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The Relationship Between Noise and Temperature to the Level of Work Fatigue in Workers in the Cutting Section

Tri Budiyanto[1, *], M. Yusuf[2], Bintang Panjiwani Kusuma As'ari[1]

[1]Industrial Engineering Department, Ahmad Dahlan University, Yogyakarta, Indonesia

[2]Mechanical Engineering Department, Politeknik Negeri Bali, Badung-Bali, Indonesia

Email address:

tri.budiyanto@ie.uad.ac.id (Tri Budiyanto)

[*]Corresponding author

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Abstract: Work fatigue is a decrease in or inability for a person to carry out work activities. Fatigue can occur due to factors in an unsupportive work environment. Workers in the cutting section at Small and medium-sized enterprises (SMEs) Gunungkidul Yogyakarta, Indonesia, carry out the production process in the form of cutting natural stone every day, which is at risk of being exposed to noise and rather high temperatures. Based on the results of the initial measurements, it was found that the level of noise intensity and temperature in the production area exceeded the allowable threshold value. This study aims to determine the relationship between the physical work environment, including noise and temperature, and worker fatigue and then analyze how much influence these factors have and which factors have the most dominant influence on worker fatigue. This study used multiple linear regression methods with randomly selected samples from several SMEs in Gunung Kidul, Yogyakarta. The results showed that the noise factor with a t test value of (4,086 > 2,093) indicated that noise had a positive and significant effect on work fatigue, while the temperature factor, based on the results of the T test, had a calculated T value of (1,787 < 2,093), which means that the temperature has no significant effect on work fatigue. With a coefficient of determination of 0.508 or an effect of 50.8% on worker fatigue.

Keywords: Noise, Temperature, Fatigue, SMEs

1. Introduction

As industrial technology develops in Indonesia, the use of machines that can become a source of noise will also increase. Production machines such as compressors, cutting grinders, and file machines have a fairly high noise level. Noise is all unwanted sounds originating from production process tools or work tools that, at a certain level, can cause hearing loss [1]. In accordance with Minister of Labor Regulations No. 13 of 2011, it has been stated that the threshold value (NAB) for noise is 85 dB with a maximum exposure time of 8 hours per day and 40 hours a week. The effects of noise on workers are physiological disturbances, psychological disturbances, communication disorders, balance disorders, and auditory effects.

Operators or field workers who frequently interact with production equipment are among those affected by the noise. One of the impacts of noise is general fatigue, which is a state of decreased efficiency and endurance at work. This situation is followed by symptoms of physical weakness such as headaches, stiffness in the shoulders, and pain in the back [2, 3].

In addition to noise, another factor that can affect work fatigue is the temperature in the work environment. The working environment's temperature can be higher or lower than the ambient environment's temperature. Environmental temperatures that are too hot or cold can cause disease disorders such as heat cramps, heat exhaustion, heat stroke, and heat loss in hot temperatures. Chilblain and frost bite at cold temperatures [4, 5]. In a cooled room, it will increase work efficiency, but temperatures that are too cold will also reduce it.

Fatigue is divided into two types: muscle fatigue, which is a

state of tremor or feeling of pain in the muscles, and general fatigue, which is a decrease in the desire to work due to monotonous work, work intensity, length of physical work, environment, and mental causes, one of which is noise [3, 6].

According to previous studies, noise ranks first on the list of occupational diseases in America and Europe with a proportion of 35%, while in Indonesia, this figure ranges from 30–50%. [5]. The production process at the Small and medium-sized enterprises (SMEs) cutting limestone in Gunung Kidul Yogyakarta starts with the stone taken from the limestone mountains, and then the white sandstone is brought to SMEs Production place. Furthermore, the sandstone is lowered and will be cut into smaller chunks. After the process of cutting the chunks into smaller pieces, they are then cut according to the customer's order. However, in practice, the production process uses tools that are a source of noise, namely a cutting and grinding machine to cut white sandstone according to the specified size. Workers who are in the production section are exposed to noise directly. The average noise level ranges from 94–104 dB when the machine is cutting white sandstone and 93 dB at idle. The average temperature measured on the cutting section ranges from 30 to 32°C.

