

Pipe Internal Defect Inspection Based on Graphene/PVDF Piezoelectric Membrane Sensor and Machine Learning

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Pipe internal inspection is one of the nondestructive testing technologies for defect detection and classification at pipe inner surfaces. Various kinds of sensing and testing techniques, such as magnetic sensors, ultrasonic sensors, eddy current sensors, etc., have been installed on Pipeline Inspection Gauge (PIG) devices for pipe inspection and maintenance missions. This paper represented a new inspection method using graphene/PVDF (Polyvinylidene Fluoride) piezoelectric membrane sensor for detecting the pipe internal defects. The membrane sensor was wrapped to form a helical shape and embedded inside a roller of a PIG. The roller has contact with the pipe inner surface as the PIG moves inside the pipe. The helical piezoelectric sensor is axisymmetric about the central axis of the roller and could general consistent piezoelectric signal pattern for the roller-to-wall contact at any rotational angle about the central axis of the roller. The in-situ measurement of time-dependent piezoelectric signal was acquired for defect classification using various kinds of machine learning methods. As the roller rolled over an area with corrosion or cracks, the acquired piezoelectric signal changed its pattern. Machine Learning (ML) methods, including Random Forest (RF), Support Vector Machine (SVM), K-Nearest Neighbors (KNN), etc., were utilized to recognize and classify the time-dependent piezoelectric signal patterns of different kinds of defects at the pipe inner surfaces.