

Assessing Mental Workload of Automotive Factory Employees Using NASA-TLX and RSME Methods

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Abstract. *The emergence of an increase in competition for automotive products has made a number of companies continue to plan and release new types of models every year. With the increase in the amount of work that must be completed, mental workload becomes one of the important things to consider to reduce the risk of production failure and the emergence of work stress. PT XXX, one of the automotive product suppliers in Indonesia, is one of the companies experiencing an increase in workload, especially in realizing new product plans in the next 2025. The increase in the number of products in the company has a direct impact on the workload of each worker in an effort to realize new car units in 2025. This makes the company must be able to measure the physical and mental stability of Human Resources which is one of the company's important assets. To understand this, this research was conducted to analyze the mental workload conditions of workers at PT XXX to determine the workload of each worker and to improve the current work system. In measuring workload, the methods used to measure the workload of workers are using the NASA-TLX and RSME methods. The result shows that the mental workload experienced by employees of PT XXX have an average NASA-TLX score of 62.09 and an average RSME score of 97.52. By using the results of the WWL mental load score calculation, this accepts the hypothesis that each different production process job has a different mental workload. This can accept the hypothesis that work using the mental mind such as observing and analyzing provides a higher mental work impact than work with repetition. Quality Assurance has the Highest Mental Work load known from calculations based on the NASA-TIX and RSME methods, each of which produces the highest value. This shows that the NASA-TLX method produces calculations that are in line with the RSME method.*

Keywords: *Mental workload, NASA-TLX, Rating Scale Mental Effort.*

I. INTRODUCTION

While world population continues to increase every year, making market demand also increase, especially in the automotive sector (Nogimori, 2020). Emergence of an increase in competition for automotive products makes a number of companies continue to plan and issue new types of models every year (Yeung, 2024). The market that continues to develop and improvise to meet customer needs and preferences in the automotive industry certainly has an impact on the automotive industry sector

in Indonesia (Tan, 2022). In addition to experiencing an increase in the number of car production, each sector of the automotive industry must also adjust the needs of automotive sub-parts that support the company in producing cars. To make a car product in addition to materials, energy and machinery, companies also need a source that is needed and expected to have good productivity, namely humans or can be called workers. If you look closely at a worker, what you are looking for is a healthy worker. Quoted from the World Health Organization (WHO) in Jacob and Sanjaya's article, the definition of healthy must be physically and mentally healthy, not just one, it must go hand in hand (Jacob & Sandjaya, 2018).

As the amount of work to be done increases, mental workload –also defined in terms of demand or resource balance where mental workload is a measure of the resources available to meet task demands (Gopher & Donchin, 1986)–becomes one of the important things to consider to reduce the risk of production failures and work stress (Aprillia, Setyaningsih, & Dewi,

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2024). Based on Fallahi et al.'s previous study, when mental load is at a medium to low state, workers often become bored and prone to making mistakes (Fallahi, Motamedzade, Heidarimoghadam, Soltanian, & Miyake, 2016). In some cases, when the mental load increases and there is information that exceeds the worker's capacity, workers often become unresponsive and delay the information provided to be processed so that workers become unresponsive in doing the work that has been given before (Hidayat, Sumin, Kartowagiran, & Ayriza, 2022). The emergence of stress and anxiety conditions resulting from worker workload is a factor in the decision-making process, diverse individual reactions, and mental processing of information from workers. This makes measuring mental workload one of the important things that must be done to prevent the risk of non-conformity of work results and maintain the health of workers (Widiasih, Nuha, 2019).

