

Determination of the Optimal Number of Workers Using the NASA-TLX Method in Chemical Company, Indonesia

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ABSTRACT

This study aims to analyze the workload of operators and analyze the optimal number of workers to complete work on the part of the production. The research was conducted at one chemical company in Indonesia and this study uses a method NASA - Task Load Index (NASA-TLX) of the six indicators to measure mental workload with the NASA-TLX method, namely mental needs, physical needs, time requirements, performance, level of frustration, and physical and mental effort obtained mental workload calculations on production operators as many as 4 operators experience mental workload categories very high, 13 operators with mental category workloads are high, 2 operators experience mental workload categories rather high, and 1 operator experiences mental workloads with moderate categories. Of the 4 work shift groups, all experienced a high mental workload so that an additional workforce was needed to reduce operator workload. After adding 1 operator in each group, the level of mental workload decreased to a rather high level. But of the 4 work shift groups, there is still 1 shift group that experiences high workloads despite having added 1 workforce.

Key Words: *Workload, Mental, NASA-TLX, Indonesia, Optimal Number of Workers, Operators.*

1. INTRODUCTION

Human activities require energy which depends on the amount of workload carried out and the physical abilities of each individual. This is due to the limited ability of humans to cause humans to experience fatigue, both physical fatigue and mental fatigue, which will result in decreased work performance. When humans perform activities that exceed their abilities can cause a person to experience fatigue, both physical fatigue and mental fatigue, which can result in decreased work performance.

The workload must consider the conditions of the workers because it could affect the company's both positive and negative influences. Excessive physical burdens can result in complaints to workers such as headaches, backaches, injuries, etc. Whereas mental overload can affect workers such as loss of work motivation, stress, and others.

This research was conducted at a company engaged in the field of chemicals in Indonesia. The company issued a policy of an average sales target of 1700 tons per month. The company also limits the amount of production operator overtime, but after the rule has passed there is a problem if one of the group shifts is unable to attend, is attending training, or is sick so that it cannot come to work, thereby reducing the number of production operators. With the reduced number of production operators, the workload is charged to the working production operators. Thus it is necessary to analyze the workload in the production department.

The study of workload has been carried out by several methods. The workload can be measured based on the time allotted to complete the work. Workload research that is measured based on total work time using the FTE (Full Time Equivalent) method has been studied in the manufacturing industry to determine the workload in the maintenance department [1]. Whereas another workload study is measuring the workload on a chemical analyst workforce [2].

Another study of workloads is based on the mental burden of operators on a garment industry using the NASA-TLX method. This study also aims to determine the right number of operators to find out the workload on the operator [3]. Research on determining the number of operators using NASA-TLX method workload analysis has also been carried out on Quality Control operators in the manufacturing industry by adding work sampling methods [4].

NASA-TLX method is a multidimensional rating method that is capable of measuring overall mental workload based on the average weighting of 6 subscales namely Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort and Frustration [5], [6]. The workload analysis method used in this study is NASA-TLX. The NASA-TLX method is a method of measuring mental workload subjectively. The formulation of the problem in this study is as follows: How much workload does the production department worker receive and what is the optimal number of workers following the workload imposed on workers in the production department.

2. METHODOLOGY

This type of research is quantitative research. Quantitative research was conducted to measure mental workload by giving questionnaires to determine mental workload scores and categories of workload levels received in each work shift group. The Primary data in this study are data from the filling out of the NASA-TLX questionnaire.

Questionnaires were distributed to 20 production operators. The questionnaire contains 6 question indicators and 6 questions. The dimensions are Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. Each indicator weights 0-15 while for rating the maximum value is 100. Questionnaires and weights can be seen in table 1.

Table 1. Questioner of Research

Indicator	Question	Weights	Score
Mental Demand (MD)	In your opinion, how much mental effort is needed for your work?	0-15	0-100
Physical Demand (PD)	In your opinion, how much physical effort is needed for your work?	0-15	0-100
Temporal Demand (TD)	In your opinion, how much pressure do you feel is related to the time to do your job?	0-15	0-100
Performance (P)	In your opinion, what is your level of success in doing your work?	0-15	0-100
Frustration (F)	In your opinion, how much anxiety, pressure, and stress you feel is related to the time to do your work?	0-15	0-100
Effort (E)	In your opinion, how much mental and physical work does it take to complete your work?	0-15	0-100

The stages in the NASA-TLX method consists of two stages, namely [6], [7]:

1. Rating

At this stage the operator will fill in the ranking of the 6 subscales that have been given, among them is a mental need (mental demand), physical needs (physical demand), needs time (temporal demand), performance (own performance), effort (effort) and stress level (frustration). The value is given from rank The range is from 0 to 100 according to the workload experienced by the operator to do their work.

