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Work Fatigue Analysis in Machining and Fabrication Department with NASA-TLX and Subjective Self Rating Test

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Abstract

During the Covid-19 pandemic, production operators at PT. Riken Engineering Perkasa is required to complete work on time, resulting in the operator working longer hours and less rest time. PT. Riken Engineering Perkasa has a 6-day work system, has a working time of 9 hours/day with a break of 1 hour/day, except for Saturdays when it is 5 hours/day. In this case, the operator may have a work accident and do the same job repeatedly due to a defect in the product. Who conducted this research on production operators in the Machining and Fabrication department of PT. Riken Engineering Perkasa aims to analyze all production operators' work fatigue and mental workload during the Covid-19 pandemic. This research was conducted using the NASA-TLX method and the Subjective Self Rating Test. The mental workload of the very high indicator category was four operators, the high indicator category value was eight operators, and the low indicator category value was one operator. As for work fatigue, the average score for the medium category is eight operators, and the average value for the standard type is five operators. It can be concluded from the mental workload and work fatigue at PT. Riken Engineering Perkasa in the Machining and Fabrication department has a reasonably high category score; the results of these studies can be used as a reference for actions taken by PT. Riken Engineering Perkasa reduces mental workload and fatigue on operators by changing operator shifts and increasing rest hours. So that these operators can achieve optimal productivity with the quality of the products produced remains stable and maintained.

Keywords: mental workload, work fatigue, NASA-TLX, subjective self-rating test

Analisis Kelelahan Kerja pada Departemen Machining dan Fabrikasi dengan NASA-TLX dan Subjective Self Rating Test

Abstrak

Pada masa pandemi Covid-19, operator produksi di PT. Riken Engineering Perkasa dituntut untuk menyelesaikan pekerjaan tepat waktu yang mengakibatkan operator tersebut bekerja dengan waktu yang lebih lama dan waktu istirahat semakin sedikit. PT. Riken Engineering Perkasa memiliki sistem kerja 6 hari, memiliki waktu kerja 9 jam/hari dengan waktu istirahat 1 jam/hari, kecuali hari sabtu waktu kerja 5 jam/hari. Dalam hal ini, operator dapat mengalami kecelakaan kerja dan melakukan pekerjaan yang sama berulang kali karena terjadi cacat pada produk. Penelitian ini dilakukan pada operator produksi di departemen Machining dan Fabrikasi PT. Riken Engineering Perkasa bertujuan untuk menganalisis kelelahan kerja dan beban kerja mental semua operator produksi pada masa pandemi Covid-19. Penelitian ini dilakukan dengan menggunakan metode NASA-TLX dan Subjective Self Rating Test, ditemukan bahwa beban kerja mental nilai rata-rata kategori indikator sangat tinggi sebanyak empat operator, nilai kategori indikator tinggi sebanyak delapan

operator, dan nilai kategori indikator rendah sebanyak satu operator. Sedangkan kelelahan kerja, nilai rata-rata untuk kategori sedang adalah delapan operator, dan nilai rata-rata kategori rendah adalah lima operator. Hal ini dapat disimpulkan dari tingkat beban kerja mental dan kelelahan kerja pada PT. Riken Engineering Perkasa di departemen Machining dan Fabrikasi memiliki nilai kategori yang cukup tinggi; dari hasil penelitian tersebut dapat digunakan sebagai acuan tindakan yang harus dilakukan oleh PT. Riken Engineering Perkasa untuk mengurangi tingkat beban kerja mental dan kelelahan kerja pada operator dengan melakukan pergantian shift operator dan menambah jam istirahat, sehingga operator tersebut dapat mencapai produktivitas yang optimal dengan kualitas produk yang dihasilkan tetap stabil dan terjaga.

Kata kunci: beban kerja mental, kelelahan kerja, NASA-TLX, subjective self-rating test

INTRODUCTION

Technological advances are increasingly helping all activities carried out by humans. The level of comfort, sense of security, and reduction of the risk of disease or danger is one of the processes that must consider increasing productivity at work. When the workload seems too big from time to time, it can affect a person's performance, such as work fatigue. Work fatigue is characteristic of a weakening of the workforce in carrying out their work or activities so that errors in work will increase, which will result in work accidents and product defects (Budiono, et al., 2003).

