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The Effect of Work Shift on Mental Workload of Maintenance Operator Using Nasa Task Load Index (TLX)

Ayu Puspa Wirani[1], Octoberry Julyanto[2], Dwi Aneka Kartini[3], Mukhlasin[4]
[1234]Universitas Faletehan

Abstract- *The workload of workers affects the performance of these workers. Workers are faced with tasks that must be completed at a certain time. Factors that affect a person experiencing a workload are divided into two factors, namely external factors in the form of work station conditions, form of work, and length of time working as well as internal factors in the form of workers' health conditions and psychological conditions of workers. This study discusses the effect of work shifts on the workload of maintenance operators. Information about the workload on the work shifts to the operator can be known based on the subjective workload measurement using the NASA-TLX method as a psychological load measurement. The operator's workload information serves to determine whether the work carried out is in accordance with the workers' abilities so that they can work optimally. The results showed that the mental load conditions of all maintenance operators were included in the high level mental workload with an average score of 62.08 workload on shift I and 69.02 shift II. The calculation results obtained that FCount (3.7)< FTable (4.414), then H0 is accepted, meaning that the work shift has an effect on the Operator's Mental Burden. In addition, the results of the calculation show that FCount (3.698) < FTable (4.414), then H0 is accepted, and it means that the average workload in shift I and Shift II is not significantly different.*

Keywords: Work Shift, Mental Workload, Trust, Maintenance Operator, NASA TLX

1. Introduction

In everyday life, humans are always faced with various kinds of work that are very draining. The size of the load can only be measured by the worker himself. The psychology of people who work greatly affects the results of their work, the higher the burden they bear, the more depressed a worker is. Workload has a direct impact based on the workload felt by workers (Manuaba, 2000). The workload received by workers must be appropriate and balanced with physical abilities and cognitive abilities as well as the limitations of each worker in accepting the workload (Nurmianto, 2004). So if workers who feel the workload exceeds normal limits will experience work stress on the physical and psychological. For example emotional reactions, headaches, and indigestion. When the workload is felt to be little or not too heavy, it will result in boredom doing work. This will have an impact on the lack of motivation to do work (Manuaba, 2000).

From the point of view of ergonomics which is the study of systems in which humans, work facilities and work environment interact with each other in order to create the main goal of ergonomics itself, namely adjusting the working atmosphere with humans (Nurmanto, 2004). The work ability of each worker is always different from other workers and this depends on the condition of the skill level, physical fitness, nutritional status, gender, age, and body size of each worker (Tarwaka et. al, 2004). Factors that affect a person's workload are divided into two factors, namely external factors and internal factors. External factors in the form of work station conditions, form of work, and length of time worked. Internal factors are in the form of workers' health conditions and workers' psychological conditions (Manuaba, 2000).

Therefore, researchers want to research the effect of shift work on the mental workload of maintenance operators. Information about the workload on the shift to this operator can be known based on subjective workload measurements. In this study, the measurement of workload was carried out using the NASA-TLX method as a subjective psychological load measurement. The operator's workload information serves to determine whether the work carried out is in accordance with the workers' abilities so that they can work optimally.

A. Work Load

Workload can be defined as the difference between a worker's ability and job demands (Meshkati, 1988). From the point of view of ergonomics, any workload received by a person must be appropriate or balanced both in terms of physical and cognitive abilities, as well as the limitations of humans who receive the load. The working ability of a worker is different from one another and is highly dependent on the level of skill, physical fitness, age and body size of the worker concerned. Tarwaka, et al (2004) workload is a burden from outside a person's body due to work activities carried out. According to Rodahl (1986), Adiputra (1998) and Manuaba (2000) in Tarwaka (2004) workload is influenced by external and internal factors. The external factor of the workload is the workload that comes from outside the worker's body(Purwanto et al. 2020; A P Wirani et al. 2018). While the internal factor of workload is a workload that comes from within the worker's body itself which appears as a form of reaction of the worker's body to the existing external load.