Based on the results of the initial survey research, which included field observations and interviews with workers, data was obtained showing that noise in the process of cutting white sandstone was quite disturbing to workers in the production process, where the results of observations that had been made with high noise levels above the standard average exceeded the threshold value. The allowable limit (NAV), which is 85 dBA for 8 hours of work as stipulated in the Decree of the Minister of Manpower Number Kep.13/Men/X/2011 [7], This causes workers to feel tired quickly and experience hearing loss. This situation is indicated by the presence of workers who are often sleepy, feel thirsty quickly, and speak in a high tone when carrying out production activities. This symptom is a sign of work fatigue.

To find out whether it is true that high noise and temperature cause work fatigue, it is deemed necessary to conduct research on the relationship of noise and temperature to the level of work fatigue in workers in the white sandstone cutting section.

2. Methods

This research was conducted using a correlational design to determine how much influence noise and temperature have on worker fatigue. The analytical method used is multiple linear regression to explore the relationship pattern between the dependent variable and the two independent variables [8]. The samples used were all from employees of SMEs in Gunung Kidul, Yogyakarta, Indonesia, in the limestone cutting section. Noise is measured using a sound level meter placed near the worker's ear. Room temperature is measured using a thermometer placed near the worker's body. Fatigue in general can be predicted using 30 fatigue items from the Japanese IFRC (Industrial Fatigue Research Committee) with four Likert scales. This questionnaire consists of three categories: weakened activity (items 1–10), decreased motivation (items 11–20), and physical exhaustion (items 21–30).

Measurements of temperature and noise are carried out from 8:00 in the morning when workers start work until 16:00 in the afternoon when workers have finished working. Measurements were repeated for up to two consecutive weeks. Meanwhile, fatigue measurements were carried out in the morning before work and in the afternoon after work. Regression analysis was carried out by calculating the partial test (t test), simultaneous test (F test), and coefficient of determination (R2) to find out how much influence noise and temperature have on worker fatigue. The analysis was carried out at a significance level of 95% or an alpha value of 5% (0.05).

3. Results and Discussion

3.1. Results of Multiple Linear Regression Analysis

Analysis of Multiple Linear Regression Equations is carried out by looking at the Unstandardized Coefficients section, where to model regression whose function is to predict the future picture with past data [9]. Based on the results of the regression analysis performed, the results of the linear regression equation are as follows:

$$Y = 0.236 + 0.644\ X1 + 0.367\ X2 \quad (1)$$

Variable descriptions in the equation above are:
Y: Fatigue
X1: Noise
X2: Temperature

Based on the results of the equation, the constant or intercept value is 0.236. The positive sign means that it shows a unidirectional influence between the independent variable and the dependent variable.

a) X1 = 0.644, or 64.4%; this shows that every time there is an increase in the noise indicator, it can increase the fatigue variable by 0.644. The positive sign means that it shows a unidirectional influence between the independent variable and the dependent variable.
b) X2 = 0.367, or 36.7%; this shows that every time there is an increase in the temperature indicator, it can increase the fatigue variable by 0.367. The positive sign means that it shows a unidirectional influence between the independent variable and the dependent variable.

3.2. Results of Partial Test Analysis (t-test)

A partial test is used to test the significant level of influence of the independent variables partially on the dependent variable [10]. Partial test results show that:

a) Noise (X1)

The noise variable has a significance value of 0.001 and a calculated T value of 4,086. so that it can be concluded that if the significance value is alpha (0.001 < 0.05) and T count (4.086 > 2.093), then Hypothesis 1 (H1) is accepted, meaning

that the noise variable has a significant positive effect on worker fatigue in the cutting section.

b) Temperature (X2)

The temperature variable has a significance value of 0.090 with a calculated T value of 1,787, so it can be concluded that if the significance value is alpha (0.090 > 0.05) and Tcount (1.787 < 2.093), then Hypothesis 2 (H2) is rejected, meaning that the temperature variable has no significant effect against worker fatigue in the cutting section.

