VOLUME 15 No. 2, 22 June 2025 Pages 158-164

NOISE ANALYSIS OF GRINDING MACHINE IN THE MATERIAL CUTTING PROCESS

ANALISIS KEBISINGAN MESIN GERINDA DALAM PROSES PEMOTONGAN MATERIAL

*Rini Dharmastiti**
Engineering Faculty, Universitas Gadjah Mada
The Graduate School of Universitas Gadjah Mada

Andi Rahadyan Wijaya and Fitri Kurniasari
Engineering Faculty, Universitas Gadjah Mada

Submitted: 2025-03-16; Revised: 2025-05-22; Accepted:2025-05-23

ABSTRAK

Mesin gerinda tangan yang digunakan untuk memotong material telah menimbulkan kebisingan bagi operator atau orang yang berada di sekitarnya. Kebisingan yang ditimbulkan oleh mesin gerinda tangan ini perlu dianalisis supaya tidak menimbulkan dampak kesehatan. Penelitian ini bertujuan mengukur tingkat kebisingan yang dihasilkan oleh mesin gerinda tangan pada saat digunakan untuk proses pemotongan material berupa keramik, logam dan batu alam. Lokasi pengukuran berada pada titik sumber suara dan pada jarak 2 m, 3 m, 4 m dari sumber suara. Sound level meter digunakan dalam pengukuran kebisingan. Hasil penelitian menunjukkan bahwa jenis material yang dipotong menggunakan mesin gerinda tangan tersebut tidak berpengaruh signifikan terhadap tingkat kebisingan yang dihasilkan. Kebisingan tertinggi terjadi pada saat memotong material plat aluminium, dengan Leq sebesar 91,6 dB pada sumber suara, sedangkan Leq terendah adalah material keramik, dengan Leq sebesar 89,7 dB. Hasil uji statistik untuk jarak dan lokasi titik pengukuran pada jarak 2 meter, 3 meter, dan 4 meter menunjukkan bahwa jarak tidak berpengaruh signifikan terhadap tingkat kebisingan. Untuk jarak 2 meter dan 3 meter, rata-rata Leq untuk semua material adalah sama, yaitu 94,2 dB, sementara pada jarak 4 meter, rata-rata Leq untuk semua material adalah 93,9 dB.

***Kata kunci**: Tingkat kebisingan; Mesin gerinda; Material; Proses pemotongan.*

ABSTRACT

The handheld grinding machine used for cutting materials has generated noise that may affect the operator and individuals nearby. The noise produced by this machine needs to be analyzed to prevent potential health impacts. This study aims to measure the noise levels the handheld grinding machine generates while cutting materials such as ceramic, metal, and natural stone. Noise measurements were taken at the noise source and distances of 2 meters, 3 meters, and 4 meters from the source. A sound level meter was used for the noise measurements. The study's results indicate that the type of material being cut using the handheld grinder does not significantly affect the noise level produced. The highest noise level was recorded when cutting the plate, with an equivalent continuous sound level (Leq) of 91.6 dB at the source. The lowest noise level was recorded when cutting ceramic

*Corresponding author: rini@ugm.ac.id

material, with a Leq of 89.7 dB. Statistical tests on the distance and measurement locations at 2 meters, 3 meters, and 4 meters from the source showed that the distance does not significantly affect the noise level. At distances of 2 meters and 3 meters, the average Leq for all materials was the same, ata 94.2 dB, while at 4 meters, the average Leq was slightly lower, at 93.9 dB.

Keywords: *Noise level; Grinding Machine; Material; Cutting Process.*

INTRODUCTION

Noise in the Workplace often presents a significant issue for workers, typically from machines and equipment. Although there may be no immediate complaints from the workers, health problems will still occur if workplace noise control is not implemented. A hazard study of low-scale noise exposure in the hand tools manufacturing industry was conducted by Singh et al. (2009). This study was conducted with five small-scale hand tools forging units of different sizes. The measurement results showed the equivalent sound pressure level (Leq) during the hammer section, cutting presses, punching, grinding, and barreling processes to be more than 90 dB(A).

