JUSTEK : JURNAL SAINS DAN TEKNOLOGI
http://journal.ummat.ac.id/index.php/justek
ISSN 2620-5475
Vol. 9, No. 3, September 2026, pp. 407-419

Fatigue Level and Operator Performance Analysis Across Shifts Based on Reaction Time and Swedish Occupational Fatigue Inventory Method in Small and Medium Industries of Tegal Regency

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ARTICLE INFO

Article History:

Received : 27-07-2026
Revised : 14-09-2026
Accepted : 15-09-2026
Online : 17-09-2026

Keywords:
Work Fatigue;
Reaction Time;
Work Shift;
SOFI;
Operator Performance;

ABSTRACT

Work fatigue in shift systems has the potential to reduce alertness, slow response time, and decrease operator performance, thereby affecting occupational safety and productivity. This study aims to analyze differences in fatigue levels and operator performance between the morning and afternoon shifts at PT. ABC, a manufacturing company located in Tegal Regency. A quantitative approach with a descriptive, comparative, and correlational design was employed. The study involved 14 production operators, all of whom were selected as respondents using total sampling (saturated sampling). Fatigue levels were measured using the Swedish Occupational Fatigue Inventory (SOFI), while operator performance was assessed through reaction time to visual, auditory, and motor stimuli. Data were analyzed using a paired-samples t-test to examine differences between shifts and Pearson correlation to determine the relationship between fatigue and reaction time. The results showed that fatigue levels were higher during the afternoon shift across all SOFI dimensions, with the largest increases in lack of motivation (128.99%) and physical discomfort (107.98%). Reaction time was also slower during the afternoon shift across all stimuli, with the largest increase in motor reaction time (18.90%). The paired-samples t-test showed significant differences between shifts in all SOFI dimensions and reaction time ($p < 0.05$). Pearson correlation analysis revealed a significant positive relationship between fatigue and reaction time, indicating that higher fatigue was associated with longer response times. Production output was also lower during the afternoon shift, decreasing by 14.36% for Operators 1–7 and 34.35% for Operators 8–14. The company is recommended to implement structured rest periods and periodic fatigue monitoring, particularly during the afternoon shift, to maintain operator performance and minimize safety risks.

A. INTRODUCTION

Work fatigue remains one of the problems affecting worker safety and productivity in the manufacturing industry sector. Based on data from Ketenagakerjaan Dalam Data (KDD) Edition 1 of 2024, the number of work accident cases in Indonesia up to Semester II of 2023 was recorded at 370,747 cases sourced from the Work Accident Insurance (JKK) program of BPJS Ketenagakerjaan, with the majority, namely 347,855 cases or approximately 93.8% of the total, being formal workers employed under companies, including manufacturing industry operators (Zulfiyadi et al., 2024), This figure indicates that the rate of work accidents in Indonesia still shows a trend that requires attention.

(Cunningham et al., 2022) emphasized that the risk of work fatigue is not evenly distributed among all groups of workers, but tends to be higher among worker groups with greater occupational vulnerability, one of which is workers under shift work systems. One of the contributing factors to work accidents is work fatigue, a condition that causes a decline in workers' physical and mental capacity to perform their duties optimally (Sarbena & Sofiyanurriyanti, 2021). This decline can reduce alertness, increase the risk of work errors, and diminish workers' ability to maintain performance during work. (Moreira & de Lucca, 2024) xplained that fatigue resulting from continuous work activity can impair cognitive function, alertness, and workers' ability to respond to job demands, thereby affecting both safety and work productivity.

