Efficient Fouling Reconstruction in the Pipelines with Four Transducers and Neural Networks

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Industrial structures can become fouled for several reasons when unwanted substances accumulate on the inner surfaces. Detection and characterization of the fouled area are thus of critical importance for efficient industrial operations. Guided waves are sensitive to such deposits or defects and are typically generated and recorded using a network of ultrasonic transducers. In this work, we present a method for accurate reconstruction of the fouling map using a pre-trained neural network. The prior information about the typical fouling location and shape can be incorporated efficiently into the training dataset that is generated using a simple attenuation model and doesn't require demanding finite element simulations. The fouling reconstruction algorithm required two measurements: one on the healthy pipe and another one with accumulated fouling. The attenuation information of the particular guided wave trajectory is then fed to the neural network that can output the fouling map within milliseconds. The proposed method is verified experimentally on the pipe structure using only four transducers that can cover long distances benefiting from the high-order helical trajectories that guided waves can propagate along. The four transducers are located in two pairs, at the lower and upper part of the left side of the pipe and the front and back side on the right side of the pipe. Such placement of the transducers allows for separation of the clockwise and anticlockwise guided wave propagation in the recorded signals, thus providing richer information about the pipe deposits with fewer sensors. Moreover, the method can be easily extended to more complex structures e.g., storage tanks or pipeline connections, as it only requires the guided wave trajectories and signal attenuation information due to contamination or defect.