Analysis of Mental Workload and Fatigue of Packer Unit Operators Using Using NASA TLX and SOFI

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Abstract. Human activities can be grouped into two main components including physical activity and mental activity. Mental workload is a combination of a component regarding the condition of workers, in terms of time and demands of work tasks related to the workload that has been given. PT. XYZ is one of the Indonesian companies engaged in the cement industry, of course a large company that has a high level of work environment risk and high demand for orders requires the company to carry out continuous production. The research focused on machine operators in the packer operation section to determine the mental workload and the level of fatigue felt by the operator using the NASA-TLX and SOFI methods. Based on the NASA-TLX questionnaire, the results of the highest level of mental workload for packing machine and palletizer machine operators are in the high category, while the SOFI questionnaire results in the highest level of fatigue on packing machine and palletizer machine operators, which are in the medium category. The results of the correlation test there is a relationship between mental workload and the level of fatigue of the two machine operators. Suggestions for improvement from this research are adjusting the work shift schedule regulations that are applied, adjusting the work of the operator based on the level of his work ability, taking adequate rest, using personal protective equipment, giving rewards for the achievements achieved by the operator.

Keywords: Physical activity, Mental activity, Machine operators, packer operation

1 Introduction

Physical and mental activities are the two categories into which human activities can be divided. While mental activity involves using the brain to consider options, physical activity involves moving the body and using the muscles required for specific tasks. These activities cannot be separated because they are so closely related. However, they can be distinguished by the energy requirements, which are met relatively more by physical activity than by mental activity, and the responsibilities, which are met relatively more by mental activity than by physical activity [2]. One aspect of the workload carried out by the physical and mental resources that might impact workers' performance is the expectations of the tasks that have been assigned and must be finished right away. A comparison between the demands of the task that must be completed and

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the workers' capacity is the workload. The discomfort experienced while doing their jobs will increase with the workload, and even employees will feel under strain. This may have a negative effect on the workers' performance and efficiency, as well as the business. The workload does take into account the human side of the worker, such as exhaustion, individualized demands, and other coordination-related factors, in addition to the amount of productive time spent [3].

Mental workload is a combination of a component regarding the condition of workers, in terms of time and demands of work tasks related to the workload that has been given with the maximum ability of the mental load of workers (Mustily Suci, 2018). Mental load activity will link between perception factors and interpretation factors. Excessive mental workload when completing work will cause work stress [1]. One of the Indonesian businesses operating in the cement sector is PT. XYZ. The primary product is cement, which is produced seven days a week in varying production volumes based on the volume of orders received. Local distributors receive product marketing from PT. XYZ. Production is one of numerous departments at PT. XYZ, and it consists of four activities: packer operations, killent operations, finish mills, and crusher mills. PT. XYZ is a sizable business with a significant level of risk in the workplace and continuous production requirements due to strong order demand. Given that cement is used as an adhesive for bricks to make walls and mixed materials for buildings that need the highest quality cement so that the construction is robust, PT. XYZ is a firm active in the cement sector that must be able to produce products with the finest quality [6]. Therefore, to support the efficiency and effectiveness of production and the company can minimize or avoid problems related to workers who can interfere with the production process, research is carried out that focuses on machine operators in the packer operation section, namely packing machine operators and palletizer machine operators. Analysis by subjectively measuring mental workload through questionnaires and calculations using the National Aeronautics and Space Administration Task Load Index (NASA-TLX) method and measuring the fatigue level felt by machine operators using the Swedish Occupational Fatigue Inventory (SOFI) method. So that later it becomes an evaluation material for the company and provides suggestions for improvements to support the comfort and safety of workers at PT. XYZ gets better [9]. Previous journals that measured mental load only used the NASA-TLX method, while in this study also used SOFI.

2 Method

The National Aeronautics and Space Administration Task Load Index (NASA-TLX) method is a subjective method in mental workload analysis [7]. That is used to determine and analyze the level of mental workload that occurs in packer operations workers in carrying out their work [11]. The NASA-TLX method was developed by Hart and Staveland in 2006 based on the emergence of subjective needs consisting of a scale of six factors including mental needs, physical needs, time needs, work performance, frustration level, effort [4]. The Swedish Occupational Fatigue Inventory (SOFI) method is used to measure the level of fatigue felt by workers when completing their work through

five dimensions including lack of energy, exertion, physical discomfort, lack of motivation, and a sense of drowsiness [12].