Ergonomics studies human aspects in the workplace regarding anatomy, physiology, psychology, engineering, management, and design Ergonomics examines the interaction between humans and machines and the factors that influence them. The goal is to improve overall system performance (Bridger, 2009). In general, implementing ergonomics aims to improve physical and mental well-being, improve social welfare, and create a rational balance between various aspects (Tarwaka, 2014a). Ergonomic principles are guidelines for the application of ergonomics in the workplace. There are 12 principles of ergonomics. Namely, working in a normal position or posture, reducing excessive loads, keeping equipment within reach at all times, reducing repetitive and excessive movements at body height, minimizing static electricity, minimizing stress points, maintaining space, and creating a comfortable work environment. Make movement, exercise, and stretch while working, make easy to understand and examples to visualize, reduce stress (Baiduri, 2008).

Workloads are tasks assigned to workers or employees that must complete at a specific time by using the skills and potential of the workforce (Munandar, 2014). Excessive stress occurs because the load level is too high, resulting in excessive energy consumption; on the other hand, stress occurs because the load intensity level is too low to seem bored or saturated (Tarwaka, et al., 2004).

Factors that affect workload are internal factors that come from within the human body due to reactions to external workloads such as age, gender, body posture, health condition (somatic factors), motivation, satisfaction, desire, or response (psychic factor). In addition, external factors come from outside the human body, including the work environment, work organization, and tasks (Koesomowidjojo and Mar'ih, 2017).

A workload affects health problems such as the body's physiological systems, heart, respiration, and body sense organs through working conditions (Munandar, 2014). Physical work can detect changes in oxygen consumption, heart rate, pulmonary air circulation, body temperature, blood lactate levels, the chemical composition of blood and urine, evaporation rate, and others (Tarwaka, et al., 2004). Physiologically, mental activity is seen as a type of light work so that the need for calories for mental activity is also lower. Whereas morally and

responsibly, mental activity is heavier than physical activity because it involves more brainwork than muscles (Tarwaka, et al., 2004).

Mental workload is the difference between the amount of work required to complete a task and the maximum mental workload of a person in a motivated state (Jex, 1988). Excessive mental workload causes work stress. Job stress is an event that poses a risk or threat, such as fear, anxiety, guilt, anger, sadness, hopelessness, or boredom in connection with work in certain conditions for a relatively long time (Fraser, 1992). Symptoms of excessive mental workload include social or behavioral signs, physical symptoms, and psychological symptoms (Hancock and Meshkati, 1988).

Subjective mental workload measurement can be done by several methods, namely NASA-Task Load Index (TLX), Subjective Workload Assessment Technique (SWAT), and Modified Cooper Harder Scaling (MCHS). Of these three methods, the most widely used and proven to give good results are NASA-TLX and SWAT (Hancock and Meshkati, 1988).

Fatigue is a feeling of tiredness caused by spending too much energy. Fatigue can also define as a variety of stresses, ranging from general fatigue to the appearance of a burning sensation in one of the body's muscles due to work-related induction (Budiono, et al., 2003). Individual factors such as age have a significant relationship with the onset of fatigue at work, based on a study in Japan showing that workers between the ages of 40 and 50 will feel fatigued more quickly than relatively young workers (Hidayat, 2003). The causes of fatigue include five main factors: the work environment, monotony, physical and mental work intensity and load, cognitive problems, and nutritional status (Suma'mur, 2009). Fatigue itself can be divided into two groups: fatigue based on process, which includes muscle and general fatigue, and fatigue based on time includes acute tiredness and chronic fatigue (Tarwaka, 2014b). The Subjective Self Rating Test (SSRT) method from the Industrial Fatigue Research Committee (IFRC) Japan is one of the questionnaires containing general symptoms of fatigue created in 1967 to measure subjective fatigue levels, including psychological and physiological aspects as reduced work capacity and endurance body.

Measurement of each mental workload and work fatigue did subjectively mental workload using the NASA-TLX method. The NASA-TLX way measures mental workload by considering six dimensions: physical needs, mental needs, time requirements, performance, frustration levels, and exertion levels. This method assesses the cognitive load at work and does not require much time and money, such as making a questionnaire and distributing it to workers. In the NASA-TLX measurement, there are five parts: comparison of indicators, evaluation, and calculation of indicator values, calculation of weighted workload (WWL), and calculation of the average WWL.

