Noise Abatement for Circular Saws

OCCUPATIONAL SAFETY & HEALTH SERVICE

DEPARTMENT OF LABOUR
TE TARI MAHI

Published by the Occupational Safety & Health Service,
Department of Labour,
Wellington, New Zealand

This booklet was compiled with the
assistance of Acousafe
Consulting & Engineering Ltd.
Illustrations by Geoff Hargreaves
and Tony Parker,
Works Design Group.

First Edition:1989

ISBN O-477-03455-1

PDF file for web site created October 1999

Contents

Illustrations

Introduction

Circular saws are widely used throughout industry— in fact they would be strong contenders as the. single most common item of mechanical industrial equipment.

Noise levels generated by circular saws in operation have been reported to vary from 80dB(A) up to 120dB(A).

Not only can the cutting noise be extreme, there is also the additional factor that, even when idling, circular saws can produce noise levels up to 95dB(A). A further contribution to noise, when sawing metal, plastic or aluminium extrusions in particular, arises from the vibration of unclamped workpieces.

In addition to these three distinct areas of cutting, idling and workplace noise, there is an extremely wide range of design parameters for circular saws which add to the complexity of the situation. Typical variables include saw blade thickness, number of teeth, specific tooth design, blade type, blade diameter and tooth type. In addition, there are operating variables including speed of blade rotation and the less tangible factor of the standard of equipment maintenance.

Each of these parameters has a direct bearing on the noise level generated by a particular saw and each, naturally, is also a factor to be considered in selecting the right saw for the job.

It is well recognised in industry that noise is a serious problem with circular saws. A large body of literature is available which discusses a wide range of noise control techniques which have been applied to circular saw noise reduction. These measures have varied in success, from moderate reductions of 3-5dB(A) up to truly spectacular returns of about 20dB(A) and more.

As well as being likely to result in permanent hearing loss in an operator, if the duration of exposure and noise level are sufficient, excessive noise can affect concentration and can therefore be a secondary cause of accidents with circular saws—which are highly hazardous items of industrial equipment if basic safety rules are ignored.

It is for these reasons that the reduction of noise from circular saws is an issue which more and more occupiers are keen to address.

This booklet discusses some of the latest research work into the reduction of circular saw noise and the methods available to achieve significant reductions in noise, in a practical and cost-effective manner and without resulting in a decrease in the efficiency of sawing operations. Its aim is to raise awareness among saw operators that noise reduction, whether by a few decibels or by a much more substantial degree, is a practicable proposition.

Obviously a publication of this kind cannot hope to cover every situation, and operators without the necessary know-how are advised to obtain expert assistance.

Some Circular Saw Arrangements

Circular saws are found in timber mills, timber joinery shops, on building sites, in aluminium joineries and in countless other operations.

An enormous array of saws and applications exist. The saw can be mounted with a portable handpiece (such as a “Skilsaw”), or it can be fixed in a bench so that a portion of the blade protrudes above the table, allowing easy ripping of timber.

The saw can be moveable within the bench, travelling up and down” (an arrangement commonly found on building sites) or moveable on an arm across the workplace (such as a draw or radial saw). The saw can be moved manually or by foot, or can be pneumatically powered. In some operations the table is adjustable to allow mitre cuts. It can be seen, then, that the saw may remain stationary and the workpiece moved through the cut, or vice versa.

Circular saws vary in size from 100 mm to over 1.6 m in diameter. In saw mills a heading circular saw, resaws and edgers may have inserted or solid swaged teeth, and in other saws tungsten tips are common.

Many operators will be aware that numerous new saw blades sold in New Zealand already incorporate some of the noise control techniques discussed in this booklet. It is important that the correct saw is used for the specific application and that noise control parameters be incorporated. Less noise will mean that the saw is operating at its optimum condition with the lowest level of vibration. This of course implies that a better finish will be achieved.

The Nature of Circular Saw Noise

The noise from a circular saw comprises two, sometimes three, distinct components. These are:

- idling noise;
- cutting noise; and
- workpiece noise.

Idling Noise

This is composed of aerodynamic noise as the major component with, in some cases, a contribution from resonant blade vibration noise, particularly in poorly maintained saws.

