NOISE REDUCTION FOR FRICTION SAWS

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Friction saws are used extensively in industry to cut steel and aluminium pipes and structural sections. In many cases they may be the only type of saw which is suitable for the task or because of their speed. The noise levels from friction sawing are such that there is a high potential for hearing damage for the operator and for others in the area. The findings from an investigation of methods for noise reduction for a friction saw are presented. The potential for noise reduction by changing various parameters associated with the sawing process and by the application of damping to the saw and to the product is discussed.

1. INTRODUCTION

A friction saw is a type of circular saw which is commonly used in the metal manufacturing industry in situations where other sawing techniques are not suitable. Friction saws have fine teeth and operate at high speeds. They produce a cut via a friction action which causes localised heating and a softening of the metal in the workpiece. The cut surface is generally rougher than for other metal sawing operations. Friction saws are used to cut thin materials because of their fast cutting speeds and reduced tendency to jam or grab the workpiece. Friction sawing often produces excessive noise levels for the operators so that it is often necessary to use the highest grade of personal hearing protection. When it is not practical to isolate the friction sawing operation to a separate area, its use may also lead to a high noise exposure for workers nearby. In many cases there are no suitable alternatives to the friction saw for cutting the product. While there has been considerable research into noise generation and subsequently noise reduction measures, for other types of saws, there has been little investigation of the noise from friction saws [1].

In this paper, the findings of a research project with the goal to reduce the noise exposure for the operators of a friction saw used to cut thin walled metal pipes are discussed. The effects on the cutting noise of saw blade parameters, such as diameter, material, thickness, tooth profile and tooth number, and of product parameters, such as production speed, pipe diameter, material and thickness, were investigated. Then experiments concentrated on various noise reduction techniques which apply damping or restraint to the saw blade or the pipe. Limited laboratory testing was also conducted to investigate variable saw speeds and feed rates which were not available in the factory environment. Despite the case study nature of much of this project, general conclusions can be drawn about the nature of noise from friction sawing and about practical noise reduction methods.

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2. CASE STUDY - HELCOR SAW

Figure 2.1 Helcor machine. Flat sheet enters formers on the left then is spiral wound and seamed. The completed pipe emerges on right. An operator is standing near the saw assembly.

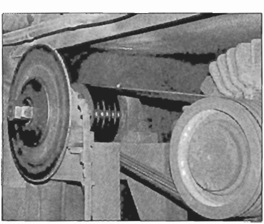

Figure 2.2: Friction saw and pulley assembly used in Helcor machine

The friction saw selected for this case study is used to cut-to-length 'Helcor pipe' which are manufactured by roll forming sheet steel or aluminium and then forming a pipe by spiral winding and seaming. The Helcor production machine, shown in Figure 2.1, is used to produce a range of products with diameter varying from 300 to 3600 mm and wall thickness from 1.5 to 3.5 mm which are cut to the length required by the customers. The chrome-vanadium friction saw blade normally used, shown in Figure 2.2, is 400 mm diameter and 6 mm thick with 240 v-type teeth. The normal rotational speed is 4350 rpm. The pipe is cut 'on the fly' while the production process continues. The saw assembly moves along with the product and is mounted on rails below the pipe. When the cut is complete the saw retracts into the assembly which then moves back ready to cut the next pipe.

3. MEASUREMENT PROCEDURES

The majority of the noise measurements were made during the production of steel pipes with a metal wall thickness of 1.6 mm and with 68 mm x 13 mm corrugations (i.e. corrugations which have a 13 mm peak to trough wave height and a 68 mm wave length). Although the operator was actually closer to the saw, it was impractical to locate the sound level meter (SLM) at a point closer than 2 m to the side of the saw table. This position avoided interference with the operator and damage to the microphone from sparks and debris.

Both noise and vibration measurements were undertaken during production. The noise level of each cut was characterised by measuring the L_{eq} over the full duration of the cutting of a pipe. The data presented in the following sections are the averaged results for a number of such tests for each condition. The repeatability was good, within ± 1 dB(A).

