Volume 1 Nomor 4 2024
E-ISSN: 3032-1301

https://economic.silkroad-science.com/index.php/IJEIRC

THE IMPACT OF TEMPERATURE ON OPERATOR FATIGUE IN THE DYEING MILLS OF XYZ COMPANY IN BANDUNG

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Article Info

Article history:
Received Feb 21, 2024
Revised March 16, 2024
Accepted Apr 17, 2024

Keywords:
Suhu, Fatigue, IFRS, dyeing mills

ABSTRACT

This study aims to investigate the impact of temperature on the fatigue level of operators in Dyeing Mills within the XYZ company environment in Bandung. The research method used is quantitative, employing a simple linear regression approach. The research sample consists of permanent employees in the production department, selected by purposive sampling. Data is collected by the measurement of ambient temperature at the workplace and the completion of the IFRC Japan questionnaire that measures the level of work fatigue. Data analysis indicates a significant correlation between ambient temperature and operator fatigue levels. The results indicate that employees working in higher temperature conditions tend to experience higher levels of fatigue. The implication of this research is the importance for companies to pay attention to the working environment conditions, particularly ambient temperature, as a factor that might affect the well-being and productivity of employees. This finding contributes to the understanding of the influence of the work environment on employee well-being, and provides a basis for companies to take necessary steps to reduce work fatigue and enhance productivity.

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INTRODUCTION

The textile industry encounters many obstacles within its business area.. The commodities in this industrial group include spun yarn, woven fabric, synthetic staple fibers, synthetic filament fibers/yarn/strips, knitted fabric, embroidered fabric, textile fibers, silk, and other textile goods. According to data from the Central Statistics Agency (BPS), the performance of Indonesia's textile industry exports weakened in 2023. Thus,

the performance of Indonesia's textile industry exports has weakened for two consecutive years, namely in 2022 and 2023. Even in 2023, the export volume was smaller than during the pandemic, marking the lowest record in the past nine years [1].

The textile manufacturing process is indeed complex and involves several distinct stages, starting with raw fibers and culminating in finished fabric. The initial stage involves the selection of textile fibers to be used, such as cotton, wool, or synthetic fibers. The carding process involves combing the fibers to make them smoother and more uniform. The process of spinning involves converting fibers into yarn. There are several spinning methods used, including ring spinning, rotor spinning, and jet spinning. After the thread is spun, the next step is coloring [2]. This process involves the utilization of dyes to impart color to the thread. Next, there is a stage called Twisting which involves the re-spinning of a single thread or many twisted threads to enhance the strength and durability of the thread. After the thread is spun and dyed, the next step is weaving. Proses ini melibatkan pengaturan benang secara saling melintang untuk membentuk kain. After weaving, the fabric can undergo several further processing stages such as washing, finishing, or the application of additional protective coatings, depending on the requirements [4].

This research focuses on PT. XYZ, which specializes in the Dyeing process, namely in dyeing yarn and fabric. The dyeing process in yarn production is the stage where the yarn fibers are colored using dye substances to get specific colors according to the requirements. This process is crucial as it imparts color to the thread, which will subsequently be used to create fabric or other textile products. The process of dyeing not only involves adding color, but also affects the quality and color fastness of the fabric or textile product. Through the application of precise coloring technology, manufacturers may achieve consistent and durable color results, while also controlling the efficiency of raw material and water usage.

Furthermore, coloring also influences the aesthetic aspect of the product, which is highly crucial in the textile industry. Therefore, the dying process is a fundamental and crucial process for the quality of the resulting products.

The dyeing process is closely associated with the use of chemicals at high temperatures, noisy machinery, and various other job characteristics that pose potential

occupational hazards. Therefore, it is expected that the employees involved in this process pay attention to Occupational Health and Safety (OHS) in every activity to prevent potential work accidents that could result in losses.

Some potential occupational hazards that may occur during the dyeing process include exposure to hazardous chemicals such as dyes and binders, which can cause skin irritation, respiratory problems, or even organ damage if not properly handled. In addition, the high temperature used in the dyeing process increases the risk of burns or injuries for workers who do not adhere to proper safety procedures, such as using appropriate personal protective equipment.