Noise-related research has also been conducted in various places (Bakhtiar et al., 2023; Qosim, 2022; Wellem et al., 2024; Wojtyto et al., 2021). Bakhtiar et al. (2023) studied the noise measurements in the work area to the operator's hearing in the process department using the work sampling method. Qosim et al. (2022) analyzed the noise level of the diesel engine in indoor conditions, while Wellem et al. (2022) analyzed the noise levels from loudspeakers on public transportation in East Nusa Tenggara. Wojtyto et al. (2021) also analyzed the noise level in a manufacturing enterprise. These studies show that the employer should continue applying the existing precautionary and preventive measures such as training or personal protective means.

Zannin et al. (2013) mapped noise in a campus in Brazil, discovering that 89.65% of 58 evaluated points exceeded 55 dB(A), the WHO-recommended limit. Fernández et al. (2009) examined noise in the construction sector, emphasizing the importance of risk assessment and noise control in workplaces. Chao et al. (2013) investigated the impact of noise, vibration, and low temperatures on workers' psychology, concluding that noise is the primary cause of temporary hearing loss (TTS). Based on these studies, noise measurement helps assess noise exposure and design control strategies.

This research adopts the sampling point method used by Zannin et al. (2013) as well as percentile noise level measurements (L10, L50, L90) from Fernández et al. (2009). In this study, the hand-power tool used as the object of research is the grinding machine. The grinding machine was chosen because it is more multifunctional than other equipment. The function of a hand-grinding machine includes grinding and cutting workpieces. It can also be used for shaping workpieces, finishing cuts, smoothing surfaces after welding, and creating angled curves. In addition, Farauq (2018) also focuses on evaluating the noise exposure levels experienced by grinding machine operators. The operators were exposed to excessive noise levels above 90 dB(A). This study differs from Farauq (2018) in terms of the types of grinding machines and the cutting process in many materials.

Grinding machines come in various brands, types, sizes, and power ratings. The machine used is selected based on the tasks being performed and the type of material being worked on. According to a survey conducted by the researcher across several industries, such as construction, woodworking, metalworking, and natural stone industries, the most used hand grinding machine is a 4-inch standard type with a power rating of 500-700 Watts. This specification is sufficient, with only the grinding wheel varying depending on the workpiece's treatment. Based on the survey conducted, in the construction industry, this machine is used for cutting ceramic tiles, smoothing ceramics, cutting foundation iron, or smoothing wood. In the natural stone industry, this machine cuts natural stones such as temples and andesites.

For stone materials,The machine is only used for cutting. In the metal industry, this machine can be used for cutting, grinding, finishing, and making indentations in metals, especially iron and aluminum. All types of iron and aluminum can be cut using a hand-grinding machine, including steel rods, mounting brackets, iron pipes, cylindrical iron, aluminum plates, and others. This study aims to measure the noise levels the handheld grinding machine produces during the material-cutting process.

The measurement results are processed to determine the effect of each measurement point and material type on the noise levels produced during the cutting process. The study also aims to provide noise control alternatives that can be implemented in the workplace.

Method

This research focuses on the process of cutting ceramic, metal (aluminum cylinder, aluminum plate, cylindrical iron, iron pipe), and natural stone materials using a handheld grinding machine. Based on the noise levels obtained from these experiments, the materi-als will be compared to determine which one generates the highest noise level.

The variables in this study include the noise level generated during the cutting of materials at various distances from each sampling point as dependent variables. The independent variables are the materials (ceramic, metal, and natural stone) and the distance of the sampling points from the sound source. The handheld grinding machine (4-inch size, 3A, 670 watts), cutting grinding discs for iron (Kinik brand), cutting grinding discs for ceramic (Bosch brand), and cutting grinding discs for aluminum (Stanley brand).

