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STUDIES ON INSERTION LOSS EXPERIMENT OF CRACKED PLATES

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Abstract

The correlation acoustic scattering experiment of 13 freedom plates of different cracks and a intact freedom plate have been investigated in this paper by using advanced acoustical experiment system. Insertion loss is used as diagnose index and experimental show that insertion loss is sensitive to the crack position and it will be decreasing with the length, the depth and the number of cracks. Insertion loss can be considered as an easy new diagnose index for non-destructive detection.

1. INTRODUCTION

Recent interest in nondestructive evaluation has resulted in several theoretical experimental developments on surface and bulk wave interaction with surface breaking cracks which are summarized by Doyle[1], scattering of surface waves for normal incidence to cracks has been treated theoretically by Achenbach [2]at all. All the researches are almost in solid and seldom in air. In this paper, insertion loss as an easy new diagnose index is presented to estimate the existence of crack and the results predicted by a model based on Huygen's principle and Kirchhoff's formulation have shown good agreements with the experiments.

2. EXPERIMENTAL MATERIALS

Thin aluminum plates are used in the experiment with length of 1m, width of 1m and thickness of 3mm. The correlative physical parameters are: Elastic modulus $E_1 = 6.89 \times 10^4 Mpa$, Poisson ratio $u_1 = 0.3$, density $\rho_1 = 2700 kg / m^3$.

The PLUSE system of B&K Company that was made in Denmark is applied in this experiment in the Semi-anechoic Room (absorption coefficient is 0.99 and floor reflected coefficient is 0.95) as shown in Fig. 1. A spherical source is placed in the double layer wooden box and a stainless steel pipe (diameter is 0.025m) is inserted in the front of it, so that sound wave can propagate along the pipeline. In this way, an acoustic beam can apply directly onto

the surface of the plate. It can be demonstrated that the acoustic insulation capacity of the double layer box is 40 to 50 dB. During the experiment, acoustic sensors are placed at the designed positions to measure the acoustic pressure. The distribution of acoustic pressure in the scattering field is obtained as the frequency is manipulated.

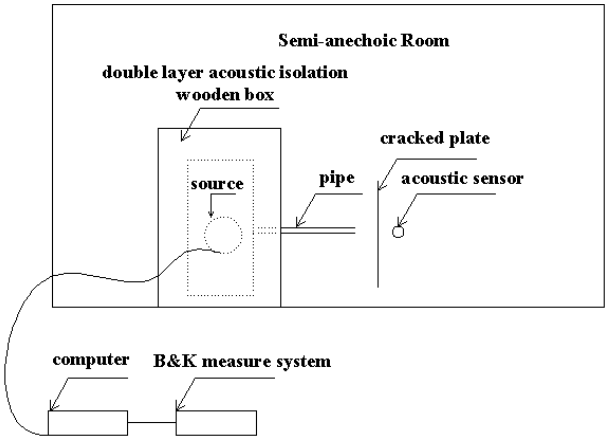


Fig.1 The equipment of experiment

3. ANALYSIS OF THE EXPERIMENTAL RESULTS

3.1 The Definition of the Insertion Loss

It is a hot topic to analyze the impact of baffle plate on sound insulation in infinite space. Skudrzy[3] (1971) definite the transmission loss as below:

$$TL = 10\log\left|\frac{1}{t_I}\right| = 20\log\left|\frac{p_i}{p_t}\right| \tag{1}$$

Where t_I is transmission coefficient, p_i is incident wave pressure, p_t is transmission pressure. From the definition above, the plate should be assumed as infinity, while it is unrealistic to obtain such an infinity dimension in this experiment. In addition, the baffle plate is not in a theoretical plane wave field. Therefore, formula (1) cannot be applied into this experiment. In this paper, we define the insertion loss (IL) as: the ratio of pressure received by sensor with the finite plate to that without the finite plate, so it can be written as:

$$IL = -20\log\left|\frac{p_a}{p_b}\right| \tag{2}$$

Where p_a is acoustic pressure with a finite plate, and p_b is acoustic pressure without a finite plate.

During the experiment, the distance between the finite plate and sensors is constant and the incident angle of the incident wave is 90^0. The distance between finite plate and acoustic source is 1cm, it is so near and the ratio of plate width and pipe diameter is 40 that we can ignore the acoustic diffraction.

3.2 Effect of Vertical Crack on IL

The vertical crack was simulated by E.D.M notches on the surface of a $0.5\times0.2\times0.004m$ aluminum sample. In Fig.2 the theoretical and experimental value are plotted together. The theoretical curve is calculated from Ref.[4]. It can be seen that good agreement between theoretical and experimental. Fig.4 shows the IL when a is 0.3m and b is 0.02m and 0.04 respectively and Fig.5 shows the IL when b is 0.4m and a is 0.3m and 0.22m, respectively.