The temperature component is one of the crucial aspects of the work environment that can significantly impact employee performance. Temperature that is not appropriate can impact the comfort, well-being, and productivity of employees in several ways. Extreme temperatures might cause physical discomfort for employees. Under excessively high temperatures, employees may experience fatigue, dehydration, and decreased concentration. On the other hand, too low temperatures can cause employees to shiver, have difficulty concentrating, and even increase the risk of contracting illnesses such as the flu or cold. In addition, uncomfortable temperatures can disrupt the sleep quality of employees, which in turn can impact their performance and alertness in the workplace. Inappropriate temperature can also affect employees' energy usage, as colder temperatures may require more energy for body heating, while hotter temperatures can increase fatigue.

On the other hand, tiredness in the production activities carried out at PT XYZ can be highly hazardous due to several risk factors, including high temperatures, exposure to chemicals, and potentially harmful products. When employees experience fatigue, their ability to concentrate, pay attention to detail, and make accurate decisions might be disrupted, hence increasing the risk of accidents and injuries. This can occur due to exposure to high temperatures in the production work environment, which has the potential to cause fatigue as the body has to work harder to maintain a stable body temperature.

When the body temperature is too high, employees may experience physical fatigue resulting in reduced performance and inability to work efficiently. Furthermore, high temperatures might also elevate the risk of dehydration and faster fatigue.

According to data from the International Labour Organization (ILO) in 2010, about two million workers die each year as a result of work-related accidents caused by fatigue. If a worker experiences a work-related accident due to fatigue, it will directly impact the level of work productivity.

The environmental factor in this company also poses a problem for its employees, as the temperature in the work area tends to be high. This is due to the fact that the work area is not equipped with air conditioning facilities, just relying on air ventilation. Based on the temperature measurements conducted by the researchers, the room temperature reached 31°C. According to the Decision of the Minister of Health of the Republic of Indonesia No. 1405/MENKES/SK/XI/2002, the standard for health in industrial workspaces is a temperature that is neither too cold nor too hot for employees, ranging from 18-30ºC, with a minimum ceiling height of 2.5 m [5].

This study aims to investigate the impact of temperature on operator fatigue in the Dyeing Mills of XYZ Company in Bandung. This demonstrates a focus on two key aspects: the ambient temperature of the work environment and its impact on the well-being and performance of employees, particularly operators in dyeing mills. The novelty of this research lies in the profound understanding of how the ambient temperature in the workplace, which can be influenced by several factors in the work environment, particularly the environmental temperature. The research gap in this study may lie in the lack of comprehensive understanding of how the specific environmental temperature in the workplace specifically affects operator fatigue in dyeing mills. Previous research may have covered certain aspects of the work environment or employee well-being, but it may not have specifically focused on operators in the Dyeing Mills industry and the impact of temperature on their fatigue levels. This has sparked the interest of researchers to conduct a study on the "Effect of Temperature on Fatigue of Dyeng Mills Operators in the XYZ Company Environment in Bandung."

METHODS

This study is a quantitative research, which refers to a research approach that utilizes numerical data and statistics to address research questions. In quantitative research, data is collected and analyzed objectively and measurably, allowing for broader generalizations to be made.

This study utilized a sample of employees from PT XYZ Dyeing mills, with a specific focus on permanent employees in the production department. The sampling technique used is non-random sampling, specifically purposive sampling, where the sample is selected based on specific criteria that align with the research objectives. This aims to ensure that the sample represents a relevant population for this study.

Data collection was conducted using a questionnaire from the Japanese IFRC consisting of 30 questions with 4 answer choices. This questionnaire has previously been tested for its reliability and validity by other researchers, making it a reliable tool for measuring work fatigue. In addition, primary data is also collected by the measurement of ambient temperature at the location where the respondents work. Ambient temperature measurement is conducted to provide direct data on the working environment conditions that can affect the level of work fatigue.

The data analysis in this study was conducted using simple linear regression analysis, which aims to understand the direct relationship between the independent variable (e.g., ambient temperature) and the dependent variable (e.g., work fatigue level). By employing this approach, researchers may assess the extent to which ambient temperature affects the level of work fatigue among employees at PT XYZ Dyeing mills, as well as get a deeper understanding of the factors influencing work fatigue in the industrial context.