The procedure of this research is carried out in several stages, the first is by conducting preliminary research, namely identifying problems that are carried out to determine mental workload problems. To identify the problem, namely through direct observation of the company, especially the machine operators in the packer operation section, including packing machine operators and palletizer machine operators, regarding the mental workload and the level of fatigue experienced by operators in the packer unit. The second stage is conducting field studies to accumulate data and information needed in research related to information in the company. Furthermore, literature studies are used to collect information, including journals, books, and previous research, to support research activities and facilitate research related to mental workloads and formulate problems for packing machine operators and palletizer machine operators related to mental workload and fatigue felt on while doing his job using the National Aeronautics and Space Administration Task Load Index (NASA-TLX) and Swedish Occupational Fatigue Inventory (SOFI) methods. Finally, by collecting data [10].

Data collection was obtained from the measurement of mental workload and the level of fatigue felt by packing machine operators and palletizer machine operators which included several stages including interviews with questions and answers to supervisors and operators to find information related to this research and make direct observations to packing machine operators and operators. Palletizer machine at PT. XYZ. Then distributed the National Aeronautics and Space Administration Task Load Index (NASA-TLX) Questionnaire by weighting, rating, and finally distributing the SOFI questionnaire and then processing the data using excel and SPSS and finding specific results from the NASA TLX method and SOFI at PT. XYZ.

3 Result and Discussion

3.1 Respondent Data

Research on mental workload analysis and fatigue level of packer unit operators at PT XYZ has been carried out from December 2021 to January 2022. This study distributed questionnaires aimed at all packer unit operators and obtained data on age, body mass index, length of work, Disease history, sleep duration, and commuting time. Filled out the questionnaire by 44 operators consisting of 24 packing machine operators and 20 palletizer machine operators. The following is the respondent's data on packing and palletizer machines, which can be seen in Table 1.

Table 1. Respondent's Data Packing Machine and Palletizer Machine

Characteristics	Packing Machine (%)		Palletize Machine (%)	
Age				
17-25	11	45,83	3	15
26-35	6	25	12	60
36-45	5	20,83	3	15
46-55	2	8,33	2	10

Characteristics	Packing Machine (%)		Palletize Machine (%)	
BMI				
Thin	2	8,33	1	5
Normal	16	66,67	17	85
Fat	4	16,67	2	10
Very Fat	2	8,33	0	0
Work (years)				
<5	18	75	15	75
>5	6	66,67	5	25
Disease History				
Yes	6	25	3	15
No	18	75	17	85
Sleep (Hours)				
<7	15	62,5	13	65
>7	9	37,5	7	35
Commuting Time (Minute)				
<43	11	45,83	8	40
>43	13	54,17	12	60

Based on the results of the questionnaire in the table above, it is known that packing machine operators with a total of 24 11 operators have an age range of 17-25 years, six operators who have an age range of 26-35 years, five operators who have an age range of 36-45 years, and two three operators have an age range of 17-25 years, 12 operators who have an age range of 26-35 years, then in the age range of 36-45 years there are three operators, and in the age range 46-55 there are two operators. Packing machine operators with a total of 24 people, there are several categories of body mass index including 8.33% there are two operators with a lean body mass index category, 66.67% in the normal category there are 16 operators, 16.67% in the fat category there are four operators. By 8.33% there are two operators with very fat body mass index categories. In contrast, 20 palletizer machine operators have each body mass index category including the lean category of 5%, there is one operator, 85% in the normal category is as many as 17 operators, and the category of body mass index fat by 10% there are two operators. The results of the questionnaire show that the length of time operators work from each packer unit including the packing machine section as many as 18 operators with a working period of fewer than five years, which is 75% and as many as 6 operators with a working period of more than 5 years, which is 66.67%, while the palletizer machine there are 15 operators with a working period of less than 5 years, which is 75% and as many as 5 operators with a working period of more than five years, which is 25%. Packing machine operators who have a history of illness are six people, which is 25%. Palletizer machine operators who have a history of illness are three people, which is 15% while packing machine operators who don't have a history of illness are 18 people, which is 75% and palletizer machine operators 17 people do not have a history of the disease that is as much as 85%. Packing machine operators with a total of 15 people, namely 62.5% experienced sleep durations below the normal limit or less than 7 hours and as many as nine people, namely with a percentage of 37.5% with normal sleep durations or more than 7 hours, while palletizer machine operators with a duration of sleep hours below normal limits or less than 7 hours as many as 13 people with a