Aerodynamic noise arises from air disturbances near the tooth and gullet area and depends, in particular, on saw tip speed, gullet depth and the ratio of gullet width to plate thickness, all of which act to influence vibration in the blade. Attention to these parameters will reduce aerodynamic noise in an idling saw.

Cutting Noise

This results both from vibration of the saw blade itself and vibration of the workpiece, both of which are excited by tooth impact. It follows that vibration damping, and/or clamping systems, will lead to a reduction in noise. Improved tooth design is another important factor, and blade enclosure is often possible.

Workpiece Noise

This is only significant where metal, plastics or other materials susceptible to vibration are the materials being cut. Aluminium is possibly the commonest and more extreme example.

When aluminium extrusions are being sawed, workpiece noise is the dominant contributor to the overall noise level. Forced vibration at the blade-workpiece interface can be reduced by a combination of workpiece clamping and enclosure. Reverberant vibration, however, extends for the whole length of the workpiece, which must therefore also be enclosed and/or clamped.

Saw Blade and Tooth Terminology

The geometry of the saw blade, particularly in the region of the cutting teeth, is an area of considerable importance for noise generation, and several of the noise control measures discussed later are concerned with crucial changes to this geometry. The terminology commonly used is illustrated in fig.1.

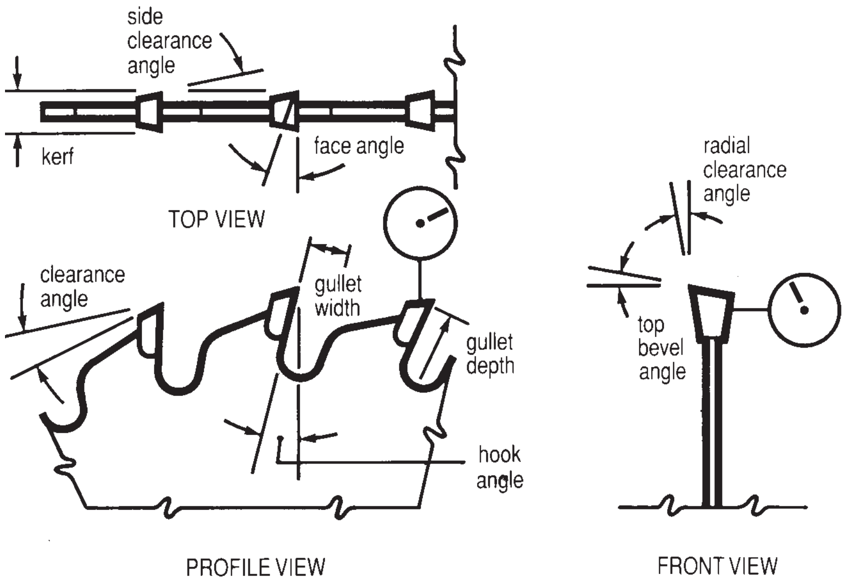


Fig.1 Saw blade terminology

Specific Methods of Noise Reduction

The points discussed here cover particular areas where reduction of circular saw noise can be achieved. In each case, if it has been reported in the literature, the expected acoustical returns for the particular treatment or method are given as a guide to the sort of results which can be obtained.

Of course not all of these methods are applicable, for various reasons, to each and every circular saw. For example, many saws are used in the meat processing industry, but enclosure of these saws is not a practical proposition for obvious hygiene reasons. Similarly, it may not be cost-effective to slow the tip speed down to an extent where significant noise reductions are obtained, since the increased cutting time may be unacceptable in a continuous production situation.

It is up to individual factory occupiers to look at their particular sawing operations and requirements, and to decide (in consultation with a factory inspector if desired) which of the methods discussed here are most applicable and the order in which they should be introduced. In this regard, it clearly makes economic sense to apply those measures which will cost little or nothing to implement first, (i.e. basic maintenance matters; variation of operational parameters). After assessing the effectiveness of these measures, the extent and necessity for further steps of an engineering noise control nature will be much clearer.

Maintenance Factors

Certain fundamental maintenance matters are crucial to both the reduction of circular saw noise and to the efficiency of sawing operations.

A reduction in the amplitude of blade vibration will be a major factor in the reduction of both idling and cutting noise. One general contributor to this vibration is the maintenance condition of the saw. If bearings, for example, are worn they will contribute to blade vibration. Similarly, if the saw collar is worn or if the arbor is sprung, then the blade will show evidence of run-out and this will also be a contributor to blade vibration and hence to operating noise.