2. Weighting

At this stage, one indicator is chosen for each indicator (15 pairs of indicators) which according to the subject more dominant in his work. After carrying out the weighting phase, continue calculation for obtaining workload (mean weighted workload) is as follows:

- Calculate the number of comparisons between pairwise factors, then add up from each indicator, so obtained the number of each factor. Thus, six values out of six are produced indicators.
- Calculate the value for each factor with how to multiply ratings by factor weights for each indicator.
- Weighted workload (WWL) obtained with how to add up the six-factor values.
- Calculate the average WWL in a way that divides the WWL by the total number of weights, i.e. 15.

After the average WWL is obtained the workload Operators can be categorized based on the value of the average of the WWL.

3. ANALYSIS OF DATA AND DISCUSSION

3.1. Data Collection

• Weighting Stage

At this stage, the operator is asked to rate each subscale with a total of 15, so the operator must choose which sub-scale is the most influential to no effect. In table 2 is the weight value for each operator.

Table 2. Weighting

No	Name	MD	PD	TD	P	F	E
1	Opt 1	2	2	3	3	1	3
2	Opt 2	3	4	2	3	1	2
3	Opt 3	3	5	1	2	0	4
4	Opt 4	2	4	2	4	0	3
5	Opt 5	2	4	2	4	0	3
6	Opt 6	2	3	2	3	2	3
7	Opt 7	3	4	2	3	1	2
8	Opt 8	1	5	3	3	1	2
9	Opt 9	2	5	3	3	0	2
10	Opt 10	2	5	3	3	0	2
11	Opt 11	4	2	4	3	0	2
12	Opt 12	1	4	4	3	0	3
13	Opt 13	0	5	3	3	0	4
14	Opt 14	2	5	3	3	0	2
15	Opt 15	2	3	2	3	2	3
16	Opt 16	2	3	2	3	2	3
17	Opt 17	0	5	3	3	0	4
18	Opt 18	0	5	3	3	0	4
19	Opt 19	2	5	3	3	0	2
20	Opt 20	2	5	2	3	1	2
Total		37	83	52	61	11	55

• Rating Stage

At this stage of rating, the operator is asked to give the value of each subscale from 0 - 100. Shown in table 3 of the rating values given by each production operator.

Table 3. Rating Stage

No	Name	MD	PD	TD	P	F	E
1	Opt 1	40	50	65	65	10	55
2	Opt 2	60	80	70	70	10	70
3	Opt 3	70	90	80	80	10	90
4	Opt 4	70	95	70	90	70	80
5	Opt 5	75	80	70	90	20	60
6	Opt 6	40	30	40	40	0	40
7	Opt 7	75	80	70	90	20	60
8	Opt 8	60	80	70	70	10	70
9	Opt 9	50	100	100	50	10	50
10	Opt 10	50	80	80	80	50	80
11	Opt 11	40	50	65	65	10	55
12	Opt 12	70	90	80	80	10	90
13	Opt 13	40	100	40	60	20	40
14	Opt 14	60	80	70	70	10	70
15	Opt 15	50	70	70	70	0	60
16	Opt 16	0	40	40	45	10	30
17	Opt 17	50	100	40	60	20	40
18	Opt 18	60	80	70	70	10	70
19	Opt 19	70	90	80	80	10	90
20	Opt 20	40	100	40	60	20	40
Total		1070	1565	1310	1385	330	1240

• Stage of product value calculation

At the calculation stage, the product value is generated from the weight value given by the operator multiplied by the rating value. After that, the product value is processed again to get the WWL value.

• The interpretation phase of the value produced

In table 4, the average value of WWL is classified with the existing tables on NASA-TLX.

Table 4. Grading Weights

No	Operator	WWL	Average WWL	Category
1	Opt 1	745	49.66	Rather High
2	Opt 2	1000	66.66	High
3	Opt 3	1260	84	Very High
4	Opt 4	1260	84	Very High
5	Opt 5	1150	76.66	High
6	Opt 6	490	32.66	Rather High
7	Opt 7	1095	73	High
8	Opt 8	1030	68.66	High
9	Opt 9	1150	76.66	High
10	Opt 10	1140	76	High
11	Opt 11	825	55	High
12	Opt 12	1260	84	Very High
13	Opt 13	960	64	High
14	Opt 14	1080	72	High
15	Opt 15	840	56	High
16	Opt 16	445	29.66	Medium
17	Opt 17	960	64	High
18	Opt 18	1100	73.33	High
19	Opt 19	1250	83.33	Very High
20	Opt 20	940	62.66	High

3.2. Discussion

• Weighting Stage

In the weight assessment section, the most significant scale weight is on the Physical Demands with a total weighting value of 83, followed by the P scale or the Performance of the operator with a total weight value of 61 (table 2). Thus the Physical and Performance needs are the most influential scales to the value of mental workload in the company.

