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Research on improvement of defect detection accuracy by resonance judgment for noncontact acoustic inspection method

非接触音響探査法のための共振判定による欠陥検出精度の向上に関する研究

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1. Introduction

Currently, we are studying the defect detection of structures by noncontact acoustic inspection (NCAI) method using an acoustic excitation and laser Doppler vibrometer [1-2]. In the process, it has been confirmed that noise increases when the light reception of the laser beam is insufficient due to the surface condition of the object, and the estimation accuracy of the defect position deteriorates. Therefore, improvement of the detection accuracy of the defect position has been studied by discriminating the signal and noise due to the resonance of the defect part.

2. Defect detection using NCAI method

2.1 Problem with noise processing in NCAI method

In the NCAI method, the structure is excited by aerial emission sound wave, and vibration is measured using a scanning laser Doppler vibrometer. Figure 1 shows a schematic diagram of the NCAI method.

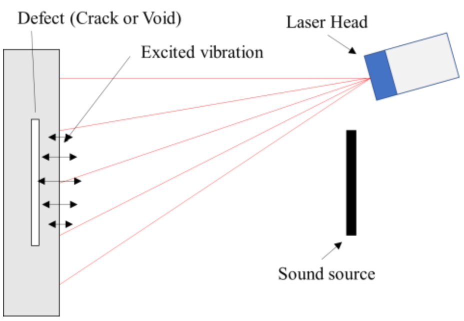

Fig.1. Schematic diagram of NCAI method.

After measurement, cut out the time zone that the measurement target is excited by sound waves in the time domain, and perform signal processing that leaves only the frequency band of the sound wave excited in the frequency domain with a filter (Time & Frequency gate). This process reduces the effects of disturbances generated during measurement.

However, the conventional processing method is affected by the noise when processing the noise having a large amplitude level caused by the poor reception of the laser. This is because the frequency band of the excited sound wave is left regardless of the presence or absence of resonance of the defect. Therefore, the procedure for applying the frequency filter was examined after determining whether or not the signal to be processed contains a periodic signal due to the resonance of the defect.

2.2 Processing method with resonance judgement

An evaluation method in which resonance judgement is added will be described. Figure 2 shows a conceptual diagram of resonance judgement.

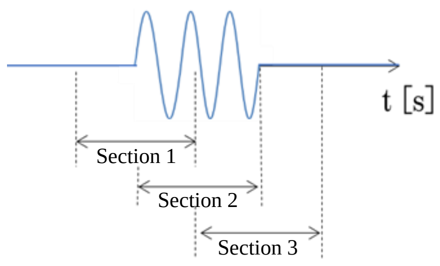

Fig.2. Conceptual diagram of resonance judgement.

As shown in Fig. 2, the time zone excited by sound wave is divided into three sections for processing. In the three sections, check for the presence or absence of a peak with the maximum amplitude within the frequency band of the excited sound wave. When the sound wave does not resonate, the probability that the peak of the maximum amplitude occurs in the frequency band decreases because the periodic signal is not included. In order to improve the accuracy of resonance peak detection, the autocorrelation function of the cut waveform is calculated to reduce the noise component, and then FFT is performed. Figure 3 shows the spectrum of the cut waveform with and without the periodic signal. In rare cases, noise that does not include a

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periodic signal may show a peak of maximum amplitude within the band of the emission frequency. Therefore, this processing method determines in a plurality of sections to prevent erroneous detection. Therefore, as shown in Fig. 3 (a), in all three sections, the process of leaving the components in the band is performed only when the peak of the maximum amplitude is confirmed inside the red line in the band of the emission frequency.

