ISOMAse
International Society of Ocean, Mechanical and Aerospace Scientists and Engineers

Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-
30 July 2026. Vol.70 No.2

DOI:
10.36842/jomase.v70i2.636

Standard Work Type 3-Based Work Time Measurement and Workload Balancing Analysis Using *Yamazumi* Chart

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Paper History

Received: 30-June-2026
Received in revised form: 21-July-2026
Accepted: 30-July-2026

ABSTRACT

Load imbalances among Material Handling (MH) operators in the automotive manufacturing industry may result in overload or idle conditions, thereby disrupting material supply and delivery accuracy. This study measured the cycle of time standard of MH activities using the Standardized Work Type 3 (SW Type 3) method, analyses workload distribution through Workload Analysis and the Yamazumi Chart, and designs a feasible workload-balancing scenario for automotive component manufacturing companies. Data were collected via time studies with five repetitions per activity in the Finished Goods (FG), Delivery, and Brake Assembly/Drum in Hat (BA/DIH) areas. Results indicated that the FG area was overloaded, with utilization rates of 115.7–120.0% of the available 480 minutes per shift. The Delivery area experienced critical overload, with utilization rates ranging from 177.0% to 207.8%. In contrast, the BA/DIH area exhibited a maximum workload gap of 70.9 minutes per shift, despite all operators remaining below the available time. The job-balancing scenario, implemented through the redistribution of Supply Empty Box activities, reduced the workload gap among operators by 72.2%, ensuring all operators remained within their available time.

KEYWORDS: *Balancing Job, Material Handling, Standardized Work Type 3, Workload Analysis, Yamazumi Chart.*

NOMENCLATURE

SW Type 3	*Standardized Work Type 3*
MH	*Material Handling*
CT	*Cycle Time*
WLA	*Workload Analysis*
YC	*Yamazumi Chart*
FG	*Finished Goods*
BA	*Brake Assembly*
DIH	*Drum In Hat*
PPIC	*Production Planning and Inventory Control*
CTSS	*Consecutive Time Study Sheet*
UT	*Utilization Rate*
WL	*Workload*
AT	*Available Time*

1. INTRODUCTION

The automotive manufacturing industry faces increasing pressure to maintain operational efficiency, product quality, and on-time delivery [1]. Material Handling (MH) is a critical factor in ensuring the smooth flow of production, as it involves the movement and provision of materials, packaging, and supporting components necessary for sustaining production and delivery processes [2]. Workload imbalances among MH operators can result in overload or idle conditions, potentially disrupting material supply and the accuracy of customer deliveries.

Previous studies have addressed the measurement of working time and workload balancing in the manufacturing industry. For example, Farhana applied Workload Analysis to determine optimal labor requirements and demonstrated its effectiveness in quantitatively identifying overload and idle conditions [3]. Sabadka et al. showed that implementing the Yamazumi Chart on automotive assembly lines improved line efficiency through workload balancing [4]. More, Chan et al. [5] developed a comprehensive measurement index based on the Yamazumi Chart, enabling evaluation of workload balance and simultaneous achievement of demand targets. Suherman et al. [6] demonstrated that Workload Analysis is effective for analyzing employee workloads and recommending optimal job redistribution. Then, Islam and Ahmed [7] found that consistent application of work standardization in lean manufacturing environments can enhance production line efficiency. However, research specifically integrating SW Type 3, Workload Analysis, and the Yamazumi Chart for MH activities

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in the automotive component industry remains limited. Therefore, this study addresses this gap.

PT. XYZ is a manufacturer of motor vehicle braking system components located in Karawang, West Java. Preliminary findings indicate a lack of standardization of MH work in the SW Type 3 format in several critical areas, preventing quantitative evaluation of workload distribution among operators. Initial measurements revealed that operator workloads in the FG and Delivery areas reached 115–120% of the available 480 minutes per shift, while the BA/DIH area exhibited a workload gap of up to 71.6 minutes per shift among operators to (1) measure the standard cycle time of MH activities using SW Type 3, (2) analyze the distribution of workload using Workload Analysis and *Yamazumi* Chart, (3) design a feasible workload balancing scenario, and (4) provide recommendations for improving the MH work system to the company.