It reveals that IL will decrease as the length of cracks increasing and the location of the crack also affects IL greatly. The closer cracks to acoustic source, the greater change of the insertion loss will be and it is easier to find the existence of the cracks.

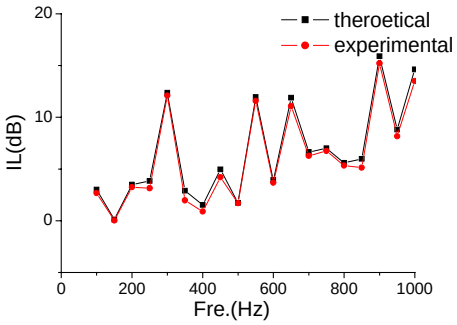


Fig.2 Comparison between theory and experiment

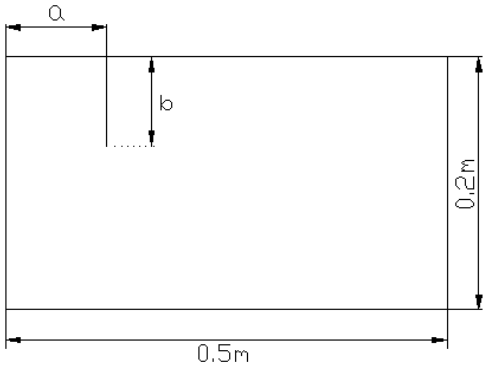


Fig.3 Vertical cracked of freedom thin Al plate

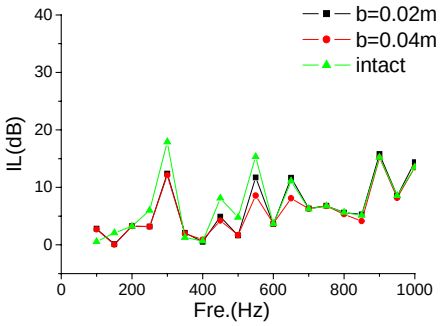


Fig.4 IL comparisons of different length between cracked and intact plate

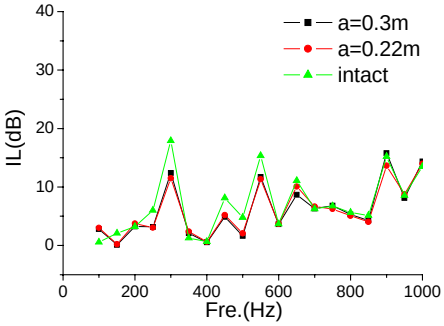


Fig.5 IL comparisons of different location between cracked and intact plate

3.3 Effect of Horizontal Crack on IL

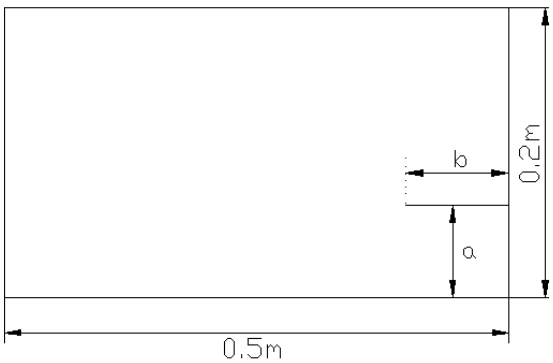


Fig.6 Marginal horizontal crack of freedom Al plate

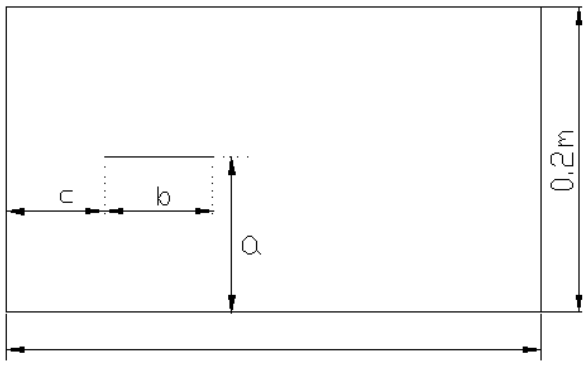


Fig.7 Horizontal crack in the middle of freedom Al plate

The horizontal crack was tested with the same method and with the same size of the cracks. Two different cracks are shown in Fig.6 and Fig.7. Fig.8 shows the IL comparisons of marginal horizontal crack and middle horizontal crack. It can be seen that the varying of IL is the same to vertical crack.

