Northeast GAS ASSOCIATION

NYSEARCH

Technology Brief

Documenting Pipeline Material Properties through the use of a Hardness Tester

Description: **This project enables the Explorer 20/26 series of robots to conduct Rockwell and Brinell hardness tests of pipelines during live In-Line Inspections (ILI). The hardness measurement can be used by the operator to establish yield strength and MAOP of the pipeline.**

Status: **Ruggedization of components and pre-commercial validation work are underway.**

BENEFITS

This project will enable EXP 20/26 series robots to conduct Rockwell and Brinell surface hardness tests of pipelines from the inside. This testing method will produce data that will enable operators to potentially characterize pipeline material and quantify yield strength or calculate the Maximum Allowable Operating Pressure (MAOP) for segments throughout their system. No such ILI hardness testing method exists today, for either piggable or unpiggable lines. This tool could also enable operators to characterize material properties of pipes that are located in areas where excavation is not an option.

BACKGROUND

Beginning in 2010, NYSEARCH commercialized a full range of Explorer robotic platforms to conduct ILI of unpiggable pipelines. Explorer operates under live pipeline conditions to examine metal loss, mechanical damage, cracks and other features while operating under live, pressurized conditions.

Figure 1: Explorer 20/26 ILI tool

Upcoming federal regulations are expected to include the documentation of the material strength and other characteristics of the pipeline material. Historically, hydrostatic testing has been used to validate a pipeline's MAOP, but the process is expensive, time consuming, and causes interruption to customer service. An alternative to hydro-testing is to use a portable hardness tester (see Figure 1) to examine the exterior of the pipe. This process is also time consuming and expensive, as it requires physical access to the pipe. If the pipeline to be inspected is underground, a series of excavations are necessary to obtain the requisite samples.

Another option to test hardness is to obtain physical cutouts, or coupons, from the pipe for testing in a laboratory. As with the external hardness test, this course of action requires physical access to the pipe, which may be obtained by excavation. Due to the costs and difficulty of implementation of these potentially destructive evaluation methods, an alternative, non-destructive testing solution has been pursued for live tests inside the pipe. Pipeline material hardness is of interest because it is correlated with yield strength, which drives the pipelines MAOP.

Figure 2: Portable hardness tester

TECHNICAL APPROACH

Building upon the success of the Explorer robots, NYSEARCH executed a feasibility study to evaluate using EXP 20/26 to conduct non-destructive hardness tests from the inside of a live pipe. Throughout the study, different methods of hardness testing were evaluated, with Rockwell and Brinell determined to be the most suitable for in-pipe testing. The study also examined the integration aspects of the hardness tester with the existing robot. Due to its modular design, Explorer 20/26 can accommodate the hardness tester in place of the axial MFL sensor (the center module as seen in Figure 1).

Prototypes were designed, fabricated, and tested, with the results compared to qualified, portable hardness testers. For a portable tester to be considered acceptable, it must produce results that are between 96-102% of those taken in a laboratory from calibrated equipment.

Prior to taking harness measurements, the surface of the pipe must be prepared in accordance with testing standards. In this case, Explorer will use a sanding mechanism to remove a small amount of material from the defined testing area. The sanding element is equipped with a sensor to detect how much material has been removed, as well as a hard stop to prevent the excessive removal of material.

The tester employs both Rockwell and Brinell methods of calculating hardness. Rockwell testing involves pressing a tungsten carbide ball into the material at defined and calibrated increments of force. The depth of the cavity caused by forcing the ball against the material is measured, resulting in a hardness reading of the material. The permanent indentation is shallow and has rounded edges, neither of which will compromise the integrity of the pipeline. Brinell testing utilizes a camera to measure the diameter of the depression created during the Rockwell testing and correlates that value to material hardness. Figure 3 shows a sample pipe after it has undergone non-destructive hardness testing.

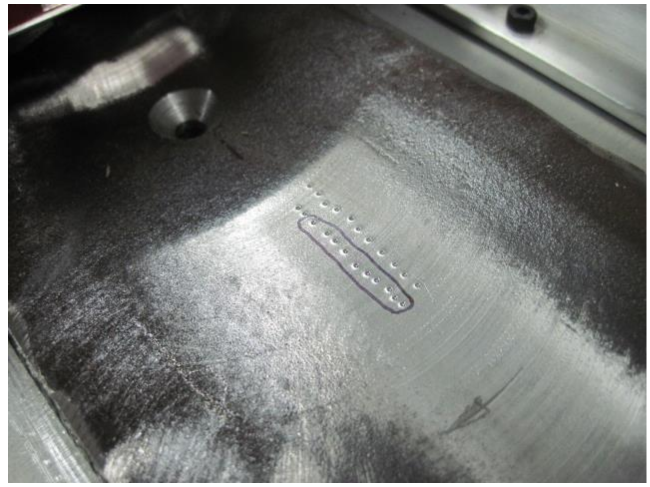

Figure 3: Prepared surface and indentations from testing

PROGRAM STATUS

A prototype module consisting of a surface preparer, Rockwell tester, and Brinell tester is complete and has undergone extensive laboratory testing on Explorer 20/26. Additionally, the tool was demonstrated at the NYSEARCH test-bed in Binghamton, NY, where it was used to collect several measurements throughout the pipeline. Throughout this testing, additional needs and design improvements were identified. The associated development and fabrication of solutions is underway at InvoDane Engineering.

While the testing module was designed and fabricated for Explorer 20/26, the design is expected to be scalable within the Explorer family of inspection tools.

Highlights

Provide pipeline material hardness from the inside the pipe

- Rockwell and Brinell hardness testing
- Can be paired with other In-Line Inspections
- Provides Yield Strength information

Enables compliance with Federal regulations and increases pipeline safety

- Characterizes pipeline material
- Establish/revise MAOP

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