NOISE REDUCTION DURING ROCK DRILLING

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INTRODUCTION

The very high levels of noise which exist in mines throughout the world is currently an area of considerable concern and subject to much pending and increasingly enforced legislation. Some of the highest noise levels to which miners are continually exposed are those produced during percussive rock drillin used extensively for tunnelling and ore removal. Although hydraulics are starti to move into this field still the most commonly used tool is the pneumatic hamme drill. These are used either handheld on an air leg or mounted on a fixed frame or mobile boom.

Pneumatic rock drills typically produce noise levels in excess of 115 dBA at 1m the primary source being the exhaust air. Other major noise sources are radiation from the vibrating drill rod ~110 dBA at 1m and mechanical impacts within the body of the drill ~ 95 →105 dBA.

Exhaust noise can be reduced by the use of a suitable silencer. Mechanical nois is related to hard metal to metal impacts as is found with many industrial machi When attempting noise control it is useful to consider a breakdown of the radiated sound energy as given by the energy accountancy equation[1].

$$L_{eq}(A)(\text{at frequency } f) = 10\log(E_{vib}) + (\text{spectral distribution})$$

$10\log(E_{vib})$: total escape energy into structure

$$+ 10\log A\frac{\sigma_{rad}}{f} - 10\log\eta_s - 10\log d + C$$

$10\log A\frac{\sigma_{rad}}{f}$: A weighted & frequency sensitive joint radiation and damping efficiency

$10\log\eta_s$: damping

$10\log d$: structure bulkiness

C: constant

The various terms represent separable variable parameters which can be considered in turn when attempting noise control. In practice it would seem that little can be done to alter structure bulkiness or radiation efficiency and the main terms for consideration are input energy and damping. Changing input energy does not imply reducing the working energy of the drill it means softening ancillary impacts and possibly smoothing very rapid changes associated with the piston/rod impact. Additive damping can be very effective on a structure or component which is initially lightly damped as in the case of the drill rod.

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NOISE SOURCES AND CONSIDERATION FOR REDUCTION

(1) Exhaust Noise

In order that the working efficiency of the drill is not substantially impaired any exhaust silencer fitted to a pneumatic drill must impart minimal back pressure. Thus a silencer must permit a free flow to the high volume of exhaust air and have no tendency to ice up. Icing up can be a severe problem in the damp conditions found in many mines leading very quickly to drastically reduced drill performance.

Building a silencer in the form of a circular duct with absorptive lining around the drill(2) has been shown to offer a possible solution. The duct also serving to enclose and insulate drill body radiated noise. Ice build up is inhibited by directing the exhaust ports onto a resilient surface in the form of a silicone rubber pad.

(2) Mechanical Noise Produced within the drill and from the support structure

Hard metal to metal impacts are the cause of mechanical noise. Identifiable impact sources(3) within the drill are piston/drill body impacts on return stroke and impacts within the valve mechanism. The boom or framework on which a drill may be mounted provides increased surface area amplifying noise radiation. Also because of poor fits these are also further sources of impact noise due to rattling between the drill and slideways and within the feed mechanism. Possible solutions are to ensure good fits and limited piston movements and the use of resilient materials to isolate vibrations and soften impacts.

(3) Drill Rod Noise

The drill rod which is essentially a large cold chisel transmits the impact energy from the piston to the rock in the form of a longitudinal stress pulse. A bit fitted to the end of the rock transfers this energy to break the rock. The rod is turned so that the bit presents a new face to the rock at each blow. Rock chippings are removed by water fed to the bit via a hole down the centre of the rod.

This longitudinal stress wave can only radiate sound along the length of the rod by Poissons ratio effects but also excited, inevitably because of the geometry of the rod and because of unsquare impacts, are transverse (bending) waves. Transverse waves are much more efficient at radiating sound and dominate in the production of noise from the rods. Fig 1 shows the noise radiation spectrum from a drill rod during drilling. Many peaks corresponding to the transverse modes of the rod are evident. Noise radiation from the longitudinal modes can also be identified reflecting the high energy these waves carry. The modal density of longitudinal waves is much less However and thus less total energy is contributed to the radiated sound.

