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Studies on Noise Analysis of Band Saws

Chiaki TANAKA*, Yozo SHIOTA* and Akira TAKAHASHI*

帯のこの騒音に関する研究

田中 千秋*・塩田 洋三*・高橋 徹*

Introduction

Band saws, circular saws, chippers and debarkers are common to any sawmill. These machines are known to generate high levels of noise and consequently many countries have enacted laws defining limits for occupational exposure to their noise.

Some technical papers[1,2] report that individual machines of this kind produce workplace noise levels as high as 100 dBA. So little research work has been done in the field of band sawing,[3] that the source of noise generation in these machines and methods of its control have yet to be determined. Similar work has been limited to circular saws[4] and planers.[5]

The best known method of band saw noise control so far is to surround the machine with sound attenuating enclosures. Considering these facts, the research work in finding the sources and cures for these noise problems should be undertaken specifically on band saws.

This paper presents an analysis of the results obtained from noise measurements on a particular band saw.

Experiment

The machine investigated is a band saw with wheel diameter of 1200 mm, equipped with a carriage for feeding lumber. It is fixed firmly by stud-bolts onto a concrete foundation block. The distance between the two shafts of the machine can be varied from 2000 mm to 2200 mm by moving the upper wheel. The lower wheel is made of cast iron with a steel rim. The top wheel has a steel core and a steel rim. The machine is driven by a 40 HP motor, using 6 V-belts. The carriage is 6.0 m long and the carriage rails provided measure 18 m in length.

The length of the sawblade investigated was 8.0 m. The width and thickness of sawblades used are given in Table 1. The number of teeth was 253 and the height of the teeth was 10 mm. Saw tooth preparation, welding sawblade, leveling of the blade, tensioning, and crowning the back edge were all examined very carefully by a saw technician. Rolling method was applied in tensioning the sawblade and in crowning the back edge of the sawblade. The degree of saw tensioning was indicated by the diameter of a circular arc

* Laboratory of Wood Science and Engineering

Table 1. EXPERIMENTAL FACTORS

Sawblade	CODE	VARIABLES
Thickness	A	A_1 : 0.9 mm, A_2 : 1.05 mm
Width	B	B_1 : 102 mm, B_2 : 127 mm, B_3 : 152 mm
Number of welded joints	C	C_1 : 1, C_2 : 4
Degree of tensioning	D	D_1 : ∞, D_2 : 9000 mm, D_3 : 6000 mm
Initial strain	E	E_1 : 500 kg, E_2 : 1100 kg, E_3 : 1700 kg
Running speed	F	F_1 : 31.4 m/sec, F_2 : 42.7 m/sec, F_3 : 52.8 m/sec

on the blade width direction of the sawblade. The amount of back crown was measured by a back gauge, These values of back crown were maintained constant, as nearly as possible, at 0.32 mm per 750 mm length of sawblade.

The several experimental factors considered were: (1) sawblade welding condition, (2) sawblade width, (3) sawblade strain, (4) running speed of the sawblade, and (5) degree of tensioning. These five factors were varied to investigate noise behavior of the band saw during idling conditions. In addition to this, the noise level during cutting was also measured and compared with that in the idling state. These factors are listed in Table 1. The running speed of these sawblades was varied by using different pulleys on the motor.

For measurements, a sound level meter, 1/3-octave band pass filter, and a level recorder were employed. The microphone was set up at the height of the ear level of the operators. This was at 1.5 m above floor level and at a distance of 2.0m from the sawblade. For the purposes of measurement of the noise levels, the dBA and dBC weighting networks of the sound level meter were used.

The band saw was located in a woodworking shop measuring 20 m in length, 10 m in width, and 4 m in height. The entire floor was built of concrete with wood covering an area immediately around the machine. The walls were covered with perforated insulation board. The shop contained 10 glass windows of 1.8 m $\times$ 2.6 m in size. On the front and back walls, shutters were provided of size 4 m $\times$ 3 m. Other major machines installed in the room were a circular saw and a planer. But these machines were not operated during the sound level measurements on the band saw.

Results and Discussion

Effects of sawblade configuration on noise

Figure 1 shows the effect of sawblade variables on noise during machine idling. The noise level was observed on sawblades without teeth, with teeth, and on a blade with teeth having four welded joints. Figs. 2 and 3 present the relationship between noise level and sawblade widths and degrees of tensioning.

Fig. 1 demonstrates that there is almost no difference in noise level between the sawblade without teeth and one with teeth. Also, it is clear that the noise level increases with the number of welded joints. The noise level also increases significantly as the width of the sawblade increases, as shown in Fig. 2. From Fig. 3 it is clear that the overall noise level tends to decrease as saw tensioning is increased.

