

## Circumferential Locating the Corrosion in Bimetal Composite Pipe based on the Longitudinal Guided Wave

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### Introduction

In oil and gas production, a lots of sulfur-compounds (hepatic gas, sulfur dioxide and sulfur trioxide, etc.) present a serious threatens for the safe of the transfer pipeline. To prolong the life and protect operation safety of the pipe, the bimetal pipe with one resistant layer is widely applied to transfer the oil and the other chemical products. So the propagation characters of the wave in the composite pipe and a suitable damage technique need to be studied and developed. In past, many researchers pay their attention into the development of NDT technique, such as Ultrasonic Testing (UT), Radiographic Testing (RT), Eddy current Testing (ET), Acoustic Emission (AE), etc. Most of these techniques scan the structures in point-by-point. And the structures can be scanned with the conditions of removing the coating and production down time. It becomes very expensive when full inspection coverage is needed. Recently, the ultrasonic guided waves techniques received many interesting by researchers and engineers. Using it, whole pipe wall could be fast scanned when guided wave propagates along the pipeline. The theoretic background is that the guided wave can be partially reflected when they encounter features (such as welds, branches, drains, corrosion patches, etc.) that locally change the geometry of the pipe. The key of the succession of this technology lies in the development of the stress wave theory.

In this paper, a bimetal pipe, which have inner layer made by alloy Incol825 and outer layer made by steel NT80ss, will be studied. The longitudinal guided wave mode in the bimetal pipe will be evaluated by mode analysis. Based on this, the L(0,2) guided wave is selected to inspect the damage in the pipe. Both the location in axis and circumferential direction are identified. Finally, a simulation will be used to verify the valid of the presented method.

### Simulation

In this section, the longitudinal guided wave of L(0,2) will be excited in a 0.8m-in-length bimetal composite pipe. And the other parameters of the pipe could be found in Tab.1.

Table.1 the geometric and material parameters of the bi-metal composite pipe

i	Material	$E$ (KN/mm <sup>2</sup> )	$\nu$	$\rho$ g/cm <sup>3</sup>	Thick ness mm	Inner radius (mm)
1	Inc.825	212.4	0.3	8.64	1.00	37.05
2	NT80ss	210.0	0.3	7.85	6.45	38.05

The actuating signal is consist of 10-cycle sine waves at 100 kHz modulated by a hanning window. The symmetrical loading was acted on all nodes at the pipe end to generate the L(0,2) guided wave.  $P_1, P_2 \sim P_{16}$  in Fig.1 are the circumferential positions of the probes which are adequate distributed around the cross-section and at 80mm from the excited end. Taking an example, a 1/4 circle at 0.4m whose thickness decrease 1mm and the width is 4mm is used to simulate the corrosion as shown in Fig.4. The circumferential position of the damage lies in the domain between  $P_1$  and  $P_5$ . Considering the average speed of the guided wave, the total time for calculation is 0.4ms and the time step is 1.2us, inspection.

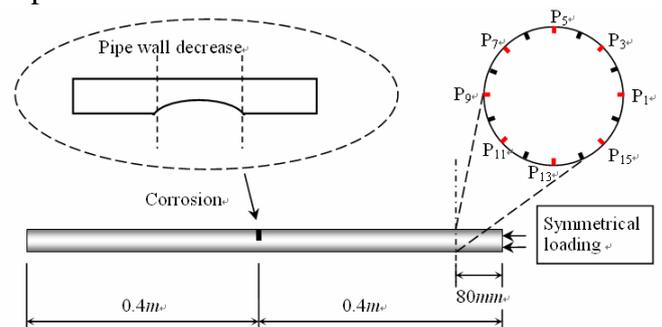


Fig.1 the damaged pipe mode and the excited location and probe location.

So, the total of the sample points are 459,i.e, the sampling period is 1.2 $\mu$ s in this paper.

It is interesting to discuss the frequency components of the signal with the variation of the time  $t$ . This is called time-frequency analysis, which is usually presented by the time-frequency distributions (TFD). In this paper, the pseudo Margenau–Hill distribution (PMHD), which is depending on a smooth window, is used to analysis the echo from the corrosion.

Figure 2 shows the PMHD of the 8-echo-signal by the corrosion for the odd probes. It is attraction that there are the same and different properties in PMHD. For example, there have high energy between sampling points 187 to 214 for every signal. That is to L(0,2) (excitation mode) mainly focuses on the time-interval. The location of the corrosion could be evaluated by the arrive time of the L(0,2) guided wave.

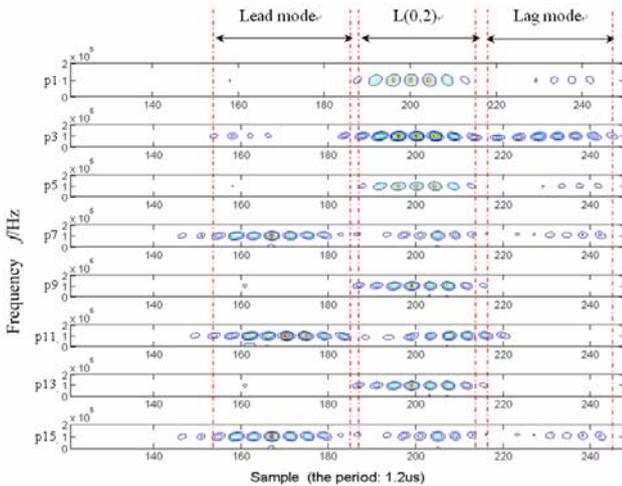


Fig. 2 the Pseudo Margenau-Hill distribution of the intercepted signal for the odd number probes.

On the other hand, the conversion mode, lead mode and lag mode, are different among the signals. For lag mode, the high energy occurs only on p1, p3, p5 and p15. They are same in the circumferential position with the corrosion. In signal processing, the energy of signal could express the intensity of the signal, it is defined as:

$$E(S) = \sum_{i=1}^n S_i^2. \quad (7)$$

Using Eq.(7), the normalized energy of the lag

mode for each signal could be calculated and plotted in Fig.6. Obviously, the energy of lag mode corresponding to damage domain is larger than the ones corresponding to the other domain. As results, the circumferential position of the corrosion could be identified since the energy corresponding to non-damage domain is very close to zero.

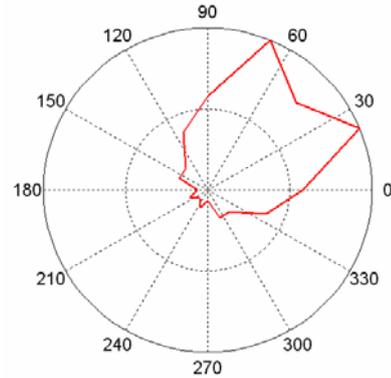


Fig. 3 the energy distribution of the lag mode around the circumference-direction.

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