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A Modified Honeycomb Panel to Improve Sound Transmission Loss

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Abstract - Honeycomb panels are widely used in aviation and aerospace industry as well as in building industry because of the properties of lightweight and high bending stiffness. However, the sound transmission loss of the panel is often low since the coincident frequency of the panel usually lies below kHz. Previous results show that a single-faced honeycomb panel may acoustically perform much better, especially when it is combined with absorptive materials. This idea is further developed to overcome drawbacks. An improved concepts of honeycomb panel is presented, which keeps the basic properties of a honeycomb panel, while the coincident phenomenon in audible frequency is avoided. The theoretical consideration behind this design is discussed. The idea is then tested experimentally. The weighted apparent sound reduction index of the modified honeycomb panel is 4 dB higher than an ordinary honeycomb panel with similar thickness and similar surface density.

Keyword - Honeycomb panel, sound transmission loss, sandwich panel

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INTRODUCTION

It is very difficult to increase the sound transmission loss of lightweight panels at, low and middle frequencies due to the light weight and less damping. Some work has been Carried out to improve the sound transmission loss of lightweight panels by increasing the thickness of panels and number of stiffeners [1, 2] but very few applications are available. NOMEX paper honeycomb sandwich panels are used because of their lighter weight than aluminium, high strength to mass ratio and improved acoustic, performance at and below resonance frequencies. The approach taken in this paper is to attach the honeycomb sandwich structure directly to the interior side of skin sub-panels by using high strength epoxy (glue).

Honeycomb panels are widely used in aviation and aerospace industry as well as in building industry because of the properties of lightweight and high bending stiffness. However, from acoustic point of view, a honeycomb panel is not a good design, since the high bending stiffness makes the coincident frequency drops in the most sensible frequency region of human ear. Besides, since the bending stiffness of a honeycomb panel is dependent on frequency, instead of one coincident frequency there is an extended coincidence [3], which may make the situation even worse. The sound transmission loss of the panel is often much lower than an isotropic panel with the same surface density because of this coincident phenomenon. Previous results [4, 5] have shown that a single-faced honeycomb panel may acoustically perform much better and meanwhile keep the high static stiffness, especially when it is combined with absorptive materials. The problem of the single-faced honeycomb panel is that the core is easy to be destroyed and hence is difficult to be directly used in practical structures.

Honeycomb panel is a type of sandwich panel. Similar as other sandwich panels, the apparent bending stiffness of a honeycomb panel decreases' when the frequency increases [6]. When the frequency is even increased, the two laminates will vibrate independently and the honeycomb panel as a whole can not be treated by equivalent bending stiffness anymore.

In practice, only the static bending stiffness of a sandwich panel is important for safety and stability requirements. Dynamic bending stiffness, however, can be much lower. This gives us a possibility to increase sound transmission loss of a honeycomb panel: to reduce the apparent dynamic bending stiffness even more and hence to push the coincident frequency to high end to avoid sensible frequencies of human ear. This is the concept behind the design of the single-faced honeycomb panel. Another possibility is to design such a panel that when it is around the coincident frequency of the corresponding honeycomb panel, the two laminates have already started to vibrate separately and hence there will be no coincident phenomenon of the whole system all. This is what we are going to discuss in this paper.