The implementation of shift work systems is a form of working time arrangement widely applied in the manufacturing industry to maintain the continuity of the production process (Darmawan et al., 2022). Although it provides benefits for companies by improving operational time utilization, the shift work system also has the potential to cause circadian rhythm disruption, reduce sleep quality, and decrease the body's recovery time after work (Pramono, 2025). Circadian rhythm disruption caused by the mismatch between work schedules and the body's biological clock has also been confirmed by (Mul Fedele et al., 2024) and (Potter & Wood, 2020), who explained that differences in shift timing can affect sleep regulation, body temperature, and workers' alertness levels throughout the day. This condition makes workers more susceptible to physical and mental fatigue, which affects their ability to maintain work performance. A study by (Ritonja et al., 2019) explained that shift work arrangements are associated with increased fatigue, decreased alertness, slower response times, and an increased risk of errors or work accidents when not balanced with adequate rest time management. Therefore, evaluating fatigue levels among shift workers becomes important as a basis for maintaining occupational safety and sustaining company productivity.

PT. ABC is a manufacturing company in Tegal Regency that implements a two-shift work system, which has the potential to create differences in fatigue levels and operator performance between shifts. Based on preliminary observations of six production operators, all operators (6/6) reported experiencing fatigue after work, particularly sleepiness and muscle soreness toward the end of the *shift*. Four operators (66.7%) reported feeling more fatigued during the afternoon *shift*, while four operators (66.7%) reported a decline in work speed toward the end of the *shift*. These conditions were supported by production *output* data, which showed an average *output* of 547,657 units during the morning *shift* and 400,608 units during the afternoon *shift*. These preliminary findings indicate differences in operator fatigue and performance across *shifts* that warrant further investigation. Work fatigue measurement can be carried out using the Swedish Occupational Fatigue Inventory (SOFI), which is able to assess fatigue based on five dimensions. This instrument has been widely used in ergonomics research because it is able to provide a multidimensional depiction of fatigue levels (Suparmam et al., 2022). In addition to measuring fatigue levels, an assessment of operator performance is also necessary to determine the impact of fatigue on workers' ability to perform their tasks. One indicator that can be used is reaction time, namely the time required by an individual to provide a response after receiving a stimulus (Yazmin et al., 2025). The higher the reaction time value, the longer the time required by the operator to respond to a stimulus, indicating a decline in operator performance (Kazemi et al., 2016) Research on shift work shows that the accumulation of fatigue can reduce alertness, slow down response time, and diminish workers' ability to maintain work performance (Prameswari, 2026).

Therefore, the simultaneous use of SOFI and reaction time can provide a more comprehensive depiction of operator fatigue and performance conditions.

The measurement of fatigue levels and operator performance is generally still conducted separately, so that the relationship between the two aspects has not been comprehensively described. Research combining fatigue measurement using the Swedish Occupational Fatigue Inventory (SOFI) with performance measurement using reaction time in manufacturing industries with a two-shift work system is still relatively limited. Furthermore, the use of production output data as supporting information to strengthen the interpretation of measurement results has also not been widely conducted. This is in line with a systematic review by (Heng et al., 2024) which highlighted that the evaluation of work fatigue should ideally combine subjective and objective measurement tools simultaneously to obtain a more accurate depiction of fitness for work, although its application in small and medium-scale manufacturing industries is still rarely found. Based on this condition, this study aims to analyze operator fatigue levels using SOFI and operator performance using reaction time in the two-shift work system at PT. ABC, as well as to present production output data as supporting information in interpreting the research results.

B. METHODS

This study used a quantitative approach with a descriptive, comparative, and correlational design. The quantitative approach was used to obtain numerical data on work fatigue levels and operator performance, which were subsequently analyzed using statistical methods. The descriptive design aimed to describe the levels of work fatigue and operator performance in each shift, the comparative design was used to analyze differences in work fatigue levels and operator performance between the morning shift and the afternoon shift, while the correlational design was used to analyze the relationship between work fatigue levels and operator performance.

This study applied a within-subject repeated measures design, in which each respondent was measured under two different working conditions, namely the morning shift and the afternoon shift. In each shift, reaction time was measured before and after work, while the level of work fatigue was measured after respondents completed their work using the Swedish Occupational Fatigue Inventory (SOFI) questionnaire. This design produced paired data, allowing for a more accurate comparison of operator conditions between the two shifts.

