

Analysis of the Workload Measurement Using Cardiovascular Load (CVL) and NASA Task Load Index (NASA-TLX) in XYZ Inc.

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Abstract: XYZ Inc. is an industrial company engaged in the processing of palm oil and its derivatives. With excessive working hours and shift pattern change of once a week, unachieved production targets, work accidents occurrence, and employees who ask for permission or absent because of illness, it can cause workload both physically and mentally at the production department. This study was conducted to analyze the workload using the Cardiovascular Load (CVL) and NASA-TLX methods. The calculation results using the CVL method showed that the greatest physical workload in the shift I and shift II was perceived by KALI from the Refra 3 station of group C with the CVL value of 36.73% and 32.38% with notes that improvement was needed. The results using the NASA-TLX method showed very high mental workload in ABD in the shift I of group B of 84.67%, ALI in the shift I of group C of 86.67%, AG in the shift I group C of 85.33 %, ALI in shift II of group C of 81.33% and AG in the shift II of group C of 85.33%. Based on the Cardiovascular Load (CVL) and NASA-TLX results, 9 employees experienced physical workloads and 5 employees experienced mental workloads.

Keywords: Cardiovascular Load, NASA-TLX, Physical Work Load, Mentally Work Load

1. Introduction

The workload is something that arises due to the demands of duties, the influence of work environment factors, skills, behavior and perceptions of workers. The workload is not only physical but also mental. Thus, the workload received must be balanced between physical abilities and cognitive abilities of the recipients. Each individual has a different level of loading so it needs to strive for an optimum level of loading intensity. The level of loading that is too high will result in overstress, while the level of loading that is too low will result in boredom and under stress [1]. An individual's physical workload can be seen with a physiological approach which will evaluate the severity of the load experienced while working on their physical work capacity. This approach measures the severity of the load received by an employee by calculating the pulse rate. Besides, the mental workload is related to the work of the brain rather than the work of the muscles.

PT. XYZ is an industrial company engaged in the processing of palm oil and its derivatives. The main raw material used is Crude Palm Oil (CPO) which is then processed at the production department. This department has 3 work stations, including Refra 1 Station, Refra 2 Station, and Refra 3 Station, with 30 employees on the production floor, consisting of an Assistant Supervisor, Foreman, and Operator that are divided into 3 groups of group A, group B, and group C. The production process is carried out by using machines and labor. The shift changes between groups are carried out once a week, from Monday to Thursday, and the

weekend shift is from Friday to Sunday. With these work shifts, it can be seen that employee working hours is excessive and the shift pattern change of once a week can cause workload. The RBDPO (Refined, Bleached and Deodorized Palm Oil) production targets that are not achieved every month make the employees in the production department experience high pressures resulting in workloads [2]. To achieve production targets, the employees must work overtime and work faster than the normal one. Increase in work hours causes symptoms of workload on employees along with the emergence of feelings of fatigue, tired, lethargic and reduced vigilance, which results in work accidents. Therefore, the work risks experienced by employees are quite high due to various work accidents. Some other factors that cause workloads are hot work environment temperatures because of the Crude Palm Oil (CPO) heating machines, which are Plate Heat Exchanger and Spiral Heat Exchanger. There are employees who ask for permission because of illness. Based on interviews with these employees, the factors that caused the sick employees were due to work fatigue [3].

Based on the background explained above, the researcher is intended to analyze the workload measurement at the production department in XYZ Inc. using the Cardiovascular Load (CVL) method, which is a physical workload measurement method based on a comparison between the work pulse with the maximum pulse, and the National Aeronautics and Space Administration Task Load Index (NASA-TLX) method, which is a mental workload measurement method based on subjective assessment of

respondents who experience the workload.

2. Research Methodology

The type of research that is being used in this study is a descriptive research. This research is done at PT. XYZ that moves in palm oil production and its derivative. This research is done at Department Production in shift 1 at 7.00 a.m. -3.00 p.m. and shift 2 at 3.00 p.m. - 11.00 p.m. First, researcher direct observations and pulse measurements of the workers at Refra 1 Station, Refra 2 Station and Refra 3 Station of Department Production. And then researcher will measure the pulse by mean of an appliance called Oximeter. The time sof taking pulse data as much as four times for each shift, namely before work, at work, at rest and at work after rest. After that, the result of the pulse is recorded in a notebook.