percentage of 65% and duration of normal sleep hours or more than 7 hours as many as seven people with a percentage of 35%. Packing machine operators with a distance from home to work with a duration of fewer than 43 minutes by 11 people, namely with a percentage of 45.83% and a duration of more than 43 minutes by 13 people with a percentage of 54.17%, while palletizer machine operators with a long-distance duration of fewer than 30 minutes as many as eight people with a percentage of 40% and a duration of more than 30 minutes by 12 people with a percentage of 60%.

3.2 Calculation

Calculation NASA-TLX Operator Packing Machine show in Fig. 1 and Reulst show in Fig. 2.

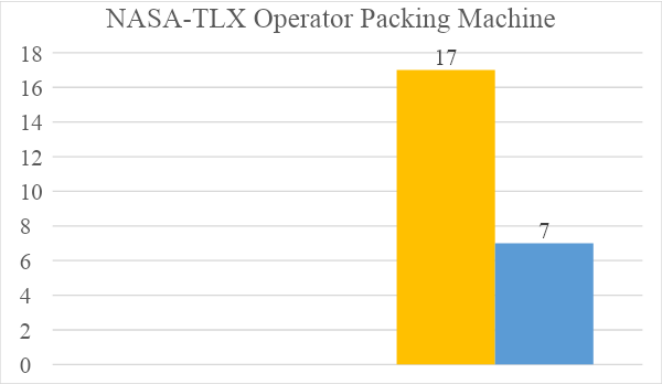

Fig. 1. Histogram NASA-TLX Operator *Packing Machine*

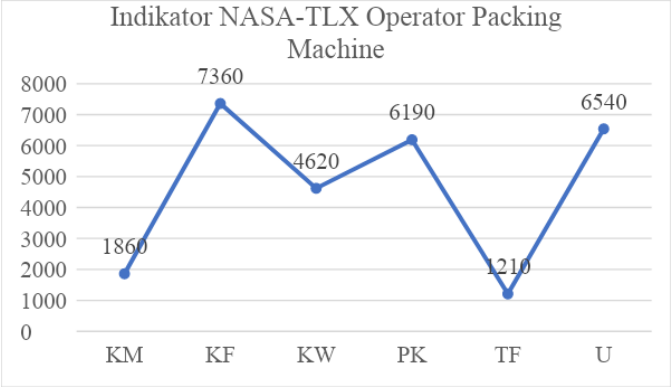

Fig. 2. Result WWL NASA-TLX Operator *Packing Machine*

Based on the results of calculations and data processing in Fig. 1, it is known that there are 24 packing machine operators who have a NASA-TLX score with a very low classification of 0%, a low classification of 0%, a medium classification of 0%, a high classification of 17 operators with percentage of 71%, and in very high classification as many as 7 operators with a percentage of 29%. Thus, it can be concluded that the results of the NASA-TLX mental workload data processing are classified as high. While in Fig. 2, it is known that the WWL value with the indicator that has the highest value is the indicator of physical needs with a total value of 7360, business indicators with a total value of 6540, and work performance indicators with a total of 6190.

Score Calculation NASA-TLX Operator Palletizer Machine show in Fig. 3 and Result show in Fig. 4.