This study was conducted in the production department of PT. ABC, which implements a two-shift work system, namely the morning shift (05:55–14:00 WIB) and the afternoon shift (13:55–22:00 WIB). The research population consisted of 14 production operators. All members of the population were used as the sample through the total sampling (saturated sampling) technique, as the population size was relatively small, allowing all operators to be involved as respondents in the study (Hardani et al., 2020). This study was conducted at PT ABC, a metal manufacturing small and medium-sized enterprise (SME) in Tegal Regency, with specific work and workplace characteristics. Therefore, the findings describe the fatigue and performance conditions of operators within the context of PT ABC.

1. Variable Measurement

This study used shift work as the independent variable, consisting of two categories, namely the morning shift and the afternoon shift. The dependent variables in this study included work fatigue levels and operator performance, each measured using different instruments.

Work fatigue levels were measured using the Swedish Occupational Fatigue Inventory (SOFI), adapted from (Suparmam et al., 2022). This instrument consists of 20 statement items grouped into five dimensions, namely lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness. Each dimension consists of four statement items assessed using a Likert scale with a score range of 0–6, where a higher score indicates a higher level of work fatigue. The questionnaire was filled out after operators completed their work in each shift. The average value of each dimension was used as the basis for analyzing operators' work fatigue levels.

Operator performance was measured using a Reaction Timer through reaction time testing on three types of stimuli, namely visual, auditory, and motor stimuli. Measurements were taken before and after operators worked in each shift. Each type of stimulus was measured three times, and the average value was then calculated as the respondent's reaction time value. The measurement results were expressed in milliseconds (ms), where a higher reaction time value indicates a longer response time, thereby indicating a decline in operator performance.

2. Research Procedure

The research procedure consisted of three stages, namely data collection, data processing, and data analysis. The data collection stage was carried out through observation of operators' working conditions under the two-shift system, followed by the administration of the Swedish Occupational Fatigue Inventory (SOFI) questionnaire after work and the measurement of reaction time using a Reaction Timer with visual, auditory, and motor stimuli. Production output data were also collected as supporting data for the study.

The data processing stage included checking data completeness, calculating reaction time values, and compiling the data using Microsoft Excel prior to analysis using IBM SPSS Statistics 22. The analysis stage comprised validity, reliability, and normality tests, descriptive analysis using mean and standard deviation values, as well as the Paired Sample t-test to determine differences in fatigue levels and performance between the morning and afternoon shifts. The magnitude of the difference was further evaluated using Cohen's d, while the relationships between the research variables were analyzed using correlation tests.

C. RESULT AND DISCUSSION

1. Respondent Characteristics

This study involved production operators of PT. ABC as respondents, with a total of 14 respondents. The details of the respondent characteristics can be seen in the following table:

Table 1. Respondent Characteristics Data

Operator	Name Operator	Age (Years)	Gender	Work Period (Months)	Body Weight (kg)	Height (cm)	Body Mass Index (BMI)	Remarks
Operator 1	Muhammad Izzul Khaq	26	Male	36	50,7	163	19,1	Normal
Operator 2	Mohammad Alfian	25	Male	60	57,3	168	20,3	Normal
Operator 3	Suhelmi Mastiko	26	Male	7	62,1	164	23,1	Normal
Operator 4	Setiyo Budi Gagah Pratama	22	Male	7	58,3	162	22,2	Normal
Operator 5	M. Faisal Amin	23	Male	24	49,8	161	19,2	Normal
Operator 6	Akhmad Mawardi	21	Male	24	55,9	166	20,3	Normal
Operator 7	M. Ibroh Awaludin	22	Male	7	56,6	160	22,1	Normal
Operator 8	M. Rizki	22	Male	12	60,5	173	20,2	Normal
Operator 9	Ageng Subekti	24	Male	48	66,3	168	23,5	Normal
Operator 10	Muhammad Aminudin	26	Male	24	59,4	160	23,2	Normal
Operator 11	M. Daniel Robbani	23	Male	24	62,1	165	22,8	Normal
Operator 12	Rayhan Maulana Yahya	19	Male	2	59,2	170	20,5	Normal
Operator 13	Moh. Firdaus Assofi	19	Male	5	67	166	24,3	Normal
Operator 14	M. Ibkar Khanif	28	Male	48	56,6	170	19,6	Normal