RESULTS AND DISCUSSION

Demographic Analysis of Research Respondents

Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	29	58.0	58.0	58.0
Female	21	42.0	42.0	100.0
Total	50	100.0	100.0	

Based on the demographic data, it can be observed that the majority of production employees at Dyeing Mills PT XYZ are male (58%) compared to female (42%).

Age of Respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
< 21 year	12	24.0	24.0	24.0
21-35 year	15	30.0	30.0	54.0
35-50 year	10	20.0	20.0	74.0
> 50 year	13	26.0	26.0	100.0
Total	50	100.0	100.0	

Generally, the age distribution of employees at PT XYZ Dyeing Mills is very even, with the highest percentage (30%) belonging to the age group of 21-35 years. However, a significant majority of employees (46%) are still above the age of 35, indicating diversity in experience and career needs.

Duration of work

	Frequency	Percent	Valid Percent	Cumulative Percent
< 1-2 tahun	12	24.0	24.0	24.0
2-5 tahun	15	30.0	30.0	54.0
5-10 tahun	10	20.0	20.0	74.0
> 10 tahun	13	26.0	26.0	100.0
Total	50	100.0	100.0	

In terms of working hours, the distribution of employees at PT XYZ Dyeing Mills is also quite equal, with the majority (56%) having worked there for less than five years.

Divisi

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pigment and Chemical	13	26.0	26.0	26.0
	Jet, Spin	14	28.0	28.0	54.0
	Coloring Bath	11	22.0	22.0	76.0
	Boiler	12	24.0	24.0	100.0
	Total	50	100.0	100.0	

Regarding the division, the distribution of employees at PT XYZ Dyeing Mills is fairly balanced, with the majority of employees spread throughout the Pigment and Chemical division (26%) and the Jet, Spin division (28%).

Ambient temperature at the workplace

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Relatively low (< 26C)	14	28.0	28.0	28.0
	Heat Presentation (26-32C)	20	40.0	40.0	68.0
	Hot (>32C)	16	32.0	32.0	100.0
	Total	50	100.0	100.0	

When it comes to ambient temperature exposure in the workplace, the majority of employees at PT XYZ Dyeing Mills (40%) experience exposure to high temperatures (26-32°C).

Fatique Score

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30-52 (klasifikasi Rendah)	13	26.0	26.0	26.0
	53-75 (klasifikasi Sedang)	14	28.0	28.0	54.0
	76-98 (klasifikasi Tinggi)	7	14.0	14.0	68.0
	99-120 (klasifikasi Sangat Tinggi)	16	32.0	32.0	100.0
	Total	50	100.0	100.0	

According to the IFRS-based fatigue classification, the majority of employees at PT XYZ Dyeing Mills (32%) reported having fatigue that was very high (ranging from 99 to 120), while 28% reported having fatigue that was low (ranging from 53 to 75). This indicates that there is a risk that is significant for employee well-being, particularly related to sleep patterns and high levels of exhaustion.

Measuring Tool Validity Test

The validity test is used to measure to what extent the data contained in the questionnaire can measure the validity of the questionary. A questionnaire is deemed valid when the question is effective in describing the things that the questionary wants to measure [7].

One method used to test validity is by comparing the counted r value with the table r value. If the counting r value obtained from the calculation or testing using the SPSS program is greater than the corresponding table r, then the question is considered valid [11].

Variable	No item	korelasi pearson	kriteria	keterangan
Fatigue Score	IFRS_01	.861**	.282	valid
	IFRS_02	.840**	.282	valid
	IFRS_03	.839**	.282	valid

Variable	No item	korelasi pearson	kriteria	keterangan
	IFRS_04	.877**	.282	valid
	IFRS_05	.815**	.282	valid
	IFRS_06	.870**	.282	valid
	IFRS_07	.860**	.282	valid
	IFRS_08	.862**	.282	valid
	IFRS_09	.799**	.282	valid
	IFRS_10	.871**	.282	valid
	IFRS_11	.831**	.282	valid
	IFRS_12	.824**	.282	valid
	IFRS_13	.833**	.282	valid
	IFRS_14	.903**	.282	valid
	IFRS_15	.835**	.282	valid
	IFRS_16	.827**	.282	valid
	IFRS_17	.873**	.282	valid
	IFRS_18	.859**	.282	valid
	IFRS_19	.851**	.282	valid
	IFRS_20	.864**	.282	valid
	IFRS_21	.847**	.282	valid
	IFRS_22	.843**	.282	valid
	IFRS_23	.864**	.282	valid
	IFRS_24	.873**	.282	valid
	IFRS_25	.808**	.282	valid
	IFRS_26	.850**	.282	valid
	IFRS_27	.824**	.282	valid
	IFRS_28	.864**	.282	valid
	IFRS_29	.840**	.282	valid
	IFRS_30	.848**	.282	valid