3.3. Results of Simultaneous Test Analysis (Test F)

The F test aims to determine whether all independent variables have a significant effect on the dependent variable [11]. In this study, the significance level of the f statistic test used was 5% (0.05), which means that the risk of making a decision error is 0.05. The results of the F test show that the significance value is 0.001 and the F count is 9.827. So that 0.001 < 0.05 and 9.827 > 2.81, it can be concluded that if Hypothesis 3 (H3) is accepted, it means that the noise and temperature variables simultaneously (together) affect the fatigue variable.

3.4. Testing the Coefficient of Determination (R2)

The coefficient of determination test (R2) is used to determine the contribution made by a variable or more X (independent) to variable Y (bound) [9, 11]. Based on the test results, it can be seen if the coefficient of determination (adjusted R square) obtained is worth 0.508 or 50.8%. This means that 50.8% of worker fatigue in the cutting section is influenced by noise and temperature variables. While the remaining percentage of 49.8% of workers' fatigue in the production room is influenced by other variables not examined in this study.

3.5. Effect of Noise on Worker Fatigue

The results of data processing in this study indicate that the noise variable has a regression coefficient value of 0.657, a T count of 4.086, and a significance level of 0.001. So it can be concluded that the noise variable succeeded in testing the first hypothesis "noise has a significant positive effect on worker fatigue". This is relevant to research explaining that there is a positive effect between noise variables on worker fatigue [12, 13]. There is a relationship between noise intensity and employee fatigue [14].

3.6. Effect of Temperature on Worker Fatigue

The results of data processing in this study indicate that the temperature variable has a regression coefficient value of 0.287, a t count of 1.787, and a significance level of 0.090. It can be concluded that the temperature variable has not succeeded in testing the second hypothesis that "temperature has a significant positive effect on worker fatigue". This is relevant to research conducted by A. Pratiwi, which states that increases in temperature, humidity, and noise in the work environment do not have a significant impact on work fatigue in workers [15].

3.7. Effect of Noise and Temperature on Worker Fatigue

Based on the results of simultaneous testing, the calculated F value was 9.287 and the F table was (o) or F calculated > F table (67,297 > 3.49). This shows that noise and temperature have a positive impact on worker fatigue. Judging from the significance of 0.001 or (0.001<0.05), it means that noise and temperature succeeded in testing the fourth hypothesis, namely "noise and temperature have a significant positive effect on worker fatigue". Based on the results of data processing in this study, the R square value was 0.508, or 50.8%, which indicates that 50.8% of the noise and temperature variables affect the fatigue experienced by workers. While the remaining 49.8% is influenced by other variables not examined in this study. This is relevant to research conducted which states that temperature and noise have a significant effect on the physical fatigue of men and women, with a significance value [16].

3.8. Risk Control

Risk control refers to the K3 risk control hierarchy; there are five methods, which can be seen in Figure 1 below:

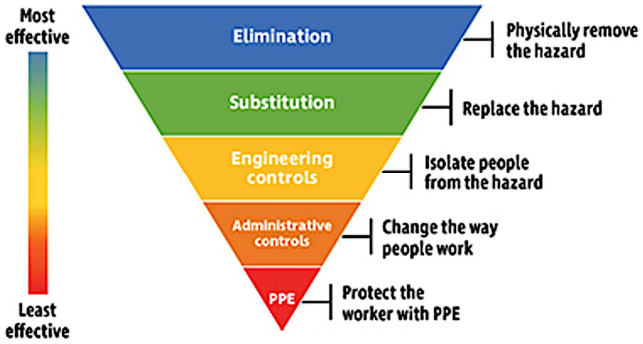
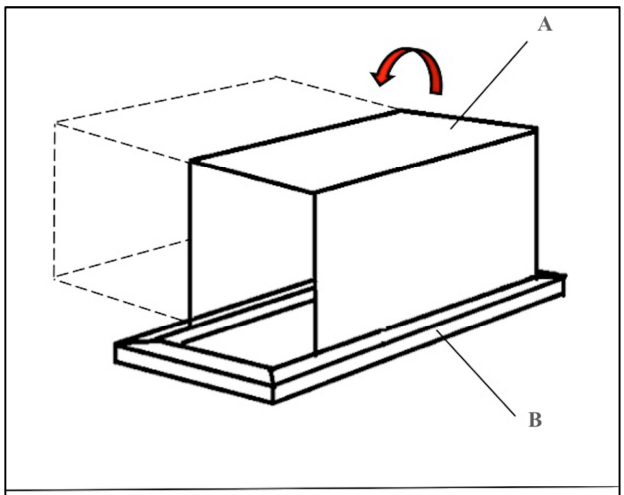