In a study of circular saws[7], it was reported that the noise level increased by 10 dBA for a saw with teeth, compared to one without teeth. The noise level in that investigation was

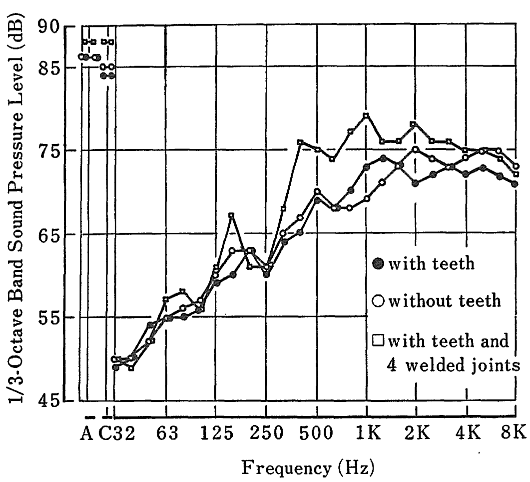


Fig. 1. Effect of tooth and welded joint of sawblade on noise during machine idling. Measuring condition : A_1-B_2-C_1-D_1-E_2-F_2.

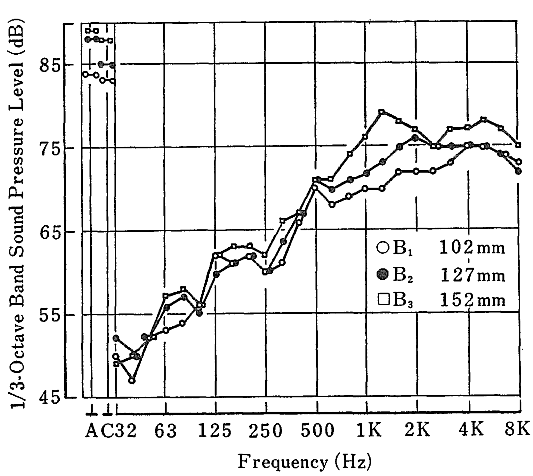
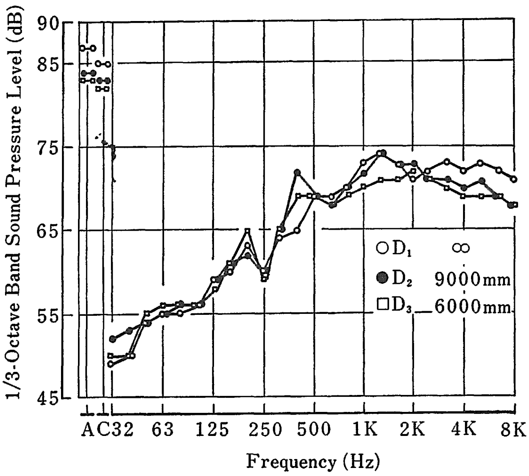
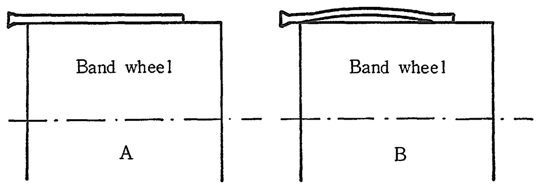


Fig. 2. Effect of sawblade width on noise during machine idling. Measuring condition : A_1-B-C_1-D_1-E_2-F_2.

higher because of the aerodynamic disturbance caused by the teeth when the circular saw was in motion. But for band saws, there is very little difference in the total noise level and sound spectra for a blade without teeth and one with teeth, as seen in Fig. 1. From this result, it probably follows that aerodynamic noise is caused to a certain extent by both sawblades with and without teeth. Anyway, the aerodynamic noise produced by the teeth of the sawblade, being small, does not seem to affect the overall noise level of the machine.

It was shown that the noise level increased with the number of welded joints and with the increase in the blade width. These results were observed when the strain was kept constant throughout the study at 1100 kg. This effect may be due to : 1) the increase in the level of impact and friction energy, both of which are generated by the contact between the sawblade and band wheel, as related to the increase in the width and number of welded joints ; 2) the increased amplitude of vibrations caused by the higher impact energy is increased the noise level ; and 3) the aerodynamically produced sound pressure in the vicinity of the blade increases due to the increase in the width of the blade.





↑Fig. 4. The contact situation between the sawblade and band wheel surface A : no tension, B : tension.

←Fig. 3. Effect of degree of tensioning on noise during machine idling. Measuring condition : A_1-B_2-C_1-D-E_2-F_2.