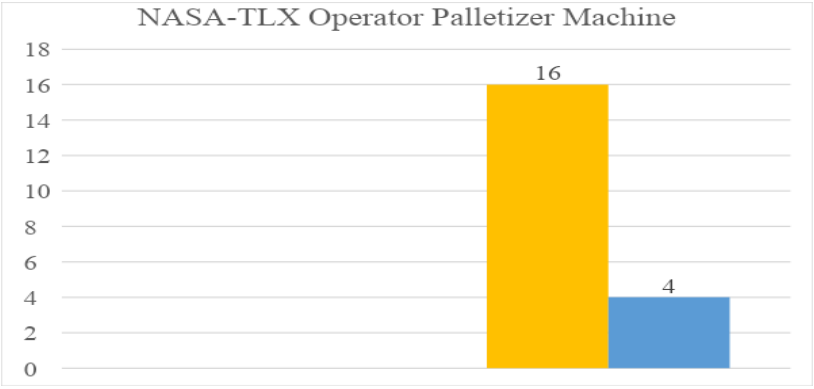

Fig. 3. Histogram NASA-TLX Operator *Palletizer Machine*

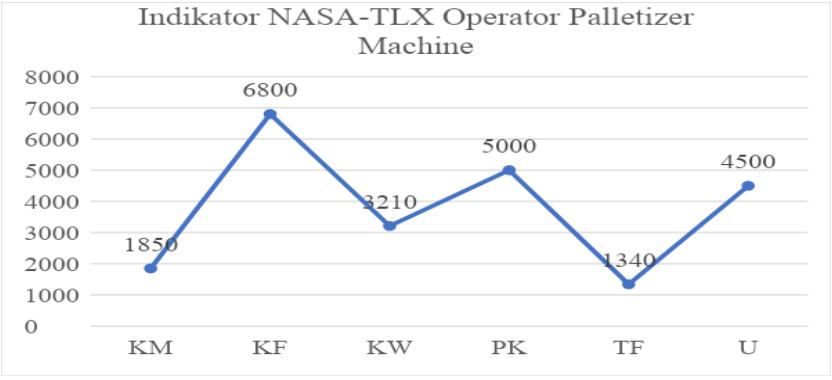

Fig. 4. Result WWL NASA-TLX Operator *Palletizer Machine*

Based on the results of data processing in Fig. 3, it is known that there are 20 palletizer machine operators who have a NASA-TLX score with a very low classification of 0%, a low classification of 0%, a medium classification of 0%, a high classification of 16 operators with a percentage of 80%, and in very high classification as many as 4

operators with a percentage of 20%. Thus, it can be concluded that the results of the NASA-TLX mental workload data processing are classified as high. While in Fig. 4, it is known that the WWL value with the indicator that has the highest value is the indicator of physical needs with a total value of 6800, work performance indicators with a total of 5000, and business indicators with a total value of 4500. Histogram SOFI operator shows in Fig. 5

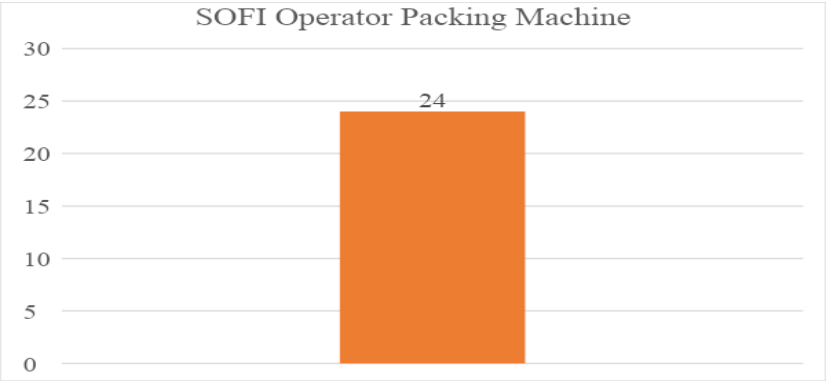

Fig. 5. Histogram SOFI Operator *Packing Machine*

Based on data processing in Fig. 5, it is known that the level of fatigue felt by the palletizer machine operator in completing his work with a low classification of 0%, then in the medium classification of 24 operators with a percentage of 100%, and a high classification of 0%. Thus, the majority of palletizer machine operators experience a moderate level of fatigue. Then the SOFI calculation produces the dimension values as in Fig. 6, it is known that the highest dimension is the dimension of lack of energy with a total of 121.4, then drowsiness with a total of 78, and exertion with a total of 76.2.