Figure 1. *Hierarchy of risk control [17].*

Based on Figure 1, there are five methods of risk control: elimination, substitution, technological engineering, administration, and use of PPE. Elimination is the first method, namely by eliminating hazardous materials or work processes. Substitution is the second method, namely by replacing materials or processes with safer ones. The third method is technological engineering, which involves making or engineering machines that endanger workers, such as providing protection for machines. The fourth method is administrative by way of job rotation, and the last is the provision of personal protective equipment (PPE) for workers [18, 19].

In this case, the method that might be applied to SMEs Gunung Kidul is by way of technological engineering, administration, and the provision of PPE that meets K3 standards. The technological engineering method is to make a housing for the grinding machine because the existing driving machine does not have a suitable container or place to reduce the sound generated by the machine. The following is the housing design for the existing propulsion engines:



No	Code	Name	Material
1	A	Top cover	Fiber glass
2	B	Framework	Hollow iron

Figure 2. *Housing design.*

For the administrative method, this can be done by reducing the exposure time for workers by setting work and rest times so that their working time is still within safe limits. This work time setting is adjusted between exposure to noise intensity and the maximum time allowed for each work area. What is meant by setting work and rest times is that if the worker is already in a noisy work environment according to the time limit allowed, then the worker must leave the workplace for a few minutes and return to the workplace to work as usual [20-22]. Provision of personal protective equipment (PPE) in MSMEs has indeed been provided. However, this personal protective equipment is still far from standard. For earplugs, only use cotton, and for body coverings, use clear plastic to protect from bits of stone and splashes of water during the cutting process. Therefore, appropriate personal protective equipment is needed, namely in the form of earplugs and appropriate wear packs.

4. Conclusion

Based on the results of the data processing that has been carried out regarding the influence of noise and temperature effect analysis on worker fatigue, it can be concluded that:

a. The Multiple Linear Regression Equation of the effect of noise and temperature on work fatigue is Y = 0.236 + 0.644 X1 + 0.367 X2 (Y: Fatigue, X1: Noise, X2: Temperature), so that it can be stated that the effect of noise is 0.644, or 64.4%, whereas the influence of temperature is 0.367, or 36.7%.
b. As for the effect of noise and temperature on work fatigue simultaneously, it shows a positive and significant effect of 50.8% on work fatigue.
c. One of the technological engineering methods to reduce the effect of noise and temperature on the cutting part is to make a housing for a grinding machine to dampen the sound and temperature generated by the machine.

References

[1] Ministry of Manpower of the Republic of Indonesia, "Minister of Manpower Regulation No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment," 2018.

[2] P. Suma'mur, *Company Hygiene and Occupational Health (HIPERKES)*. Jakarta: Agung Seto, 2013.

[3] K. H. E. Kroemer and E. Grandjean, *Fitting The Task To The Human, Fifth Editione A Textbook Of Occupational Ergonomics*. London: CRC Press, 2009.

[4] J. D. Périard, T. M. H. Eijsvogels, and H. A. M. Daanen, "Exercise under heat stress: thermoregulation, hydration, performance implications, and mitigation strategies," *Physiol. Rev.*, vol. 101, no. 4, pp. 1873–1979, Apr. 2021.

[5] S. Racinais *et al.*, "Consensus recommendations on training and competing in the heat," *Br. J. Sports Med.*, vol. 49, no. 18, pp. 1164 LP – 1173, Sep. 2015.