Secondly, the researcher give a NASA - TLX questionnaire to measure the mental workload distributed to all employees at the Refra 1, Refra 2 and Refra 3 stations of the department production. The questionnaire in this researcher is referenced to collect data containing a list of questions that have been determined by weighting and rating the NASA TLX method. While an employee fill out or after completing the questionnaire also accompanied by direct interviews with employees relating to workload. After measuring the pulse and completing the questionnaire, researchers then processed the pulse data using the Cardiovascular Load (CVL) method, which is to calculate the value of % Cardiovascular Load (CVL) with the following formula [4].

$$\% \text{ CVL} = \frac{100 \times (\text{Working Pulse} - \text{Resting Pulse})}{\text{Maximum Pulse} - \text{Resting Pulse}} \quad (1)$$

The resting pulse is the average pulse before work begins, the working pulse is the average pulse during work and the maximum pulse rate is (220 - age) for men and (200 - age) for women. From the calculation of% CVL is then compared with the classification that has been determined as follows [2]:

- <30% = No fatigue occur
- 30- <60% = Repair is needed
- 60- <80 = Short-term work
- 80-<100% = Immediate action is needed
- > 100% = Not allowed to move

After that, the researchers conducted the questionnaire data processing NASA-TLX method, namely calculating the weighting and rating that has been filled in the questionnaire and then calculate the Weighted Workload (WWL) with the following formula.

$$\text{Score Workload (WWL)} = \frac{\sum \text{Weight} \times \text{rating}}{15} \quad (2)$$

Then submit to a classification of mental workload based on analysis by NASA TLX [2]:

- 0-20 = Very Low
- 21-40 = Low
- 41-60 = Medium
- 61-80 = Height

81-100 = Very High

Finally, after getting the results of the category of physical and mental workload levels, an analysis of workloads is carried out based on the results of data processing

3. Results and Discussions

In this study, the data collected are the results of measurements of the employees' pulse and the results of the distribution of the NASA-TLX questionnaire to 30 employees as shown in Table 1.

Table 1: Production department worker data

Group	Station	Name	Type of work	Gender	Age (Years Old)	Working Experience (year)
A	Refra 1 dan 2	S	Assistant Supervisor	Male	42	21
	Refra 1	M A D	Foreman	Male	45	20
	Refra 1	W M	Operator	Male	41	18
	Refra 2	M	Foreman	Male	41	24
	Refra 2	I	Operator	Male	41	19
	Refra 2	R	Operator	Male	35	8
	Refra 2	DAR	Operator	Male	42	20
	Refra 3	DAS	Assistant Supervisor	Male	40	20
	Refra 3	SU	Operator	Male	41	19
B	Refra 3	ADE	Operator	Male	40	19
	Refra 1 dan 2	ERWIN	Assistant Supervisor	Male	43	21
	Refra 1	BAS	Foreman	Male	40	20
	Refra 1	JULI	Operator	Male	43	20
	Refra 2	AHMAD	Operator	Male	29	7
	Refra 2	MUKH	Operator	Male	40	20
	Refra 2	ABD	Operator	Male	41	20
	Refra 2	RIM	Foreman	Male	41	20
	Refra 3	WAHYU	Assistant Supervisor	Male	40	19
C	Refra 3	LEO	Foreman	Male	43	20
	Refra 3	TRI	Operator	Male	30	6
	Refra 1 dan 2	ALI	Assistant Supervisor	Male	40	19
	Refra 1	AG	Operator	Male	39	18
	Refra 1	BUDI	Foreman	Male	43	20
	Refra 2	HAIRUL	Operator	Male	40	18
	Refra 2	AM	Foreman	Male	40	19
	Refra 2	IL	Operator	Male	31	7
	Refra 2	LAM	Operator	Male	46	22
	Refra 3	KALI	Assistant Supervisor	Male	46	23
	Refra 3	ER	Foreman	Male	42	21
	Refra 3	AGU	Operator	Male	34	7

Based on Table 1, the pulse data were collected by using an oximeter. Moreover, the time to collect the pulse data while working on shifts 1 and 2 in time interval are listed in Table 2. While the time to collect the data on the resting pulse on shifts 1 and 2 in time interval can be seen in Table 3.

Table 2: Timing of worker pulse rate - 1

Measurements To-	Time Measurements Shift 1	Time Measurements Shift 2
1	9:00 am – 9:30 am	5:00 pm – 5:30 pm
2	1:00 pm – 1:30 pm	9:00 pm – 9:30 pm

Table 3: Timing of worker pulse rate - 2

Measurements To-	Time Measurements Shift 1	Time Measurements Shift 2
1	06:30 am – 07:00 am	2:30 pm – 3:00 pm
2	12:00 pm – 12:30 pm	08:00 pm – 08:30 pm

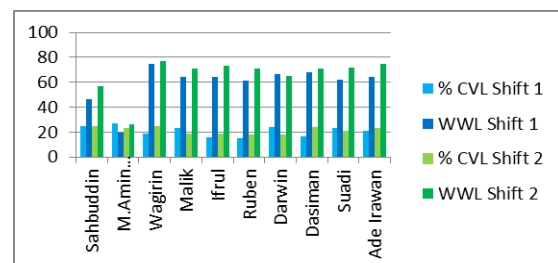
The recapitulation results of Cardiovascular Load (CVL) and NASA TLX recapitulation calculations in each group for shift 1 dan shift 2 can be seen in Table 4.