To measure mental workload, subjective assessment techniques are often used because of their ease of measurement, low cost, and sensitivity in varied conditions (Reid & Nygren, 1988). Well-known and frequently used methods in conducting such assessments are the National Aeronautics and Space Administration Task Load (NASA-TLX) and Rating Scale Mental Effort (RSME) methods. NASA-TLX is one of the subjective measurement methods whose use is able to measure the mental workload of workers using six scales, namely mental demand, physical demand, temporal demand, performance, effort, and frustration level (Seker, 2014). Meanwhile, RSME is a subjective measurement that assesses mental workload using scores from mental work with a single scale (Auwadri & Astuti, 2023). Although in the research of Matthews et al. in 2020 questioned research with subjective techniques because of the lack of conformity with performance-based and physiological workload measures (Matthews, Winter, & Hancock, 2019), but because to measure mental workload involves personal sensations related to effort and elements that need to be verified such as task assessment, subjective measurements are

measurements that can be used to measure mental workload.

PT XXX is an automotive sub-assy part product company in Indonesia, one of the companies that experienced an increase in workload, especially in realizing new product plans in 2025. The increase in production at the company has a direct impact on the workload of each worker in pursuing the targets given by the company. This makes the company must be able to measure the physical and mental stability of Human Resources (HR) which is one of the company's important assets. To maintain performance and productivity, both individual and organizational, and minimize the risk of work accidents or stress due to workload, it is necessary to measure workload and understand the mental workload conditions experienced by workers (Widiarto, As'adi, & Rizal, 2023).

Regarding productivity, our research started with information and complaints from the supervisors of the production and quality departments about fluctuating productivity in recent months. The company has made improvements and adjustments to some production process issues. The company has made some improvements but the changes obtained are not significant and there are still fluctuations in productivity. Before productivity is improved, should be stabilized first. Because until now the company has only seen from the physical, both the process and the product. Through this research, it is the first time for the company to see the mental productivity of its workers. To understand this, this research was conducted to analyze the mental workload conditions of workers at PT XXX to determine the mental workload of each worker and to improve the current work system. In measuring the mental workload used, the NASA-TLX and RSME methods. The use of NASA-TLX in measuring workers mental workload has proven to be efficient for conducting workload assessment.

Referring to previous research from Alfianto and Azizah in 2024, the NASA-TLX method was proven to be able to measure mental workload on employees at PT Muliaglass Float Division (Alfianto & Azizah, 2024). Alfianto and Azizah

study used employees in the float division as the object of research to determine the WWL value and proposals that could be given from the existing conditions at that time. Similar research from Siahaan et al. in 2021 also shows that the RSME method can be used to measure employee mental workload (Siahaan & Pramestari, 2021). The study used employees in a division as the object of research to determine the most severe mental workload. Based on previous research from Mindandi et al. in 2023, the use of NASA-TLX and RSME can be combined in measuring mental workload because the two methods have a correlation in evaluating the results of mental workload calculations (Mindandi, Astuti, & Suhardi, 2023). In its use, NASA-TLX has advantages in validity (Hancock, Longo, & Hancock, 2021), higher sensitivity (Du, Ren, Liu, & Li, 2022), and easy yet quite cheap to use (Campoya, Gonz  les-Mu  oz, & Arellano, 2019). Meanwhile, the RSME method is a unidimensional method that is more reliable than the Overall Work Scale and Integrated Work Scale (Alimohammadi, Damiri, Rahmani, Parsazadeh, & Yeganeh, 2019). From these references, the object used as research material is employees in four production processes of PT XXX, namely Assy Operator, Assy Inspector, Quality Control, and Quality Assurance using the NASA-TLX and RSME methods. This research aims to obtain the results of the mental load score produce a hypothesis of the results of the mental load score assessment of each production process job.

Besides from the main goal, another goal that this study aim is that from the results of the score assessment, the mental load category of each production process will be obtained so that it can be known which production process has the heaviest mental workload. Because from the results of the mental load score assessment of each production process job, the mental load category of each production process will be obtained and it is expected to analyze the cause of the problem and provide suggestions for improvement. This can provide a hypothesis that work that uses mental thoughts such as observing and analyzing has a higher mental work impact than work with repetition.