In addition, work fatigue with the subjective self-assessment test method is a measurement method consisting of 30 questions with ten separate questions, each covering weakening activities, weakening motivation, and physical fatigue. This method is used to find out the early symptoms of work fatigue experienced by workers and does not require much time and money, such as making questionnaires and distributing them to workers. In the measurement of the Subjective Self Rating Test, there are four categories of choices, namely very often (VO) with a value of 4, often (O) with a value of 3, sometimes (S) with a value of 2, and never (N) with a value of 1.

PT. Riken Engineering Perkasa is a company engaged in five fields: fabrication, machining, welding, civil, construction, and consulting engineering. In making products related to the five fields above, companies need several production processes that tend to be dangerous, especially those that cause work accidents, such as experiencing mental stress in the production process and work fatigue.

Activities that cause mental workload and work fatigue are when Who must complete the order received from the customer with the target has been determined by increasing working

hours or overtime. In the production process, the operator performs activities such as cutting iron for part of the customer order about 15 pcs of the gas station board and misting iron for the inside of the petrashop of the customer's on-demand order of about seven pcs. In this case, if not further evaluated about the mental workload and work fatigue on the fabrication and machining section operator, it can directly affect the company's productivity, which results in ineffective or inappropriate work processes and can cause work accidents.

Production processes that involve mental workload and labor fatigue include: turning raw materials, cutting and grinding of raw materials, lifting of raw materials with tools, drilling of raw materials, welding of raw materials, and others. The operator must be careful and not carelessly carry out the production process in this case. If the operator makes a mistake in the production process, he will experience mental stress and work fatigue due to repeating the same thing during the production process.

METHOD

This research was conducted at PT. Riken Engineering Perkasa with a research period from March to June 2021 for approximately three months with an actual observation period of one month; the rest is time to conduct research and complete research data.

The subject in this study was PT. Riken Engineering Perkasa. The issues of this study were mental workload and work fatigue in operators in the Machining and Fabrication departments reviewed from the NASA-Task Load Index method and the Subjective Self Rating Test method.

The object in this survey is an employee who works at PT. Riken Engineering Perkasa. Based on 2021 data, the survey consists of 20 employees, seven office areas, and 13 operators. PT. Riken Engineering Perkasa has a working system for six days, especially morning shifts. The sample from the study was 13 operators from the Machining and Fabrication department.

The types of data for this survey are primary data and secondary data. Primary data collection methods were carried out through observation and interviews. Secondary data were obtained from several articles and journals for research analysis. Interviews were conducted to obtain direct data from survey subjects, namely 13 operators in the Machining and Fabrication department of PT. Riken Engineering Perkasa. Interviews were conducted to obtain data about the aspects studied and further strengthened by the documentation results. What carried out the documentation for data collection using closed questionnaires in the form of company ownership documents, notes, reports, and a list of respondents and question tables. Questionnaires are filled out by the operator based on responses from the research sample at the time of the interview.

In this study, data processing was carried out qualitative and quantitative through qualitative data processing, which analyzed rating values from 0 to 100 through documents and interviews for each operator. On the other hand, quantitative data processing was carried to investigate and calculate mental workload and worker fatigue in the Machining and Fabrication department using the NASA-Task Load Index method and the Subjective Self Rating Test method.

Several indicators are used in the analysis using the NASA-Task Load Index method, ranging from physical needs, mental needs, time requirements, performance, frustration levels, and exertion levels. Indicators are classified into different load categories ranging from low, medium, high, and very high. While the analysis of the Subjective Self Rating Test uses the types of fatigue, weakened motivation, and work fatigue with assessment categories ranging from very often, often, sometimes, to never.

RESULTS AND DISCUSSION

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The mental workload measurement analysis in Table 1 was carried out on 13 operators of different ages and work divisions because the research subjects were operators of the production division in the Machining and Fabrication department. Of the 13 operators, various indicators such as Physical Demand (KF), Mental Demand (MD), Temporal Demand (TD), Performance (OP), Frustration Level (FR), Effort (EF) data were collected using. When measuring mental workload using the NASA-Task Load Index method, first calculate the comparative value for each indicator. The results of the index comparison are as on Table 1.