Checks on these matters at regular intervals will ensure that the bearings, collar and arbor are all in good condition, and so three potential contributors to saw blade vibration can be eliminated during the course of the regular maintenance programme which should be practised in any industry using this sort of precision equipment.

Another maintenance factor which has a major potential influence on saw noise is the sharpness of teeth. It has been reported that reductions of up to 10dB(A) can be obtained by the simple act of sharpening a dull blade, with no other control measures applied. Naturally, sawing efficiency is considerably enhanced as well

Setting Basic Operational Parameters

To minimise air turbulence noise, (i.e. aerodynamic noise) each saw should be operated at the minimum speed (rpm) allowable by surface finish and wear requirements, so reducing tooth tip speed to the minimum.

A 50% reduction in rpm has been claimed to reduce noise levels by 15dB(A), and a 25% reduction by 6-8dB(A). Individual saws may show variations on these returns but the concept certainly bears consideration and investigation.

Idling noise can also be generated by saw blade vibration and the condition sometimes develops into a so-called “screamer”, creating idling noise levels well in excess of 100dB(A) at the operator position. Obviously this condition cannot be tolerated.

Blade speed by itself does not appear to be a significant factor in reducing cutting noise, and chip thickness (bite per tooth) plays a minor role in the noise generation process (in the order of 3dB(A) per doubling thickness within the practical range).

A further operational variable which can be altered to reduce noise, without affecting cutting efficiency, is the depth of cut. This should be altered so that the minimum cut depth necessary for the job is obtained, i.e. the saw blade just clears the work piece. The effectiveness of this step in reducing noise often depends on other measures being taken in conjunction, such as, where the arrangement allows, saw blade damping by air cushioning of the area of the blade position below the cutting table. Maximising this area (i.e. minimising cut depth) will act to improve the extent of noise reductions obtained.

Saw Blade Design and Tooth Geometry

The effects of changes in the design of circular saw blades and of the geometry of the saw teeth have been investigated by a number of researchers. In some cases, their results have been incorporated into commercially available saw blades, and in other instances changes can be incorporated by a competent saw doctor. The use of tungsten carbide tipped saws has been shown to reduce cutting noise levels by up to 14dB(A). These saws are readily available commercially and, although more expensive than standard blades, they retain their sharpness longer and therefore require less maintenance, as well as offering a substantially quieter operating performance.

The use of slotted saw blades has received widespread support as a noise control measure from applied research work. Various slot configurations have been suggested, with the most widely accepted design having four slots cut to a depth of one-sixth of the saw blade diameter (see fig.2) in a radial direction, and equally spaced around the blade.

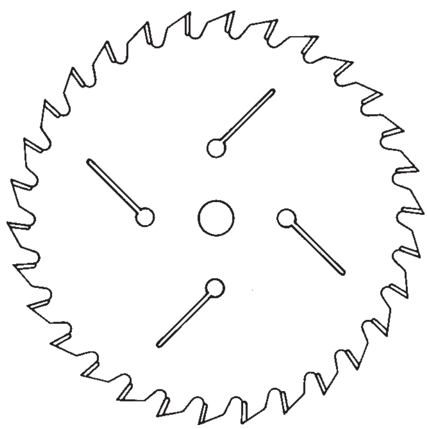


Fig.2 Deep slots in saw blade

Such slots are exceptionally deep, leaving large segments of the rim in limbo. Experiments show that such treatment reduces the noise level substantially, but presents serious difficulties to the saw shop when doctoring becomes necessary. This concept has been developed and “dashes” cut into the saw (see fig. 3). This also results in good reductions in saw noise, but again creates doctoring difficulties..