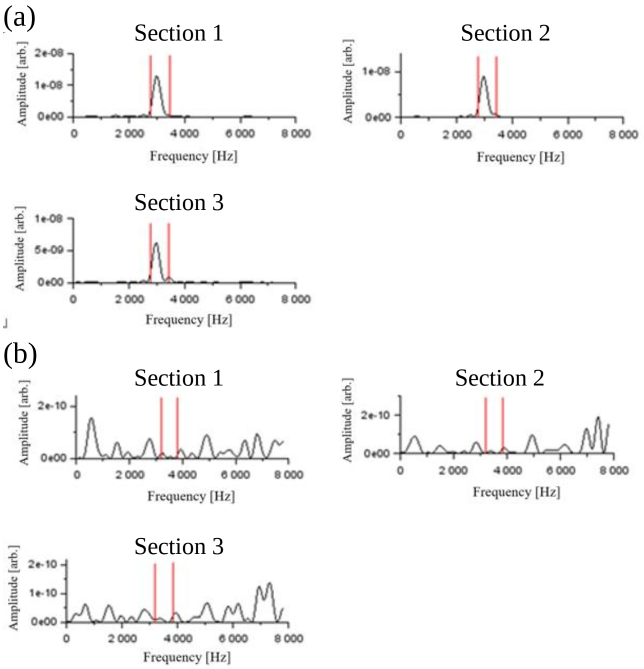

Fig.3. Vibration velocity spectrum
(a) Including periodic signal,
(b) No periodic signal.

3. Application example of processing with resonance judgement

As mentioned at the beginning, noise increases or decreases depending on the amount of light received by the laser due to the surface condition of the measurement target. Figure 4 shows the vibration velocity spectra of the measurement points with average noise level and high noise level. As shown in Fig. 4, it can be confirmed that the noise level is high in almost all frequency bands at the measurement points where the amount of light received by the laser is low. The resonance peaks around 640 Hz and 1500 Hz are the resonance peaks of the Galvano mirror of the laser head. Next, Fig. 5 shows the vibration energy with and without resonance judgment using the data of 5 measurement points with an average noise level and 2 measurement points with a high noise level. The calculation range of vibration energy is 500 Hz to 4100 Hz.

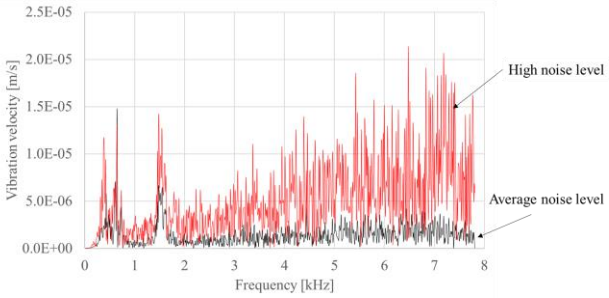

Fig.4. Vibration velocity spectrum.

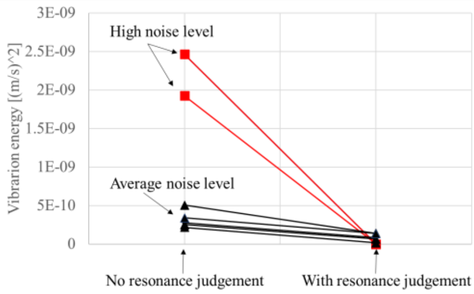

Fig.5. Difference in vibration energy before and after resonance judgment.

From Fig.5, it can be seen that the noise level affects the vibration energy in the case of the conventional Time & Frequency gate that does not use the resonance judgment. On the other hand, when the resonance judgment is used, the vibration energies of the measurement point having a high noise level and an average noise level have the same value. From this result, it can be expected that the vibration energy of the measurement point of the healthy part is less likely to become a high value by the resonance judgment. That is, it is thought that the healthy part and the defective part can be easily distinguished and the detection accuracy is improved.

4. Conclusion

This time, a method for improving the detection accuracy of the defect position using the resonance judgment by the emission frequency was studied. This method distinguishes between the noise and signal due to the resonance of the defective portion of the measured signal. As a result, it was confirmed that the calculation result of the vibration energy is less affected by the noise level by using the resonance judgement. We consider that the accuracy of defect detection will be improved by using this method.

Reference

1. R. Akamatsu, T. Sugimoto, N. Utagawa, and K. Katakura: Jpn. J. Appl. Phys. **52**, (2013) 07HC12.
2. K. Katakura, R. Akamatsu, T. Sugimoto, and N. Utagawa: Jpn. J. Appl. Phys. **53**, (2014) 07KC15.