Source : (Processed Data, 2026)

Based on Table 1, this study involved 14 production operators as respondents. The respondent characteristics presented include age, gender, length of service, body weight, height, and body mass index (BMI). This characteristic information was used to provide a general overview of the respondents' conditions as research subjects. Differences in these characteristics may influence physiological conditions and levels of work fatigue, and are therefore presented as supporting information in interpreting the research results.

2. Operator Work Fatigue Level

The operators' fatigue level was analyzed using the Swedish Occupational Fatigue Inventory (SOFI) method, which consists of five dimensions, namely lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness. The analysis was conducted to compare the fatigue levels of operators between the morning shift and the afternoon shift based on the average value of each SOFI dimension. The results of the operator fatigue level analysis are presented in Figure 1.

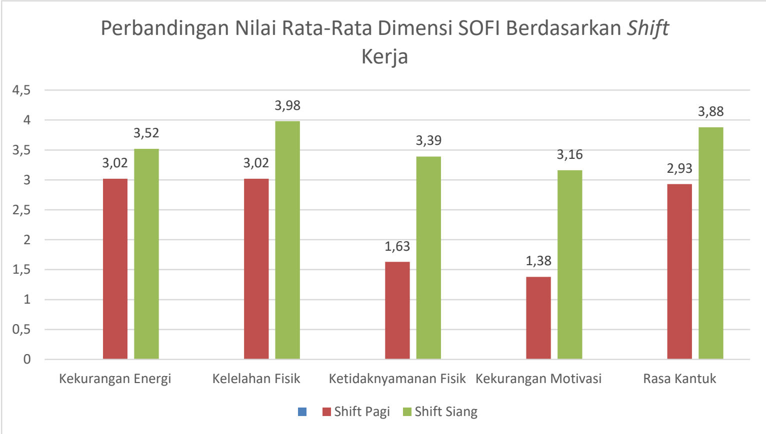

Figure 1. Comparison of Average SOFI Dimension Scores by Work Shift

Source : (Processed Data, 2026)

Based on Figure 1, all SOFI dimensions showed higher mean values during the afternoon shift compared to the morning shift. The physical exertion dimension recorded the highest mean value during the afternoon shift, at 3.98, while the physical discomfort dimension showed the largest increase compared to the morning shift. These results indicate that operators on the afternoon shift experienced a higher level of subjective fatigue than those on the morning shift.

This increase in fatigue is presumably influenced by the nature of the operators' work at PT. ABC, which is repetitive, requires continuous concentration, and takes place throughout the entire working period, thereby leading to fatigue accumulation. This condition results in reduced energy, increased physical burden, and drowsiness among operators after work. These findings are consistent with (Santos et al., 2017), who reported that repetitive work increases fatigue across various SOFI dimensions, as well as (Irianti, 2017), who reported increased physical fatigue and drowsiness among shift workers. In addition, (Benton et al., 2025) stated that shift workers tend to experience a decline in motivation and physical comfort when working under fatigued conditions. Accordingly, the two-shift work system at PT. ABC is associated with increased subjective fatigue among operators, particularly in the dimensions of physical exertion, physical discomfort, and drowsiness.

3. Operator Performance

Operator performance in this study was measured using the reaction time method, which included three types of stimuli, namely visual, auditory, and motor stimuli. Measurements were conducted to determine operators' response ability during the morning shift and the afternoon shift as a performance indicator. A higher reaction time value indicates a longer response time, thereby indicating a decline in operator performance. The results of the reaction time measurements for both shifts are presented in Figure 2.