II. RESEARCH METHOD

In this study, a quantitative descriptive method was used as the research methodology. Data is taken subjectively using questionnaires distributed directly to all employees of the company with the location of the production process section described earlier. The results of filling out the questionnaire will be used in identifying mental workload using the NASA-TLX and RSME methods. Because the data used is subjective, validity and reliability tests need to be carried out to determine whether the data can be used for research or not. A data is declared good if the data can reveal data from the actual variables (valid) and the data can be trusted as a data collection tool (reliable). Therefore, validity and reliability tests are important to do (Ramadhan, 2018).

This research was conducted at the company by measuring the mental workload using the methods (The National Aeronautical and Space Administration Task Load Index) NASA-TLX and (Rating Scale Mental Effort) RSME. This research was conducted on several production processes in the company, namely 116 employees consisting of four production processes, namely the quality control production process there are 13 employees, quality assurance there are 10 employees, assy operators there are 68 employees, and assy inspectors there are 25 employees. This research stage is the first to conduct field studies and literature studies related to mental workload. The second stage is to formulate the problem in the research to be carried out by determining the object of research, namely company employees. The third stage is to determine the objectives of the research conducted, the purpose of this research is to determine the risks and factors that affect the mental workload experienced by employees. The fourth stage is collecting data using the NASA-TLX weighting questionnaire, NASA-TLX indicator rating questionnaire and RSME rating questionnaire. The fifth stage conducts data processing on the NASA-TLX method with indicators of mental demand (MD), physical demand (PD), temporal demand (TD), effort (EF),

performance (OP) and frustration level (FR). Then processing data on the RSME method with six six mental workload indicators, namely, work load, work difficulties, job satisfaction, mind work, work anxiety and work fatigue. The sixth stage analyzes and discusses the data that has been obtained thoroughly related to the interpretation of each mental workload in the NASA-TLX and RSME methods experienced by employees. This stage draws conclusions and suggestions from the results of the mental workload analysis in the form of suggestions for improvements given by the author to the company to reduce high mental workload. To measure mental workload from the questionnaire rating results, the NASA-TLX and RSME score interpretations are shown in Table 1. In Table 1, it can be seen that the conversion value from the results of data processing using NASA-TLX can describe the mental workload experienced by employees. Values 0-9 indicate mental workload in the low category, values 10-29 in the medium category, values 30-49 in the average high category, values 50-79 in the high category, and values 80-100 in the very high category. Furthermore, the interpretation of RSME scores is shown in Table 2. It can be seen that the conversion values from the results of data processing using RSME can describe the effort required by employees to perform and complete their work. Values 29-39 indicate very little effort, values 40-58 indicate little effort, values 59-70 indicate rather much effort, values 71-80 indicate considerable effort, values 81-99 indicate great effort, values 100-110 indicate very great effort, and values 111-150 indicate extreme effort from employees.

Table 1. NASA-TLX Mental Workload Category

NASA-TLX Mental Workload Category			
0	-	9	Low
10	-	29	Average
30	-	49	Moderate High
50	-	79	High
80	-	100	Very High

Table 2. RSME Effort Score Category

RSME Effort Score Category	
29-39	A little low effort
40-58	Low Effort
59-70	Rather much effort
71-80	Considerable effort
81-99	Great effort
100-110	Very great effort
111-150	Extreme effort

III. RESULT AND DISCUSSION

Starting with the participants, data collection is carried out by direct observation, interviews and distributing questionnaires based on the NASA-TLX method and the RSME method with the aim of obtaining weighting data from production process workers assy operators, assy inspectors, quality control, and quality assurance. Questionnaires were collected in the working area from 116 participants which can be seen in Figure 1.