The same grinding disc is used to cut the aluminum cylinder and plate. A similar grinding disc is also used for cutting ceramic and Banjar black stone materials. Similarly, the grinding discs for cutting cylindrical iron and iron pipes are similar. Table 1 shows the types of materials, and the grinding discs used for cutting.

Table 1.
Types of Materials and Grinding Disc Used

Material	Grinding Disc Type
Aluminum Cylinder	Tungsten Carbide
Aluminum Plate	Tungsten Carbide
Stone	Green Silicone Carbide
Ceramic	Green Silicone Carbide
Iron Cylinder	Aluminium Oxide
Iron Pipe	Aluminium Oxide

Source: Author Analysis (2025)

Figure 1 presents the operator, tripod position, and noise measurement points. Figure 2 shows the distance of the noise measurement points.

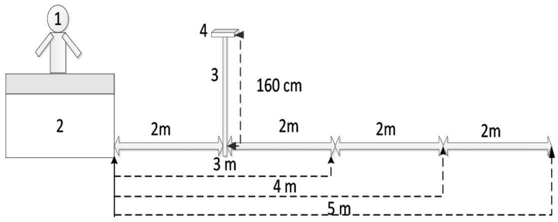

Figure 1.
Operator, Tripod and measurement Position
Source: Author Analysis

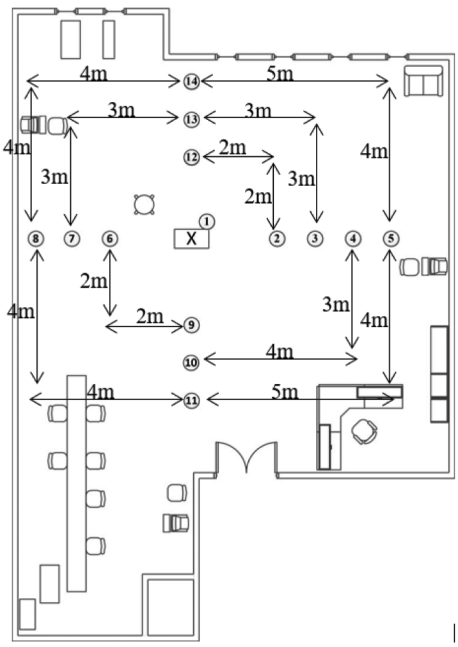

Figure 2.
Distance of Noise Measurement Points
Source: Author Analysis (2025)

Based on the Indonesian Standard SNI (2017) regarding the Method for Measuring Noise Intensity in the workplace, the sound pressure level on the A-weighting scale in decibels is described by the following formula (1):

LpA = 20 log (PA / P0)................................(1)

Where:
LpA = sound pressure level with A-weighting
P0 = reference sound pressure (20 μPa = 2.10^-5 N/m²)
PA = RMS sound pressure with A-weighting (Pascal)
The formula (2) gives the average square value of the equivalent sound pressure level that fluctuates at a specific measurement time.

$$\text{Leq}\ (\text{T}) = 10 \log \left(\frac{1}{\text{T}} \left(\sum_{i-1}^{t} t_i 10^{0,1Li} \right) \right) \quad .....(2)$$

Where:
Leq = equivalent continuous noise level
T = noise measurement time
t = measurement time at the i-th point
Li = sound intensity level

RESULTS AND DISCUSSION

To determine the noise from the hand grinder, the noise of the unloaded tool was measured at 14 measurement points for 30 seconds. The noise measurement began when the machine was first turned on and was not used for cutting. Table 2 presents the results of the unloaded tool noise measurements at 14 measurement points, and the sound pressure level (SPL) graph at the sound source is shown in Figure 3.