Basically there are several types of workload, one of which is mental workload. Mental workload is the difference between mental work demands and the mental abilities of the worker concerned (Julyanto, Ikatrinasari, and Hasibuan 2020). Mental work is difficult to measure through changes in body physiology(Ayu Puspa Wirani et al. 2019). 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 clearly heavier than physical activity, because it involves more brain work (white-collar) than muscle work (blue-collar) (Tarwaka, 2004).

B. Work Shift

Work shift means being at the same work location, either regularly at the same time (continuous work shift) or at different times (rotational work shift). Shift worker is defined as someone who works outside normal working hours in a week (Lanfranchi, et.al., 2005).

Shift work has two types, namely rotational shifts and permanent shifts. In designing the rotation of the shift there are two kinds that must be considered, namely:

1. Lack of rest or sleep should be suppressed as small as possible so as to minimize fatigue.
2. Make as much time as possible for family life and social contacts.

Knauth (1988) (Irawan, Nasiatin et al. 2020) in his journal entitled The Design of Shift System suggests that there are 5 main factors that must be considered in work shifts, including type of shift (morning, afternoon, evening), long shift time, start and end time of one shift, distribution of rest time, and direction of shift transition. While there are 5 criteria in designing a work shift, including :

1. There must be at least 11 hours between the start of two successive shifts
2. A worker may not work more than 7 consecutive days (should be 5 working days, 2 days off)
3. Provide a weekend off (at least 2 days)
4. Rotation shift following the sun
5. Create a simple and memorable schedule

C. NASA TLX

The NASA-TLX method was developed by Sandra G. Hart of NASA-Ames Research Center and Lowell E. Staveland of San Jose State University in 1981. NASA-TLX is a subjective measurement method that is often used in measuring mental workload on individuals or workers in various industries or companies. NASA TLX is a theoretical development of a rating scale that uses ten indicators:

1. Overall workload (OW)
2. Task difficulty (TD)
3. Time pressure (TP)
4. Performance (OP)

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5. Physical effort (PE)
6. Mental effort (ME)
7. Frustration level (FR)
8. Stress level (SL)
9. Fatigue (FA)
10. Activity type (AT)

The weighting for the overall workload (OW) is separated from the others so that there are nine indicators remaining. After going through several stages of testing on various working conditions, the final form of the scale is obtained based on the order of the most relevant, namely TD, TP, OP, PE, ME, FR, SL, FA, and AT. The three scales in the last order are reduced, namely SL, FA, and AT. Two scales are combined, namely ME and PE into EF (effort) and TD is divided into two, namely MD (mental demand) and PD (physical demand). In this NASA TLX method, there are 6 components that will be measured from each individual, namely mental needs, physical needs, time needs, performance, level of effort, and level of frustration.

II. METHOD

In this study, there are two data used, namely primary data and secondary data. Primary data can be obtained by interviewing employees related to research and field studies. While secondary data is supporting data obtained from data sources and not obtained directly from the field. The measurements were carried out using the NASA Task Load Index (TLX) method. In data processing, calculated the weighting of mental workload on shift I and shift II, rating of mental load indicators in shift I and shift II, and Anova test to determine the effect of work shifts on the mental workload of maintenance operators.

III. RESULTS AND DISCUSSION

A. Mental Workload

Based on data collection, the research data obtained from the mental workload of maintenance operators in shifts I and II.

