inter·noise 96
25th Anniversary Congress – Liverpool

INCE: 38.3

NEW CONCEPT OF CLOSE FITTING ACOUSTICAL ENCLOSURE WITH ACTIVE VIBRATION CONTROL

M Kamata, T Yamada & T Yamazaki

Engineering Research Institute, Faculty of Engineering, The University of Tokyo, 2-11-16 Yayoi Bunkyo-ku, Tokyo 113, Japan

1. INTRODUCTION

Close-fitting acoustical enclosure[1] effectively reduces the machinery noise especially in high frequency range. In low frequencies, however, the reduction performance is degraded due to some reasons. In many cases, this is because of the acoustical resonances of the air-gap inside of the enclosure, or the structure-borne noise transmission due to mechanical connections between the machine and the enclosure plate. To solve this degradation problem, a new concept of the close-fitting technique with active control system is investigated.

In this paper, noise reduction mechanism of the close-fitting technique is first studied experimentally. Then, the effect of active control is examined. Finally, a hybrid close-fitting scheme, which has passive noise reduction in high frequency range and feedforward active control in low frequency range, is shown.

2. MECHANISM OF CLOSE-FITTING

· Experimental Apparatus

The experimental apparatus shown in Fig.1 is modeled as a part of the cylinder block of the diesel engine for trucks. Thicknesses of the vibration plate and the enclosure plate are 6mm and 1mm. Dimension of the vibration plate surface is 440×156mm. Both plates are clamped to the upper and the lower frames.

· Noise Reduction by Close-Fitting

The effect of the enclosure plate was first reconfirmed. Fig.2 shows the difference of sound radiation with/without the enclosure plate. In high frequency range, the radiated sound power is reduced more than 20dB by fitting the enclosure plate.

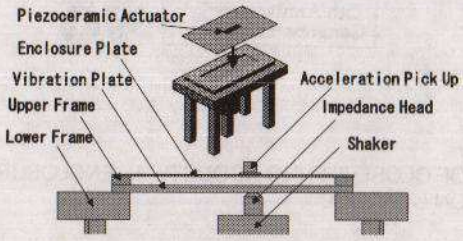

Fig.1 Schematic View of the Experimental Apparatus

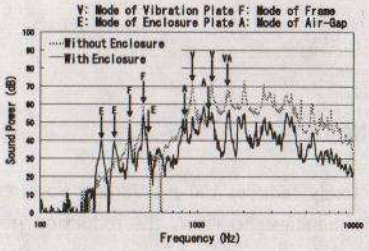

Fig.2 Sound Intensity with or without Enclosure

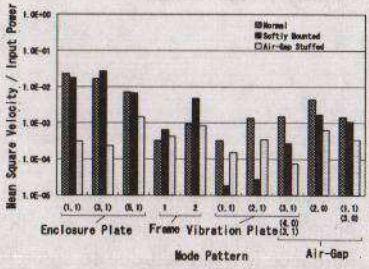

Fig.3 Effect of Structure/Air-Borne Sound Insulation

In low frequencies, however, there are some peaks which are absent without the enclosure plate. As the result of the modal analysis, it was revealed that these peaks are caused by the resonances of the enclosure plate. Further investigation made it clear that each peak of the sound power was due to the reasons shown in the figure.

· Mechanism of Phenomenon

The separation of the air-borne and the structure-borne sound was next attempted. Mean square velocity of the enclosure plate were obtained in three conditions; (1)normal, (2)softly mounted, and (3)air gap stuffed. The result shown in Fig.3 indicates the following things. At the enclosure plate modes, it can be found that the transmitted power becomes less when the air-borne sound is insulated. Thus, the power is transmitted mainly through the air-gap at these frequencies. On the other hand, at the vibration plate modes, the transmitted power becomes less when the structure-borne sound is insulated. Thus, the power is transmitted mainly through the mechanical connection at these frequencies. Generally, it can be said that the air-borne sound is dominant at the modal frequencies of the en-