Table 2.
Noise measurement of unloaded tool

Number	Mean (dB)	Leq (dB)	L10 (dB)	L50 (dB)	L90 (dB)
1	94,4	94,6	95,2	94,7	93,8
2	94,3	94,5	95,0	94,6	93,8
3	94,4	94,6	95,1	94,6	93,9
4	94,2	94,4	95,0	94,5	93,8
5	94,3	94,6	95,2	94,6	93,8
6	94,4	94,6	95,2	94,7	93,9
7	94,5	94,7	95,3	94,7	94,0
8	94,3	94,5	95,1	94,6	93,8
9	94,4	94,6	95,2	94,7	94,0
10	94,4	94,6	95,2	94,6	94,0
11	94,4	94,6	95,2	94,7	93,9
12	94,3	94,6	95,2	94,6	93,7
13	94,5	94,7	95,2	94,7	94,0
14	94,5	94,7	95,2	94,7	94,0

Source: Author Analysis (2025)

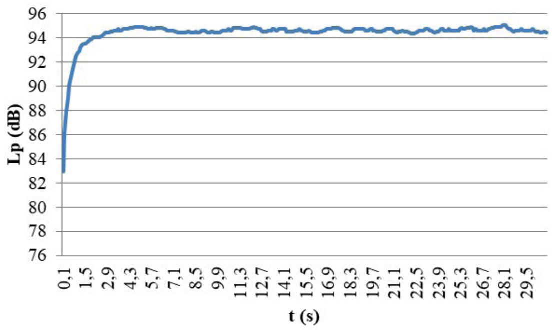

Figure 3.
Noise measurement of unloaded grinding machine, at the sound source
Source: Author Analysis (2025)

From the calculation of the average Leq of the unloaded tool noise, the highest noise levels are found at points 7, 13, and 14, which are located 3 meters west of the sound source, 3 meters north of the sound source, and 4 meters north of the sound source, with a value of 94.7 dB. The Leq at Point 1, or the sound source, is 94.6 dB, with an upper fluctuation limit (L10) of 95.2 dB, while the median fluctuation of the noise (L50) is 94.7 dB, and the lower fluctuation limit (L90) is 93.8 dB. The average Leq at each distance and each material is shown in Table 3.

Table 3.
The average Leq (dB) at each distance

Material	Distance		
	2 m	3 m	4 m
Aluminum Cylinder	95,6	95,6	95,4
Aluminum Plate	96,1	95,9	95,7
Natural Stone	95,4	95,2	95,3
Ceramic	89,6	89,9	88,5
Iron Cylinder	94,1	94,3	94,3
Iron Pipe	94,2	94,2	94,2

Source: Author Analysis (2025)

The average Leq for all materials at a distance of 2 meters is 94.2 dB; at 3 meters, it is 94.2 dB; and at 4 meters, it is 93.9 dB. Therefore, at distances of 2 meters and 3 meters, the noise exposure intensity is the same, while at a distance of 4 meters, the noise exposure decreases by 1.7 dB compared to the 2-meter and 3-meters.

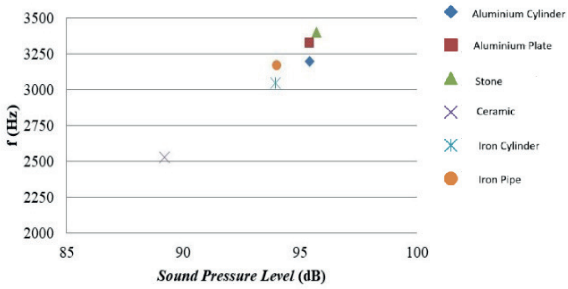

Figure 4.
Frequency and SPL in each material
Source: Author Analysis (2025)

Most material cutting operations have a noise level of more than 94 dB and a frequency of more than 3000 Hz, such as cutting operations on aluminum cylinders, aluminum plates, natural stone, iron pipes, and iron cylinders (Figure 4). The ceramic material has the lowest noise level of all the materials, with a noise level of 89.7 dB and a frequency of 2530 Hz.