Three basic methods are available to reduce noise from the rods (i) reduce or modify the input energy (ii) shroud or enclose the airborne sound (iii) damp the vibrations of the rod. Apart from the degratory step of reducing blow rate or working energy, energy input into the flexural waves can be minimised by maintaining good piston/rod alignment to ensure square impacts. Secondary chuck collar impacts occur as the rod returns to the drill after impact. These can be reduced by the use of resilient inserts or rubber collars on the rods.

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Shrouds may be placed around the rod to reduce the transmission of airborne sound. These can be mounted to the rod or on the drill but dimensions are very restricted if the tube is to enter the hole and still leave enough clearance for chip removal. A shroud tube for circular rods is suggested in Ref 2 which incorporates a steel outer tube with a high density polymeric inner tube spaced on a layer of absorbent material.

As the standard drill rod is only lightly damped, the main damping eminating from friction within the chuck area and from the rock, any additive damping will lead directly to noise reductions as indicated in Equation 1. It is undesirable, however, to instill a too high level of damping as this will dissipate the working energy from the longitudinal stress wave within the rod and drilling efficiency will be lost. Damping treatments are more effective on the flexural noise producing vibrations and treatments providing 4 to 6 dBA noise reduction have been developed without any substantial loss of drilling performance. The noise levels measured during drilling with a damped rod and silenced drill are shown in Fig 2.

CONCLUSIONS

Reducing rock drilling noise requires attention to the three main components of the drilling string; the drill, its mounting or boom and the drill rod. In order to withstand the rigorous conditions of mining and be acceptable and maintained by the miners any silencing treatments must be robust, durable and have minimal effect on drilling operation and efficiency.

Using a silenced pneumatic or a hydraulic drill, with vibration isolation and a damped or shrouded drill rod noise levels can be reduced from the present 115 dBA at 1m to below 100 dBA.

Drill rod damping treatments developed by the Institute have proved to be effective at reducing noise and robust enough to withstand the rigours of test drilling. Tests of the long term durability and efficiency of these treatments are currently being carried out.

REFERENCES

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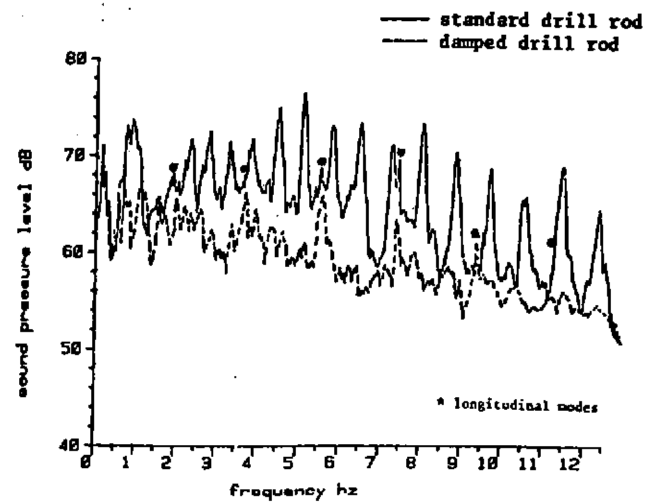

FIGURE 1: Sound pressure level spectra for drilling with standard and damped drill rods

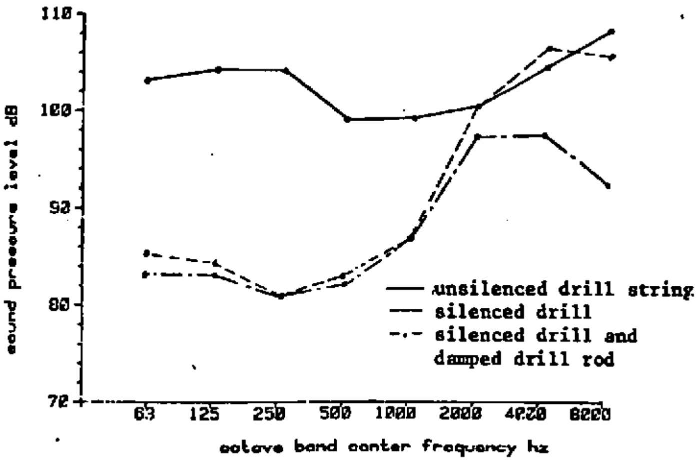

FIGURE 2: Octave band spectra of the noise from a standard and silenced drill string