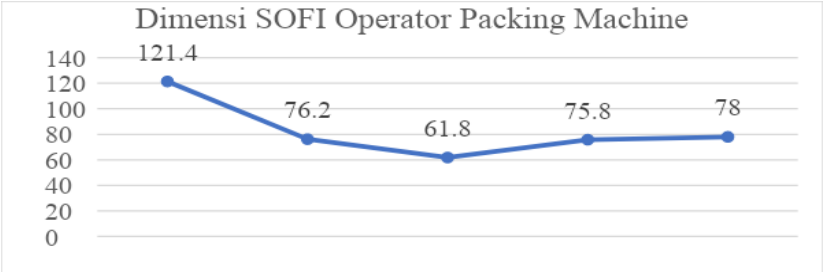

Fig. 6. Score Result SOFI Operator *Packing Machine*

Based on data processing in Fig. 7, it is known that the level of fatigue felt by palletizer machine operators in completing their work with a low classification of 0%, then on a medium classification as many as 20 operators with a percentage of 100%, and a high classification of 0%. Thus, the majority of palletizer machine operators experience a moderate level of fatigue. Then the SOFI calculation produces dimensional values as

in Figure 8, it is known that the dimension with a high total value is the dimension of lack of energy with a total of 99.6, then drowsiness with a total of 64, and lack of motivation with a total of 56.2.

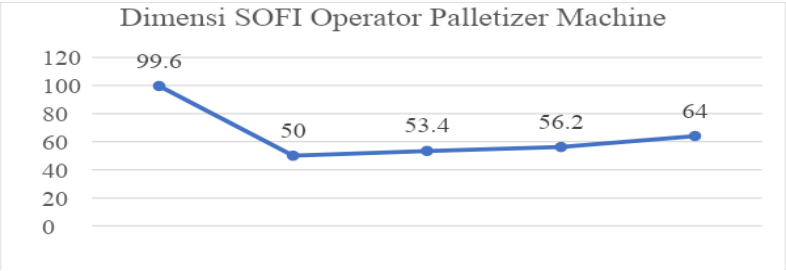

Fig. 7. Score Result SOFI Operator *Palletizer Machine*

Statistical tests used are normality test and correlation test. Normality testing is used to determine or assess the distribution of data in a group of data or variables that are normally distributed or not distributed then the correlation test is used to determine the close relationship between variables and find out the relationship leads to positive or negative. The statistical test used before doing the correlation test is the normality test first. This study uses the Shapiro-Wilk Test normality test can be seen in Table 2.

Table 2. Result of Normality Test

	Shapiro-Wilk Test		
	Statistic	df	Sig.
Packing Operator Mental Burden	0,918	24	0,177
Tired of Packing Operators	0,934	24	0,249
Palletizer Operator Mental Burden	0,969	20	0,809
Palletizer Operator Fatigue	0,935	20	0,189

Based on the results of the normality test processing of the Shapiro-Wilk Test NASA-TLX and the SOFI packing machine operator and palletizer machine operator, the results obtained are Sig. on the packing machine operator with a mental workload of 0.177 and the level of operator fatigue or fatigue of 0.249, while on the palletizer machine operator with a mental workload of 0.809, and the level of operator fatigue or fatigue is 0.189. The result of the value of Sig. which is obtained is Sig. > level of significant 5% (0.05), so it can be concluded that the four data are normally distributed. After testing for normality, then testing the close relationship between variables, namely correlation testing using the Pearson correlation test because the data used is parametric data. Correlation testing is carried out one by one, namely between NASA-TLX and SOFI on each packer unit operator. The following is a correlation test for packing machine operators can be seen in Table 3.

Table 3. Correlation Test Operator *Packing Machine*

Correlation test	
Sig.	0,030
Correlation Coef.	0,444

Hypothesis in Research:
H0: There is no correlation between mental workload pressure on the level of fatigue in packing machine operators.
H1: There is a correlation between mental workload pressure and fatigue level of packing machine operators.