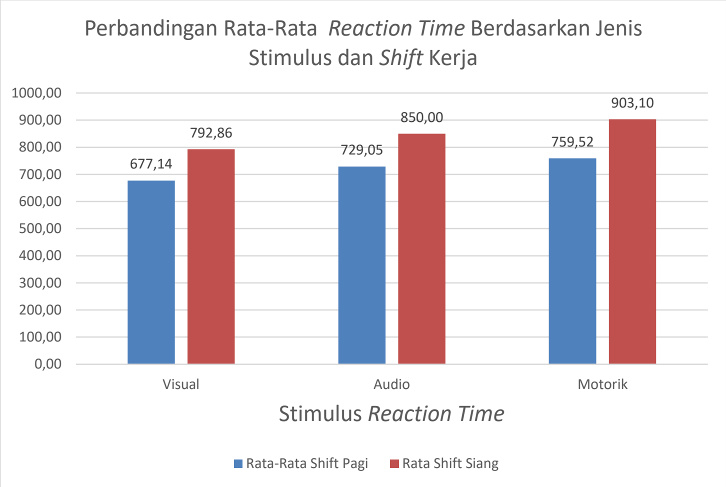

Figure 2. Comparison of Average Reaction Time by Stimulus Type in the Morning and Afternoon Shifts

Source : (Processed Data, 2026)

Based on Figure 2, the mean reaction time after work across all stimulus types was higher during the afternoon shift compared to the morning shift. Increases in reaction time were observed for the visual (17.09%), auditory (16.59%), and motor (18.90%) stimuli, with the largest increase occurring in the motor stimulus. These results indicate that operators required a longer response time during the afternoon shift, suggesting a decline in performance. This condition is presumably influenced by the accumulation of fatigue during work, which slows down the processes of information perception, decision-making, and response execution.

The motor stimulus recorded the highest reaction time value, which is presumed to be related to the nature of the stamping operators' work, who operate the press machine using a foot pedal. This activity requires coordination between the nervous system and limb movement, so that fatigue experienced by operators may slow down motor responses. These findings are consistent with (Irianti, 2017), who stated that shift work systems affect increases in reaction time, requiring workers to take longer to respond to stimuli after work.

4. Statistical Test

a. Validity Test

Validity testing was conducted to determine the ability of each statement item to measure the variable under study by comparing the calculated r value (r hitung) with the critical r value (r table) at a 5% significance level. The results showed that all statement items in the Swedish Occupational Fatigue Inventory (SOFI) questionnaire had calculated r values greater than the critical r value of 0.5324, so that all items were declared valid.

For the energy deficiency dimension, the calculated r values ranged from 0.725–0.847; the physical exertion dimension ranged from 0.759–0.895; the physical discomfort dimension ranged from 0.584–0.792; the lack of motivation dimension ranged from 0.644–0.655; and the sleepiness dimension ranged from 0.588–0.792. The calculated r values, all of which exceeded the critical r value, indicate that each statement item was able to represent the fatigue dimension being measured. Accordingly, the SOFI instrument met the validity criteria and was deemed appropriate for use in subsequent analysis.

b. Reliability Test

Reliability testing was conducted to determine the internal consistency of the instrument in measuring the research variable. The test results showed that the Swedish Occupational Fatigue Inventory (SOFI) questionnaire, consisting of 20 statement items, had a Cronbach's Alpha value of 0.832. This value exceeded the minimum threshold of 0.60, so the SOFI instrument was declared reliable. These results indicate that all statement items possessed adequate internal consistency, and the instrument was deemed appropriate for use in the study.

c. Normality Test

Normality testing was conducted using the Shapiro-Wilk method, as this is one of the prerequisites that must be met before parametric tests can be applied. The test was performed separately for each SOFI dimension and each reaction time stimulus during both the morning and afternoon shifts, with data considered normally distributed if the significance value (Sig.) was greater than 0.05.

