International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Mental Workload Analysis Of Production Department Employees Using The Nasa TLX Method At PT. X

Dio Gilang Ramadhan[1], Akhsani Nur Amalia[2], Pandena Kicky Basuki Putri[3]

[1,2,3] Sekolah Tinggi Teknologi Wastukancana

Corresponding E-Mail : dgr2019dio@gmail.com

Abstract

The automotive battery manufacturing industry has work characteristics that require precision, concentration, and speed, thus potentially increasing the mental workload of operators. This study aims to analyze the level of mental workload of operators in the AMB Charging area of PT. X, identify the factors that most influence mental workload, determine the workstation with the highest mental workload, and provide recommendations for improvements. The study used a quantitative method with a descriptive approach. The study population was all 10 AMB Charging area operators and all were sampled based on the Slovin formula calculation. Data collection was carried out through observation, interviews, documentation, and the NASA-TLX questionnaire that measures six dimensions of mental workload. Data analysis was carried out through weighting, rating, Weighted Workload (WWL) calculation, and interpretation of NASA-TLX scores. The results showed that all workstations had mental workload levels in the high to very high category. The Process Dumping, Refilling, Adjustment, and Checker workstations obtained the highest score of 90.20, while the Process Packing obtained the lowest score of 62.00. The most dominant dimensions were Mental Demand, Time Demand, and Effort. This study concludes that mental workload management needs to be prioritized at the highest-scoring workstations through work system improvements, operator training, production target evaluation, and increased automation to reduce human error and improve product quality.

Keywords: Mental Workload, Manufacturing Industry, NASA-TLX, Occupational Ergonomics, Production Operator

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

INTRODUCTION

The manufacturing industry demands high levels of precision, speed, and consistency in maintaining product quality. In addition to physical workload, workers also face mental workload related to attention, perception, and decision-making. According to Hart & Staveland (1988), mental workload is the interaction between task demands and an individual's capacity to process information, which can impact work performance.

In the car battery manufacturing industry, activities such as quality control, product testing, and machine operation are carried out under the pressure of production targets and shift work systems. These conditions have the potential to increase mental workload. According to Hancock & Meshkati (1988), excessive mental workload can reduce performance and increase work errors. Meanwhile, Tarwaka (2015) states that task complexity, time pressure, and the work environment are factors that influence mental workload.

PT X is a battery manufacturing company that still uses a semi-manual production system in the Amb Charging area. Observations revealed various operator errors at eight workstations, including machine settings, program selection, component installation, and inspection. These errors led to product defects, rework, processing delays, and even customer claims.

This situation indicates differences in job demands at each workstation, potentially leading to varying mental workloads. In addition to the 0.12% annual product defect rate, the company also faces the risk of high employee absenteeism. According to (Eni Mahawati, 2021), workload is a job responsibility that can take the form of physical or mental stress, depending on the capabilities of each employee.

This study aims to determine the level of mental workload, the factors that influence it, determine the workstation with the highest mental workload, and formulate improvement efforts. This research is important as a basis for evaluation in improving productivity and work quality. The novelty of this study lies in the analysis of mental workload in the Amb Charging area by comparing eight workstations to identify the workstation with the highest mental workload.

RESEARCH METHODS

This study uses a quantitative method with a descriptive approach to describe the level of mental workload of operators using the NASA-TLX method. The object of the study is the AMB Charging area operator of the Production Department of PT. X, an automotive battery manufacturing company in Karawang Regency that applies a semi-

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

manual production process that has the potential to cause mental workload and human error.

The study population consisted of all 10 AMB Charging area operators at PT. X. The sample was determined using the Slovin formula with a 5 percent error rate (Dewi et al., 2025). The calculation yielded a value of 9.75, which was rounded up to 10 respondents, thus making the entire population the research sample.

Data were collected through observation, interviews, documentation, and secondary data in the form of company documents and supporting references. The research instrument used was the NASA-TLX questionnaire, which measures six dimensions: mental needs, physical needs, time needs, performance, effort level, and frustration level.

Data analysis was performed by weighting each dimension using pairwise comparisons, assigning a rating on a scale of 1 to 100, then calculating the Weight Workload (WWL) and the average WWL. The calculation results were interpreted into very low, low, medium, high, and very high workload categories to determine the level of mental workload, identify its root causes, and develop recommendations for improvement.