The frequency of impact of welded joints of the sawblade on the band wheel is given by : $f_1 = V \cdot n/1$, where 1=the length of sawblade in meters, V=the running speed of the sawblade in m/sec., and n=number of welded joints on the sawblade. In this experiment $f_1=5.3$ Hz when $n=1$, $f_1=21.1$ Hz when $n=4$. The rotational frequency of the band wheel is given by : $f_2=R/60$, where R=revolutions per minute of the wheel. f_2 was constant at 11.3 Hz for the experimental conditions considered in this section. The tooth passage frequency is given by : $f_3=V \cdot N/1$, where V = running speed of the sawblade in m/sec and N=number of teeth. f_3=was maintained at 1334 Hz in these experiments. The fundamental resonance frequency of the sawblade was calculated[6] as 19 to 33 Hz. If there is a great influence of the spectrum level of the frequencies f_1, f_2 and f_3, the 1/3 octave band sound pressure level of these frequencies should give significant peaks at these values on the spectrum. The frequency levels of f_1, f_2 and natural frequency were not within the measurement range of 32 Hz to 8000 Hz, considered in the experiments. Also f_1 and f_2 do not fall within the audible frequency ranges and can be considered negligible. Only the tooth passage frequency f_3 was within the range of the experiment. It was noted that at this frequency there was no significant peak observed, as seen in Fig. 1, 2 and 3.

When there is no tension in the sawblade, the contact situation between the sawblade and the surface of the band wheel is as shown in Fig. 4−A. If the sawblade is tensioned then the situation of the contact of the blade with the surface will be as shown in Fig. 4−B. Thus, we see that there is a reduction in contact area between the sawblade and the wheel surface with an icrease in tensioning. In the present experiments, the minimum diameter reached was 6000 mm. This is the maximum tensioning used. Due to the reduced area of contact between the blade and the surface of the wheel, by increased tensioning, both the friction and the impact are reduced and hence the sound pressure level is expected to decrease. From Fig. 3 we can observe that the 1/3-octave band sound pressure level is lower in the case of tensioning condition as compared to the no tension condition, above the 1000Hz frequency range. Hence, we can conclude that the main component of the noise produced by impact and friction between the sawblade and band wheel lies in comparatively higher frequency range. Also, it is apparent that a considerable amount of noise is produced by the impact and friction of the sawblade with the surface of the wheel.

Effects of process variables on noise

The effect of strain and the running speed of the sawblade on noise are shown in Figs. 5 and 6, respectively. When the speed of the sawblade is increased from 31.4 m/sec to 52.8 m/sec, the noise level increases by about 6 dBA. Similarly, when the strain is increased from 500 Kg to 1700 Kg, the noise level increases by about 6 dBA. These effects are more significant in the higher frequency ranges above 1000 Hz. These results are similar to the effect of the variables considered in the discussion above, on noise level. The increase in the overall noise level proportional to velocity may be due to the following effects : The increase in the running speed of the sawblade increases the centrifugal force in the part of the blade on the band wheel. This increase in centrifugal force tends to pull the blade away from the wheel over its contact length. But the strain loads applied to the band saw keep the blade in contact with the wheels. This loading may create not only a larger area of contact, but may also create added impact of the blade on the wheel, which incredses the noise level.

Fig. 7 compares the relationship between the sound pressure levels for idling versus cutting conditions. The figure also includes the curve obtained by plotting the conditions

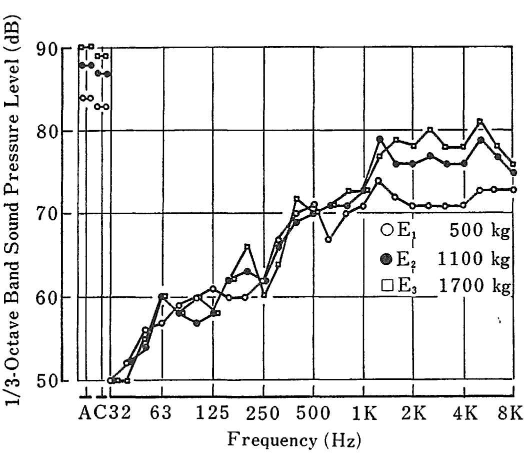


Fig. 5. Effect of initial strain on noise during machine idling. Measuring condition : A_2-B_2-C_1-D_1-E-F_2.

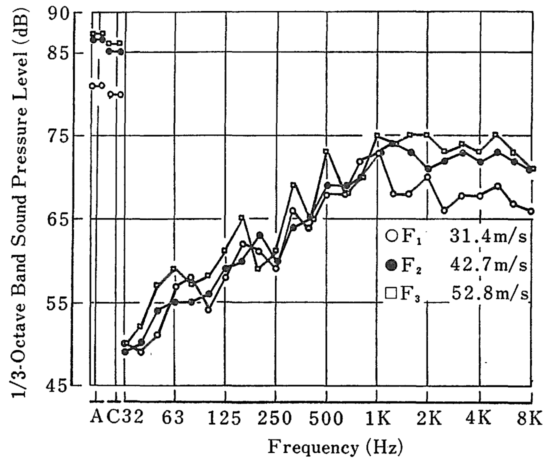


Fig. 6. Effect of the running speed of sawblade on noise during machine idling. Measuring condition : A_1-B_2-C_1-D_1-E_2-F.