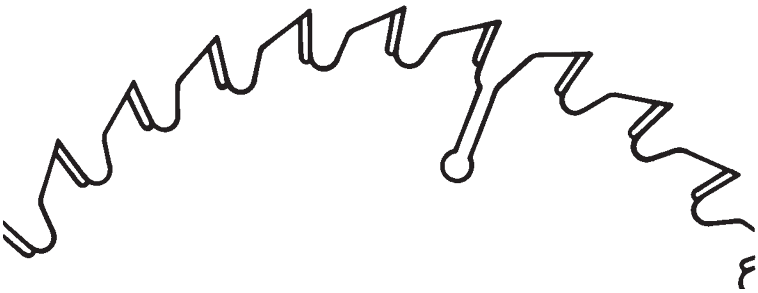


Fig.3 Dashes in saw blade

The tooth and gullet region of the blade has also received much attention. Again, various parameters have been investigated and the consensus of opinion favours the following modifications (terminology as in fig. 1):

- Specific applications require different saw blade designs, although as a general rule selecting tooth geometries which employ positive clearance and hook angles and top or face bevels should result in substantial noise reductions in most cases (see fig. 1).
- Increased gullet size will result in marginally greater noise levels.
- Deepening or slotting of, for example, every fourth gullet, leads to a decrease in noise levels (fig. 4). On some blades a tooth has been removed altogether at regular intervals to widen the gullet to obtain noise reduction (fig. 5).

Specific applications require different saw blade designs. It is impossible to cover the infinite number of variables that could arise in a publication of this kind: the above are a reflection of recommendations that appear in literature and which seem to hold for a variety of materials.

Vibration Damping

Effective damping of saw blade vibration can contribute substantially towards the control of both idling and cutting noise from circular saws, with claimed reductions in the range of 15-17dB(A). There are several methods of vibration damping which have been investigated, and some designs have been adapted for commercial application.

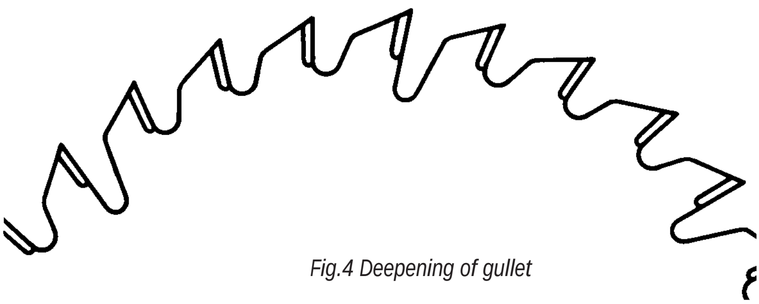


Fig.4 Deepening of gullet

Fig.5 Widening gullets by removal of teeth

Vibration damping collars have been used with great success. These have the damping material sandwiched between concave steel plates, with the whole bonded to each side of the saw blade and extending over as great an area of the blade as possible (see fig. 6). The damping collars should be at least one-half the blade diameter to be effective.

Special viscoelastic layered materials have similarly proved to be effective as vibration dampers when bonded to saw blades. Again, as large an area as possible should be covered (at least 30%) and the damping layer must not come into contact with the material being cut. Noise reductions of the order of 15dB(A) have been obtained. Saw guides have been applied to advantage to reduce vibration. These have a lubricating fluid which creates a fluid film between the bearing and blade, with the fluid being water, oil, air or various mixtures. Some success has also been reported by mounting a paint brush with the brushes in contact with the blade.