The research began with problem identification and primary and secondary data collection in the AMB Charging area of PT. X. Next, mental workload measurements were carried out using the NASA-TLX method through the stages of weighting, rating, and WWL calculation. The results of the analysis were then used to determine the level of mental workload of operators and to develop recommendations for improvements according to company conditions.

RESULTS AND DISCUSSION

Data collection



Picture1*Process Acid Initial*

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR



Picture2Process Loading Unloading



Figure 3 Process Dumping, Refilling, Adjustment, Checker



Picture3*Process Wasing*



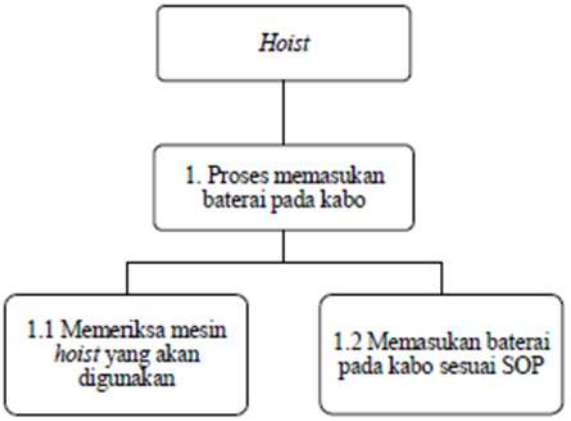
Picture4Sticker and Stamp Process

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

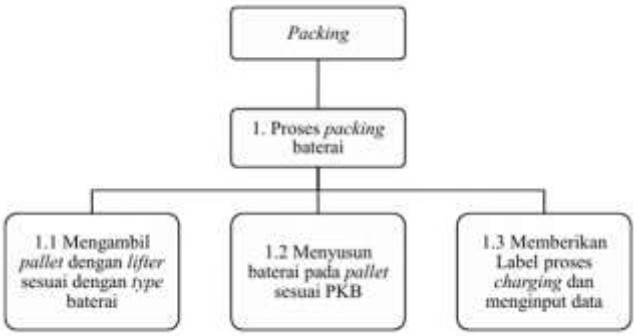
International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR



Picture5PLT and Checker Machine Process



Picture6*Process Hoist*



Picture7*Packing Process*

Data processing

Table.1Process Acid Initial

No	Indicator	Weight	Rating	WWL
1	MD	3	90	270

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

2	PD	2	80	160
3	TD	4	85	340
4	P	1	75	75
5	EF	3	86	258
6	FR	2	80	160
Total WWL				1263
SCORE				84.2

Based on the NASA-TLX calculation results for the Acid Initial Process, the total Weighted Workload (WWL) was 1263 with a NASA-TLX score of 84.2. Based on the NASA-TLX classification, this score is included in the very high category. The highest indicator in the acid initial process is Time Demand (TD). Operators are required to fill the acid water correctly, ensure the type of battery and the type of acid used meet standards, and correctly adjust the nozzle and machine program. Errors in this process can cause the battery to not meet quality standards or even cause defective products. In addition, operators also face quite high time pressure because they have to maintain a smooth production flow towards the battery charging process. Therefore, the Acid Initial Process is one of the workstations with the highest level of mental workload.

Table.2*Process Loading Unloading*

No	Indicator	Weight	Rating	WWL
1	MD	3	80	240
2	PD	4	90	360
3	TD	2	75	150
4	P	2	70	140
5	EF	2	75	150
6	FR	2	60	120
Total				1160
SCORE				77.33

Based on the NASA-TLX calculation results on the Loading Unloading Process, the total WWL is 1160 with a NASA-TLX score of 77.33, which is included in the high category. The highest indicator in the Loading Unloading Process is Physical Demand (PD) of 360. This shows that in addition to requiring considerable physical activity in

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

moving and arranging batteries, operators are also required to remain concentrated in installing connections on the batteries. Errors in installing connections can cause battery damage and even potential work accidents. In addition, operators must work according to production targets in a physically tired condition, which causes quite high mental stress. Therefore, the workload on this workstation is considered high and needs to get the company's attention.