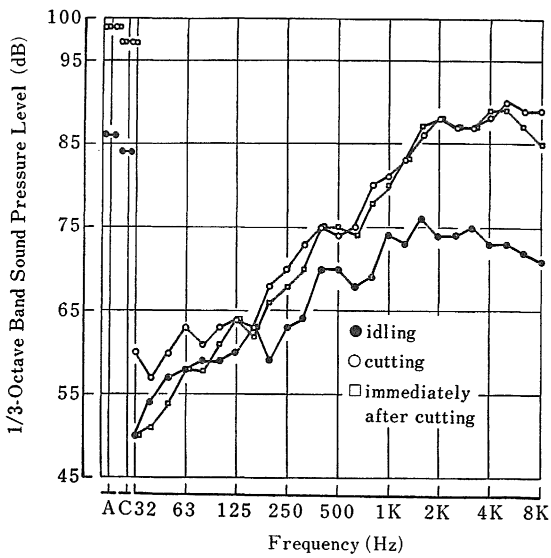


Fig. 7. Comparison of noise during machine idling and cutting conditions. Measuring condition : A_1-B_2-C_1-D_2-E_2-F_3.
Wood species : cryptomeria D. Don, Depth of cut : 200 mm, Width of cut : 20 mm, Length of cut : 2000 mm, Feed speed : 200 mm/sec.

measured immediately after cutting. This figure shows that the noise level is more than 10 dBA higher during cutting, compared to that during idling. The noise level is seen to reach about 100 dBA during cutting. The 1/3-octave band sound pressure levels during cutting are higher than those during idling, especially in ranges above 160 Hz. The difference in the sound pressure level between the cutting and idling conditions is more than 10 dB in the range above 1000 Hz on the frequency scale. Fig. 7 also shows that the noise level and sound pressure spectra measured immediately after cutting are similar to those during cutting. It was confirmed that these high noise levels, immediately after cutting, were caused by sawdust on sawblade and band wheel. This was verified by wiping off the sawdust (using a brush dipped in oil), which caused the noise level to drop down immediately to that of the idling conditions. Hence, two types of mechanisms are shown to be responsible for producing the noise in band saws, i. e., the friction and impact between the sawblade and workpiece during cutting and the presence of sawdust between sawblade and the band wheel which creates impact noise. This latter condition seems to be a dominating factor in the noise production.

Conclusion

Noise levels during machine idling as well as during cutting were measured on a 1200mm band saw with a log carriage. The variables investigated in this work were : (1) number of welded joints on the sawblade, (2) width of the sawblade, (3) degree of saw tensioning, (4) initial strain, and (5) running speed of the sawblade. The results obtained are summarized as follows :

(1) The noise level during machine cutting conditions is more than 10 dBA higher than that during idling. The overall noise level reached about 100 dBA.

(2) The sound pressure level at comparatively higher frequency ranges controls the overall noise level during both idling and cutting conditions.

(3) The noise produced by friction and the impact of the sawblade on the surface of the band wheel is considered to be a dominant factor in the band saw noise.

Summary

Noise level of a 1.2 m band saw were measured during the idling state and while cutting. Results obtained are as follows : (1) Noise levels during cutting are about 10 dBA higher than during idling. (2) The sound pressure level at higher frequencies dominates the overall noise level both during idling and cutting. (3) Noise produced by friction and the impact of the blade on the band wheel was the dominating factor in overall noise level during idling.

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摘　　要

製材用 1200 mm 帯のこ盤の空転および切削時での騒音を検討した．帯のこの接合部数，幅，緊張力，のこ速度および腰入の程度を変化させた．歯の有無は騒音のレベルに影響を与えないが，接合部数，のこ幅，緊張力およびのこ速度を増大させると騒音レベルは上昇する．腰入量の増大は騒音レベルを減少させる．切削時では空転の場合より10ホン以上増大し，騒音レベルは100ホンにも及ぶ．帯のこの騒音は 1 KHz 以上の領域の音圧が主成分で，特に切削時ではこの領域の音圧が著しく大きくなること等がわかった．空転時ではのこととのこ車間で生ずる摩擦や衝撃が，また切削時ではのこくずとのこおよびのこ車間での摩擦や衝撃が主騒音源であると考えられる．