Table 1
Results of Comparison of Indicators

Subject 1	Age (Years)	Work Section	Indicator					
			KF	MD	TD	OP	FR	EF
Asep	47	Flanged Machine	1	2	3	4	0	5
Aji	47	Lathe Operator	1	0	2	3	5	4
Sukardi	45	Totem operator	2	2	1	3	2	5
Jayadi	41	Drill Operator	2	3	4	2	0	4
Roy	40	Operator Welding	1	1	3	4	5	1
Nandar	37	Welding	1	0	2	5	4	3
Kurniawan	35	Welding	1	2	4	2	3	3
Karyono	33	Lathe Operator	3	2	3	5	2	0
Akbar	33	Welding	1	5	3	2	2	2
Dian	24	Lathe Operator	1	0	2	3	5	4
Gugun	23	Milling Operator	4	4	2	1	0	4
Shaepul	23	Milling Operator	3	4	4	1	0	3
Tirta	23	Lathe Operator	2	3	4	1	0	5

Table 2
Rating Results for Each Indicator

Subject 1	Age (Years)	Work Section	Indicator					
			KF	MD	TD	OP	FR	EF
Asep	47	Flanged Machine	80	80	50	70	30	90
Aji	47	Lathe Operator	50	80	90	70	50	70
Sukardi	45	Totem operator	65	50	75	50	30	80
Jayadi	41	Drill Operator	50	60	70	60	80	70
Roy	40	Operator Welding	90	90	80	80	30	85
Nandar	37	Welding	90	90	95	90	50	90
Kurniawan	35	Welding	60	50	40	70	50	60
Karyono	33	Lathe Operator	70	50	70	100	70	70
Akbar	33	Welding	90	90	100	100	100	100
Dian	24	Lathe Operator	50	30	40	60	80	70
Gugun	23	Milling Operator	65	50	75	50	30	80
Shaepul	23	Milling Operator	80	80	80	80	80	80
Tirta	23	Lathe Operator	100	100	70	85	75	100

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Table 2 shows that the rating value of each indicator is data from the analysis of interviews with each operator that have been carried out previously. The evaluation interval used is a value between 1 and 100.

The next step is to calculate the value of this indicator by multiplying the evaluation interval by a weight factor. Below are the results of the WWL calculation and a diagram of the average WWL results (Figure 1).

Table 3
WWL Calculation Results

Data	Indicator						Total	Average	Load Category
	KF	MD	TD	OP	FR	EF			
1	80	160	150	280	0	450	1120	74,67	High
2	50	0	180	210	250	280	970	64,67	High
3	130	100	75	150	60	400	915	61,00	High
4	100	180	280	120	0	280	960	64,00	High
5	90	90	240	320	150	85	975	65,00	High
6	90	0	190	450	200	270	1200	80,00	Very High
7	60	100	160	140	150	180	790	52,67	Moderate
8	210	100	210	500	140	0	1160	77,33	High
9	90	450	300	200	200	200	1440	96,00	Very High
10	50	0	80	180	400	280	990	66,00	High
11	260	200	150	50	0	320	980	65,33	High
12	240	320	320	80	0	240	1200	80,00	Very High
13	200	300	280	85	0	500	1365	91,00	Very High

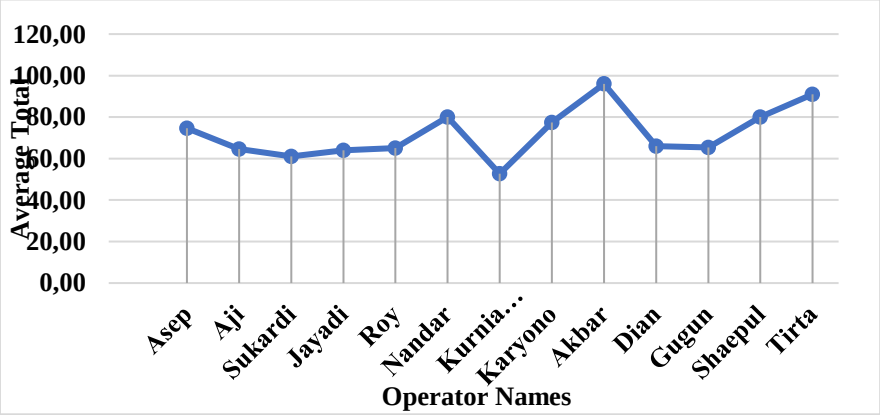

Figure 1. Diagram of WWL Mean Yield.

