U.S. Department of Transportation

Differential Impedance Obstacle Detection Sensor (DIOD) Phase 2
OTA# DTPH56-06-T-000005
November 2006

OPS ACCOMPLISHMENTS

Pipeline Safety Research and Development for Damage Prevention and Pipeline Mapping/ Location

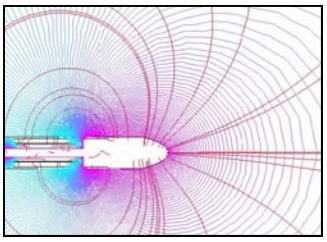
Challenge

To minimize excavations and public inconvenience, utilities often use horizontal directional drilling (HDD) to create underground pathways for the installation of pipes, cables, and other utility lines. While HDD provides efficiency improvements over conventional open-trench methods, inadvertent strikes of existing lines can occur. To address the issue, a variety of obstacle-detection technologies have been investigated in recent years with limited success. Ground-penetrating radar (GPR) – the most common method – employs high frequencies, costly electronics, and is often blocked by damp or mineralized soils. Other obstacle systems under development require receivers on the surface near the drill head, making them unfeasible for river or highway crossings. In response, researchers are developing a DIOD sensor to detect metallic and non-metallic obstacles at a greater range, in a variety of soils, and with the ability to send data directly to a receiver at the drill rig.

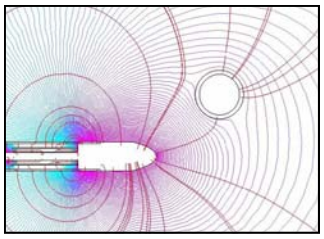
Technology Description

With the DIOD system, an AC current in the 100kHz frequency range is injected into the soil ahead of the drill head. Elements around the drill head detect changes in the electrical field and dielectric properties of the soil. When an obstacle is present, the impedance of the AC current path changes and the sensor signal is affected. For this R&D effort, investigators are focused on developing finite element modeling of sensor configurations to improve system characteristics, fabricating and testing prototypes, and conducting field tests and technology transfer activities.

Finite Element model of field lines with no obstacle present



Obstacles cause changes in the electrical field



Accomplishments

In laboratory-scale proof-of-concept testing at Gas Technology Institute (GTI), a prototype system was able to differentiate between metallic and non-metallic obstacles placed to the side of the sensor elements. Tests established that each of the four elements (distributed around the sensor) could detect obstacles in the quadrant that it faced. Sensitivity to obstacles directly ahead of the sensor assembly was lower than desired; however, improvement efforts (e.g., the use of 2-D and 3-D finite element modeling for alternate configurations) are under way.

Additional accomplishments to date include:

- Formation of an advisory group with members from AGA, APGARF, and NGA
- Redesigned electronics to improve signal-to-noise ratios
- CAD modeling to improve mechanical robustness.

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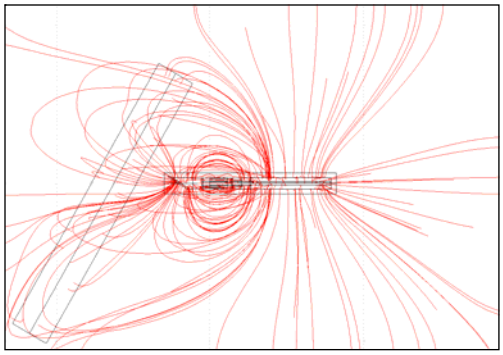

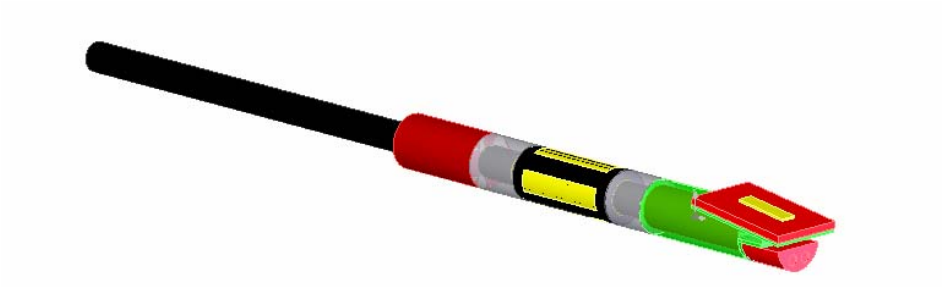

Top Left: Current Prototype
Top Right: 3-D Finite Element Model, Sensor, and Obstacle
Bottom: Alternate Configuration

Benefits

Significant safety and cost-saving benefits can be obtained through the use of a system that can accurately detect buried obstacles during HDD installations, alert operators to their presence, and effectively avoid inadvertent utility strikes. The DIOD technology is reasonably priced as compared to higher-frequency systems, and can be used for installations under river crossings. With an effective obstacle-detection system, operators will be able to take advantage of the benefits provided by HDD while enhancing the safety and efficiency of utility installation operations.

Future Activities

Prototypes of alternate configurations will be fabricated and tested. Research goals are to develop a robust sensor applicable to HDD conditions to detect plastic, ceramic, and metallic obstacles with no "false positives." Tests will be conducted in at least three different soil materials. GTI will consult with industry standards and compliance groups and seek a commercial partner for technology transfer.

Partners in Success

- Gas Technology Institute (GTI), lead organization: www.gastechnology.org
- Louisiana Tech Trenchless Technology Center: www.ttc.latech.edu
- American Gas Association (AGA): www.aga.org
- Atmos Energy, on behalf of AGA: www.atmosenergy.com
- APGA Research Foundation (APGARF): www.apgarf.org
- City of Mesa, on behalf of APGARF: www.cityofmesa.org
- Northeast Gas Association (NGA): www.northeastgas.org
- Awwa Research Foundation (AwwaRF), cost-sharing partner: www.awwarf.org

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CITY OF MESA Great People, Quality Service!

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