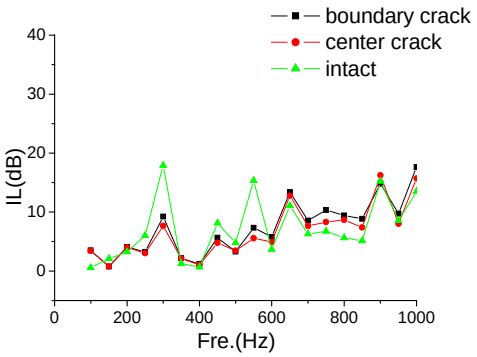


Fig.8 IL comparisons of marginal horizontal crack and middle horizontal crack

3.4 Effect of Surface Crack on IL

Plates with surface crack is common in modern structure engineering, the condition of a=0.016m, c=0.082m, b=0.004m and the depth being 0.002 is tested. The results are plotted in Fig.9. The results show that IL of the plate with penetrable cracks will be lower than that of surface cracks.

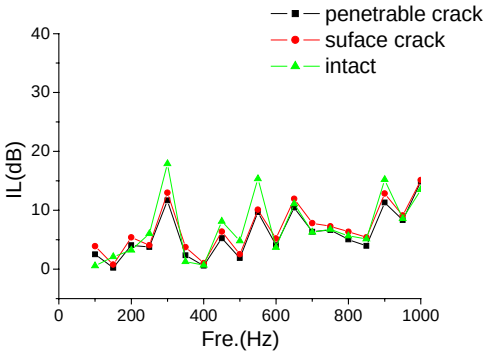
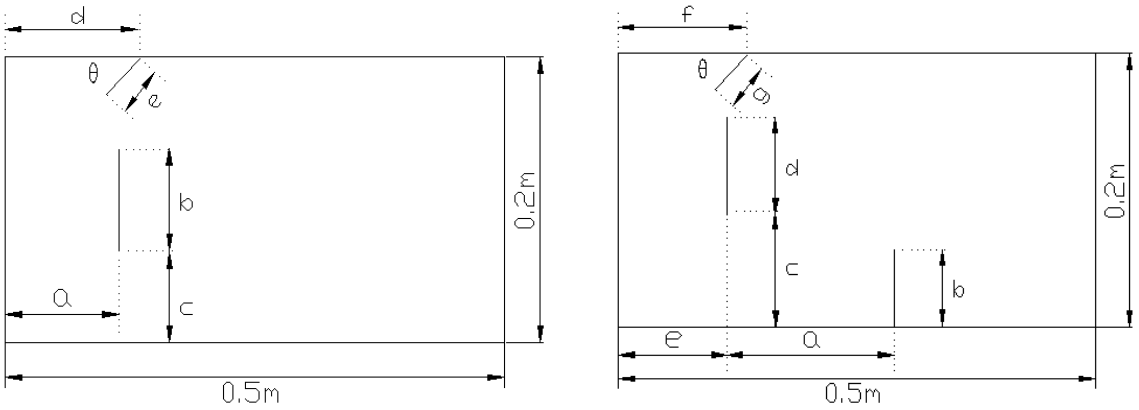


Fig.9 IL comparisons of surface crack and penetrable crack

3. 5 Effect of Multi-cracks on IL



a) 2 cracks damage plate b) 3 cracks damage plate

Fig.10 Multi-cracks damage in the freedom thin Al plate

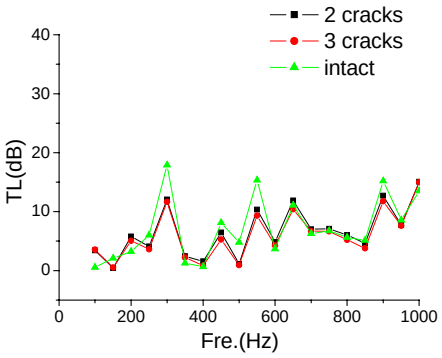


Fig.11 IL of Multi-cracks Al plate

In the experiment, multi-cracks are used for measurement. Fig.10 shows the position of the multi-cracks. The correspond two cracks damage plate parameters are: a=0.2m, b=0.04m, c=0..08m, d=0.3m， e=0.04m, $\theta = 60^0$, three cracks damage plate parameters are: a=0.1m, b=0.04m.,c=0.08m, d=0.04m， e=0.1m， f=0.3m， g=0.04. The results reveal that IL will decrease with the cracks increasing.

4. CONCLUSIONS

The performances of insertion loss with cracked freedom AL plate were tested using a acoustical experiment system in a well Semi-anechoic Room. The results show that insertion loss will decrease with the length, the depth and the number of cracks increasing. Insertion loss is an easy diagnose index for non-destructive detection.

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4. X.T. ZHU and R. Lyons, “ An impulse technique of measuring insertion loss of open Screens”, *ACTA ACUSTICA* **19**, 53-58 (1994).