From Table 3, it can be seen that the results of measuring the mental workload of 13 operators in the Machining and Fabrication department at PT. Riken Engineering Perkasa, four operators, have very high category scores, namely Nandar and Shaepul with a score of 80, Akbar with a score of 96, and Tirta with a 91. In this case, PT. Riken Engineering needs to review the work system to reduce the mental workload on the four operators.

Then eight operators with high scores in the category, namely Asep with 74.67, Aji with 64.67, Sukardi with 61, Jayadi with 64, Roy with 65, Karyono with 77.33, Dian with 66, and

Gugun with 65.33. Meanwhile, one operator has a moderate category value, namely Kurniawan, with 52.6.

The average value for each parameter is calculated from the six categories of indicators. The very high category is the Effort (EF) with a value of 83.69, and the high type is the Performance (OP), with a value of 77.

Table 4
Work Fatigue Calculation Results

Data	Work Fatigue			Total	Category
	Activity Weakening	Weakening of Motivation	Work Fatigue		
1	23	14	17	54	Moderate
2	19	21	20	60	Moderate
3	14	10	16	40	Low
4	16	15	17	48	Low
5	23	19	23	65	Moderate
6	21	18	15	54	Moderate
7	28	19	21	68	Moderate
8	22	19	22	63	Moderate
9	19	11	13	43	Low
10	25	24	24	73	Moderate
11	16	15	13	44	Low
12	20	18	17	55	Moderate
13	14	13	14	41	Low

From Table 4, it can be seen that the results of the work fatigue measurement of 13 operators in the Machining and Fabrication department at PT. Riken Engineering Perkasa, eight operators, have an average work fatigue score, namely Asep with a score of 54, Aji with a score of 60, Roy with a score of 65, Nandar with a score of 54, Kurniawan with a score of 68, Karyono with a score of 63, Dian with a value of 73 and Shaepul with a score of 55. In this case, PT. Riken Engineering continues to review the work system so that the work fatigue of 8 operators does not increase.

Then five operators have a low category score, namely Sukardi with a value of 40, Jayadi with a value of 48, Akbar with a value of 43, Gugun with a value of 44, and Tirta with a value of 41. Work fatigue calculated the average value in each category. A high category is 20 points, which is a weakening of activity. The middle type is work fatigue, with a score of 17.85. The low score is 16.62, which is a weakening of motivation.

Like the workload received by the operator in the production process of each piece of work, the medium category score is eight operators for work fatigue, and the high category value is eight operators for the mental workload. The framework requires accuracy and time, especially when ordering from customers, such as making frames for petrashops. Operators must complete orders within five days and work overtime to complete the order. When a defect occurs in the production process, the operator is not satisfied with the results and repeats the production process from the beginning. Things like that cause the operator's physical and mental activity to increase.

Recommendations for improvement to overcome the problem of high and very high operator mental workloads are as follows:

1. Increase the number of operators in each work section and cycle to reduce previous workers' mental burden.
2. Extend workers' rest time to reduce worker fatigue.
3. Listening to music increases productivity and reduces the workload of workers.

CONCLUSION

The mental workload in the Machining and Fabrication department of PT. RIKEN Engineering Perkasa can be seen from the average WWL, four operators in the very high indicator category, eight operators in the high indicator category, and one operator in the low indicator category. Most of the causes of mental workload are the Effort (EF) and the level of performance (OP), with index values of 83.69 and 77, respectively.

Fatigue of Machining and Fabrication operators PT. Riken Engineering Perkasa, we can see an average of eight operators for the medium fatigue category and five operators for the low fatigue category. Most of the factors that cause work fatigue are the weakening of activities and the weakening of work, with values of 20 and 17.85, respectively.

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