In the context of a table r (Pearson Product Moment) with a degree of significance of 0.05, when the number of samples (N) is 50, then the table r value obtained is 0.282. Therefore, if the resulting count r value is greater than the table's r value, then the question can be considered valid. It was found that the items studied had a correlation value > t table of 0.282. Thus, the items used to measure fatigue have good validity.

Reliability Test

Reliability test is a method for evaluating a questionnaire that is an indicator of a particular variable or construction. A questionnaire is considered to be reliable or reliable if a person's response to the statements in the questionnary is consistent over time.[6]. In this study, the technique used to measure reliability is by using the Cronbach's Alpha coefficient. A variable is considered reliable if the obtained value is greater than 0.7 [7]. Basic decision-making related to instrument reliability is as follows:

a) If the Cronbach's Alpha (α) value is greater than 0.7, then the statement in the questionnaire is considered reliable.
b) If the value of Cronbachs Alpha (a) is less than 0.7 then the questioner's statement is considered unworthy to be used. (not reliable).

Reliability Statistics

Cronbach's Alpha	N of Items
987	30

Based on the table, the relative value for the fatigue score was 0.987. Thus, if Cronbach's Alpha value (α) is greater than 0.7, then the statement in the questionnaire is considered reliable for both variables.

Classical Assumption – Normality Test

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		50
Normal Parameters[a,b]	Mean	0E-7
	Std. Deviation	8.45586361
Most Extreme Differences	Absolute	.091
	Positive	.044
	Negative	-.091
Kolmogorov-Smirnov Z		.645
Asymp. Sig. (2-tailed)		.800

a. Test distribution is Normal.
b. Calculated from data.

Test of classical assumptions – heterosexuality

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-7.390E-015	10.247		.000	1.000
	Suhu rata-rata pos kerja	.000	.359	.000	.000	1.000

a. Dependent Variable: Unstandardized Residual

Test regression equation

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-108.109	10.247		-10.550	.000
	Suhu rata-rata pos kerja	6.485	.359	.934	18.087	.000

a. Dependent Variable: Fatigue Score

The author uses a double linear regression method that corresponds to the research problem studied. Therefore, the data analysis technique applied is a model for the analysis of double lineary regression formulated as follows:

$$Y = a + bX+3$$

$$Y = -108.109 + 6.485\ x$$

In this formula:
- Y is a variable that represents fatigue
- a is a constant.
- b is a regression coefficient
- X is the variable Average temperature post work
- e is a measurement error or error in the model.

Test the hypothesis (Uji t)

The t-test is primarily used to assess the magnitude of the individual influence of an independent variable in explaining a dependent variable[9]. Ini adalah prinsip dasar dalam mengambil keputusan untuk uji t :

a) If the significance value is more than the alpha value (α = 5% or 0.05) (sig. > 0.05) and the calculated t-value is less than the critical t-value, then the null hypothesis (H_o) is accepted and the alternative hypothesis (H_a) is rejected. This indicates that the independent variable does not have a significant individual impact on the dependent variable.
b) If the significance value is smaller than the alpha value (α = 5% or 0.05) (sig. < 0.05) and the calculated t-value is greater than the critical t-value, then the null hypothesis (H_o) is rejected and the alternative hypothesis (H_a) is accepted. This indicates that the independent variable has an individual influence on the dependent variable.

The hypothesis being tested is :

- H0: There is no influence of the average workplace temperature on the tiredness scores of employees at PT XYZ Dyeing mills.
- Ha: There is an influence between the average temperature of the post of work on the fatigue score of employees of PT XYZ Dyeing mills

Thus, the t-statistic test provides information on the individual influence of each independent variable on the dependent variable in the model. The critical t-value for df = 50-1 is 2.000. Based on the table above, in this Hypothesis Test, a significance value of 0.000 was obtained, which is smaller than the alpha value (α = 5% or 0.05) (sig. < 0.05), and the calculated t-value (10.087) is more than the critical t-value (2.000). Therefore,

the null hypothesis (H_o) is rejected and the alternative hypothesis (H_a) is accepted. This indicates that the independent variable has an individual influence on the dependent variable. This implies that there is a correlation between the average workplace temperature and the fatigue scores of employees at PT XYZ Dyeing mills.

