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REDUCTION OF THE NOISE FROM CIRCULAR SAW BLADES

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INTRODUCTION

Initiated by the Danish slaughteries and Slagteriernes Forskningsinstitut, SF (The Danish Meat Research Institute) a project whose purpose was to reduce the noise from hand-held circular saws used in the slaughteries has been carried through. The diameters of the saw blades of the most noisy saws, with a noise level about L_{Aeq} = 100 dB, are 220-500 mm. While it is the saws with 220 mm saw blades* that causes the largest environmental problems for most workers in this industry the main part of the work reported herein will concentrate on these saws.
Due to the veterinary requirements imposed on the slaughteries it is almost impossible to cover the saws. Therefore, the work has been directed primarily towards changing the noise generation mechanism in such a way that the generated noise is acceptable. Because it is the saw blade itself that is the main noise source this actually means that we had to change the vibration modes of the saw blade when in use.
Fig. 1 shows a picture of the old and the new 220 mm saw blade. The new saw blades are based on the same fundamental geometry as the traditional ones, but with a new and untraditional tooth configuration whose development is based on the theory of stochastic processes. Furthermore the blades are slotted and mounted with vibration damping material.
With the new saw blade design)* the noise level is reduced by 12-15 dB, and the cutting efficiency - compared with the old blades, is at least as good.
(thickness 1 mm)) Patent pending

The new saw blade is now produced in Denmark and in use in the major Danish slaughteries.

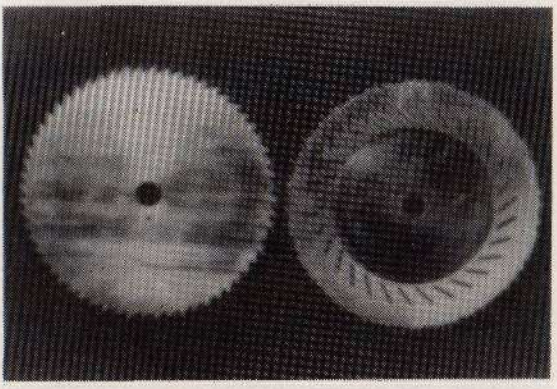

Fig.1. Old and New Saw Blades.

Saw Tooth Angle

Figure 2 shows the definition of the tooth angle which is closely related to the gradient of the cutting force, $f'(t)$. While this gradient is very often significant for the noise level the tooth angle should be optimized in order to reduce the influence of $f'(t)$ and at the same time taking into account the efficiency of the saw blade. It turned out that a tooth angle of about 15^{o} was optimal with respect to both noise level and cutting efficiency. Even though the noise level was not sensitive to changes in the tooth angle between 10^{o}-20^{o}. Furthermore in this case the noise reduction was not very significant (1-2 dB) when changing the angle from 0^{o} to 15^{o}.

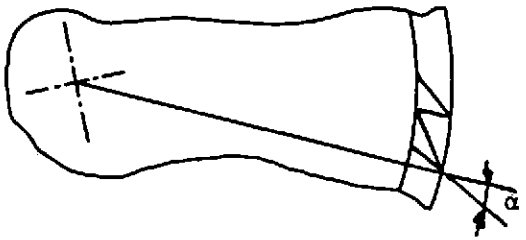

Fig.2. Definition of the Tooth Angle.

Tooth Configuration

Figure 3 shows a segment of a saw blade with the new tooth configuration. This configuration consists of a number of equally shaped teeth and unevenly spaced on the circumference. This uneven spacing aims against reducing the effect of the pure tones known from saw blades with equally spaced teeth. The tooth configuration used here is based on a Pseudo Random Binary Sequence (PRBS) which has the effect of changing the input power spectrum to be constant within the frequency band of interest. Assuming linear blade dynamics the presence of resonance in the output power spectrum therefore originates from the blade dynamics. As known the output power spectrum and the noise spectrum is closely related. In order to evaluate the characteristics of the blade dynamics we have used the noise spectrum.