A milling machine was used to conduct some tests under laboratory conditions. Although the milling machine allowed better control of rotational speed and product feed rate than with the Helcor production facilities, the milling machine had limited power and a low maximum spindle (saw) speed. Actual noise levels in laboratory tests were lower due, *inter alia*, to differences in workpiece geometry and clamping arrangements. Hence noise levels in laboratory tests are not directly comparable to noise levels in production conditions, however the effects of parameter changes are comparable.

4. SUMMARY OF FINDINGS

4.1 Product Parameters

The first investigations involved determination of the effect of product parameters on the noise output. It was found that increasing the pipe diameter and increasing the thickness of the pipe material both led to an increase of up to 5 dB(A) in the noise level. This indicates that different modes of vibration were excited and that there was difference coupling between the pipe and the saw blade but it was not possible to examine this in detail within the framework of this project. The effects of changes to the various parameters related to the production process are summarised in Table 1.

DESCRIPTION OF ACTION	EFFECT on CUTTING NOISE
CHANGES TO SAW BLADE	
Metal spray one side: low carbon steel	Decrease 4 dBA
Damping sheet on blade	Decrease 2 dBA
Damping collars on blade	No change
Different tooth profiles	Increase 3 to 7 dBA
CHANGES RELATED TO SAW OPERATION	
Saw rotation clockwise vs anticlockwise	Increase 1 dBA
Saw speed increase: 2060 to 4350 rpm with pulleys	Decrease 7 dBA
Tip speed increase: 375 to 400 mm diameter blade	Increase 4 dBA
Production speed increase: 2.41 to 4.68 m/min, gear 2 to 3	Increase 1 dBA
Production speed increase: 4.68 to 11.31m/min, gear 3 to 5	Increase 4 dBA
MAINTENANCE	
New bearing, replace worn bearing on saw shaft	Decrease 3 dBA
Sharpened saw teeth	Decrease 3 dBA
DAMPING OF PRODUCT	
Flat metal bands wrapped on pipe at 50 mm from saw	Decrease 2 dBA
Profiled metal bands wrapped on pipe at 25 mm from saw	Decrease 3 dBA
Loaded vinyl over pipe at 200 mm from saw	Decrease 2 dBA
Damping of guide rollers	Decrease 1 dBA
CUMULATIVE EFFECTS	
Damping sheet on blade plus minimum production speed	Decrease 5 dBA
Above plus product damping	Decrease 6 dBA
Metal spray on blade plus minimum production speed	Decrease 7 dBA
Above plus product damping	Decrease 10 dBA

Table 1: Effect on noise level in terms of L_{Aeq} for changes in various parameters.

4.2 Changes to Saw Blade

Three different methods for damping the blade were investigated. Two of these were conventional approaches to damping by the application of damping sheet to the blade and by the use of damping collars. However greater reduction was achieved with the use of a blade treated with a low carbon steel metal spray. An annulus 100 mm wide (145 mm inner diameter, 245 mm outer diameter) and 1 mm thick was machined in one surface of the blade. This annulus was then overfilled with metal spray. The blade was remachined in the region of the metal spray so that a smooth surface resulted. The natural frequencies and their damping factors for the normal blade and the blade with the metal spray treatment were investigated with the aid of modal analysis. The resonant frequencies for the modes were found to be very close for the two blades and the differences between the damping factors are shown in Figure 4.1.

Helcor pipes are currently cut using v - type profiles. Other profiles tested were pendulum profile (inverted v), brobo style (one side bevel alternately) and Hi-lo profile (alternate square/trapezoidal). It was clear that the currently used v - type produced lower noise level and the reasons for this need further investigation.

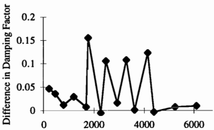

Figure 4.1: Increase in damping factor (%) for the blade with metal spray as compared with the normal blade.