Table3*Process Dumping, Refilling, Adjustment, Checker*

No	Indicator	Weight	Rating	WWL
1	MD	4	95	380
2	PD	1	83	83
3	TD	4	93	372
4	PD	1	82	82
5	EF	3	88	264
6	FR	2	86	172
Total				1353
SCORE				90.20

Based on the NASA-TLX calculation results on the Dumping, Refilling, Adjustment, Checker Process, the total WWL was 1353 with a NASA-TLX score of 90.20 which is included in the very high category. This workstation is the workstation with the highest level of mental workload compared to other workstations. The highest indicator in the Dumping, Refilling, Adjustment, Checker Process is Mental Demand (MD) of 380. The operator must perform several activities simultaneously, namely disposing of old acid water, refilling acid water, adjusting the acid water level, and checking the adjustment results. The entire process requires a high level of accuracy and concentration because small errors can cause battery quality to decrease. In addition, the operator must also make different machine settings according to the type of battery being produced. The high responsibility for product quality causes this workstation to have the highest level of mental workload.

Table4*Process Wasing*

No	Indicator	Weight	Rating	WWL
1	MD	2	60	120

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

2	PD	3	70	210
3	TD	4	75	300
4	P	1	65	65
5	EF	3	70	210
6	FR	2	62	124
Total				1029
SCORE				68.60

Based on the NASA-TLX calculation results in Process Washing, the total WWL is 1029 with a NASA-TLX score of 68.60, which is included in the high category. . The highest indicator in Process Washing is Time Demand (TD) of 300. This shows that the operator faces quite high time pressure and physical activity during the battery washing process. The operator must ensure battery cleanliness, install the ventplug, and check the condition of the battery after the charging process. If the washing process is not carried out properly, it can cause the product to look dirty and not meet quality standards. Although the level of mental workload at this workstation is not as high as the previous workstation, it is still included in the high category so it is necessary to evaluate the operator's workload.

Table5*Sticker and Stamp Process*

No	Indicator	Weight	Rating	WWL
1	MD	3	65	195
2	PD	1	60	60
3	TD	4	75	300
4	PD	2	75	150
5	EF	3	65	195
6	FR	2	75	150
Total				1050
SCORE				70

Based on the NASA-TLX calculation results on the Sticker and Stamp Process, the total WWL was 1050 with a NASA-TLX score of 70, which is included in the high category. The highest indicator in the Sticker and Stamp Process is Time Demand (TD) of 300. Operators are required to work quickly to meet production targets while ensuring

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

that the type of sticker and stamp used matches the battery type. Errors in installing stickers or stamps can result in customer claims, product rework, and company losses, so operators experience quite high time pressure. Therefore, even though physical activity at this workstation is relatively low, operators still require high concentration in carrying out their work.

Table6*Process*PLT and Checker Machines

No	Indicator	Weight	Rating	WWL
1	MD	3	85	255
2	PD	2	70	140
3	TD	3	80	240
4	PD	1	77	77
5	EF	3	70	210
6	FR	3	75	225
Total				1147
SCORE				76.47

Based on the NASA-TLX calculation results on the PLT and Checker Machine Process, the total WWL is 1147 with a NASA-TLX score of 76.47, which is included in the high category. The highest indicator in the PLT and Checker Machine Process is Mental Demand (MD) of 255. The operator is responsible for checking the battery voltage and ensuring that no defective products pass to the next process. This high level of responsibility causes the operator to work with full concentration. Errors in the checking process can cause defective products to reach customers, increasing the risk of product claims. Therefore, this workstation has a high level of mental workload.

Table7*Process Hoist*

No	Indicator	Weight	Rating	WWL
1	MD	1	50	50
2	PD	3	60	180
3	TD	4	75	300
4	PD	3	70	210
5	EF	2	60	120
6	FR	2	65	130

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Total	990
SCORE	66

Based on the NASA-TLX calculation results on the Process Hoist, the total WWL was 990 with a NASA-TLX score of 66, which is in the high category. The highest indicator on the Process Hoist is Time Demand (TD) of 300. This indicates that the operator faces quite high time pressure and physical activity during the operation of the hoist machine. The operator must ensure the battery transfer process runs smoothly and safely. Errors in hoist operation can cause production delays and product damage. Although the score obtained is lower than other workstations, it is still in the high category so that supervision and evaluation of the operator's working conditions are necessary.

