MICRO MEASUREMENTS
A VPG Brand

Case Study

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Residual Stress Measurement Inside a Welded Pipe

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Due to their small size and high durability, strain gages from Micro-Measurements, a brand of Vishay Precision Group (VPG), are chosen by Hill Engineering for a hole drilling application to measure the residual stress on the inner diameters of pipes. The strain gages are placed in pipes of varying diameter and length and monitored by Micro-Measurements Model D4 Data Acquisition Conditioner. This unique application of a conventional residual stress measurement method provides more reliable data and allows for a lower assumed safety margin.

Company/Institute: Hill Engineering, LLC

Industry/Application Area: Material testing and engineering services

Product Used: CEA-06-062UL-120 Residual Stress Strain Gages,
D4 Data Acquisition Conditioner

The Challenge

The inner diameter of pipes is a critical location for design and performance assessment. Corrosion, fatigue, and stress corrosion cracking often attack the pipe's inner diameter, which can lead to leakage and possible failure of the system. Tensile residual stresses in welded pipe joints can have a significant impact on structural integrity and performance because they accelerate crack initiation and growth. In engineering design, understanding the magnitude and distribution of residual stresses on a pipe's inner diameter allows accurate structural assessment and planning for inspection. Measuring residual stress on a pipe's inner diameter is challenging and provides a unique opportunity for innovation.

The Solution

Hole drilling is a mature technology for the measurement of near-surface residual stress and has been standardized by ASTM in E837. The method can be applied to quantify the average residual stress over the depth of a drilled hole (typically 1.0 mm depth). While hole drilling is a well-defined method for residual stress measurement, applying it to the inner diameter of pipes comes with additional challenges, including placing a strain gage and drilling a hole with limited access for tooling.

Micro-Measurements CEA-06-062UL-120 strain gages were used in this application due to their small size and high durability. Hill Engineering designed and manufactured a special guide tool to allow precise and secure mounting of strain gages in pipes of varying diameter and length (Figure 1).

Figure 1: Photograph showing three hole-drilling strain gage rosettes installed on the pipe's inner diameter

Access for a conventional drill is limited when working inside of a small welded pipe, so Hill Engineering developed a miniature precision drilling system that provided measurement access at the pipe's inner diameter.

During testing, the strain gages placed around the perimeter of the hole were monitored using a Micro-Measurements Model D4 Data Acquisition Conditioner, which is a portable, USB-powered precision instrument for use with resistive strain gages and strain-gage-based transducers.

Following completion of the hole drilling experiment, the strain versus hole depth data were used to compute residual stress (Figure 2). These residual stress measurement data provided engineering a basis for structural integrity assessment and inspection planning.

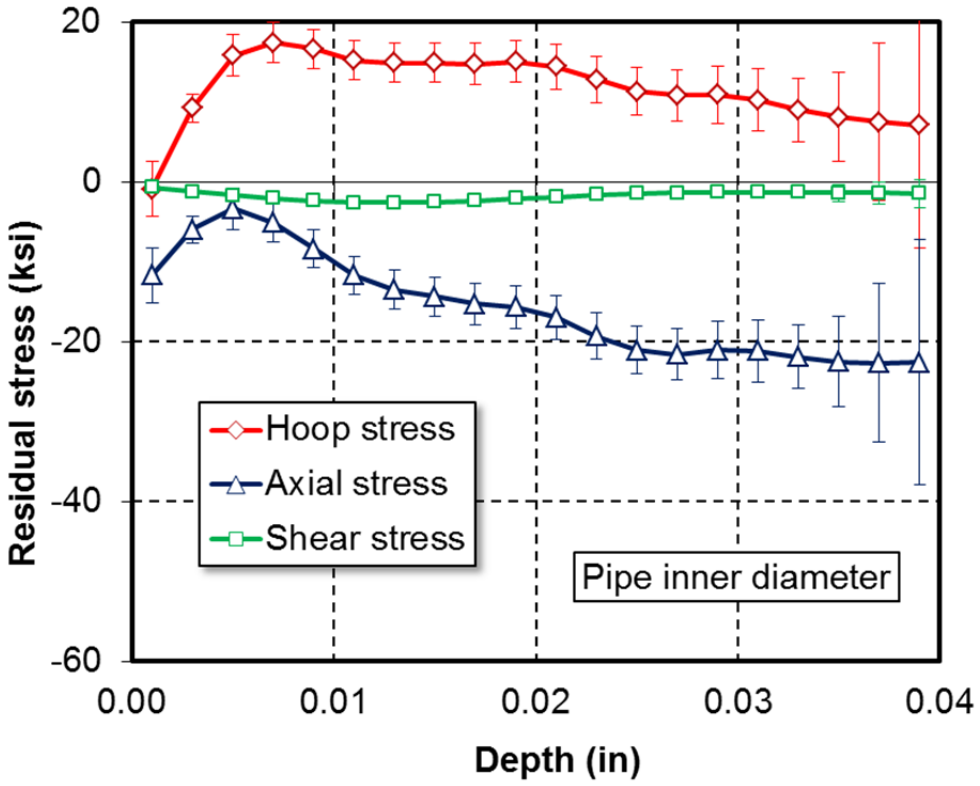

Figure 2: Residual stress measurement data from hole drilling at the inner diameter of a welded pipe

The Customer Explains

This unique application of a conventional residual stress measurement method provided data for structural integrity assessment of the welded piping system. Prior to the development of this measurement capability, engineering decisions were based on conservative assumptions and a large safety margin. The new capability provides reliable measurement data and allows for a lower assumed margin.

Hill Engineering has extensive experience with hole drilling, and a reputation for providing high-quality residual stress data. We also offer precise installation of instrumentation in tight spaces, on unique and exotic materials, for complex parts, and in other challenging applications.

“The high-quality residual stress strain gages from Micro-Measurements enable Hill Engineering to achieve our extraordinary goals for precision and accuracy”

Acknowledgement:

Hill Engineering is the world leader in the Contour Method and provides the same level of precision and accountability in a broad range of residual stress measurement methods, including slitting, hole drilling, ring core, x-ray diffraction, and neutron diffraction. Hill Engineering's mission is to develop and deliver innovative methods for material testing and analysis that meet customer needs during design, manufacturing, and operation. For engineers seeking residual stress measurements, Hill Engineering is a trusted source for a broad range of best-in-class measurement capabilities. Organizations that select Hill Engineering receive actionable data that enables critical decisions with a high degree of confidence.

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