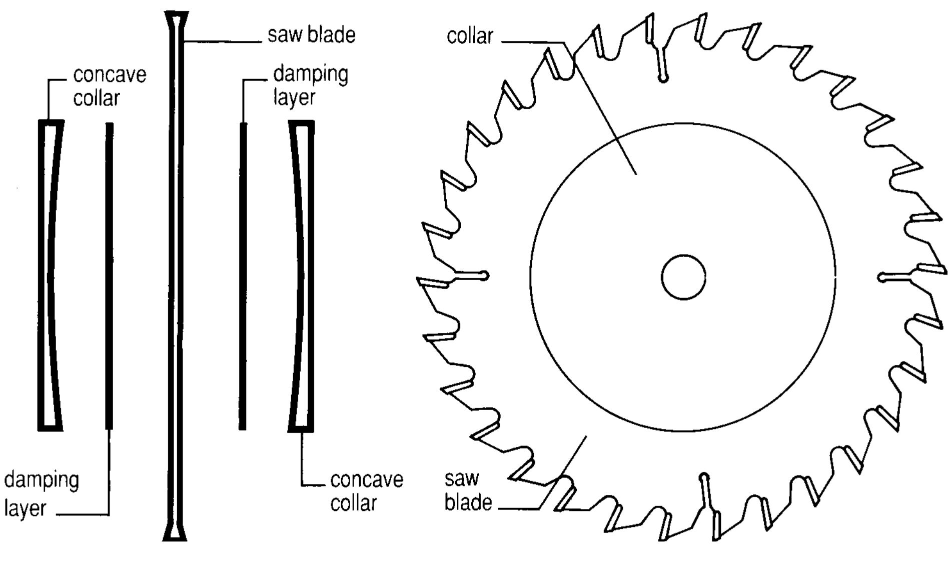


Fig.6 Design of vibration damping collars

It must be remembered that the damping of the saw blade will have the added advantage of a much finer finish to the cut material, as well as the reduction in noise levels. This improvement can be quite distinct and can result in a saving of cost in subsequent machining.

Investigations into the damping effect of positioning two parallel sheets of relatively heavy grade material (e.g.18mm particle board), one on each side of the blade and as close as possible to it (approximately 0.5 cm) have shown good results. The air cushion which is created between the blade and the damping boards upon rotation has enabled idling noise reductions of up to 17dB(A) and some reduction in cutting noise.

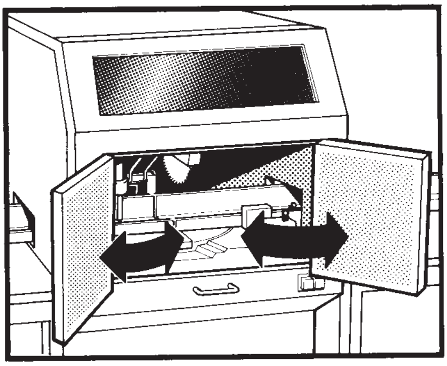
Blade Enclosure

In addition to the various noise reduction measures discussed above, noise from both idling and cutting circular saws can be substantially reduced by the provision of a simple acoustic enclosure. Such an enclosure can take the form of a close-fitting housing over that part of the blade which projects above the cutting table, or it may be a larger enclosure which surrounds both the blade and the general cutting area (see fig. 7).

Clearly, individual enclosures have to be designed for specific saws, but the basic principles are that:

- The enclosure must not interfere with the operation of the blade.
- It should be self-retracting during feeding of workpieces (if it is a blade enclosure)
- The inside surface of the enclosure should be lined with suitable sound-absorbent material, which is itself retained by a perforated metal sheet, to ensure that wood or metal chips do not abrade the sound-absorbent layer.