Table8*Packing Process*

No	Indicator	Weight	Rating	WWL
1	MD	1	50	50
2	PD	5	65	325
3	TD	4	60	240
4	PD	1	70	70
5	EF	3	60	180
6	FR	1	65	65
Total				930
SCORE				62

Based on the NASA-TLX calculation results in the Packing Process, the total WWL was 930 with a NASA-TLX score of 62, which is in the high category. The largest indicator in this workstation is Physical Demand (PD) of 325. This indicates that physical activity is a dominant factor in the packing process. Operators must arrange batteries on pallets according to standards and ensure that production labels are attached correctly. Errors in the packing process can cause product identification errors and problems in the distribution process. Although this is the workstation with the lowest score compared to other workstations, the mental workload felt by operators is still in the high category and therefore requires company attention.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

International Journal of Economics, Business and Innovation Research
https://e-journal.citakonsultindo.or.id/index.php/IJEBIR
E-ISSN : 2964-0865
IJEBIR

Table9Score results and categories

Workstation	Score	Category
Acid Initial	84.2	Very high
Loading Unloading	77.33	Tall
Dumping, Refilling, Adjustment, Checker	90.2	Very high
Washing	68.6	Tall
*Sticker*and Stamp	70	Tall
PLT and Checker Machines	76.47	Tall
Hoist	66	Tall
Packing	62	Tall

The results indicate that all workstations have high to very high levels of mental workload. The workstations with the highest mental workload were Process Dumping, Refilling, Adjustment, and Checking, with a score of 90.20, while the workstation with the lowest mental workload was Process Packing, with a score of 62.00.

In general, the factors that most influence high operator mental workload are Mental Demand (MD), Time Demand (TD), and Effort (EF). This indicates that operators face high concentration demands, significant production time pressure, and high mental effort in carrying out their work. Therefore, companies need to implement improvements such as operator training, production target evaluation, work SOP refinement, and increased process automation to reduce mental workload and minimize errors.

Analysis

Based on mental workload measurements using the NASA-TLX method, it was found that all workstations in the AMB Charging area had high to very high levels of mental workload. Therefore, an analysis of improvements is needed to reduce the mental workload of operators, thereby increasing work productivity, reducing the risk of human error, and maintaining product quality.

1. Process Acid Initial

   The Initial Acid Process has a NASA-TLX score of 84.20, which is considered very high. The high mental workload is caused by the high concentration required for acid filling, machine parameter settings, and production time pressure. Possible improvements include:

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

a. Rotate work between operators to reduce boredom.
b. Implement a barcode or scanner system to verify battery type, thereby reducing the risk of program input errors.
c. Add an automatic alarm if the acid water volume does not meet the standard.
d. Provide regular training on acid water filling procedures.
e. Add recovery time or micro breaks during peak production hours.

With the automatic verification system and clearer work standards, operators do not need to remember many parameters manually so that mental requirements can be reduced.

2. Process Loading Unloading

The Loading and Unloading process has a NASA-TLX score of 77.33, which is considered high. The workload is a combination of physical and mental activity in battery assembly and connection. Possible improvements include:

a. Using more ergonomic material handling tools.
b. Added visual guide for connecting installation on each production line.
c. Rotate work between operators to reduce physical fatigue levels.
d. Adjust the number of operators as production volume increases.
e. Prepare a preventive maintenance schedule to prevent machine breakdowns.

This improvement can reduce physical fatigue and increase operator focus while working.

3. Process Dumping, Refilling, Adjustment, Checker

The Dumping, Refilling, Adjustment, and Checker processes were the workstations with the highest score, at 90.20. The high workload is due to the numerous activities that must be performed simultaneously and the high risk of quality errors. Suggested improvements:

a. Rotate work between operators to reduce boredom.
b. Adjust the number of operators when setting the machine to change the battery type.
c. Provide regular training on machine setting procedures.
d. Prepare a preventive maintenance schedule to prevent machine breakdowns.
e. Conduct production target evaluation to match operator capacity.

Since this workstation has the highest workload level, the main priority for improvements should be focused on this area.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

4. Process Wasing

The Washing Process received a score of 68.60, which is in the high category. Workload is affected by time pressure and physical activity during battery washing. Suggested improvements:

a. Rotate work between operators to reduce boredom.
b. Adding automatic aids to the washing process.
c. Prepare a preventive maintenance schedule to prevent machine breakdowns.
d. Provide training on washing quality standards.

These improvements can reduce the need for physical effort from operators and speed up work processes.