The results showed that all SOFI dimensions, namely energy deficiency, physical exertion, physical discomfort, lack of motivation, and sleepiness, had significance values ranging from 0.096–0.938 for both the morning and afternoon shifts. Similarly, for reaction time, the significance values for the visual, auditory, and motor stimuli ranged from 0.122–0.935 across both shifts. Since all significance values obtained were above 0.05, it can be concluded that all research variables were normally distributed and satisfied the normality assumption for subsequent parametric statistical testing.

d. Difference Test

Differences in subjective fatigue levels based on the Swedish Occupational Fatigue Inventory (SOFI) dimensions and reaction time between shifts were analyzed using the Paired Sample t-Test. A recapitulation of the difference test results was compiled to provide an overall picture of the average differences between the morning shift and the afternoon shift, as well as the significance results for each variable. The recapitulation of the SOFI and reaction time difference test results is presented in Table 2.

Table 2. Results of the Difference Test for Fatigue Level and Reaction Time between the Morning Shift and the Afternoon Shift

Variable	Indikator	Morning Shift Average	Afternoon Shift Average	Sig. (2-tailed)	Remarks
SOFI	Lack of Energy	3,02	3,52	0,000	A significant difference exists
	Physical Exertion	3,02	3,98	0,000	A significant difference exists
	Physical Discomfort	1,63	3,39	0,000	A significant difference exists
	Lack of Motivation	1,38	3,16	0,000	A significant difference exists
	Sleepiness	2,93	3,88	0,000	A significant difference exists
Reaction Time	Visual	677,14	792,86	0,006	A significant difference exists
	Audio	729,05	850	0,000	A significant difference exists
	Motorik	759,52	903,1	0,000	A significant difference exists

Source : (Processed Data, 2026)

Table 7 shows that all Swedish Occupational Fatigue Inventory (SOFI) dimensions and the three reaction time stimuli had significance values below 0.05, so H_1 was accepted. These results indicate that there was a significant difference between the morning shift and the afternoon shift, both in subjective fatigue levels and operator reaction time, with the average values of all SOFI dimensions and reaction time tending to be higher in the afternoon shift compared to the morning shift.

An increase in fatigue occurred across all SOFI dimensions during the afternoon shift, with the largest increases observed in physical discomfort, from 1.63 to 3.39, and lack of motivation, from 1.38 to 3.16. A similar pattern was observed for reaction time, namely visual reaction time increasing from 677.14 to 792.86 ms, auditory reaction time from 729.05 to 850.00 ms, and motor reaction time from 759.52 to 903.10 ms. The largest increase in motor reaction time indicates a slowing of foot movement response, which is relevant to stamping work that uses a foot pedal and may potentially affect work accuracy and safety.

These findings are consistent with (Irianti, 2017), who showed that shift work systems influence increased fatigue and decreased performance as measured by reaction time. Meanwhile, a study by (Febrina Kodrat, 2011) on workers at the PT X Labuhan Batu palm oil factory found that the greatest decline in performance actually occurred during the night shift. This difference indicates that although the general pattern of increased fatigue due to shift systems is consistent, the peak time of fatigue may vary depending on the characteristics of workload, shift duration, and industry type. Overall, these findings confirm that stamping operators at PT. ABC experienced increased subjective fatigue and decreased performance during the afternoon shift compared to the morning shift. This condition highlights the importance of fatigue management through additional rest period arrangements, evaluation of the shift work system, and the implementation of fatigue control programs to maintain operator safety and performance, particularly during the afternoon shift.

e. Corellation Test

The correlation between subjective fatigue levels based on the Swedish Occupational Fatigue Inventory (SOFI) dimensions and reaction time among stamping operators at PT. ABC is presented in the form of a recapitulation as a basis for discussing the research results. The recapitulation of the correlations for the morning shift and the afternoon shift is presented in Table 3 and Table 4.

