Technology Brief

Northeast GAS ASSOCIATION
NYSEARCH

Development of a MFL Sensor to Inspect Bends in Unpiggable Pipelines

Description: **A project to design, build, and test an MFL sensor to inspect bends in unpiggable pipelines. This sensor is intended to replace the existing MFL sensor on the Explorer 20/26 inspection tool.**

Status: **Sensor development is complete and is commercially available.**

BENEFITS

This project will enable Explorer (EXP) 20/26 series robots to employ an optimized, Magnetic Flux Leakage (MFL) sensor that will inspect pipeline bends at a performance level comparable to that seen in straight pipe. This new sensor will expand the EXP inspection capability for unpiggable pipes and address an area of user concern. It will replace the existing MFL sensor on the EXP 20/26 robot, and will be used to inspect both straight pipe and bends.

Figure 1: Explorer 20/26 equipped with an MFL sensor

BACKGROUND

Beginning in 2010, NYSEARCH commercialized a full range of Explorer robotic platforms to conduct In-Line Inspections (ILI) of live, unpiggable natural gas pipelines. The subsequent progression of technology, continued investment, and outstanding industry needs have brought additional capability to the Explorer robots. One of the areas identified for additional research and development investment was that of designing and building an MFL sensing module able to fully capture bend integrity information.

Due to geometric constraints, existing MFL sensors face a number of challenges associated with inspecting bends that are not encountered during the inspection of straight pipe. As seen in Figure 1, when the sensor module passes through a bend, the individual sensors lift off of the wall on the outer radius of the bend. The opposite is true on the interior radius, where the sensors encounter direct contact with the wall while the magnetic bars' ends are forced away from the wall. As a result of the compression along the interior radius and limited expansion possible on the outer radius, the wheels along the outer radius can slip, thereby altering the equi-angular spacing of the magnetic bars. Additionally, individual sensors can be damaged from contacting the wall, and the magnetic field is not uniform throughout the pipe due to the variable distance of the magnets from the wall.

The magnetic bars along the outer radius will travel at a faster rate than at the centerline of the sensor, and bars along the inner radius will travel slower. The magnet bars in the middle of the sensor will slide, or drift through the bend instead of translating along a defined path. The combination of these phenomena results in lower fidelity inspection through a bend than in straight pipe, and represents an area for improvement and optimization.

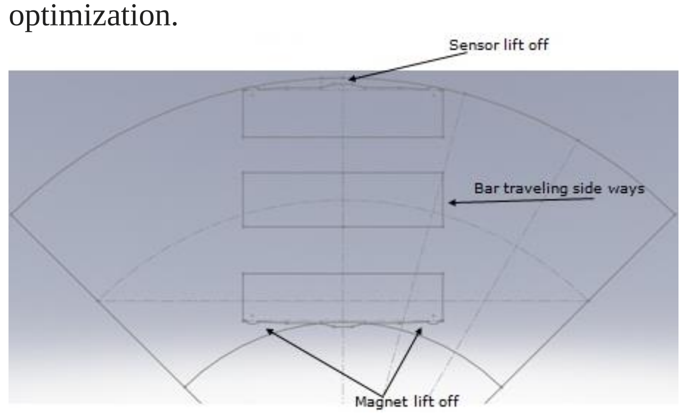

Figure 2: Illustration of MFL travel through pipe bend

TECHNICAL APPROACH

Building upon the success of the Explorer robots, NYSEARCH executed a feasibility study to examine whether or not the limitations imposed by the geometry of an MFL sensor could be overcome in order to inspect bends in pipe at an accuracy level compatible to that of straight pipes. The study focused on the mechanics of how the sensor assembly is aligned and rides through the bend, as well as the magnetization of the pipe wall. Figure 2 shows the analysis of the magnetic field within a pipe bend. The results indicated that it is indeed feasible to develop and implement an MFL sensing capability on Explorer robots for the inspection of bends that will significantly improve upon that existing on existing sensors.

Given the favorable results of the study, baseline performance information was collected on the existing sensor and its associated algorithms. The magnet bars were then redesigned to eliminate some of the challenges associated with the geometry of the original sensor module. The center body of the sensor module was also redesigned to increase its strength and to maintain consistent spacing of the magnet bars through a bend. These changes optimized the position of the sensors as well as their path when traveling through a bend. An updated, computational algorithm was also developed to more accurately calculate the size and location of defects based upon dissimilar sensor component speeds.

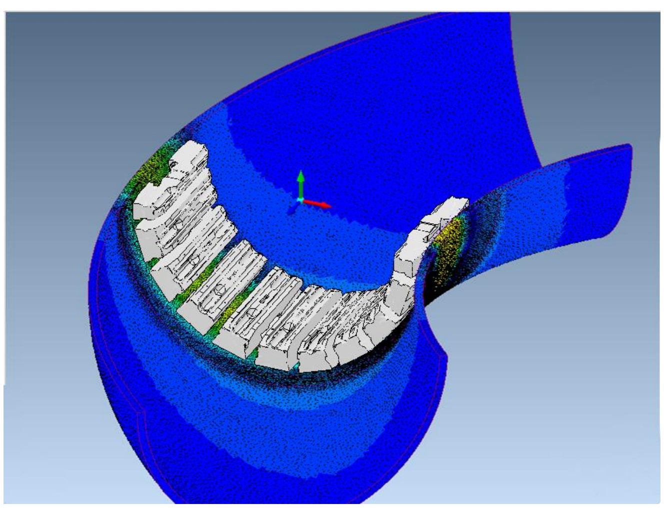

Figure 3: Magnetic flux data plot around a bend

Once assembly was complete, the new sensor was installed on Explorer and the system underwent extensive laboratory testing on 20” pipelines and bends. The initial lab tests proved that the new system was able to collect data throughout sections of straight pipe as well as in bends. The sensor was then taken to the NYSEARCH test-bed in Binghamton, NY to further evaluate its capabilities. It was able to collect data throughout the 20” underground piping system, which had not been possible using the previous MFL sensor.

PROGRAM STATUS

The development of the sensor is complete and it is now commercially available on the Explorer 20” robot. Although the initial work was done for a 20” system, the principles behind the technology allow it to scale both up and down in size. Work is currently underway to incorporate the lessons learned from this design on the MFL sensor on the Explorer 6 robot, which will be used to inspect pipes 6” in diameter.

Highlights

Detects metal loss in bends to comparable standards as straight pipe

Negotiates and collects data in live, unpiggable natural gas pipelines

Replaces existing MFL sensors on Explorer

Scalable to other sizes

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