5. Sticker and Stamp Process

The Sticker and Stamp process received a score of 70.00, which is in the high category. The mental workload stems from the precision required in sticker and stamp application. Suggested improvements:

a. Rotate work between operators to reduce boredom.
b. Using a sticker installation template or jig.
c. Implement a poka-yoke system to prevent installation errors.
d. Provide visual examples of standard products in the work area.
e. Conduct quality inspections by sampling to reduce operator stress.

With an error prevention system, the risk of human error can be minimized.

6. PLT and Checker Machine Process

The PLT and Checker Machine Process achieved a score of 76.47, which is in the high category. Workload is affected by the operator's responsibility in ensuring the quality of the final product. Proposed improvements:

a. Rotate work between operators to reduce boredom.
b. Added visual indicators for non-standard parameters.
c. Create a digital inspection result recording system.
d. Provides battery defect analysis training.
e. Added cross-checking by other operators under certain conditions.

This improvement can help reduce the mental stress that arises from the high responsibility for product quality.

7. Process Hoist

The Process Hoist received a score of 66.00, which is in the high category. The workload is dominated by physical activity and time pressure during battery transfer. Proposed improvements:

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

a. Rotate work between operators to reduce boredom.
b. Conduct routine inspections of the hoist machine.
c. Optimizing material movement paths.
d. Provide regular work safety training.

These improvements can increase operator safety and reduce work stress.

8. Packing Process

The Packing Process received a score of 62.00, the lowest-scoring workstation, but still falls into the high category. Suggested improvements:

a. Rotate work between operators to reduce boredom.
b. Using more ergonomic pallet stacking tools.
c. Using barcode system for product verification.
d. Reduce repetitive manual activities through semi-automation.

With these improvements, the physical and mental burden on operators can be reduced so that work productivity increases.

Based on the NASA-TLX scores, the improvement priorities can be ranked as follows:

1. Process Dumping, Refilling, Adjustment and Checker (90.20)
2. Process Acid Initial (84.20)
3. Process Loading Unloading (77.33)
4. PLT and Checker Machine Process (76.47)
5. Sticker and Stamp Process (70.00)
6. Washing Process (68.60)
7. Process Hoist (66.00)
8. Packing Process (62.00)

These priorities indicate that improvements should be focused first on workstations with the highest NASA-TLX scores because they have the potential to cause greater mental fatigue, work stress, and human error than other workstations.

CONCLUSION

This study shows that all workstations in the AMB Charging area of PT. X have a mental workload level that is in the high to very high category based on the NASA-TLX method. The Process Dumping, Refilling, Adjustment, and Checker workstations have the highest score of 90.20, making them a top priority for improvement efforts, while the Process Packing obtained the lowest score of 62.00 but is still in the high category. The most dominant dimensions influencing mental workload are Mental Demand, Time

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

Demand, and Effort, which indicate that operators face high concentration demands, time pressure, and significant mental effort during the production process. These findings indicate that the characteristics of work at each workstation provide different levels of mental workload, requiring management strategies that are appropriate to the conditions of each work process.

This study was limited to one production line in the AMB Charging area with a relatively small number of respondents, so the results cannot be generalized to all departments or companies. Furthermore, measurements using NASA-TLX are based on respondents' perceptions and are therefore subjective. Further research is recommended involving a wider range of workstations and a wider number of respondents, as well as combining NASA-TLX with other measurement methods to obtain a more comprehensive picture of the workload. Practically, the results of this study can serve as a basis for companies in setting improvement priorities through job rotation, operator training, production target evaluation, refinement of work procedures, and increased automation at workstations with the highest mental workload to reduce human error, increase productivity, and maintain product quality.

BIBLIOGRAPHY

Dewi, I., Khotimah, H., Nasution, R., Hariyati, T., & Rusli, A. (2025). Population theory and sampling. Journal of Literasiology, 14(2). https://doi.org/10.47783/literasiologi.v9i4

Eni Mahawati, D. (2021). Analysis of workload and work productivity. Kita Menulis Foundation

Hancock, P. A., & Meshkati, N. (1988). Human mental workload. In Advances in Psychology (Vol. 52). Elsevier.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), Advances in Psychology (Vol. 52, pp. 139–183). Elsevier. https://doi.org/10.1016/S0166-4115(08)62386-9

Tarwaka. (2015). Industrial ergonomics: Basics of ergonomic knowledge and applications in the workplace (Second Edition). Harapan Press.

Copyright at authors some right reserved this work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.