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PERFORMANCE OF PANEL ABSORBER USED FOR DUCT NOISE REDUCTION AT LOW FREQUENCY

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1. INTRODUCTION

Low frequency noise breakout through duct walls of the ventilation system is a serious problem. This experiment is to investigate and analyze the noise reduction due to panel absorber by changing the parameters, such as face sheet thickness, fibre-glass thickness and cavity depth, for the sound absorption used in-duct and breakout noise reduction at low frequency. Recently, Guthrie[1] and Cummings[2] have been carried out on the sound transmission through rectangular duct wall at low frequency. The panel absorber can be used to reduce both in-duct noise and breakout noise in a ventilation duct due to the energy loss caused by the internal vibration of the face sheet. The range of effective sound absorption frequency band can be widened by selecting the thickness of face sheet, absorption material inside the cavity and changing the lateral dimensions. The panel absorber is considered as a coupled mechanical-acoustical system. It is found that the new design of duct with panel absorber is more effective than conventional fiberglass blanket.

2. EXPERIMENTAL METHOD

Tests were carried out between two reverberant rooms. The sound transmission loss (STL) measurements were made. The rooms are isolated from each other and a 1.8m long square duct opening of nominal dimensions of 0.33m x 0.33m is the only means of transferring airborne sound between the two rooms. The flanking transmission was reduced by a massive concrete block. An "anechoic" termination was incorporated to reduce the magnitude of reflected acoustic and structural waves. Not only it is acted as an effective acoustic absorber but also damped the wall vibrations progressively. The construction was shown in Fig. 1. Sound generating equipment for measurements included a Bruel & Kjaer random noise generator type 1027, connected via a power amplifier to loudspeaker placed in the corner of the source room. Random sound field was produced inside the source room. Sound measuring equipment comprised two half-inch microphone type 4155, the output of which was fed to a B&K digital frequency analyzer type 2144. The microphone inside the duct was used to measure the internal in-duct sound pressure level along the center axis, and the breakout sound pressure level was measured with use of the external microphone.

3. EXPERIMENTAL RESULTS

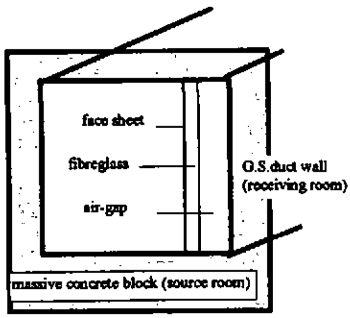
To compare noise breakout through the duct wall for different panel absorbers with different configurations, a total of nine specimens were built and tested in a ventilation duct. They were constructed of single layer face sheet and fiberglass, or fiberglass and air gap. The detail parameters and section of the duct were given in Table 1 and Fig. 1 respectively.

Table 1: Detail structural parameters of panel absorber

	Thickness(mm)			
No.	G.S.Facesheet	Fibreglass	Cavity Depth	Symbol
1	0.3	60	40	G.S(0.3,60,40)
2	0.3	60	0	G.S(0.3,60,0)
3	0.3	30	70	G.S(0.3,30,70)
4	0.3	30	25	G.S(0.3,30,25)
5	0.1	60	40	G.S.(0.1,60,40)
6	0.1	60	0	G.S(0.1,60,0)
7	0.1	30	70	G.S(0.1,30,70)
8	0.1	30	25	G.S(0.1,30,25)
9	Nil	50	0	N(0,50,0)

G.S. — galvanized steel N — no face sheet

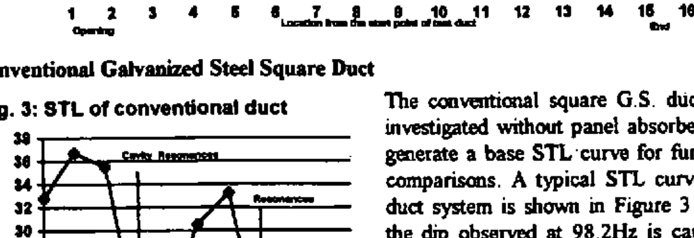
Fig. 1: Details of square section duct



In-Duct Noise Characteristics

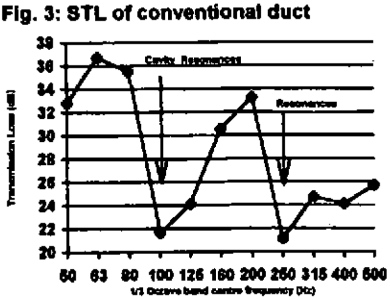
Fig. 2 shows some typical axial sound pressure patterns measured inside the duct. At low frequency of 100Hz, the standing wave ratio of G.S(0.3,30,70)is only 3dB. The reason of using 100 Hz is that it is the first acoustic resonances, however, it is rather difficult to attenuate in practice. Comparing to the conventional duct, G.S(0.3,30,70) has a 4dB in-duct noise attenuation at the end of the duct.

Fig.2: In-duct axial SPL at 100Hz



Conventional Galvanized Steel Square Duct

Fig. 3: STL of conventional duct



The conventional square G.S. duct is investigated without panel absorber to generate a base STL curve for further comparisons. A typical STL curve of duct system is shown in Figure 3 and the dip observed at 98.2Hz is caused by the axial acoustical resonances inside the conventional duct. Below 100Hz, it is the stiffness controlled region, the STL is relatively high. The reason for the other dip at .250Hz is identified by the acoustics resonances.