Rapid access
during operation



1. Workpiece clamps
2. Sound deadening table
3. Windows
4. Lights
5. Small apertures

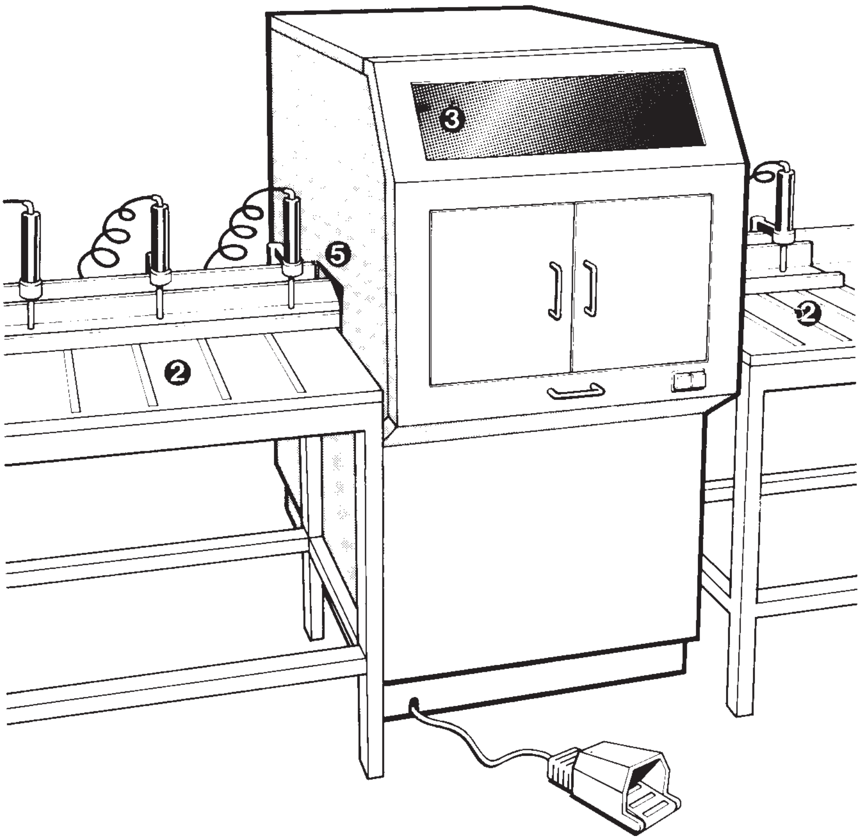
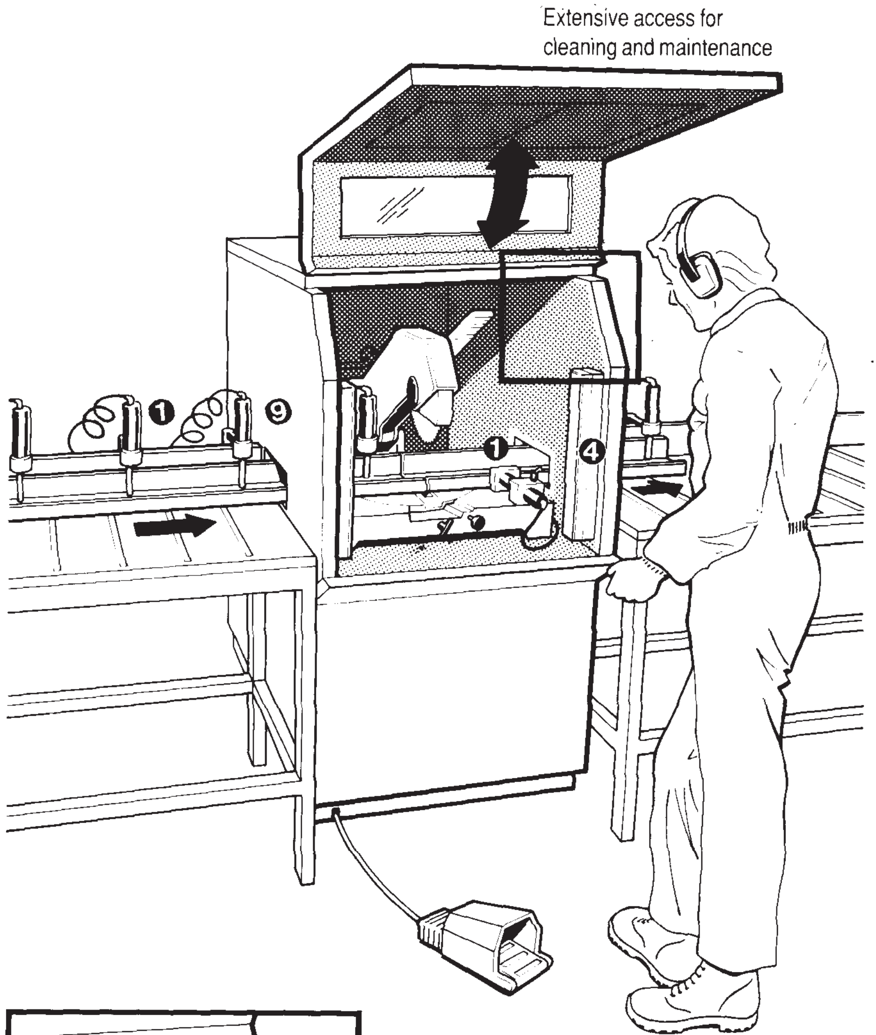
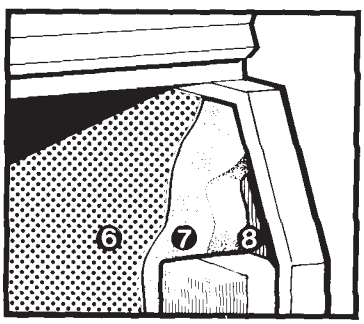


Fig.7 Circular saw enclosure ready for use





6. Light-gauge perforated steel sheet
7. Sound-absorptive material
8. Solid outer skin
   12mm timber board
9. Sheet steel 1–2 mm
   or similar

Fig. 8 Examples of materials for enclosure

Control of Workpiece Noise

As noted earlier, noise generated by vibration of the workpiece during cutting is of particular significance for the sawing of aluminium; indeed, it is the principle contributor to the noise levels generated during such work. In fact, there is little point in carrying out any noise control measures associated with the saw blade if aluminium workpiece noise is not addressed as well.

