CAAP Quarterly Report

Date of Report: *March 31th, 2019*

Contract Number: *693JK318500010CAAP*

Prepared for: *U.S. DOT Pipeline and Hazardous Materials Safety Administration*

Project Title: Brain-Inspired Learning Framework to Bridging Information, Uncertainty and Human-Machine Decision-Making for Decoding Variance in Pipeline Computational Models

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For quarterly period ending: *March 31, 2019*

Business and Activity Section

(a) Generated Commitments

No changes to the existing agreement

Some purchase of steel plates and piezoelectric sensors

(b) Status Update of Past Quarter Activities

In the second report, the major work aimed to integrate sample design and laboratory test associated with varying mechanical damages, while numerical simulation enriched datasets for mechanical damage, as summarized below:

1.1 Datasets from experimental/numerical studies using Lamb wave

In recent years, structural health monitoring (SHM) becomes one key component in civil engineering, including oil/gas pipelines and highway bridges. The aim of SHM is to monitor the performance of a structure during in-serve stages when subjected to varying load and environmental stresses. The response of the structure can be collected by imputing a diagnostic signal. Then, analyze the response and extract features. Though the data-driven techniques and machine learning methods, the damage type and level of the structure can be obtained. The traditional methods of SHM usually consists of transducers for actuation and sensors for reception. Several methods have been proposed in recently, which include vibration-based techniques, guided wave-based techniques and so on. Comparing other damage detection methods, guide wave involve high frequency wave which could detect minute damage and low-frequency vibration could not interfere with it. Moreover, the structure damping has less influence on guide wave. Therefore, the guided wave could be used for pipeline structure, steel structure and others.

1.2 Experiment design

The experiment is performed on several 2.38-mm thick steel plates. Prepare 10 steel plates. The size of them is equal (762mm*127mm*2.38mm). The type of the steel is A36 which the Young's modulus is 200GPa and the Poisson's ratio is 0.26. The stripe actuator (piezoelectric sensor) is mounted on the steel plate as the signal actuator and the receiver as well, which can receive the signal as an electronic signal. The wave generator, Agilent 33220A, is to send an exacted signal. The oscilloscope (Tektronix TDS2014C), illustrated in Figure 4d, is used as the data acquisition to store data for later analysis and has functions of data visualization in real time. These studies are under the way and we will report the results and data analysis associated with detailed tests in the following report period.

1.3 Numerical simulation

Finite element method (FEM), as a numerical tool, could simulate a similar situation with the real state. The result of the FEM can be validated with the experimental results.

The excitation is 5 cycles sine function and operated with a hanning window. The frequency of the signal is 250kHz. The equation can be shown as follow

$$u(t) = A(1 - cos\frac{2\pi f_c t}{n})\sin(2\pi f_c t)$$

where A is amplitude of the signal, f_c is the frequency, n is the cycles number. Then the signal can be plotted in Figure 1.