Table 3. Correlation Test Results between Fatigue Level (SOFI) and Operator Performance (Reaction Time) in the Morning Shift

SOFI Dimension	Visual (r)	Sig (r)	Audio	Sig (r)	Motorik (r)	Sig (r)	Category
Lack of Energy	0,935	0,000	0,885	0,000	0,829	0,000	Very Strong
Physical Exertion	0,872	0,000	0,832	0,000	0,742	0,000	Strong-Very Strong
Physical Discomfort	0,371	0,192	0,559	0,023	0,379	0,181	Weak-Moderate
Lack of Motivation	0,300	0,297	0,532	0,050	0,475	0,860	Weak-Moderate
Sleepiness	0,674	0,008	0,709	0,005	0,673	0,008	Strong

Source : (Processed Data, 2026)

Table 4. Correlation Test Results between Fatigue Level (SOFI) and Operator Performance (Reaction Time) in the Afternoon Shift

SOFI Dimension	Visual (r)	Sig (r)	Audio	Sig (r)	Motorik (r)	Sig (r)	Category
Lack of Energy	0,706	0,005	0,882	0,000	0,828	0,000	Strong-Very Strong
Physical Exertion	0,667	0,009	0,850	0,000	0,851	0,000	Strong-Very Strong
Physical Discomfort	0,693	0,006	0,784	0,001	0,800	0,001	Strong-Very Strong
Lack of Motivation	0,724	0,003	0,756	0,002	0,672	0,008	Strong
Sleepiness	0,646	0,013	0,691	0,006	0,774	0,001	Strong

Source : (Processed Data, 2026)

Tables 3 and 4 show that the relationship between subjective fatigue and reaction time exhibited different patterns between the morning and afternoon shifts. During the morning shift, the strength of the relationship varied from weak to very strong, and not all SOFI dimensions were significantly related to reaction time. In contrast, during the afternoon shift, all SOFI dimensions showed a positive and significant relationship with all three reaction time stimuli, with strengths ranging from strong to very strong. This indicates that the higher the operators' subjective fatigue during the afternoon shift, the longer the time required to respond to stimuli.

This condition is presumably related to the repetitive nature of stamping work, which demands high concentration and involves continuous visual, auditory, and foot movement coordination throughout the shift. This finding is supported by (Herqutanto et al., 2020), who explained that working conditions affecting concentration are associated with increased reaction time, as well as (Lubis & Mu'minah, 2022), who showed that high workload increases fatigue across various SOFI dimensions. Overall, the relationship between subjective fatigue and reaction time was stronger and more consistent during the afternoon shift than the morning shift, indicating that increased operator fatigue during the afternoon shift genuinely decreases performance through slower reaction time. This finding is important for the company to anticipate such conditions through more effective rest period arrangements tailored to the workload of each shift, evaluation of the duration and intensity of work in the stamping process, and periodic fatigue monitoring that combines subjective (SOFI) and objective (reaction time) measurements. This is further supported by (Qu et al., 2024), who found that establishing a fatigue allowance can help accelerate worker recovery. This recommendation is in line with (Wong & Swanson, 2023), who emphasized the importance of adjusting work schedules, educating workers, and continuously monitoring fatigue.

5. Comparison of Production Output

A comparison of production output was conducted to observe performance trends based on operator groups and work shifts. The comparison results of production output, fatigue levels, and reaction time are presented in Table 5.