• Rating Stage

At this stage, the highest scale weights are PD (Physical Demands), P (Performance), and TD (Temporal Demands) scales. Although the value of mental burden is influenced by physical needs and performance, the production operators at the company do not experience high levels of frustration.

• Product Value

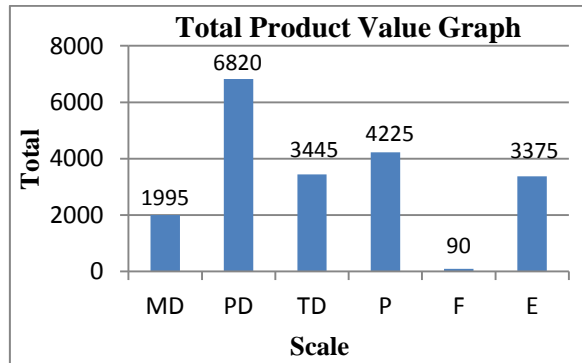


Figure 1. Total Product Value

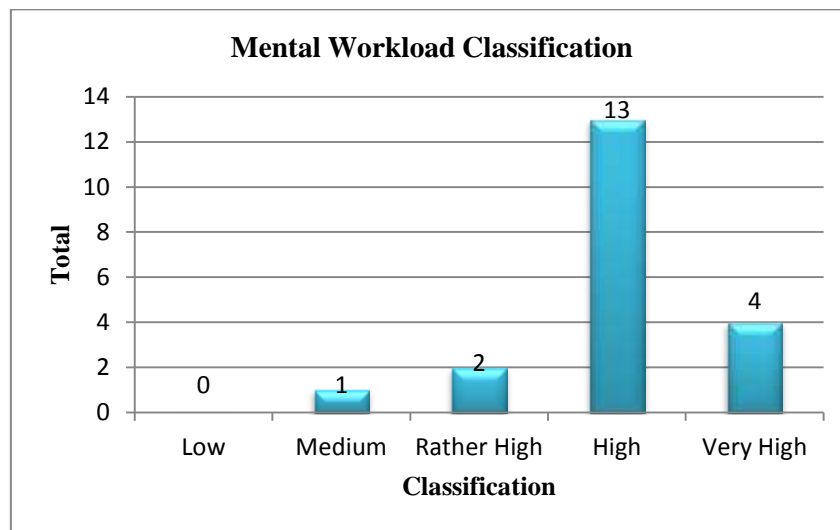


Figure 2. Total Product Value

• Determination Of Number Of Employees

Based on the results of the analysis that has been done, almost all employees and each group have a high mental workload. So to prevent the high mental burden is needed high energy or employees.

Table 5. Mental Workload Value average/group (before adding employee)

No	WWL/Group Value	Category
1	$360.98 / 5 = 72.19$	High
2	$306.98 / 5 = 61.39$	High
3	$311.00 / 5 = 62.20$	High
4	$302.98 / 5 = 60.59$	High

Table 5 shown if in each group 5 employees are working, seen from the category of mental workload, all groups have a high mental workload.

Table 6. Average Mental Workload Value (after adding 1 employee/group)

No	WWL/Group Value	Category
1	$340.98 / 6 = 60.15$	High
2	$306.98 / 6 = 51.16$	Rather high
3	$311.00 / 6 = 51.83$	Rather high
4	$302.98 / 6 = 50.4$	Rather high

Table 6 is a table of mental workload values after adding 1 employee in each shift group, although there is 1 group still in the category of high mental workload, there has been a decrease in mental workload in the other 3 groups.

4. CONCLUSION

Based on the results of data analysis done, there are conclusions in this study as follows.

1. Based on the results of mental workload analysis using the National Aeronautics Method and Space Administration Task Load Index (NASA-TLX) there are 13 operators experiencing mental loads with high levels of mental workloads, 4 operators experiencing mental loads with very high workload levels, 2 people experiencing a mental burden with a rather high level of mental burden, and 1 operator experiencing a mental burden with a moderate level of a mental burden.
2. Viewed from 4 groups, all experienced a high mental workload, it is necessary to add an optimal workforce to reduce workload in each work. After adding 1 workforce in each group, the mental workload experienced has decreased in categories from high to rather high. But there is still 1 group that still experiences high workloads even though 1 worker has been added.

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