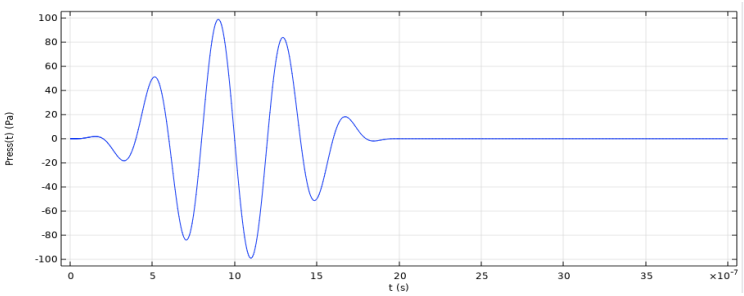
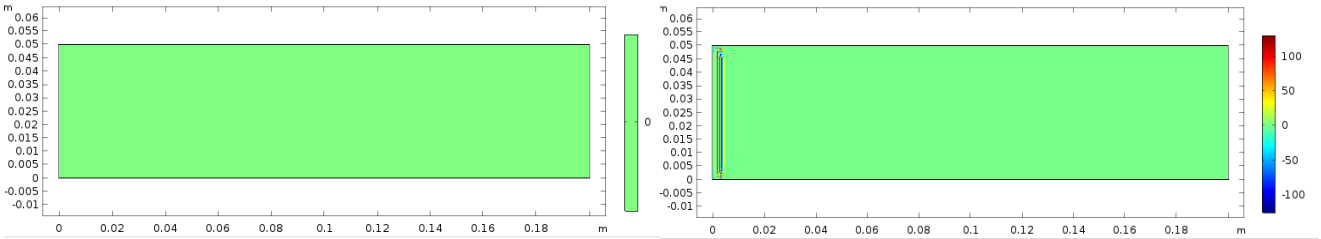
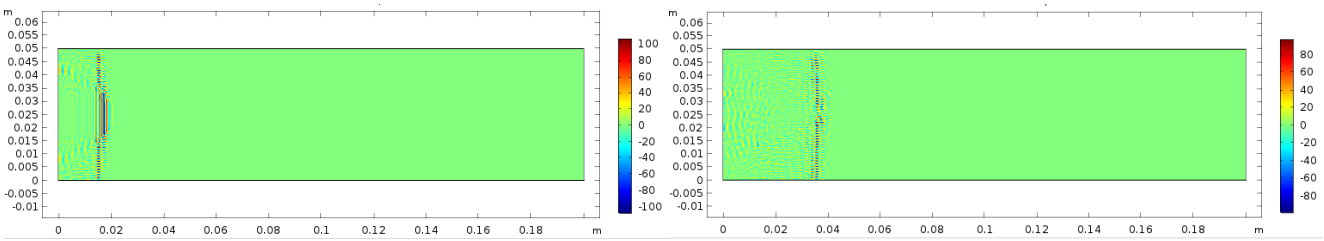


Figure 1 Input signal

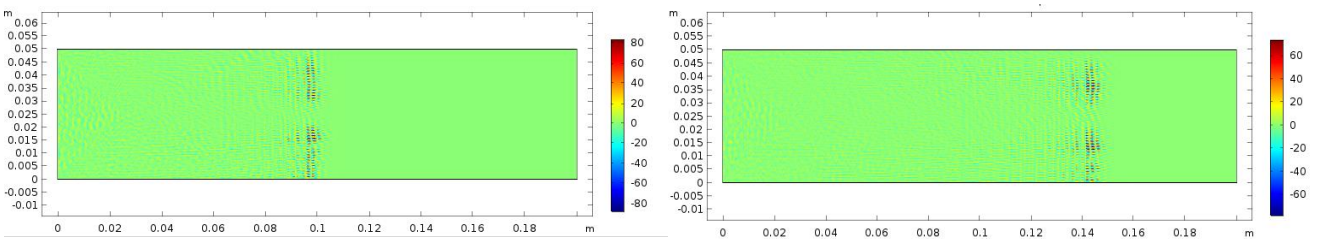
Figure 2 shows the signal propagation through the steel plate. For instance, the waveform at a certain point (x=0.013, y=0.022) in the coordinate system was displayed in the time domain as shown in Figure 3.



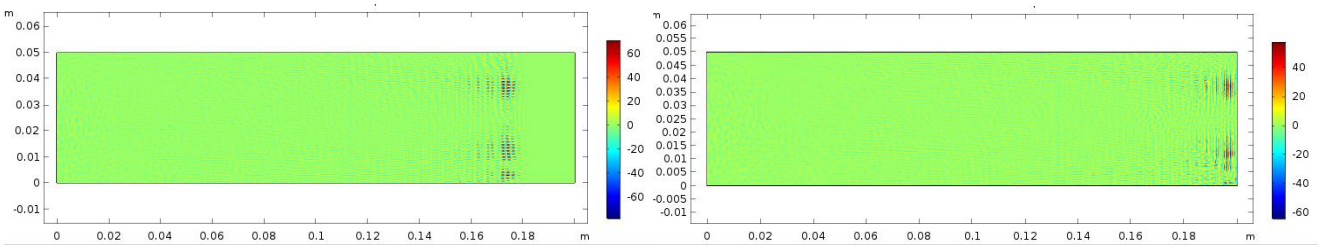
(a) at the onset (b) time=2.2e^{-6} s



(c) time=7.9e^{-6} s (d) time=1.68e^{-5} s



(e) time=4.38e^{-5} s (f) time=6.38e^{-5} s



(g) time=7.7e^{-5} s (h) time=8.99e^{-5} s

Figure 2 Time history of signal propagation along the plate: (a)-(h)

