Holistic Electromagnetic and Ultrasonic NDE Techniques for Plastic Pipeline Aging and Degradation Characterization

Subrata Mukherjee[1,3], Obaid Elshafiey[1,3], Yoganandh Madhuranthakam[1,4], Changyong Cao[1,4], Sunil Chakrapani[1, 4], Yongming Liu[1,5], Yiming Deng[1,3]

3 Electrical and Computer Engineering, 4 Mechanical Engineering, 5 Aerospace Engineering and Mechanical Engineering

1 Michigan State University, 2 Arizona State University

Main Objective

This objective of this work was to design an integrated near-filed flexible microwave sensor Fig 1. (a), waveguide sensor Fig 1. (b), dual band resonator Fig 1. (c), and non-linear ultrasonic probing tool using trough transmission Fig. 2 (a) and Pulse echo method Fig. 2 (b) to detect the extent of plasticizer loss in the pipes and characterize the plastic degradation. Provide an uncertainty minimized prognostic framework to assist in the maintenance of pipelines.

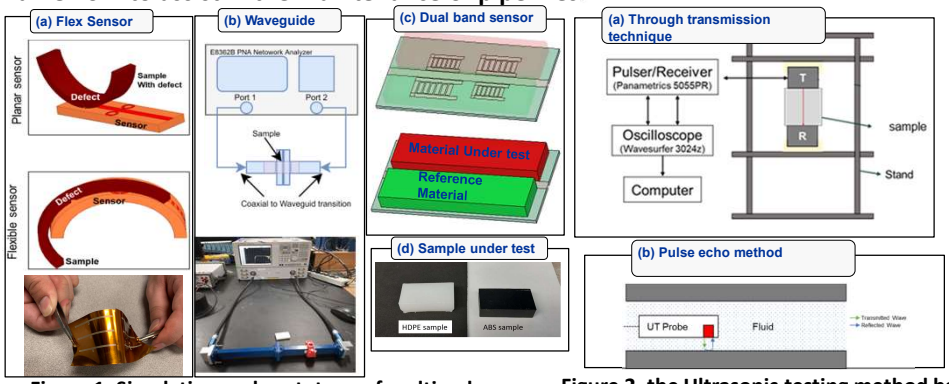


Figure 1. Simulation and prototype of multiped Electromagnetic method for measuring .

Figure 2. the Ultrasonic testing method based on measuring the longitudinal and shave velocity passing through a sample

Project Approach/Scope

Plasticizer loss in pipelines occurs gradually over time, it can go unnoticed with conventional nondestructive evaluation (NDE) techniques. The proposed method will involve:

- Development of microwave sensors that can confirm plasticizer loss from S parameters
- Developing a nonlinear ultrasonic method for evaluating plasticizer loss
- Quantifying uncertainty parameters in measurement (parameters such as lift off and noise)

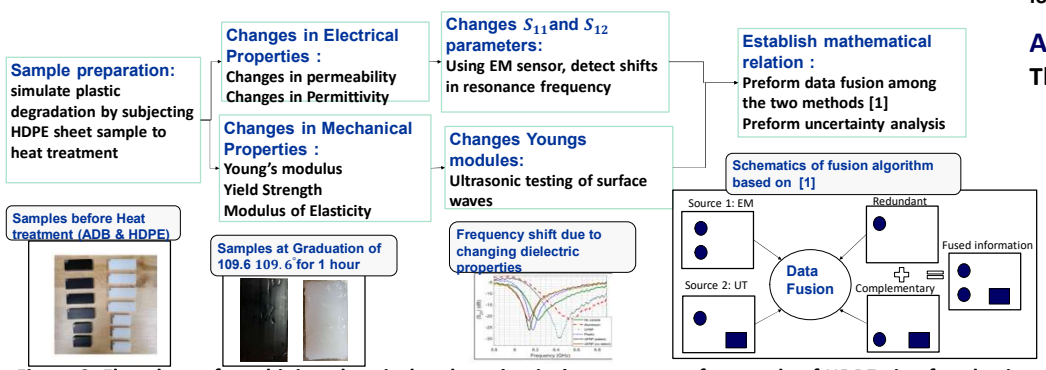


Figure 3. Flowchart of combining electrical and mechanical assessment of a sample of HDPE pipe for plastic degradation

Expected Results or Results to Date

- The developed microwave sensors detect plasticizer loss from changes in resonance frequency, the sensors insertion loss is measured using VNA were resonant frequency corelates to changes in dielectric property, Fig. 4
- Experimental UT techniques are presented to measure pipe samples' linear and nonlinear properties , Fig. 5[2,3]
- Results from both methods can be used in imaging applications, detecting surface and subsurface defects
- An innovative fusion with registration method presented in [1] is used to combine UT and EM sources. Fig. 6

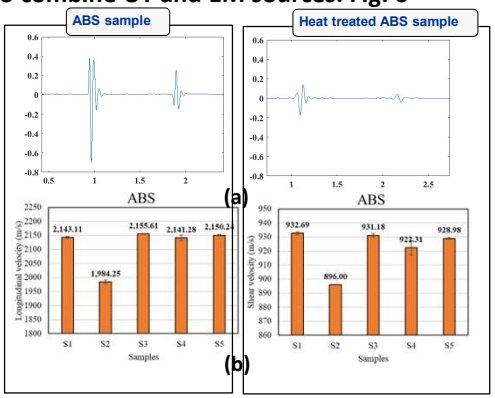


Figure 5. (a) Longitudinal waveforms and (b) longitudinal velocity of ABS and heat-treated ABS

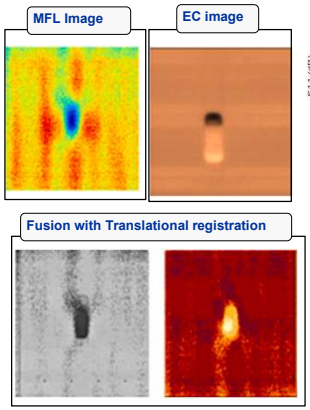
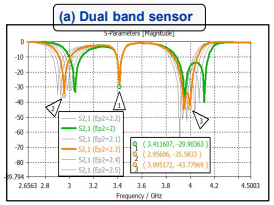
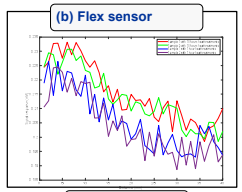


Figure 6. the fusion method was implemented to combine an MFL with an EC image.





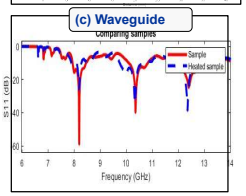


Figure 4. (a) Simulation results form Dual band sensor (b) experimental results form flex sensor with different heat-treated samples (c) experimental results from waveguide.

Acknowledgments

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[2] Chakrapani, S.K. and Barnard, D.J., 2017. Determination of acoustic nonlinearity parameter (β) using nonlinear resonance ultrasound spectroscopy: Theory and experiment. *The Journal of the Acoustical Society of America*, *141*(2), pp.919-928.

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