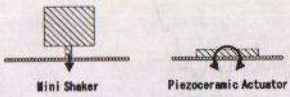

Fig.4 Force/Moment Input

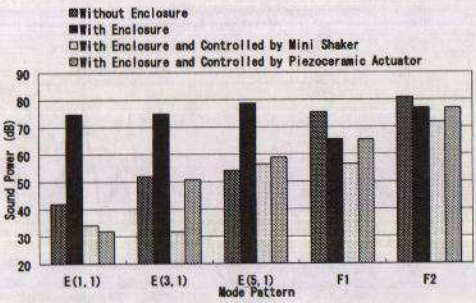

Fig.5 Active Control Possibility at Modal Frequency

closure plate or the air-gap and the structure-borne sound is dominant at that of the vibration plate or the frame.

3. APPLICATION OF ACTIVE VIBRATION CONTROL

Many research results have been reported on the active control of sound; especially reduction of sound pressure by secondary source[2], vibration control[3] for reduction of sound radiation, or sound transmission. However, whole suppression of 3D sound radiation is difficult, and the application of control force to high stiffness structure needs big power. Therefore, we tried the active vibration control of the close-fitting enclosure plate in order to reduce the resonances in low frequency range. Few researches have been reported on the active control applied to the close-fitting. The mini shaker or the piezoceramic element of 60×20×0.2mm dimension which was bonded to the center of the enclosure plate was used as an actuator. The mini shaker produces vertical force input and the piezoceramic actuator yields moment input to the enclosure plate as shown in Fig.4.

First, sinusoidal wave signal was used to ascertain the possibility of the active vibration control. The results are shown in Fig.5. 'E' represents the modes of the enclosure plate, while 'F' represents the modes of the frame. The resonances of the enclosure plate can be actively well controlled. The resonances of the frame is reduced by the 'passive' enclosure and controlled actively moreover. However, due to the lack of the enough power, the piezoceramic actuator cannot produce enough reduction of the sound of the frame modes.

Next, periodic random noise signal was used. A feedforward control system, in which the control signal is primarily calculated from the input signal, was used. In this case, the control signal was only calculated around 250Hz, 300Hz, and 480Hz which correspond to the modal frequencies (1,1), (3,1), and (5,1) of the enclosure

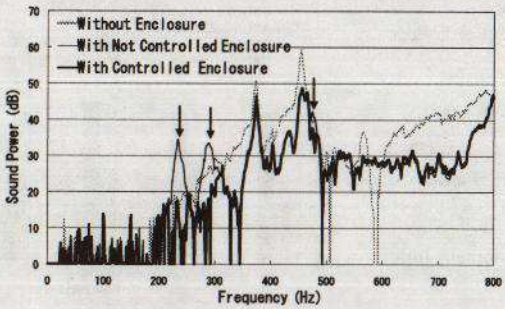

Fig.6 Effect of Active Vibration Control

plate. Thus no control action was activated except for these frequencies. Output clock frequency was 10.24kHz and data number was 10240. So, the period of the output was 1sec. The peaks caused by the resonances of the enclosure plate can be actively controlled as shown in Fig.6.

4. CONCLUSION

Conclusion of this study is summarized as follows.

- Mechanism of radiated sound reduction in close-fitting enclosure technique is investigated experimentally.
- Noise reduction of about 20dB is attained in high frequency range due to the transmission loss of the enclosure plate.
- In low frequency range, however, the insertion loss by the enclosure plate is small, in some frequencies negative.
- The negative IL, which is caused by the resonance of the enclosure plate, can be suppressed by application of active control.
- This hybrid close-fitting scheme (low freq.:active, high freq.:passive) makes it possible to obtain whole range noise reduction.

References

[1] K. P. Byrne, H. M. Fischer, and H. V. Fuchs Sealed, Noise Control Engineering Journal, Vol.31-1, July-August, 1988

[2] P.A.Nelson and S.J.Elliott, Active Control of Sound, Academic Press, 1992

[3] C.R.Fuller, S.J.Elliott and P.A.Nelson , Active Control of Vibration, Academic Press, 1996