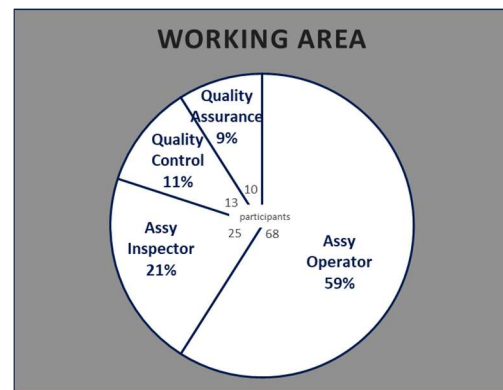


Figure 1. Number of Participants Data

In the initial stage, a validity test was used on all respondents to find out whether there are respondents who need to be excluded or not presented. Table 3 show validity and reliability test results. The results of the validity test that have been carried out for all respondents are valid. Therefore, data from all respondents can be used for further tests. Then the results of the reliability test that has been carried out for all respondents are valid. This result is evidenced by the Cronbach's Alpha value of all respondents and all dimensions exceeding the value of 0.6.

Therefore, the data collected for the NASA-TLX and RSME methods can be used. The data collection process begins with selecting the dominance of each of the two indicators. After filling in based on the NASA-TLX method of weighting the dominance questionnaire of paired indicators, data is taken on all workers, then the results are recapitulated which can be seen in Table 4. The calculation of the NASA-TLX method

is then continued with a subjective assessment of the respondent's scale score for the same six mental workload indicators as before. The scale given is 0-100. The results of the recapitulation of the percentage rating of the NASA-TLX method can be seen in Table 5. Then, Table 6 shows the recapitulation of the results of filling out the mental workload effort rating questionnaire using the RSME method.

Table 3. Validity and Reliability Test Results

No.	Indicator	Pearson Correlation	Cronbach's Alpha	Sig. Value (2-tailed)
1	MD	0,86	0,929	0,195
2	PD	0,87	0,926	0,195
3	TD	0,92	0,917	0,195
4	PD	0,907	0,92	0,195
5	FL	0,76	0,942	0,195
6	EF	0,904	0,921	0,195
7	WL	0,804	0,744	0,195
8	WD	0,72	0,767	0,195
9	JS	0,59	0,806	0,195
10	MW	0,82	0,736	0,195
11	WA	0,68	0,797	0,195
12	WF	0,65	0,789	0,195

Table 4. NASA-TLX Questionnaire Weighting Results

No	Name	MD	PD	TD	PD	FL	EF	Total
1	A	5	0	3	4	2	1	15
2	B	5	0	2	3	1	4	15
3	C	4	2	3	0	1	5	15
:	:	:	:	:	:	:	:	:
116	XXX	5	2	3	3	0	2	15

Table 5. NASA-TLX Rating Scale Results

No	Name	MD	PD	TD	PD	FL	EF
1	A	80	80	80	80	30	80
2	B	90	90	90	90	30	90
3	C	90	70	70	90	50	90
:	:	:	:	:	:	:	:
116	XXX	90	90	80	90	50	70

Table 6. RSME Rating Scale Results

No	Name	WL	WD	JS	MW	WA	WF
1	A	100	100	100	99	100	100
2	B	90	50	80	100	50	80
3	C	150	80	150	150	150	150
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
116	XXX	120	120	100	140	140	100

Table 7. NASA-TLX WWL Results

No	Name	MD	PD	TD	PD	FL	EF	WWL Results
1	A	400	0	240	320	60	80	1100
2	B	450	0	180	270	30	360	1290
3	C	360	140	210	0	50	450	1210
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
116	XXX	450	180	240	270	0	140	1280

Table 8. RSME WWL Results

No	Name	WL	WD	JS	MW	WA	WF	WWL Results
1	A	100	100	100	99	100	100	599
2	B	90	50	80	100	50	80	450
3	C	150	80	150	150	150	150	830
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
116	XXX	120	120	100	140	140	100	720

The data collection process begins with selecting the dominance of each of the two indicators. After filling in based on the NASA-TLX method of weighting the dominance questionnaire of paired indicators, data is taken on all workers, then the results are recapitulated which can be seen in Table 4. The calculation of the NASA-TLX method is then continued with a subjective assessment of the respondent's scale score for the same six mental workload indicators as before. The scale given is 0-100. This rating value will be multiplied by the weight value to get the WWL value. The results of the recapitulation of the percentage rating of the NASA-TLX method can be seen in Table 5. Then, Table 6 shows the recapitulation of the results of filling out the mental workload effort rating questionnaire using the RSME method.