Table 4: Recapitulation results of the CVL value and NASA-TLX scores

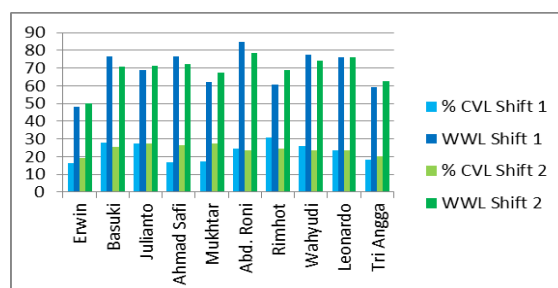
Group	Name	Shift	%CVL	NASA-TLX Score
A	S	I	25,11	46,67
		II	24,74	56,67
	M A D	I	26,69	19,33
		II	23,52	26,00
	W	I	19,06	74,67
		II	25,12	76,67
	M W	I	23,12	64,67
		II	18,68	70,67
	I	I	16,11	64,00
		II	18,55	73,33
	R	I	15,28	61,33
		II	17,87	71,33
	DAR	I	23,83	66,67
		II	17,89	65,33
	DAS	I	16,35	68,00
		II	24,35	71,33
	SU	I	23,04	62,00
		II	20,83	72,00
B	ADE	I	20,83	64,00
		II	23,23	74,67
	ERWIN	I	16,34	48,00
		II	19,12	50,00
	BAS	I	28,11	76,67
		II	25,38	70,67
	JULI	I	27,55	68,67
		II	27,51	71,33
	AHMAD	I	16,81	76,67
		II	26,48	72,00
	MUKH	I	17,37	62,00
		II	27,60	67,33
C	ABD	I	24,53	84,67
		II	23,68	78,67
	RIM	I	30,55	60,67
		II	24,47	68,67
	WAHYU	I	26,08	77,33
		II	23,68	74,00
	LEO	I	23,71	76,00
		II	23,68	76,00
	TRI	I	18,26	59,33
		II	20,18	62,67
	ALI	I	28,84	86,67
		II	29,59	81,33
	AG	I	29,30	68,67
		II	31,86	58,00
	BUDI	I	31,42	66,67
		II	30,43	48,00
	HAIRUL	I	32,55	66,00
		II	30,41	75,33
	AM	I	24,31	60,00
		II	21,05	52,67
	IL	I	25,21	62,00

	LAM	II	27,57	64,67
		I	20,10	58,00
	KALI	II	25,96	65,63
		I	36,73	72,00
	ER	II	32,38	70,67
		I	34,44	65,33
	AGU	II	28,94	74,00
		I	28,19	85,33
		II	28,84	85,33

Based on Table 4, the CVL value with the category of improvement needed are mostly found in group C of Refra 1 and Refra 2 stations. This is because the age of group C workers is an average of 40 years old and they are at Refra 1 and Refra 2 stations, in which both stations use machines that are not as good as Refra 3 Station, so that the activities of employees at Refra 1 and 2 stations are not more productive due to frequent ups and downs related to the troubled machines. This can cause physical fatigue to workers. After seeing table 4 above, a comparison chart between the percentage of CVL and NASA-TLX can be made in the whole group for each shift as presented in Figure 1.

**Figure 1:** Comparison Graph of % CVL and NASA-TLX Employees of Group A Shift I and II

Based on Table 4 and Figure 1, it can be seen that all group A employees experienced physical workload with a category of without fatigue during shift 1 and a number of 8 employees experienced mental workload with a high category, 1 employee in the moderate category and 1 employee in the very low category during shift 1. Further, all group A employees experienced physical workload with a category of without fatigue during shift 2 and a number of 8 employees experienced mental workload with a high category, 1 employee in the moderate category and 1 employee in the very low category during shift 2.

**Figure 2:** Comparison Graph of % CVL and NASA-TLX Employees of Group B Shift I and II

Based on Table 4 and Figure 2, it can be seen that 1 employee of group B experienced physical workload with a category of improvement needed and 9 employees experienced physical workload with a category of without

fatigue during shift 1 and 1 employee experienced mental workload with a very high category, 2 employees in the moderate category and 7 employees in the high category during shift 1. Furthermore, all group B employees experienced physical workload with a category of without fatigue during shift 2 and 9 employees experienced mental workload with a high category, 1 employee in the moderate category during shift 2.

