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IN-LINE INSPECTION OF BOTH AXIAL AND BENDING STRAINS: A MORE COMPREHENSIVE APPROACH TO DEFINE PIPELINE STRAIN CONDITIONS

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ABSTRACT

In-Line inspection (ILI) tools consisting of combined sensor technologies provide a unique opportunity for operators to understand the conditions of pipelines. While many threats including bending strain can be monitored by inline inspection, axial strain has required localized strain monitoring at known high-risk sites. Currently, (Inertial Measurement Unit) IMU in-line inspections allow for the delimitation of areas of localized bending strains and run-to-run movement analysis, but do not detect either pure axial tensile or compressive strains. Operators now can use the new in-line axial strain inspection tool (AXISS™) to measure axial strain in pipelines without the need to expose the pipeline for the installation of surficial pipe monitoring systems (primarily strain gauges) or destructive testing. The key advantage of the new technology is the measurement of total axial strain at the time of inspection whereas current methods of stress/strain measurement (including the installation of strain gauges) only detect strain changes going forward from the date of installation. The AXISS technology delivers the additional data that, when combined with the IMU inferred bending strain, provides a fuller understanding of the total strain state of a pipeline.

Keywords: In-Line Inspection, Pipeline Strain

1. INTRODUCTION

Running an IMU tool as part of an ILI survey has become a routine practice for most pipeline operators. The IMU is used to provide mapping information which, aligned to the ILI data, provides a means to accurately and easily locate pipeline anomalies, features and fittings. Specialized assessment of data from a single IMU survey can be performed to calculate curvature along the full pipeline. The approach used to determine the level of bending strain is based on the pipeline curvature data, i.e., on the measured pipeline shape. Bending strain in a deformed pipeline can be found from the change in curvature between the initial and the final pipeline position.

IMU inspections allow for the identification of areas of localized bending strains and run-to-run movement analysis, but do not detect either pure axial tensile or compressive strain. The IMU technology provides geometry-based measurements of the centerline curvature which can be directly converted to strain using established definitions. Any elastic, plastic, or residual strain that changes the centerline curvature can be detected by the IMU. Detection capabilities for low level bending strain are typically above 0.125% strain measurement or above 0.04% strain change between one ILI run and another run. However, IMU strain measurements alone cannot differentiate within which strain condition the bending strain exists. For example, using a subsequent inspection and run to run analysis is needed to determine whether a strain occurred during the operation of the pipeline (vs during construction) and if an increase/decrease in strain can be attributed to an active applied in-service load.

2. MATERIALS AND METHODS

The axial strain measurement technology provides a measurement of the linepipe material magnetic properties which can be converted to an absolute strain value based on the calibration factor for the pipe material. Axial strain sensors are designed and calibrated to operate in the elastic strain region of steel. Axial strain sensors have a small footprint and therefore represent a local elastic strain measurement at discrete locations around the pipe length and circumference. The AXISS technology can measure pure axial tensile or compressive strain but will not currently measure axial strain beyond the elastic strain limit.

Both IMU and AXISS technologies provide information regarding the presence of strain due to geotechnical

events but neither can independently provide the full total strain information. Indeed, the technologies complement each other, and the real benefit comes in using and combining the information from both IMU and ILI axial strain tool technologies together enabling a fuller understanding of the total strain condition at any point along the pipeline. The benefits of combining the information from both strain measurement technologies include:

- Identification of the pure axial tensile and compressive strain as well as the bending strain.
- Discrimination of pipeline strain induced by geological instabilities vs curvature introduced during pipeline construction,
- Identification of areas of plastic deformation by comparing elastic bending strain measured with the axial strain tool vs the IMU measured bending strain,
- The strain demand information necessary to perform an engineering criticality assessment of the strain state of a pipeline section to determine severity and remediation needs.

This paper/presentation will give an introduction to the technique, the technology implementation and discuss the benefits of integrating the assessment of both the IMU bending strain and axial strain data streams.

REFERENCES

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