The questionnaire data that has been collected is then calculated to determine the mental workload weight of the NASA-TLX method using formulas (1), (2), and (3). Meanwhile, to calculate the weight of mental work using the RSME method, using formulas (4) and (5). The results of the NASA-TLX calculation for mental workload weighting are shown in Table 7. After going through the data processing process with the NASA-TLX method indicator, the resulting Weighted Workload (WWL) average is 62.09 and falls into the high workload category.

The results of the RSME method calculation for mental workload weighting are shown in Table 8. Respondents give a rating score of 0 – 150 which can categorize from no effort at all to the most severe feeling is the effort made is very large on each question item consisting of six mental workload indicators. After going through

the data processing process with the RSME method indicator, the resulting Weighted Workload (WWL) average is 92.52 and falls into the large effort category.

In the observations that have been made, there is some information obtained regarding the work done by each worker in the production process. Assembly Operator, this process is assembling the product with ready-made parts. Assembly Inventory, this process is an inspection for the assembly of parts on the product. Quality Control is the inspection of product quality (part items/product appearance). Quality assurance is product testing to ensure product quality meets requirements/regulations. From the results of data processing that has been done, the results of each weight are categorized. It can be seen in Figure 3, the assessment of mental load categories starts from low and the heaviest is very high based on the NASA-TLX method. The diagram below shows that the mental workload of the entire production process is in the high category. It can be meant that the whole process requires quite high observation and analysis skills at work.

Based on the same research, after going through the data processing process with the RSME Method indicator. It can be seen in the Figure 4, that the category of all production processes is effort made is large except the quality assurance process which gets the highest category, namely effort made is very large. Figures 3 and 4, the results of data processing show that each production process experiences a large effort made category with an average of 62.09 from the NASA-TLX method and 97.52 from the RSME method. These results indicate that each production process used as research material in the company has a high workload category and requires great effort and mental workload in doing its work. This encourages

observations to distinguish and look further with regard to the production process. The following are the results of observations of the process taken in Table 9.