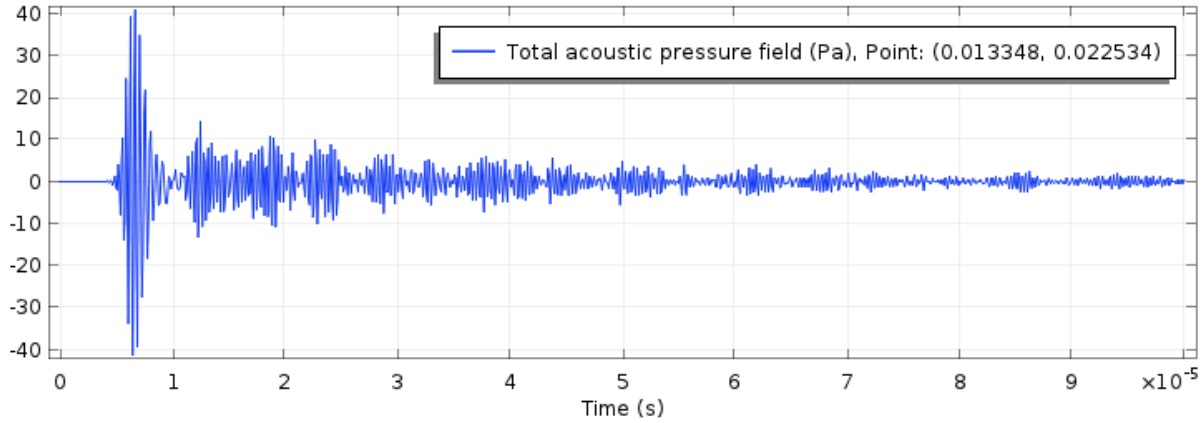


Figure 3 Signal waveform located at a certain point in the time domain

Continuous wavelet transform (CWT) is used to decompose a signal into wavelets which are small oscillations. The time-frequency result shown in Fig. 4 could provide full-spectrum feature extraction using feature box through the domains.

Therefore, the inclusion of damage/cracks experienced in the structure into the model could provide change of signals in time-domain (DWT), frequency domain (FFT), or time-frequency domain (CWT). Thus, the next work will provide more information associated with damage-induced change for feature extraction and representation classification.

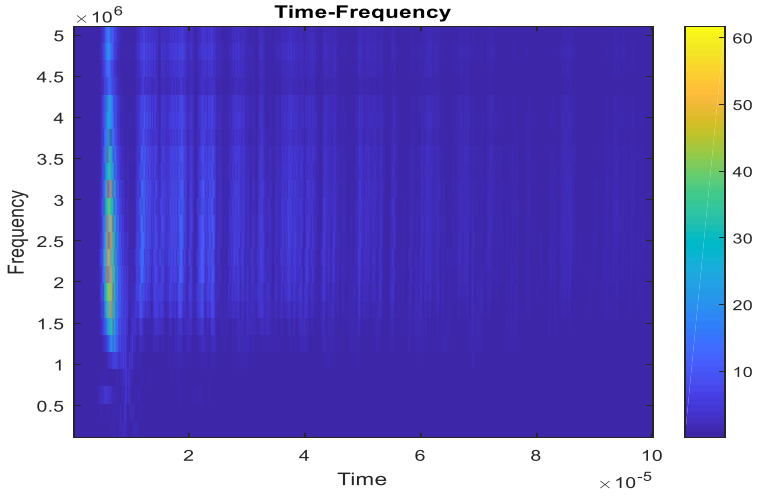


Figure 4 Continuous Wavelet Transform

(c) Description of any Problems/Challenges

No problems are experienced during this report period

(d) Planned Activities for the Next Quarter

The planned activities for next quarter are listed below:

- the experimental tests will be conducted, while the data on specified mechanical damage will be recorded and analyzed.