Calculating the Coefficient of Determination

According to [8], the purpose of the coefficient of determination test is to evaluate the extent to which independent variables may explain the variation in the dependent variable, as expressed through adjusted R^2. The use of modified R^2 is chosen because this study involves more than two independent variables. The adjusted R^2 value ranges between 0 and 1.

Model Summaryb

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.934[a]	.872	.869	8.54349

a. *Predictors*: (*Constant*), Suhu rata-rata pos kerja
b. *Dependent* Variable: *Fatigue Score*

The obtained R square (R2) value is 0.872. Thus, the value of the coefficient of determination (KD) is obtained as 0.872 x 100 = 87.2%. Thus, it is found that the influence of temperature on fatigue score is 87.2%. Meanwhile, the remaining 12.8% is attributed to unexplored variables in other studies.

DISCUSSION

Elevated ambient temperature in the workplace can lead to discomfort and disrupt the physical and mental well-being of employees. The discomfort can include increased exhaustion, dehydration, and sleep disturbances, which in turn can contribute to the onset of fatigue. Fatigue or tiredness can occur as a response to various factors, including suboptimal working conditions.

Elevated outside temperature can increase the body's need to maintain a stable internal temperature through processes such as sweating, which requires additional energy. Employees may also experience increased fatigue and difficulty concentrating when consistently exposed to high temperatures[12].

From the hypothesis test, H_o is rejected and H_a is accepted. This indicates that the independent variable has an individual influence on the dependent variable. This implies that there is a correlation between the average workplace temperature and the fatigue score of employees at PT XYZ Dyeing mills. The occurrence of this positive influence can be attributed to several factors. Overall, there can be a positive influence between the ambient temperature in the workplace and weariness, which can occur through various interrelated mechanisms [13]. The increase in environmental temperature can disrupt the

body's equilibrium and affect several physiological systems, ultimately leading to an increase in feelings of tiredness and exhaustion among employees.

Firstly, high environmental temperature can result in increased fluid loss from the body through the process of sweating. Apabila seorang pekerja kehilangan sejumlah besar cairan tubuh tanpa mendapatkan penggantian yang memadai, hal ini dapat mengakibatkan terjadinya dehidrasi [14].

Secondly, high environmental temperatures can also impose additional stress on the body's recovery system. When the body consistently strives to maintain an optimal internal temperature, it can disrupt the usual recovery processes that occur during rest. Consequently, employees may experience increased fatigue and reduced vitality even after sufficient rest.

Thirdly, continuous exposure to high environmental temperatures might lead to thermal stress on the body [15]. Thermal stress occurs when the body is unable to rapidly or efficiently dissipate the heat generated by physical activity and high environmental temperatures. This can result in an elevation of core body temperature, which in turn can lead to decreased physical and mental performance, as well as increased fatigue.

CONCLUSION

The conclusion that can be drawn from this research is as follows:
When it comes to ambient temperature exposure in the workplace, the majority of employees at PT XYZ Dyeing Mills (40%) experience exposure to high temperatures (26-32°C). The classification of fatigue according to IFRS indicates that the majority of employees at PT XYZ Dyeing Mills (32%) experience a very high level of fatigue (99-120), while 28% experience a moderate level of fatigue (53-75). This indicates a significant risk to employee well-being, particularly in relation to high temperature exposure and fatigue levels. In this Hypothesis Test, a significance value of 0.000 was obtained, which is smaller than the alpha value (α = 5% or 0.05) (sig. < 0.05), and the calculated t-value (10.087) is more than the critical t-value (2.000). Therefore, the null hypothesis (H_o) is rejected and the alternative hypothesis (H_a) is accepted. This indicates that the independent variable has an individual influence on the dependent variable. Ini menunjukkan bahwa ada hubungan antara suhu rata-rata di tempat kerja dengan skor kelelahan karyawan di PT XYZ Dyeing mills.

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