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STONE CUTTING SAW NOISE: CONTROL USING THE WATER SUPPLY

S. Shaw (1) and N.A. Halliwell (2)

(1) Fraunhofer-Institut für Bauphysik, Königstrasse 74, D-7000 Stuttgart 70, W. Germany.
(2) Institute of Sound and Vibration Research, The University, Southampton, England.

INTRODUCTION

Noise produced by stone cutting circular saws in general exceeds an L_{eq} of 90 dB(A) in the operator's position and as such presents a serious risk of hearing damage. The circular blade is impregnated with diamonds around its periphery and a rotary grinding action excites blade and workpiece into vibration. This vibrational energy is distributed throughout the machine which then radiates a small portion acoustically. It is usual to find that a dominant noise source is the blade itself, although for smaller machines the saw frame noise itself can be significant. To date, noise control treatment of choice is to dampen the blade (usually by constrained layer damping) but for many saws the blade is discarded when the diamonds become worn and this precludes the use of damped blades for economic reasons. To solve this problem, a method of applying damping 'externally' has been developed which utilizes the water supply to the saw. The latter is a standard fitting on industrial machines to cool the blade and damp down the dust during cutting. A full report which tests the feasibility of this idea and compares and contrasts results with more traditional means of applying damping can be found in reference [1].

NOISE GENERATION MECHANISMS

In order to identify noise generation mechanisms and decide on noise control measures at source it is useful to consider a breakdown of the total acoustic energy (E_{rad}) at a frequency (f) radiated in a small bandwidth Δf. This is given by [2]

$$10 \log E_{rad} = 10 \log E_{vib}(f, \Delta f) + 10 \log A\sigma_{rad} - 10 \log f - 10 \log \eta_s - 10 \log d + \text{Const.} \qquad (1)$$

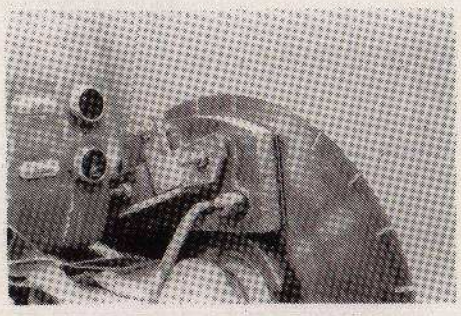


Plate 1.

where E_{vib} = spectral distribution of vibratory energy; $A\sigma_{rad}$ = A-weighted radiation efficiency of structure; η_s = damping or loss factor; d = average structural thickness.

Confining attention to the blade itself, the variation of cutting depth, feed rate and depth of penetration have all been shown [3] to change the level of sound produced. This can be attributed to a modification of the exciting forces which in turn affect the spectral distribution of the vibratory energy (E_{vib}). Radiation efficiency of the saw blade is unity above the coincidence frequency which, for 3 mm thick steel plate, is typically ($\hat{=}$ 6 kHz). Below this frequency the blade may radiate from its edges and this effect is significant at natural frequencies of the latter where vibrational amplitudes are high. It is clear from equation (1) that whenever the loss factor is low (steel $\approx 10^{-4}$), a significant reduction in acoustic energy output is achieved if this factor can be increased.

THE NOISE CONTROL PAD

This consists of a metal pad with a perforated face plate which is mounted flush with the blade surface allowing for a small gap between the two. Water from the saw is supplied to the pad to provide a viscous layer between the latter and the blade surface during rotation. The pad design was tested on a small portable 'tile' saw and is shown mounted in position in plate 1. The optimum position on the blade surface was chosen from vibration velocity levels measured whilst the blade was actually cutting. This was achieved using a laser vibrometer [4] and contours of velocity levels in m/s r.m.s. are shown in fig. 1. The optimum position corresponded to an area opposite the cutting edge.

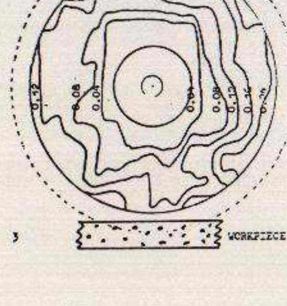
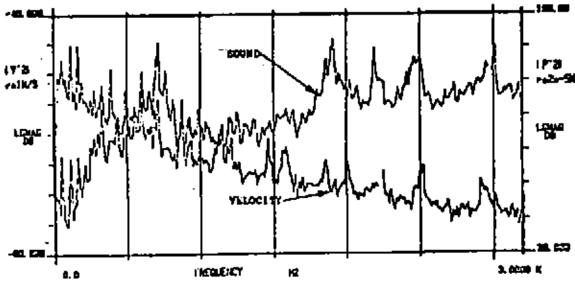


Fig. 1

Fig. 2



RESULTS AND DISCUSSION

In order to identify primary sound sources on the saw mineral wool and lead were used to clad the frame, motor and drive unit. Results showed that the frame was the major sound source (as pointed out earlier for small saws) and the total SPL for the uncladded machine cutting granite was 103 dB(A). Cladding the frame reduced the overall level to 99 dB(A) from which it can be deduced that if the blade were completely shrouded, the overall SPL would be 100.7 dB(A). Granite was cut during all the tests and a comparison made between a workpiece having one hundredth the area of another but no significant difference in overall SPL could be produced. It should be noted, however, that sound radiation from workpieces of several square metres may contribute significantly in industrial applications. A comparison of sound spectra and velocity spectra taken with the laser are shown in fig. 2. This figure shows the correspondence between peaks in the two spectra although there are fewer significant peaks in the sound spectra as not all modes radiate efficiently. The 'twinned' peaks in the velocity spectra suggest the presence of 'spinning modes' previously only inferred from measured static modes as described by Bies [5].

With water supplied to the pad, various pad-blade separations of typically 0.1 mm were tested. The maximum reduction of 12 dB(A) occurred for a separation of 0.2 mm (0.008") and fig. 3 shows the octave band spectra of this result. The SPL reduction increased with frequency for all cases, which is typical when the primary mechanism is viscous damping and the latter is achieved as water is forced to and fro in the narrow gap between pad and blade. It would be expected that the amount of dissipation achieved would critically depend on the pad-blade separation for a fixed water pressure supplied to the pad.

From the sound reduction achieved it is clear that the pad severely affects the energy flow to the saw frame via the blade axle. The level of 91 dB(A) is 8 dB(A) below that radiated by the frame alone when the pad is not present. An experiment with a spring mounted pad [1] which effectively 'lifted off' the blade and self-aligned, did demonstrate slight coupling and energy transfer between pad and blade. This was very small, however, and occurred at low frequencies as water was effectively 'trapped' in the narrow gap.

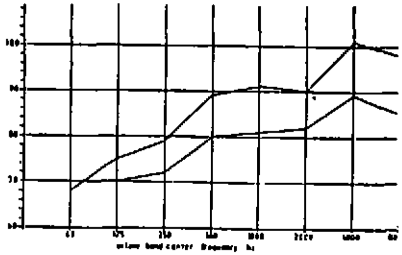


Fig. 3

CONCLUSIONS

The Noise Control Pad is simple to construct and a viable alternative to other means of increasing saw blade damping. It will be of particular use in the stone industry where saw blades are discarded once they have become worn.

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