[6] A. Manuaba, "Accelerating OHS-Ergonomics Program By Integrating 'Built-In" Within The Industry's Economic Development Scheme Is A Must-With Special Attention To Small And Medium Enteprises (SMEs)," in *Proceedings the 21st Annual Conference of The Asia Pasific Occupational Safety & Health Organization*, 2005.

[7] Decree of the Minister of Manpower and Transmigration, *Threshold Value of Work Environment Physical Factors*. 2011, p. Nomor: Kep.13/Men/X/2011. Jakarta. 2011.

[8] G. K. Uyanık and N. Güler, "A Study on Multiple Linear Regression Analysis," *Procedia - Soc. Behav. Sci.*, vol. 106, pp. 234–240, 2013.

[9] E. C. Alexopoulos, "Introduction to multivariate regression analysis.," *Hippokratia*, vol. 14, no. Suppl 1, pp. 23–28, Dec. 2010.

[10] H. Huang *et al.*, "Multivariate linear regression analysis to identify general factors for quantitative predictions of implant stability quotient values," *PLoS One*, vol. 12, no. 10, p. e0187010, Oct. 2017.

[11] T. W. Klaus Backhaus, Bernd Erichson, Sonja Gensler, Rolf Weiber, "Multivariate Analysis," 1st ed., London: Springer Gabler Wiesbaden, 2021.

[12] M. Edem, E. Akpan, and N. Pepple, "Impact of Workplace Environment on Health Workers," *Occup. Med. Heal. Aff.*, vol. 05, no. 02, 2017.

[13] BSN, *Threshold value for working condition under heat, noise, vibration hand-arm, and ultraviolet sun light exposure, SNI 16-7063-2004*. Jakarta: Badan Standarisasi Nasional, 2004.

[14] E. W. Utomo, S. R. Rahayu, and Y. Wijayanti, "Noise Analysis, Lighting, Work Climate, Mechanical Vibration, Work Tenure and Nutritional Status Towards Fatigue," *Public Heal. Perspect. J.*, vol. 5, no. 2, pp. 128–136, 2020.

[15] A. N. Pratiwi, "The Correlation between Physical Environmental Factors and Fatigue of The Workers at Ship Repair Workshop Hubungan Faktor Lingkungan Fisik dengan Kelelahan pada Pekerja Workshop Reparasi Kapal," *Indones. J. Occup. Saf. Heal.*, vol. 8, no. 3, pp. 274–282, 2019.

[16] A. M. Abbasi, E. Darvishi, M. A. Rodrigues, and K. Sayehmiri, "Gender differences in cognitive performance and psychophysiological responses during noise exposure and different workloads," *Appl. Acoust.*, vol. 189, p. 108602, 2022.

[17] NIOSH, "Hierarchy of Controls," *CDC - Centers for Desease Control and Prevention*, 2022. [Online]. Available: https://www.cdc.gov/niosh/learning/safetyculturehc/module-3/2.html. [Accessed: 19-Jun-2023].

[18] R. S. Bridger, *Introduction to Ergonomics, 3rd Edition*. London: Taylor & Francis, 2008.

[19] A. Manuaba, "Total approach is a must for small and medium enterprises to attain sustainable working conditions and environment, with special reference to Bali, Indonesia," *Ind. Health*, vol. 44, no. 1, pp. 22–26, 2006.

[20] M. Yusuf, "Design of Jewel Stone Sharpener to Increase Jewel Worker Work Productivity in Bali," in *International Conference on Engineering, Technology, and Industrial Application (ICETIA)*, 2014, pp. 353–357.

[21] T. Budiyanto and M. Yusuf, "Improvement of Wok Molding Station Increases Work Comfort and Productivity of the Workers," *Int. J. Psychosoc. Rehabil.*, vol. 24, no. 4, pp. 8883–8892, 2020.

[22] I. K. G. J. Suarbawa, M. Arsawan, M. Yusuf, and I. M. Anom Santiana, "Improvement of environment and work posture through ergonomic approach to increase productivity of balinese kepeng coin workers in Kamasan village Klungkung Bali," in *Journal of Physics: Conference Series*, 2018.