number of options for external pipeline inspection. A common industry challenge is finding a high resolution inspection technique that is able to inspect through subsea pipeline coatings.

The development
The lightweight ROV-operated ARTEMIS inspection tool was created with a focus on meeting the requirements of the operator. It can inspect in water depths of up to 10 000 ft and is neutrally buoyant in water. Artemis provides high resolution real time inspection data through optical fibre or Ethernet connection through the ROV’s umbilical and is able to inspect pipeline that have diameters of 6 - 17 in. and wall thicknesses of 2.5 - 100 mm.

The result
In order to qualify the technology and system, a series of blind tests were conducted for several clients. Figure 4 presents an example of the scan results of internal metal loss through a typical subsea coating. The results provide detailed information concerning pipeline ovality, coating integrity and remaining wall thickness.

The ARTEMIS system was tested over an 18 month period. It has since performed several operations for various clients without downtime.

Ongoing development
While both ART Scan and ARTEMIS have been used for many value-added oil and gas pipeline applications, several developments using ART are continually being made. For example, ART solutions are currently being developed for pipeline coating disbondment, crack detection, flexible riser inspection and well integrity. One development that has recently been completed is the multidiameter ART Scan.

A major challenge that pipeline operators are facing is the inspection of pipelines with multiple diameters. In this particular study, the multidiameter pipeline has additional challenges of having a low flowrate and wye passage. Halfwave was commissioned to develop a custom built tool to suit the needs of the operator.

With a low flowrate of 0.1 m/sec. in this pipeline, the tool needed to be able to pass through a minimum of two wyes and inspect 24 in., 28 in. and 30 in. pipe sections in one single run. There were also wax deposits in the line that may have affected readings.

A new multidiameter ART Scan with 192 transducers was engineered, manufactured and tested within nine months. The tool executed two weeks of testing in Bergen (Norway) and a further three weeks of testing in the US, at the operator’s location. Testing for this project was completed in May. The tool is planned to run in two separate multidiameter pipelines in the Gulf of Mexico during summer this year.

ART Scan is a versatile and flexible inspection platform that is ideal for customisation to suit the challenges that operators face. These challenges include wye passing, low flowrate, bidirectional operations or multidiameter pipelines. Depending on the application, the tool can be configured from 24 - 34 in.