Table 10. Comparison of Production Output, Fatigue Level, and Reaction Time by Operator Group and Shift

Operator Group	Shift	Number of Days	Total Output (Units)	Average Output/ Day (Units)	Comparable 12-Day Output (Units)	Fatigue Level (Average SOFI Score)					Reaction Time		
						Lack of Energi	Physical Exertion	Physical Discomfort	Lack of Motivation	Sleepiness	Visual	Audio	Motorik
Operator 1-7	Pagi	12	289.318	24.110	289.318	17,75	18	6,5	4,5	17	4413,33	4866,67	4986,67
Operator 1-7	Siang	13	268.400	20.646	247.754	21,25	25,25	20,25	19,25	25,25	5000,00	5840,00	6100,00
Operator 8-14	Pagi	13	331.296	25.484	305.812	24,5	24,25	16,25	14,75	24	5066,67	5340,00	5646,67
Operator 8-14	Siang	12	200.757	16.730	200.757	28	30,5	27,25	25	29	6100,00	6060,00	6543,33

Source : (Processed Data, 2026)

Production output was used as supporting data to strengthen the interpretation of the SOFI and reaction time results. Descriptively, output during the afternoon shift tended to be lower than during the morning shift, coinciding with increased SOFI scores and reaction time. The increase in motor reaction time from 759.52 ms to 903.10 ms indicates a slowing of response that is relevant to the characteristics of stamping work using a foot pedal, which may potentially affect the speed of completing work cycles and result in decreased production output during the afternoon shift compared to the morning shift.

These findings are consistent with (Kodrat, 2022), who showed that increased fatigue is associated with decreased productivity. (Li et al., 2024) also found that fatigue resulting from repetitive work can reduce work efficiency when rest periods are inadequate. Although production output was not analyzed using statistical tests together with the SOFI and reaction time variables, the consistent pattern shown by the three variables indicates that increased fatigue during the afternoon shift was accompanied by slower reaction time and a tendency toward decreased production output as an indicator of declining operator performance.

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D. CONCLUSION AND SUGGESTIONS

1. CONCLUSION

Based on the results and discussion regarding the level of fatigue and operator performance under the two-shift work system at PT. ABC using SOFI and reaction time, supported by production output data, the following conclusions can be drawn:

a. Operator fatigue levels during the afternoon shift were higher than during the morning shift across all SOFI dimensions, with the largest increases observed in the lack of motivation dimension (128.99%) and physical discomfort dimension (107.98%), followed by sleepiness (32.42%), physical exertion (31.79%), and lack of energy (16.56%).

b. Operator reaction time during the afternoon shift was slower than during the morning shift for all stimuli, with the largest increase observed in the motor stimulus (18.90%), followed by the visual stimulus (17.09%) and the auditory stimulus (16.59%), indicating a decline in operator performance during the afternoon shift.

c. Production output during the afternoon shift was lower than during the morning shift, decreasing by 14.36% in the Operator 1–7 group and 34.35% in the Operator 8–14 group, further reinforcing the indication of declining operator performance during the afternoon shift.

d. The difference test results showed significant differences between the morning shift and the afternoon shift across all SOFI dimensions and reaction time ($p < 0.05$), so the research hypothesis regarding differences in fatigue levels and operator performance between shifts can be accepted.

e. The correlation analysis results showed a positive correlation between fatigue levels and reaction time, with the strength of the correlation being more consistent and stronger during the afternoon shift than during the morning shift. This indicates that the higher the fatigue experienced by operators, the longer the response time to visual, auditory, and motor stimuli, resulting in a tendency toward declining operator performance.

2. **SUGGESTIONS**

Based on the results of this study, PT. ABC is advised to improve the management of work fatigue, particularly in the dimensions of physical exertion, sleepiness, and lack of energy, through the provision of micro breaks, job rotation, stretching, and education on rest patterns and nutrition, as well as to strengthen the prevention of human error through the implementation of SOPs and toolbox meetings, and to enhance operators' work motivation. For future researchers, it is recommended to include additional variables such as physical workload, sleep quality, and working environment conditions, to use a larger sample size with a longer observation period, and to control production output more strictly so that the correlation between work fatigue and production output can be analyzed more accurately.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to the company where this research was conducted for the permission and facilities provided, to all operators who participated as respondents, and to the supervising lecturer for the guidance and direction given throughout this study.

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