Table 1. Mental Workload Data Collection for Maintenance Operators with Nasa TLX on Shift I (10 operator)

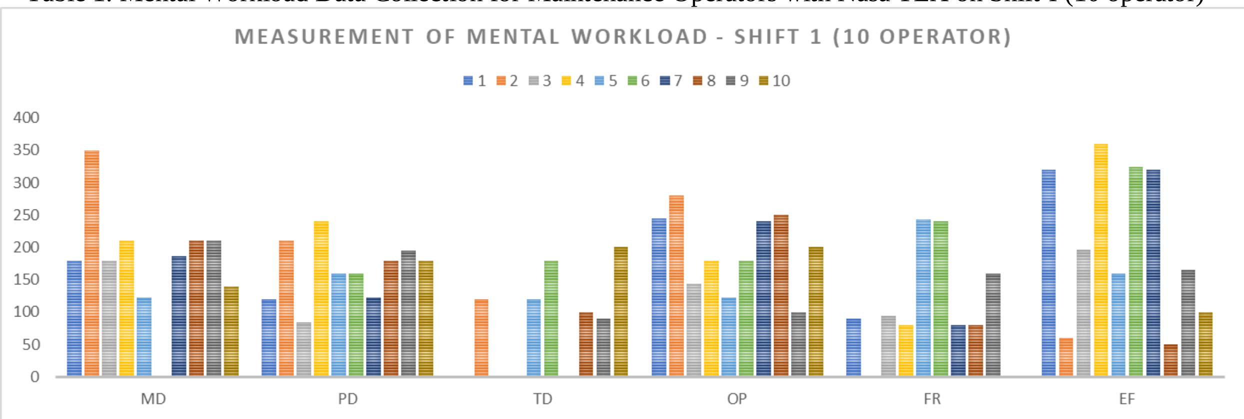
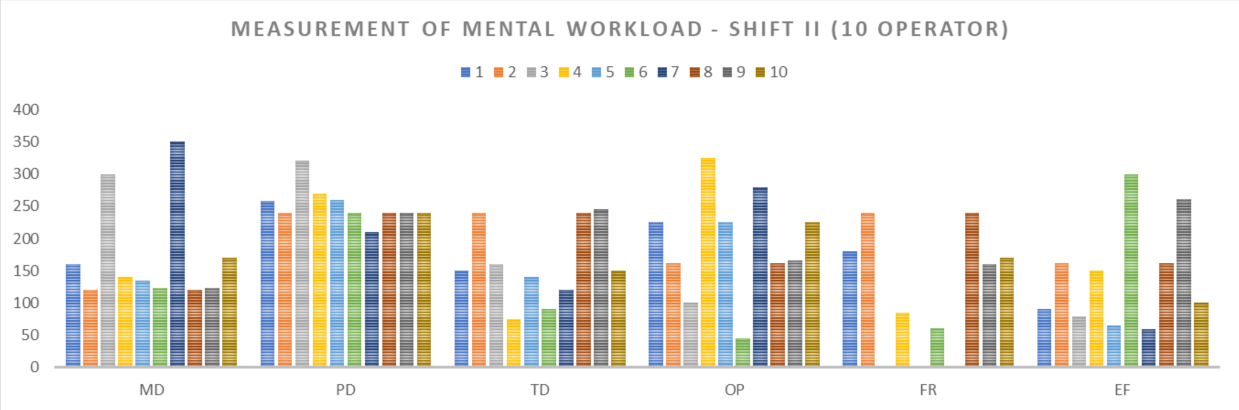


Table 2. Mental Workload Data Collection for Maintenance Operators with Nasa TLX on Shift II (10 operator)



The following table is the result of calculating the total workload of maintenance operators.

Table 3. Average Mental Workload of Maintenance Operator - Shift I & II

Operator	*Shift*	
	I	II
1	63.6	70.9
2	68	77.6
3	46.5	64
4	71.3	69.7
5	61.8	55
6	72.3	57.3
7	63.3	68
8	58	77.6
9	61.3	79.8
10	54.7	70.3
Total	620.8	690.2
Total Shift I & II	1131	

B. *Manual Data Processing*

Manual calculation steps:

1. H0 : μ1 = μ2
2. H1 : μ1 ≠ μ2
3. α = 0,05
4. Critical Region :

   H0 not accepted if $F_{Count} > F_{table}$

5. For the same sample (n): Testing on Shift 1 and Shift II.
   a) SSTotal $= \sum_{i=1}^{k} \sum_{j=1}^{n} y^2\, ij - \frac{T^2}{nk}$