Aluminium extrusion workpieces generate noise by forced vibration near the blade-workpiece interface, and by reverberant vibration which extends over the whole length of the workpiece. The noise level generated varies greatly with the type of extrusion being cut. Noise control measures which should be applied include:

- Secure clamping of the workplace on both sides of, and near the cutting point, so that vibration is negated. The clamp must, however, be designed with production efficiency in mind, so that quick and easy release is facilitated. Pneumatically operated clamps synchronised to the saw operation are one method of achieving this.
- Acoustic enclosure of the blade-workpiece interface area.
- Clamping or damping the workpiece along its length so that the effects of reverberant vibration are negated.
- Acoustic enclosure of the workpiece over its length.

All of these systems must be designed as far as possible to cause the minimum amount of disruption to the flow of production. The enclosures illustrated in figs 7 and 8 show how operators of circular saws can, with a little forethought and ingenuity, manage to achieve considerable success in reducing noise, without reducing work from their machines.

Summary

Circular saws are used in many different industries, in countless ways. Such saws are invariably a hazard to he hearing of workers in the vicinity of the machines, and generate noise of a particularly objectionable quality.

Operators of circular saws have an obligation, under law, to take all practicable steps to reduce the noise emissions of these machines by engineering means. Management must also ensure that workers not immediately involved in the operation of the saws are isolated from the noise.

Good reductions in noise levels are achievable. On certain saws the noise levels can be reduced to below 85dB(A), so that the hearing of operators can be protected.. On other operations it will be impracticable to achieve such reductions, and hearing protectors will also have to be worn.

References

1. E Stephensen, D Plank. *Circular Saws*. Thomas Robinson and Son Ltd. 1972.

2. M F Devries, J G Bollinger, D F Dauw. “Techniques for Noise Control in Aluminium Extrusion Saws”. North American Metalworking Research Conference, 1979.

3. R K Miller, W V Montone, M D Oviatt. *Noise Control Solutions for the Wood Products Industry*. Fairmont Press, Georgia, 1980.

4. ME Gonzalez. “Noise Reduction of Circular Saws”. *Internoise 79*.

5. E Azzaretto, I Barducci. “ Criteria Underlying Noise Control Measures for Single-Blade Disk Saws Used in Woodworking”, *Internoise 80*.

6. U R Kritiansen. “ Pure Tone Noise from Idling Circular Saw Blades”. *Internoise 80*.

7. C D Mote, MC Leu. ”Whistling lnstability in Idling Circular Saws”. *Journal of Dynamic Systems, Measurement and Control,* June 1980.

8. S Kulczycki. “Problem of Vibration Modal Density in Noise Reduction of a Metal Cutting Circular Saw”. *Internoise 81*.

9. L L Johnston. “Some Refinements in Sawing Techniques for Circular Saws in the Sawmill”. Conference of the New Zealand Educational Sawdoctors Association, Taupo, October 1982.

10. N E Hansen. “Reduction of the Noise from Circular Saw Blades”. *Internoise 83*.

11. JS Stewart. “Aluminium Extrusion Sawing Noise Reduction”. *Internoise 84*.

12. J S Stewart. “Aluminium Extrusion Sawing Noise Reduction”. *Extrusion Productivity through Automation,* Vol .2 1984.

13. C D Mote, Wen Hua Zhu. “Aerodynamic Far Field Noise in Idling Circular Sawblades”. *Journal of Vibration, Acoustics Stress and Reliability in Design,* July 1984.

14. C D Mote, M C Leu. “Vortex Shedding. The Source of Noise and Vibration in Idling Circular Saws”. *Journal of Vibration, Acoustics, Stress and Reliability in Design*, July 1984.

15. C D’Angelo, N T Alvarado, K W Wang, C D Mote. “ Current Research on Circular Saw and Band Saw Vibration and Stability”, *Shock and Vibration Digest*, Vol.17, No. 5, May 1985.

16. M Williston (Ed.) *Saws: Design, Selection, Operation, Maintenance*. Miller Freeman Publications, 1978.