MODIFIED HONEYCOMB PANEL

In order to improve the acoustic performance of a honeycomb panel, we have to avoid two types of resonance: coincidence of the whole structure, and the double-wall resonance of the two laminates. Is it possible to avoid both phenomena in the frequency region of interest by changing bonding technique? The idea is that instead of bonded the facing in the whole surface, we try to use glue only in a certain mesh. The laminate thus acoustically works like a ribbed panel, with the ribs at the positions of the glued mesh. Statically, the areas between meshes are still supported by the honeycomb core, which ensures the whole system still keeping roughly the same static strength. At low frequencies, the wavelength of the bending wave in facing material is much longer than the size of the mesh, and the whole structure vibrates together and shows the behaviour same as an ordinary honeycomb panel. At higher frequencies, the laminates start to act separately. When the frequency is higher than the first resonant frequency of the sub-laminates (clamped laminate with the size equal to the size of the mesh), the laminates vibrate totally separately and the two laminates are decoupled. The Whole system may act like a double wall with many bridges in this frequency region. If we design the mesh in such a way that near the double wall resonance of the system, the system behaves mainly like a honeycomb panel, so that we may avoid the double wall resonance of the two laminates. The size of the mesh should also be big enough that the first resonant frequency of the sub-laminate is much lower than the coincident frequency of the corresponding honeycomb panel. Hence near the coincident frequencies of the corresponding honeycomb panel, the two laminates do not work together. The possible coincidence may also be avoided, The sound transmission loss of the modified honeycomb panel in that case may reach the value of an isotropic panel with the same surface mass.

For the system concerned (24 mm resin impregnated paper honeycomb core with 2 mm FRP sheet at each side), the double wall resonance is estimated to be about 512 Hz. From earlier measurements of similar panel, the coincident frequency of the corresponding honeycomb panel can also be estimated to be around 1.2 kHz-1.6 kHz. Hence, if the first resonant frequency of the sub-laminate is around 1 kHz, the system may fulfil the requirement mentioned above. A simple calculation shows that in that case, the distance of the mesh should be around 70 mm. The width of the glue is chosen to be 10 mm, The final design of the modified Nomex paper honeycomb panel is illustrated in Figure 1.

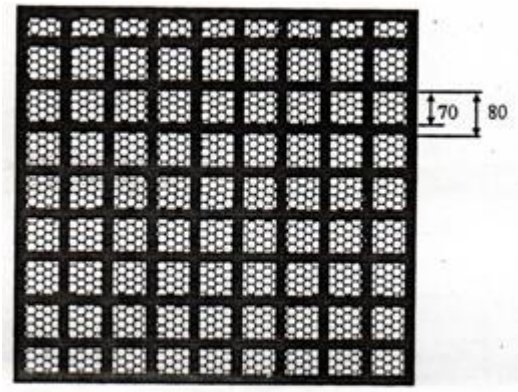

Figure 1: Illustration of the mesh of bonded area shows design of modified honeycomb panel

The sound reduction index will also show a drop at the first resonant frequency of the sub-panel of a ribbed plate [7]. In order to smear out this drop, uneven mesh may achieve better results. For the panel used, since it is manufactured in the-laboratory, the positions and width of the glue lines are not accurate. This fact may help to reduce the possible drop's sound transmission loss near the first resonant frequency of the sub-panel.

EXPERIMENTAL DETAILS

All TL measurements were carried out by installing the specimens in the specimen frame of nominal size 0.94 m x 0.64 m between the two reverberation rooms at the Acoustics Section, National, Physical Laboratory (NPL), Both the source room and receiving room in the laboratory are irregular in shape with volumes of approximately 257 and 271 m3 and are equipped with stationary diffusers.

Equipment included a steady sound source of white noise was produced from noise generator, the noise signal was then fed into and enhanced by a power amplifier, and finally emitted through a loudspeaker to produce a reverberant sound (diffused) field inside the source room. Sound pressure levels inside the two rooms were sampled by means of two sets of 1/2 inch calibrated microphones type 1220 each coupled with a microphone pre-amplifier type 1201 and fed to a Norwegian Electronics type 830 dual channel real-time analyzer (RTA - 830) for 1/3 octave band spectrum analysis. Tests were conducted in accordance with the requirement of ASTM E90-1990, and of ISO 140/3 1978 (E) in the one-third-octave bands from 100 Hz to 5 kHz. The TL was calculated by the well-known equation:

$$TL = L_{p1} - L_{p2} + 10 \log_{10} (S/A),$$

Where L_{p1}, L_{p2} , S and A are average source room and average receiving room sound pressure levels, specimen area and receiving room equivalent absorption area, respectively.

