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c Health Monitoring Using Fiber Optic Sensors and Ultrasonic Acoustic NDE

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ABSTRACT

United States (US) pipeline infrastructure provides safe and secure transportation of diverse oil-and-gas streams to millions of consumers countrywide. Because it has been in operation for many decades and tends to deteriorate due to damage caused by corrosion, cracks, and other defects, structural integrity of pipelines is critical to enable improved reliability and resiliency of infrastructure with greater operational efficiency and mitigating significant safety and economic challenges.

For structural health monitoring (SHM) of pipelines, ultrasonic guidedwaves (UGW) is the popular Non-destructive Evaluation (NDE) technique for damage assessment and defects detection. The technique relies on the excitation of guided waves and evaluating the measured ultrasonic acoustic signatures to identify structural defects (welds, corrosion, crakes etc.) and their growth rate. Towards SHM/NDE applications, optical fiber sensing technology, such as fiber Bragg grating has been widely explored due to its obvious advantages such as, flexible, and lightweight, thin, easy to be embed into any structure and high sensitivity as well as the capability for performing quasi-distributed interrogation along the pipeline length.

This work explores the application of alternative fiber-optic acoustic sensor technology combined with UGW excitation for nondestructive health monitoring of damaged pipeline structure. Two similar 16-ft long carbon-steel pipes (diameter=6-inch, SCH40) are set up for investigation; one consists of various defects such as welds, and corrosion potholes, and the other is healthy without any defect for reference. Fiber optics sensor made by a multimode no-core fiber which has an ultrasonic sensing range up to 1 MHz is remotely bonded at 45^{o} w.r.t pipe axis near the active source. The pipes are actively excited by employing magnetostrictive collar on one end as an ultrasonic source that generated torsion guided waves on the exterior surface, and the characteristics of reflection waveforms detected by the fiber-optic acoustic sensor at the varying ultrasonic frequencies are investigated. Figure 1 shows a reflection waveform obtained from a damaged pipe for an excitation frequency of 32 kHz and 3 cycles. The measured reflection waveforms are also compared to those obtained by the numerical simulation of the damaged pipe model. Our work presents a practical approach for pipelines damage detection using a multimode fiber-optic acoustic sensing and ultrasonic guided waves NDE.

Keywords: Pipeline monitoring, ultrasonic testing, optical fiber sensor, acoustic NDE

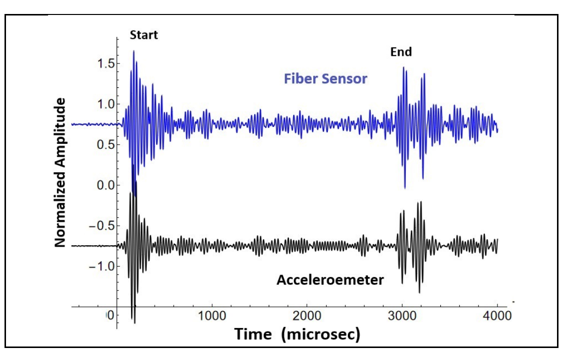

Figure 1: Reflection waveform detected by the fiber sensor in response to ultrasonic guided wave excitation.