4.3 Changes to Saw Operation

Increases in the production speed, ie the rate at which the product passes the blade, and the blade tip speed led to increases in the noise level. It was only by increasing the saw speed that a reduction in the noise level was achieved. From the laboratory tests it was found that noise levels depended on both feed rate and saw speed in a non-linear manner. However the practical limitations associated with the operation of the Helcor saw restricted the number of options that could be investigated.

4.4 Maintenance

These findings showed that maintenance is important in minimising noise output. The regular sharpening of the teeth and the replacement of worn bearings can assist to reduce the noise level for the operation of the saw and while it is idling.

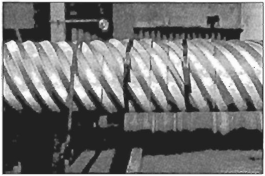

Figure 4.2: Profiled bands on both sides of the cutting line.

4.5 Product Damping

From the analysis of the noise and the vibration data, it was clear that vibrations induced in the product by the sawing process were a major source of radiated noise. As the Helcor pipe production process requires pipe rotation during cutting, this does not allow the simple methods of clamping to improve damping and restraint on the workpiece. However several techniques were investigated with the primary aim was to determine the effectiveness and with the recognition that considerable development would be required for the production environment.

Greater reduction was achieved with the use of metal bands having the same profile as the product so that the damping was applied to the full circumference of the pipe. Figure 4.2 shows the set up with the profiled bands, secured with metal straps on the pipe at 25 mm from the saw cutting line for which a reduction of 3 dB(A) was achieved. This result indicates that dampening the pipe close to the saw cutting line could reduce the radiated noise.

4.6 Combinations

After the effects of individual parameters and some noise reduction techniques were determined, the cumulative effects of both optimising various parameters and applying control techniques were investigated. An overall noise reduction of 10 dBA was achieved from the optimised operation of the saw plus noise control measures, including blade damping, minimum production speed and product damping. Blade damping and minimum production speed, leading to a reduction of 7 dBA, can readily be immediately applied to the Helcor production process. The pipe damping needs considerable development for use in normal production.

It would appear from the tests on the Helcor saw that the normal operating conditions are close to an optimum as, with the exception of the replacement of the bearing, all the changes to the operation of the saw led to increased noise levels. The greatest potential for the reduction of the overall noise level appears to be from changes to the saw blade and with the application of damping to the product.

4.7 Operator Noise Exposure

The use of minimum production speed effects the time duration for the cutting noise. This consideration, combined with the very high noise from the friction sawing, means that a reduction of 10 dBA is not sufficient for the operator of this particular machine to dispense with personal hearing protection. However such a reduction would enable the use of lower grade hearing protectors. In addition, the improvement would assist in reducing the noise exposure for the other workers in the factory.

In this case an enclosure for the machine is not practical so the remaining option is an enclosure for the operator. The demands on such an enclosure would be reduced following the reduction of the noise at the source.

5. CONCLUSION

This study has shown that significant reductions in noise from friction sawing can be achieved through the following types of measures.

- Optimising Sawing Parameters. In particular optimising the saw rotational speed, the product feed rate, the blade thickness and the tooth profile can reduce noise.

- Blade Damping. Blade damping through the application of metal sprays or damping materials was found to be an effective noise reduction technique.
- Product Damping or Restraint. Product vibration was shown to be a major source of noise in friction sawing which could be reduced by providing improved damping or restraint for the product.

For a particular application of friction sawing, the amount of noise reduction which can be achieved will need to be explored on a case by case basis. However, in the case study reported here, a 7 dBA reduction was readily achieved by practical measures. Combined with product damping, where practical, the reduction could be increased to 10 dBA. Such a reduction can be worthwhile even if it is insufficient to allow the operator to dispense with personal hearing protection. This reduction can enable the use of lower grade hearing protectors, can greatly improve working conditions for personnel in other parts of a factory and reduce the extent of noise reduction required by an enclosure.

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