The sound reduction indexes of an ordinary honeycomb panel and the modified honeycomb panel are compared. The descriptions of the samples are listed in Table 1.

Table 1: Description of compared samples

Test sample	Description	Thickness	Surface density
Standard honeycomb panel	2 *mm* FRP Sheet bonded to each side of an 24 *mm* Nomex paper honeycomb core	28 *mm*	6.2 kg/m^2
Modified. honeycomb panel	2 *mm* FRP Sheet bonded, at meshes, to each side of 24 *mm* Nomex paper honeycomb core. Distance between meshes: 70 *mm*, and glue width: 10 *mm*, see Figure 2	29 *mm*	6.2 kg/m^2

Both test samples are of different thickness and same surface density. The standard honeycomb panel is manufactured by industry while the modified one is prepared in the laboratory by using existing materials. That explains why the thickness of the 'modified panel is different from the compared standard honeycomb panel. This may introduce some system error in comparison at low frequencies.

Figure 2 shows the comparison of sound reduction index of an ordinary honeycomb panel and the modified one. The two panels have same surface density (6.2 kg/m^2). As a reference, field mass law for a corresponding isotropic panel is also illustrated in the same figure. As we expected, there is neither drop in frequency of possible double wall resonance nor in coincident frequency. The property of the modified, honeycomb panel is, close to an isotropic one. The weighted apparent sound reduction index Rw (ISO 717-1: 1996) for the modified honeycomb panel is 25 while for the ordinary honeycomb is 21.

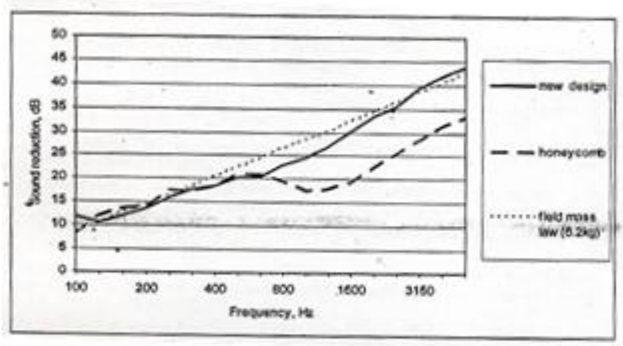

Figure 2: Comparison of sound reduction index of modified and ordinary honeycomb panel

CONCLUSIONS

Sound reduction index of an ordinary honeycomb panel can be improved by changing bonding techniques. From acoustic point of view, laminates are should be designed in such a way that the first resonant frequency of the sub-laminate (laminate clamped at the mesh) is higher than the double wall resonance of the system, and is lower than the coincident frequency of the corresponding ordinary honeycomb panel.

The design principle can also be applied to any other types of sandwich panels. For some core materials there might be a problem of the core being eaten up when there is a relative motion between core and laminates.

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REFERENCES

[1] L.R. Koval, "Effect of stiffening on sound transmission in a cylindrical shell in flight", *American Institute of Aeronautic and Astronautics Journal,* **15,** 899-900 (1977).

[2] R. Vaicaitis and M. Slazak, "Noise transmission through stiffened panels", *J Sound Vib,* 70(3), 413-426 (1980).

[3] A.C. Nilsson, "Wave propagation in and sound transmission through sandwich panel", *J. Sound Vib.* 138, 73-94 (1990).

[4] L. Feng and A. Nilsson, "A new design of lightweight panel to improve both static strength and sound insulation", *Inter-noise,* Nice, France, paper 149 (2000).

[5] H. Wen-clbao and C.F. Ng, "Sound insulation improvement using honeycomb

sandwich panels", *J. Sound Vib.* 53(1-3), 163-177 (1998).

[6] E. Nilsson and A.C. Nilsson, "Prediction and measurement of some dynamic properties of sandwich structures with honeycomb and foam cores", *J. Sound Vib.* 251(3), 409-430 (2002).

[7] L.L. Beranek (editor), *Noise and Vibration Control* (Institute of Noise Control Engineering), 316-317 (1988).

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