Based on the results of the processing of the correlation test in Table 3 that has been carried out, it is known that the results of the correlation test of mental workload pressure with the level of fatigue on the packing machine operator, obtained the results of Sig. (2-tailed) of 0.030, so the value of Sig. (2-tailed) < level of significant 5% (0.05), so it can be concluded that there is a relationship between mental workload and fatigue level on packing machine operators with a correlation coefficient value of 0.444 which means that the relationship between mental workload and level of fatigue shows a positive direction with a moderate level of closeness or correlation. After testing the correlation on the packing machine operator, then testing the correlation between NASA-TLX and SOFI palletizer machine operators can be seen in Table 4.

Table 4. Correlation Test Operator *Palletizer Machine*

Correlation test	
Sig.	0,040
Correlation Coef.	0,462

Hypothesis in Research:
H0: There is no correlation between mental workload pressure on the level of palletizer machine operator fatigue.
H1: There is a correlation between mental workload pressure on the level of fatigue of the palletizer machine operator.

Based on the results of the correlation test processing in Table 4 that has been carried out, it is known that the results of the correlation test for mental workload pressure with the level of fatigue on the palletizer machine operator, obtained the results of Sig. (2-tailed) of 0.040, so the value of Sig. (2-tailed) < level of significant 5% (0.05) then H0 is rejected, so it can be concluded that there is a relationship between mental workload and fatigue level on palletizer machine operators when doing their work with a correlation coefficient value of 0.462 which means that the relationship between mental workload and fatigue level shows a positive direction with a moderate level of closeness or correlation.

3.3 Improvement

According to data calculations and research findings on mental workloads using the NASA-TLX method, packing machine operators and palletizer machine operators have

a high classification; therefore, the following proposed improvements can be made to reduce the high mental workload on packer unit operators:

1. A bodily requirements indicator
   Operators of packing units have significant physical demands since their jobs necessitate or depend more on physical activity. In addition, because packing units use enormous machinery, their operators must constantly deal with these devices throughout the day, necessitating a fit body. to provide your full attention to your work.
2. Business metrics
   The unit packer operator exerts a lot of effort, so work adjustments are made to the operator based on his height and level of work ability, conduct quick briefings or small meetings prior to working, and enhance the work environment by providing amenities and a welcoming environment so that employees feel at ease.
3. Workplace performance metrics
   In addition to conducting routine health checks to assess employees' physical condition and health so they can perform their jobs as effectively and efficiently as possible, the corporation gives awards or rewards to employees who perform well and are disciplined in their work. According to research that has been done on fatigue levels using the SOFI method and data calculations, packing machine operators and palletizer machine operators have a moderate classification. Therefore, the following proposed improvements can be made to reduce the high level of fatigue in packer unit operators:
   a. A lack of vigor (lack of energy)
      Maintaining health also entails getting enough rest, sleeping for a regular amount of time, eating nutritious food, and staying away from hot and high-fat foods because they can disrupt sleep and digestion.
   b. Disposition
      Use the proper personal protection equipment (PPE) when working, and try to avoid exceeding the limit with your physical activity.
   c. A lack of drive (lack of motivation)
      The business can conduct out work evaluations for operators, reward operators for accomplishments with allowances, bonuses, and other forms of compensation, penalize operators who don't follow procedures, and maximize safety talk activities.
   d. Sleepiness
      Maintain a regular sleep schedule of 7-9 hours per day. In addition, the operator can sleep for around 30-45 minutes prior to starting work to improve alertness and perform light stretches before starting work.The following are broad recommendations for enhancements that can be made:
      (1) Plan production and schedule workers and equipment according to the packer unit's staff members' skill levels.
      (2) To sustain muscle tension and adapt to the surroundings, warm up before working.
      (3) Regularly provide nourishing food intake to enhance work effectiveness.

4 Conclusion

PT. XYZ can take height and level of work ability into account when adjusting the workload of operators to enhance human resource management (HR) programs such workload, work shift management, and so on. The company monitors matters related to mental workload by conducting employee surveys on a regular basis to find out the ups and downs of the workload of employees in the company.

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