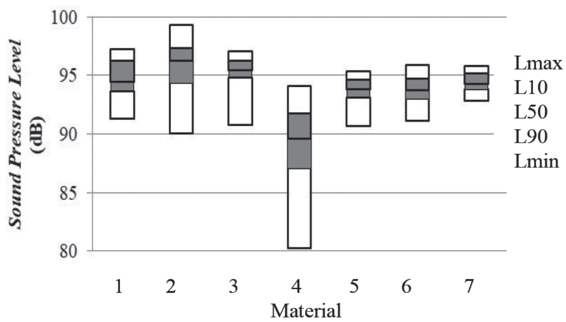

Figure 5.
Noise level distribution of each material (1= Alumunium Cylinder, 2= Alumunium Plate, 3=stone, 4=Ceramic, 5= Iron cylinder, 6=Unloaded)
Source: Author Analysis (2025)

Figure 5 shows that the highest Lmax was produced from cutting an aluminum plate at 97.3 dB, with L10 at 96.3 dB, L50 at 95.4 dB, L90 at 93.7 dB, and Lmin at 91.4 dB. The cutting process with the lowest Lmax was from ceramic material, producing 94.1 dB, with L10 at 91.8 dB, L50 at 89.2 dB, L90 at 87.1 dB, and Lmin at 80.2 dB. For machine noise without load, the Lmax was 95.8 dB, with L10 at 95.2 dB, L50 at 94.7 dB, L90 at 93.8 dB, and Lmin at 92.8 dB.

The Friedman Test was conducted with a confidence level of 95% and $\alpha = 0.05$ to observe the effect of distance at the measurement points on the noise level. The correlation test for materials such as aluminum cylinder, aluminum plate, stone, ceramic, iron cylinder, and iron pipe, with p-values generated from all distances more than 0.05. This indicates that all distances do not affect the noise level of the material-cutting process. The result of the noise measurement sampling area is exposed to the same noise level. Even though the components of the materials differ and the cutting blades used are different, the noise level produced during the material cutting process does not affect it.

In addition, the results of statistical tests to determine the effect of distance and location between measurement points, particularly the measurement points at distances of 2 meters, 3 meters, and 4 meters, on the noise level of material cutting also show that there is no significant effect at each measurement point.

It shows that the noise exposure level received by individuals in the measurement area is the same. In each material cutting, the point with the highest Leq is not always at Point 1 or the sound source due to sound re-flection and wave propagation. Sound reflec-tion from walls or objects around the sound source causes the sound received by the sound level meter at points near the objects or walls to be louder compared to points near the sound source.

Sound wave propagation can also affect the noise intensity received at each measurement point. According to Ver & Beranek (2005), sound or acoustic waves are longitudinal waves, which means their direction of propagation is the same as the direction of vibration, such as sound waves and waves on springs. These waves consist of compression and rarefaction. Compression refers to regions where coils come closer together, while rarefaction refers to regions where coils move apart momentarily. At measurement points with higher Leq than the sound source, this occurs because the point is affected by the compression of the sound wave propagation, resulting in a higher noise level being received.

CONCLUSIONS

The average Leq noise level of the hand grinding machine with the highest load at Point 1 (sound source) was produced by aluminum plate material at 96.1 dB, and the lowest was produced by ceramic material at 89.7 dB. Meanwhile, the Leq noise level of the hand grinding machine without load at the sound source was 94.6 dB. The statistical test results show that the type of material being cut (aluminum cylinder, aluminum plate, Banjar black stone, ceramic, cylindrical iron, and iron pipe) does not significantly affect the noise level produced.

At distances of 2 and 3 meters, the average Leq for all materials was the same, at 94.2 dB, while at 4 meters, the average Leq for all materials was 93.9 dB. Both during material cutting and when the tool was unloaded, the statistical test results showed that the measurement points at 2 meters, 3 meters, and 4 meters at each location (cardinal directions) did not show significant differences in the noise levels.