Panel Absorber

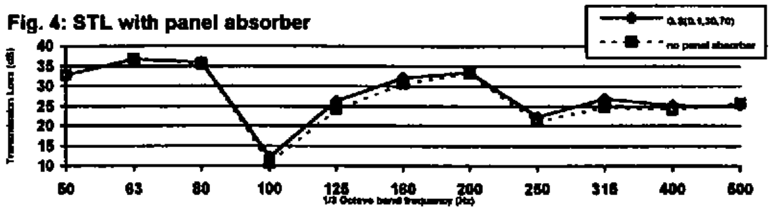


Fig. 4: STL with panel absorber

The result of conventional duct with panel absorber is plotted in Fig 4 together with the results of the conventional G.S. duct, it showed an improvement effectiveness of the panel absorber on the STL of the conventional G.S. duct over the whole frequency above 100Hz. Below the fundamental reasonance frequency, the wall impedances capactive, and is "stiffness controlled". G.S.(0.1,30,70) panel absorber tend to provide excellent sound absorption at low frequency. It bring in an increment of 1-3 dB for noise reduction at the region of 100-200Hz, that is more interesting for actual noise reduction application. As expected, the resonance frequencies of the duct are affected by the presence of panel absorber. The 70mm air-gap between the 30mm fibreglass and the duct wall, provide low frequency sound absorption. The mechanism of sound absorption is the resonant mass-spring behavior of the system which dissipates sound energy. The primary effect of fibreglass on the STL is the reduction in the amplitude of lateral standing waves in the cavity, thereby improving the STL above minor dip frequency.

Cavity Depth

Fig.5: STL with cavity depth

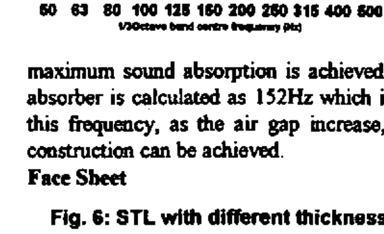


Fig. 5 indicates the typical effect of the absorptive material with different cavity depth in a G.S. face sheet. The transmission loss of G.S (0.3,60,0) is better than that of G.S(0.3,60,40) except 100Hz & 200Hz-500Hz. Between 100Hz-200Hz. the greater cavity depth will increase TL which is agree to the properties of panel absorber. The panel-controlled resonance of the G.S. face sheet is 98.6Hz(i.e. f(1,3)), however, the maximum sound absorption is achieved at the resonances frequency of the G.S panel absorber is calculated as 152Hz which is the features of panel absorber functionally at this frequency, as the air gap increase, the reduction improvement of sandwich duct construction can be achieved.

Face Sheet

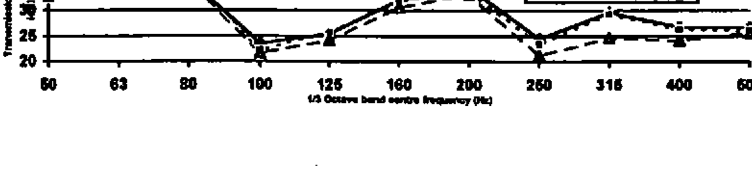


Fig. 6: STL with different thickness of G.S. facesheet

Fig. 6 illustrates the transmission loss for using 0.1mm G.S. face sheet is higher than that of 0.3mm G.S. face sheet at low frequency except 98.6 Hz due to the panel-controlled resonance frequency of the G.S. sheet. (i.e. f(1,3)=98.6Hz) where the fiberglass width and the cavity depth were kept constant. After the stiffness-controlled frequency range, the smaller the thickness of G.S.face sheet, the higher is the transmission loss at low frequency.

Thickness of Fibreglass

Fig. 7:STL with different fibreglass thickness

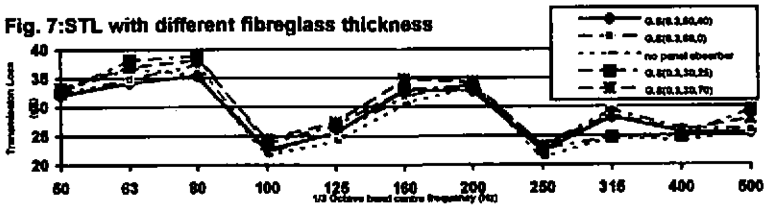


Fig. 7 also indicates that different fiberglass thickness with different cavity depth at the same total space, G.S(0.3,30,25) behaves the best acoustic performance between 0-100Hz. Between 200-500Hz, G.S(0.3,60,0) attain the highest transmission loss. Between 100-200Hz, the G.S(0.3,30,70) was better than the other two, it shows that the 30mm fibreglass with 70mm cavity depth at 0.3mm G.S. face sheet was the best configuration of the panel absorber in this low frequency range.

4. SUMMARY

This paper is in an attempt to illustrate the typical trends of panel absorbers in noise reduction. Key findings include:

- Low frequency sound transmission through finite duct depends not only upon the geometric and physical parameter characteristic of panel itself, but also upon the sound field, especially the acoustic resonant modes, inside the cavity. Panel absorber behaves its maximum absorption in a narrow frequency range (i.e. 100-200Hz).
- In 100-200Hz, there are some improvements in acoustic performance by using 30mm fibreglass with 70mm air-gap in 0.3mm G.S face sheets, especially the reduction in cavity resonance but there is no significant improvement by increasing the thickness of fiberglass filled in between face sheet and duct wall.
- Air-gap existed in between the fiberglass layer and duct wall increases significantly the sound absorption in a narrow-band frequency range (i.e. between the cavity-controlled mode and panel-controlled mode). Increasing the cavity depth will increase the STL at low frequency range after acoustic resonances. It is indicated that simultaneous optimization of the acoustic insulation is possible by an appropriate choice of fibreglass and facesheet thickness.

5. REFERENCES

[1] A.Guthrie 1979 MSc Dissertation, Polytechnic of the South Bank, Low frequency acoustic transmission through the walls of various types of ducts.

[2] A. Cummings. J. of Sound and Vibration 174, 433-450 (1994).