On The Mechanical Behavior Of Vacuum Applied Surface Treatments

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1. INTRODUCTION

Surface treatments are sometimes used to reduce the amplitudes of vibration in large, shell-type structures (Nashif et al., 1985). The pads normally consist of a viscoelastic layer that may or may not be laminated with a thin constraining plate. When the pads are bonded onto the structure, additional damping is provided either through extensional (unconstrained) or shear dissipation (constrained pads) within the viscoelastic layer.

Viscoelastic damping pads are also used as a noise control element, owing to their ability for reducing transverse vibrations. However, in some applications such as aircraft skin assembly, adhesive bonded pads obviously may not be used. In these cases, a vacuum applied damping treatment can be used. It is bonded temporarily, and is removed once the skins are fastened, leaving no vestige on the aircraft.

Vacuum applied damping pads (VA pads) where shown to be quite efficient in reducing impact noises. However, when compared with traditional adhesive bonded pads, a major difference in the acoustic pressure time signal was observed, but was only partly explained (Ross, Amram, Ostiguy, 2001). In this paper, vibration measurements provide additional insight on the matter.

2. EXPERIMENTAL SETUP

Experiments were performed on a simply supported, rectangular aluminum plate. A steel, ball-ended hammer was used to strike the 0,9m x 0,6m x 4,8mm plate at its center point. VA pads were placed symmetrically at 25mm on either sides of the impact point.

One particular configuration was used as an extreme experimental case. In this configuration, the VA pads consisted of the single constraining layer. It was meant to show the effects of added mass and rigidity on the plate, without any viscoelastic damping. The two 1,5mm thick aluminum pads added an extra 31% to the thickness of the plate. A small degree of damping was possible through dry friction on the interface, as the pads were vacuum applied onto the plate.

3. NOISE MEASUREMENTS

During the impacts, the acoustic pressure was sampled at various points on a plane grid positioned 50mm from the surface of the plate. Figure 1 shows the data obtained at a measurement point located close to the impact axis (normal to the plate, passing through the impact point).

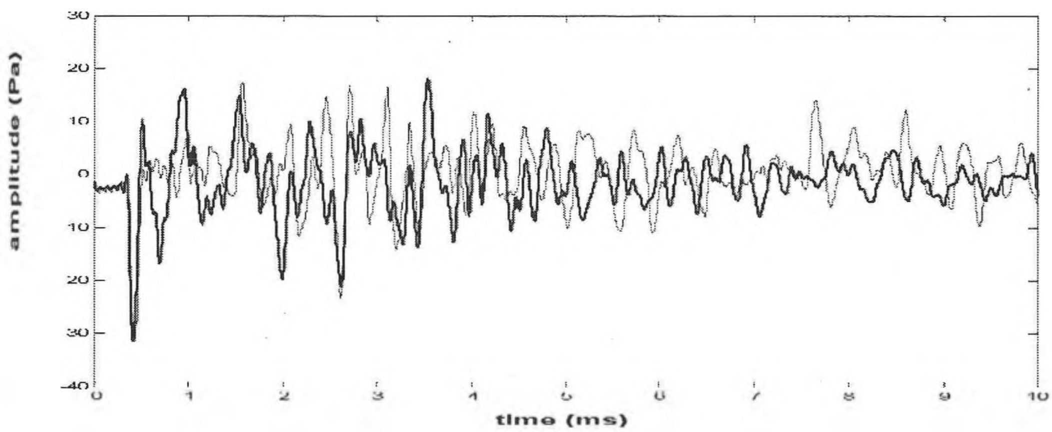

Fig. 1. Acoustic pressure along the impact axis (light: bare plate; dark: with VA pads).

The thin curve is the acoustic pressure due to the impacts on the bare plate (no pads). The acceleration peak is easily identified, and is followed by a "quiet" period before the ringing noise is established.

The thick curve is the acoustic pressure obtained when the VA pads were applied. These VA pads did not have a viscoelastic layer. The acceleration peak is similar to that of the bare plate. However, a large amplitude oscillation immediately follows this first peak and amplifies the radiated noise. This oscillation was previously thought to be the result of a local vibration of the plate between the two VA pads (Ross, Ostiguy, Amram, 2001).

4. VIBRATION MEASUREMENTS

Recent experimental work led to a better understanding of the phenomenon. Lightweight accelerometers were positioned at various locations on the system. Transverse vibrations of the plate were compared, with and without the VA pads. Figure 2 shows the transverse acceleration of the plate, measured at 50mm from the impact point. When the VA pads were used, the acceleration was measured both on the plate (back side) and on the pad (front side), at the same location as above.

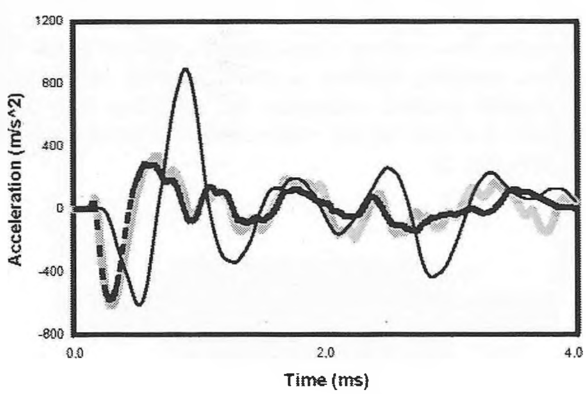

Fig. 2. Transverse acceleration of the plate at 50mm from the impact point (gray: bare plate; - - -: plate with VA pads; : VA pad).

It can be seen that for nearly 2ms, there are insignificant changes in the behavior of the plate, when the VA pads are applied. Changes that do occur seem to affect relatively high frequencies only.

The VA pad itself, however, does not seem to follow the movement of the plate. Its transverse acceleration signal shows that a very large oscillation exists at many but not all locations on the surface of the pad. It seems that the vacuum interface allows a certain amount of freedom to the VA pads, and some regions may temporarily separate from the plate (or may not be in contact at all). This may also hold true for the viscoelastic VA pads, with a lesser degree since these ones are much heavier and more rigid than the constraining layer alone.

The vibration of the VA pads — and not that of the plate — seems to be the cause of the amplified acoustic pressure in the near field of the impacted plate. The VA pads therefore act as a second noise source, in addition to the plate.

5. CONCLUSIONS

It was shown, through experimental analysis, that the transverse acceleration of vacuum applied pads is partly independent of the motion of the impacted plate. In the future, a finite element analysis of the system should yield a complete view and better understanding of the motion of the pads. The use of Nearfield Acoustical Holography on such data would confirm the effect of this vibration on the sound pressure field. Observations and analysis should be performed on viscoelastic VA pads, in order to detect any similar behavior.

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AUTHORS NOTE

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