Based on the noise measurements, most of the Leq values generated from the material cutting were more than 90 dB. According to the noise exposure limits set by Menteri Tenaga Kerja Republik Indonesia (1999), the maximum exposure duration is 2 hours per day without personal protective equipment. If this limit is exceeded, noise control measures need to be implemented. Noise control recommendations that can be applied to workers using hand grinding machines with ceramic, metal (aluminum plate, aluminum cylinder, cylindrical iron, and iron pipe), or natural stone materials include administrative controls and the use of personal protective equipment (PPE) with a noise reduction rating (NRR) adjusted to the workplace noise conditions (20-30 dB) to prevent health disturbances.

Acknowledgements

We would like to express our gratitude to Ergonomics Laboratory Universitas Gadjah Mada for providing the necessary resources and facilities to conduct this research.

BIBLIOGRAPHY

Bakhtiar, Edi Yusuf, & Muhammad Reza Fahlevi. (2023). Analysis of Noise Measurements in the Work Area To the Operator'S Hearing in the Process Department Using the Work Sempling Method. *Multica Science and Technology (Mst) Journal*, *3*(1), 136–141. https://doi.org/10.47002/mst.v3i1.428

Chao, P. C., Juang, Y. J., Chen, C. J., Dai, Y. T., Yeh, C. Y., & Hu, C. Y. (2013). Combined effects of noise, vibration, and low temperature on the physiological parameters of labor employees. *Kaohsiung Journal of Medical Sciences*, *29*(10), 560–567. https://doi.org/10.1016/j.kjms.2013.03.004

Fernández, M. D., Quintana, S., Chavarría, N., & Ballesteros, J. A. (2009). Noise exposure of workers of the construction sector. *Applied Acoustics*, *70*(5), 753–760. https://doi.org/10.1016/j.apacoust.2008.07.014

Menteri Tenaga Kerja Republik Indonesia. (1999). Nilai Ambang Batas Faktor Fisika Di Tempat Kerja Menteri Tenaga Kerja Republik Indonesia. *Kep.51/Men/1999*, 15–20.

Qosim, N. (2022). Analysis of the Noise Level of the Diesel Engine With 1100 Rpm in the Indoor Condition. *Journal of Applied Engineering and Technological Science*, *3*(2), 84–89. https://doi.org/10.37385/jaets.v3i2.406

Singh, L. P., Bhardwaj, A., Deepak, K. K., & Bedi, R. (2009). Occupational noise exposure in small scale hand tools manufacturing (forging) industry (SSI) in Northern India. *Industrial Health*, *47*(4), 423–430. https://doi.org/10.2486/indhealth.47.423

SNI. (2017). Metoda Pengukuran Intensitas Kebisingan di Tempat Kerja. *Standar Nasional Indonesia*, 2000–2001.

Ver, istvan l., & Beranek, leo l. (n.d.). *(Wiley) Noise and Vibration Control Engineering (2005).pdf*.

Wellem, T., Nataliani, Y., & Manongga, D. (2024). *Measurement and Analysis of Noise Levels from Loudspeakers on Public Transportation in Kupang , East Nusa Tenggara Pengukuran dan Analisis Tingkat Kebisingan dari Pengeras Suara pada Angkutan Umum di Kupang , Nusa Tenggara Timur*. *24*(October), 133–147.

Wojtyto, D., Michalik, J., & Angelova, M. (2021). Noise Level Measurement and Analysis in a Manufacturing Enterprise. *System Safety: Human - Technical Facility - Environment*, *3*(1), 192–200. https://doi.org/10.2478/czoto-2021-0020

Zannin, P. H. T., Engel, M. S., Fiedler, P. E. K., & Bunn, F. (2013). Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil. *Cities*, *31*, 317–327. https://doi.org/10.1016/j.cities.2012.09.008