   SSTotal = $((63{,}6^2 + 68^2 + 46{,}5^2 + \cdots + 79{,}8^2 + 70{,}3^2) - \frac{1311^2}{(10x2)}$

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SSTotal = 1412,89

b) SSTreatment = $\frac{\sum_{i=1}^{k} T_i^2}{n}$ - $\frac{T^2}{nk}$

SSTreatment = $\frac{((620{,}8)^2 + (690{,}2)^2)}{10} - \frac{(1311)^2}{20}$

SSTreatment = 240,818

c) SSError = SSTotal - SSTreatment

SSError = 1412,89 - 240,818

SSError = 1172,07

Tabel 4. Analysis of Variety for Completely Randomized Design

Source Variance	Number of Squares	Degrees of Freedom	RMS	Fcount
Treatment	240.818	1	240.818	3.69834
Error	1172.07	18	65.11511111	
Total	1412.89	19		

6. Conclusion :
H0 accepted (FHitung (3,698) < FTabel (4,414)). It can be concluded that the average workload in shift I and shift II is not significantly different.

C. Discussion

Based on the results of measurement and data processing, the results obtained on the weighting of the workload in the first shift is 6.36; 68 ; 46.5 ; 71.3 ; 61.8 ; 72,3 ; 63.3 ; 58 ; 61.3 ; 54.7 and the weighting on shift II is 70.9 ; 77.6 ; 64 ; 69.7 ; 55 ; 57.3 ; 68 ; 77.6 ; 79.8 ; 70.3. Based on the data above, it can be seen that the total mental load in shift I is 620.8 which has an average value of 62.08 which is included in the category of high-level mental load which is between the range of 61 - 80, while the total mental workload in shift II is 690.2 which has an average of 69.02 which is included in the category of high-level mental load which is between the range of 61 - 80. So it can be concluded that the average mental workload weight in shift I and shift II has similarities which are included in the load high level of mental work.

To determine the effect of work shifts on the operator's mental workload, the ANOVA test can be carried out which aims to test the variance and average and the difference in mental workload between each shift, whether there is a significant difference or not. This ANOVA test is done manually and minitab 14 software, which will test and analyze whether there are differences in the mental workload of the operator from each shift. With the hypothesis if FCount > FTable then H0 is rejected, and if FCount < FTable, then H0 is accepted. By using the confidence level = 0.05.

From the results of manual calculations, it can be obtained that Fcount is 3.698 while FTable is 4.4144. So that it can be concluded that F Count < FT table, then H0 is accepted, and it means that the average workload on shift I and shift II is not significantly different. From the results of the calculation software can be obtained F Count is 3.70 while FTable is 4.4144. So that it can be concluded that F Count < FT table, then H0 is accepted, and it means that the average workload on shift I and shift II is not significantly different. To reduce the workload, operators should pay attention to the arrangement of working hours, rest periods, holidays (recreation), and others. In addition, the operator must also pay attention to the ability of the body, meaning that the energy expenditure does not exceed the input by taking into account the limitations. Because excessive levels of fatigue will reduce the burden on each operator, and must maintain healthy lifestyles with the direction of management and themselves to the operator. And it is better to do research on mental burden with different methods, for example by using the SWAT method.

IV. Conclusion

The results showed that the mental load conditions of all maintenance operators were included in the high level mental workload with an average score of 62.08 workload on shift I and 69.02 shift II. The calculation results obtained that FCount (3.7) < FTable (4.414), then H0 is accepted, meaning that the work shift has an effect on the Operator's Mental Burden. In addition, the results of the calculation show that FCount (3.698) < FTable (4.414), then H0 is accepted, and it means that the average workload in shift I and Shift II is not significantly different. To reduce the workload, operators should pay attention to the arrangement of working hours, rest periods and pay attention to the ability of the body, meaning that the energy expenditure does not exceed the input by taking into account the limitations.

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