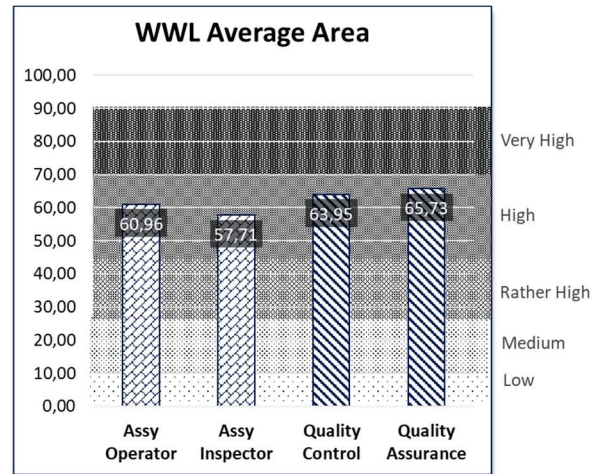


Figure 2. NASA-TLX Method Production Process Category Diagram

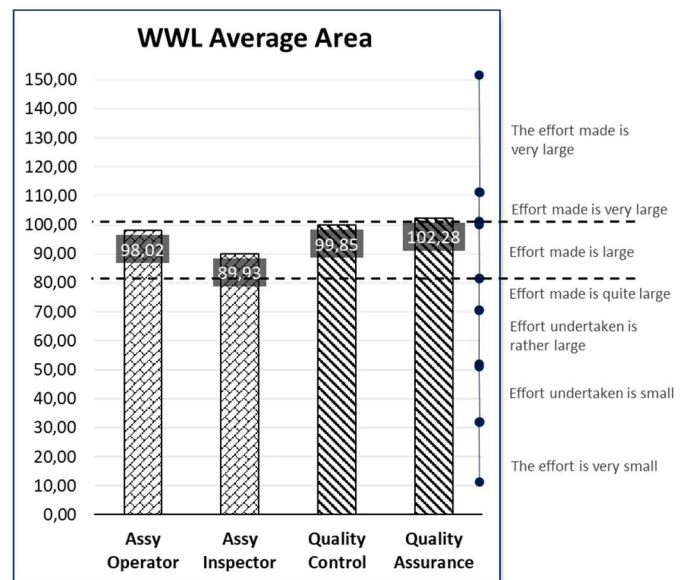


Figure 3. RSME Method Production Process Category Diagram

Table 9. Production Process Observation Results

Production Process	Department	Focus and Attention	Job Every Worker (Job/Worker)	Job Process
Assembly Operator	Production	Process	1 product line	Repetition
Assembly Inspection	Production	Inspection parts on product	1 product line	Repetition
Quality Control	Quality	Inspection product (check item parts/appearance)	1-3 product line (sampling or total check)	Repetition + Observing + Analyzing
Quality Assurance	Quality	Product testing (make sure quality met requirement/regulation)	3-8 lines sampling	Repetition + Observing + Analyzing

Of the four production processes, the quality assurance production process has a very large effort category and is the largest compared to other production processes. In addition, the work performed in the quality control and quality assurance process has a higher value when compared to the assy operator and assy inspector process. In the interpretation of the mental workload category, quality assurance work has a high mental workload value compared to other production processes. Similar to the NASA-TLX results, the results of data processing using RSME also show that the quality control and quality assurance process have higher values when compared to assy operators and assy inspectors. The weight results support the initial hypothesis of this research that the type of work performed by employees affects mental workload.

Based on the results of mental workload measurement, there are findings from the NASA-TLX method that the frustration level indicator (TF) is the indicator with the lowest weight when compared to the others. This shows that employees at PT XXX are able to face obstacles and challenges well or that the work environment at PT XXX supports each employee at work. Conversely, the level of effort (K) is the indicator with the highest weight. This shows that employees need to make more effort in order to complete their work. In addition, the existence of pressure or excessive workload is one of the supporting factors for the high weight of effort. In the RSME method, work anxiety has the lowest weight when compared to other indicators. This

shows that the work done by employees can still be handled properly so that the effort expended is not as great as other indicators. Meanwhile, mental/thought work and job satisfaction are the two indicators with the greatest weight. This shows that the work done by employees has high pressure and the work produced is not well appreciated by the company.

IV. CONCLUSION

From the results of research and data processing that has been done, it can be concluded that the calculation of the use of NASA-TLX and RSME methods shows the mental workload experienced by employees of PT XXX with an average NASA-TLX score of 62.09 and an average RSME score of 97.52. By using the results of the WWL mental load score calculation, this accepts the hypothesis that each different production process job has a different mental workload. Then with regard to Workload Category Assessment based on NASA-TLX all production is categorized as high while based on RSME all processes are categorized as "effort made is large" except for the quality assurance production process which falls into the "effort made is very large" category in completing the work. This can accept the hypothesis that work using the mental mind such as observing and analyzing provides a higher mental work impact than work with repetition. Quality assurance process has the highest mental work load known from calculations based on the NASA-TLX and RSME methods, each of which produces the

highest value. This shows that the NASA-TLX method produces calculations that are in line with the RSME method.

In response to this, the proposed improvements that can be made as a first step are to hold a simple morning meeting for each work process location unit as a form of building a cheerful spirit to do daily work, giving more appreciation related to work that is successfully completed according to the target to increase enthusiasm, and building routine discussions to complete work that needs problem solving assisted by work team colleagues. Suggestions that can be given from the results of further research are to be able to calculate takt time and motion studies, installing automation and digitizing quality and continued by using more analytical methods to find the root cause of the mental problem of high employee workload.

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