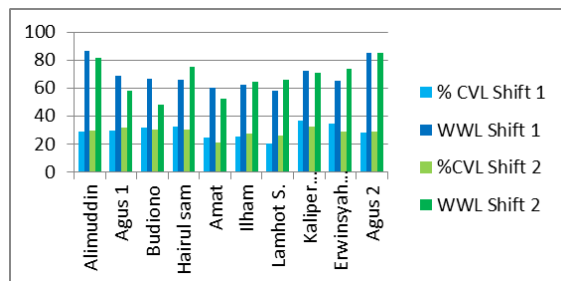


Figure 3: Comparison Graph of % CVL and NASA - TLX Employees of Group C Shift I and II

Based on Table 4 and Figure 3 above, it can be seen that 4 employees of group C experienced physical workload with a category of improvement needed and 6 employees experienced physical workload with a category of without fatigue during shift 1 and 2 employees experienced mental workload with a very high category, 1 employee in the moderate category and 7 employees in the high category during shift 1. Then, 4 employees of Group C experienced a physical workload with a category of improvement needed and 6 employees experienced physical workload in the category of without fatigue during shift 2 and 2 employees experienced mental workload with very high category, 3 employees in the moderate category and 5 employees in the high category during shift 2.

In this regard, the overall amount of physical workload in the category of improvement needed and mental workload in the very high category for each group and shift can be seen in the following Table 10. Based on Table 10 above, it can be seen that 5 employees experienced physical workload with a category of improvement needed during shift 1 and 4 employees experienced physical workload with a category of improvement needed during shift 2 and 3 employees experienced mental workload with a very high category during shift 1 and 2 employees experienced mental workload with a very high category during shift 2, so there were 9 employees experienced physical workload and 5 employees experienced mental workloads at PT. XYZ.

Afterwards, the first analysis was conducted, which was an analysis based on the calculation of physical workload using the CVL percentage. It shows that employees at the production department in XYZ Inc. who have high physical workloads for the shift I and shift II were the employees at Refra 3 station of group C, which was KALI with the CVL value of 36.73% and 32.38%. From the classification of the percentage of the CVL value with the category of improvement needed, there were nine employees in the shift I of five employees and shift II of four employees. This was generally due to a poor work shift system, in which the shift change was done once a week with only three groups, with

the employees working on shift 2 had increased work fatigue [5]. Work activities as a foreman that sometimes also plays a role as an operator, the company that does not provide drinking water for employees at the production department, age factor that also affects the workload of the average age of employees which is above 40 years old [6], and hot temperatures due to the location of XYZ Inc. which is directly next to the sea can also cause employees to feel tired.

Finally, after the Cardiovascular Load (CVL) and NASA-TLX analysis, a comparative analysis was conducted based on the calculation of physical workload using the percentage of CVL and the results of processing the NASA-TLX questionnaire data. A total of 5 employees experienced physical workload in the category of improvement needed during shifts 1 and 4 employees experienced physical workload in the category of improvement needed during shift 2 and 3 employees experienced mental workload with a very high category during shift 1 and 2 employees experienced mental workload with a very high category during shift 2, so there were 9 employees experienced physical workloads and 5 employees experienced mental workloads in PT XYZ. However, there were no employees of XYZ Inc. who experienced physical workloads and mental workloads which were equally high, but they only experienced workloads on physical and mental workloads only. In this case, it is due to factors that cause different workloads experienced by employees as explained by [4], including different levels of employee emotions, different body weights of workers, different nutritional status of workers, different motivations of workers and different trust of workers.

4. Conclusion

Based on the results of calculations using the Cardiovascular Load (CVL) method, the greatest physical workload in shift I and shift II was felt by KALI from group 3 C refra station with % CVL values of 36.73% and 32.38% with information needed improvement. Then Based on the calculation of mental workloads using the NASA - TLX method, it is known that the average mental workload experienced by 30 production department employees is classified as moderate and high. But there is also a very high mental workload, namely in shift I by ABD from Refra 2 Station group B at 84.67%, ALI from Refra 1 Station and Refra 2 grub C at 86.67%, Agus 2 from Refra Station 3 group C was 85.33%. Then in shift II ALI from Refra 1 Station and Refra 2 grub C was 81.33% and AGU from Refra 3 Station group C was 85.33%. So that as many as 5 employees experienced physical workload in the category needed improvement during shift 1 and 4 employees experienced physical workload in the category needed improvement during shift 2 and 3 employees experienced mental workload in the very high category during shift 1 and 2 employees experiencing mental workload in the very high category during shift 2 therefore there are 9 employees experiencing physical workload and 5 employees experiencing mental workload at PT. XYZ.

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