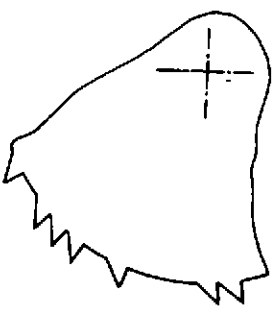

Fig.3. Segment of a PRBS-Configuration

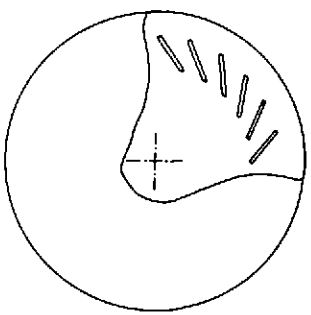

Fig.4. Saw Blade with slots

Slotted Saw Blades

Figure 4 illustrates how the saw blades are slotted. In the literature concerning noise reduction of circular saw blades it is some times stated that slotting the saw blades in a way like the one shown should reduce the noise level, but very little has been reported about the mechanism behind. It seems however, that the mechanism is that no circular nodes (the circular nodes corresponds to the vibration modes responsible for a large part of the noise radiation) can be generated within the slotted area. This means that there can only exist circular nodes inside the slotted area and these nodes corresponds to higher frequencies. Furthermore the slots have the effect that they reduce the bending stiffnes of the part of the saw blade that is slotted and hereby improves the radial distribution of the vibration amplitudes. The above described vibration pattern of the slotted saw blades has been verified by holographic measurements.

Viscoelastic Damping

Figure 5 shows the vibration damping material mounted on the saw blade. The damper is built of two disks. Eash disk consists of a thin steel plate laminated with a special selected viscoelastic material.

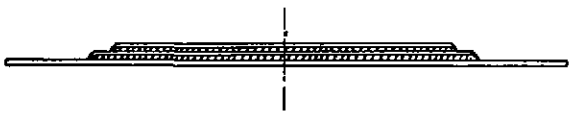

Fig.5. Vibration Damper.

The design of the damper has been optimized to be effective in the frequency range corresponding to the circular nodes that can be generated in the saw blade itself inside its slotted region.

Closing Remarks

Through theoretical investigations evaluated by a series of experiments and measurements the following results have been obtained.
In figure 6 and 7 is shown the noise spectra for the original saw blade and the new saw blade.

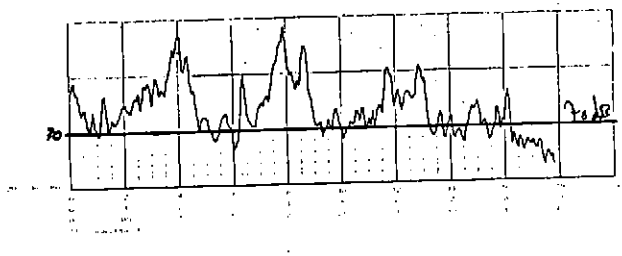

Fig.6. Noise Spectra for the Original Saw Blade.

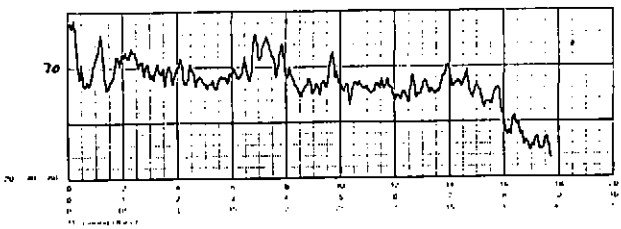

Fig.7. Noise Spectra for the New Saw blade.

Each of the above mentioned noise reducing means typically reduces the noise level 1-3 dB when acting solely. However, the integrated effect of the three noise reducing means reduces the noise level 12-15 dB, which is significantly more than the sum of the individual effects.