U.S. Department of Transportation

Non-Destructive Quantitative Residual Stress Assessment Tool

DTRT57-11-C-10024

OPS ACCOMPLISHMENTS

Pipeline Safety Research and Development

Challenge

Mechanical damage is the greatest global threat to pipeline integrity. The challenge was to develop and utilize electromagnetic sensors to evaluate mechanical damage severity. G2MT demonstrated a unique next-generation solution for pipeline integrity assessment. The residual stresses around mechanical damage (e.g. dents, gouges, and wrinkle bends) determines the speed of cracking and failure. G2MT's quantified residual stress analysis provides an effective method for real-time assessment of the severity of the damage that will dramatically improve pipeline repair and integrity management. G2MT achieved this goal by performing 3-D residual stress measurements on different forms of mechanically damaged steel pipelines in comparison with neutron-based and destructive testing practices.

Technology

Real-time scanning and hand-held electromagnetic pipeline probe systems, as shown in Figures 1 and 2, were developed to provide quantified three-dimensional residual stress measurements. Further improved assessment and scanning systems now allow for rapid mapping of large regions and for precision focus on selected areas for additional analysis. This next-generation technology goes far beyond shape-based assessment, allowing a leap in the quality and effectiveness of pipeline assessment. The 3-D testing allows measurement of otherwise hidden problems, including re-rounded dents, accumulated stresses, and improper welding.

Accomplishments

G2MT successfully developed and demonstrated a three-dimensional sensor to measure the residual stress levels associated with mechanically damaged regions in pipeline steel. G2MT measured residual stress levels associated with both low and high strength steel pipelines and compared the three-dimensional residual stress measurements to three-dimensional neutron diffraction data for validation. G2MT's residual stress scanning probe system for large areas is shown in Figure 1 and the hand held residual stress probe system is shown in Figure 2.

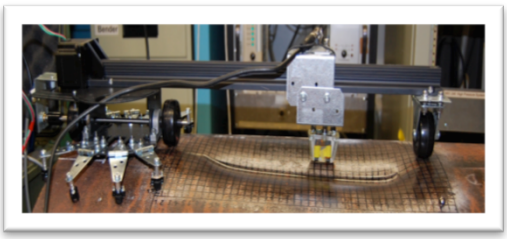

Figure 1: G2MT preliminary residual stress scanning system for steel pipelines.

Figure 2: G2MT residual stress hand-held probe for steel pipelines.

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Benefits

The new system will drastically enhance Risk-Based Inspection and improve pipeline integrity management. Three-dimensional quantitative knowledge of the residual stress levels associated with pipeline steel mechanical damage will allow damaged locations with the highest residual stress levels to be pinpointed and receive the highest priority for repair. Residual stress measurements can be effectively applied to aging infrastructure as well as new construction. The G2MT system is portable and designed for rapid in-field use. Figure 3 (a) shows the change in residual stress profile across the wrinkle bend and as a function of depth into the steel in Figure 3 (b). Figure 4 shows the comparison of residual stress profiles across seven different wrinkle bends indicating the wrinkle bends with the highest residual stress levels.

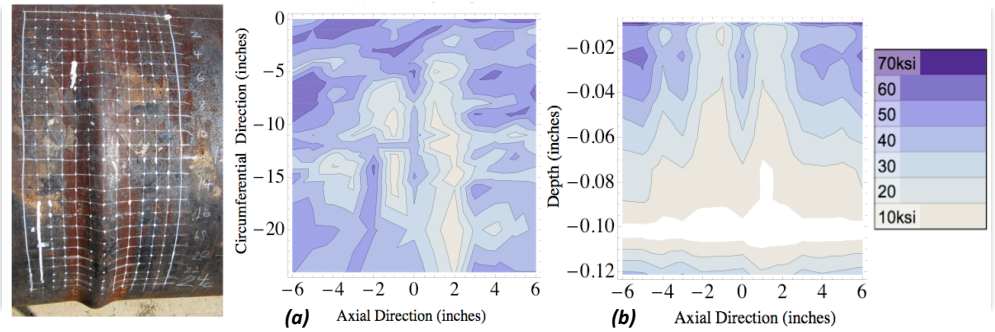

Figure 3: Residual stress contours of a pipeline wrinkle bend (pictured on the left) as a function of circumferential direction and axial direction. (a) Top view of residual stress 0.008 inches beneath the surface. (b) Residual stress contours of circumferential position -7 inches in cross-section as a function of depth and axial direction.

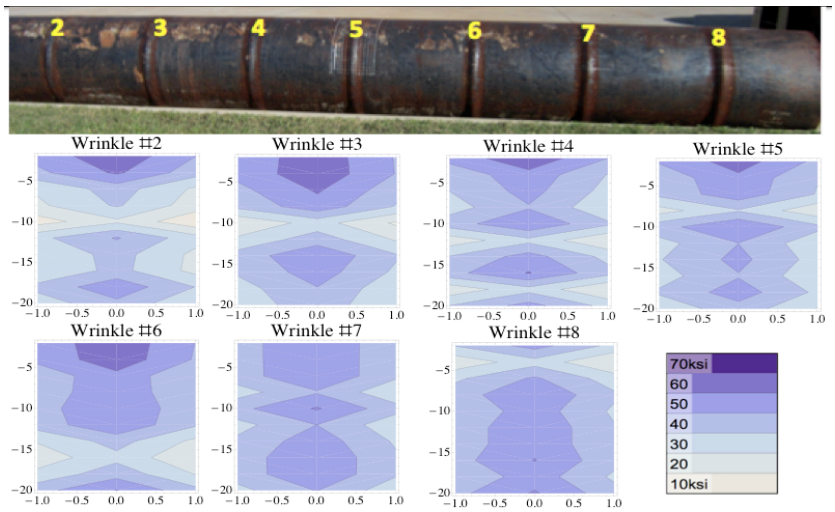

Figure 4: Top view of residual stress contours 0.008 inches below the surface as a function of circumferential and axial directions (same as in Figure 3(a)) for the seven different steel wrinkle bends shown in the above photograph.

Future Activities

Future activities include: (1) Further refinement of residual stress calibration procedures to increase accuracy of residual stress measurements and (2) Continue to ruggedize equipment through collaboration with the customers, service companies, and inspectors who would utilize the sensors.

Acknowledgments

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