Workload Analysis has been applied to identify labor requirement, the *Yamazumi* Chart has been used to balance production lines and the analysis of work standardization in lean manufacturing environments, but rarely in combination, and not in a single framework for the analysis of Material Handling (MH) operations in the automotive component industry [7]. Most of the existing studies mainly focus on assembly-line balancing or workforce allocation, but do not establish standard work measurements as the basis for workload balancing. The novelty of this paper is that Standardized Work Type 3, Workload Analysis and the *Yamazumi* Chart are applied as a stepwise procedure starting from standard cycle time measurement, moving on to quantitative workload assessment and ending with the design of feasible workload balancing scenarios. Therefore, this research offers a pragmatic approach to enhance MH operations, which is based on work data that is standardized and not just workload estimation.

2. RESEARCH METHODS

This research was conducted at PT XYZ, an automotive component manufacturer in Karawang, West Java, from December 2025 to February 2026. The research concentrated on MH operators and their work activities across FG, Delivery, and BA/DIH. The one of objective of the study was to develop the company’s first operational cycle-time database by direct observation under normal production conditions. PT XYZ had not previously built standardized work documentation for material handling activities. Thus, the measured cycle times are representative of baseline operational cycle times reality on the shop floor. These cycle times were then used as the basis for workload analysis and workload balancing rather than as engineered standard times based on performance rating and allowance adjustments.

2.1 Data Collection

Primary data were obtained through a time study using a stopwatch and a Consecutive Time Study Sheet (CTSS). Measurements were carried out 5 times for each activity to obtain a representative cycle time. Abnormal data were excluded from the standard cycle time calculation. In addition, interviews were conducted with operators to obtain data on irregular work and operational limitations. Secondary data on daily production volume and packaging capacity were obtained from the PPIC department. Each material handling activity was observed five times in normal operating conditions. The selected activities were very repetitive and followed standard operating procedures therefore the cycle times observed had little variation between repetitions. In industrial engineering practice, where the objective is to develop practical standard cycle times for the purpose of operational improvement, rather than for statistical inference. Then, a small number of repeated observations can be used to characterize a repetitive operation with stable work methods. Therefore, for a subsequent analysis of the workload, the mean of the five observations was used as representative.

2.2 Data Processing

The standard cycle time obtained from the time study is converted into workload per shift through the following three calculation stages [3]:

$$y\ packaging/day = \frac{Daily\ Volume\ (pcs/days)}{Qty\ per\ packaging} \quad (1)$$

$$Cycle/day = \frac{Qty\ per\ packagin}{Packaging\ volume/c} \quad (2)$$

$$Cycle/day = Cycle/day\ x\ Time/cycle \quad (3)$$

The total workload per shift is obtained by summing regular and irregular work. The formula determines the operator utilization rate:

$$Utilisasi\ (\%) = \frac{Workload/shift}{Available\ time} x\ 100\% \quad (4)$$

2.3 Workload Analysis and Balancing Job

The distribution of workloads is visualized using the *Yamazumi* Chart for each cycle and shift. The identification of workload gaps between operators was carried out based on these visualizations. The balancing job scenario was designed with functional feasibility, proximity to the area, the receiving operator's capacity, and the impact on the smooth production process in mind. The effectiveness of balancing was evaluated using the gap reduction formula [8]:

$$Gap\ reduction\ (\%) = \frac{Gap\ before - Gap\ after}{Gap\ before} x\ 100\% \quad (5)$$

3. RESULTS AND DISCUSSION

3.1 Cycle Time Measurement Results

The time-study measurement was conducted on 7 MH operators across three areas. In the FG area, there were two operators (Operator A and Operator B) who each handle several production lines with various types of packaging. In the Delivery area, two operators (Operator C and Operator D) deliver products to various customers. In the BA/DIH area, three operators (E, F, and G) were responsible for supplying

JOMAse | Received: 30-June-2026 | Accepted: 30-July-2026 | [(70) 2: 171-176]
Published by International Society of Ocean, Mechanical and Aerospace Scientists and Engineers, www.isomase.org., ISSN: 2354-7065 & e-ISSN: 2527-60

materials to the assembly line. A recap of the average cycle time per area is presented in Tables 1, 2, and 3. The highest cycle time was observed in the Carton Box supply activity (17.0 minutes/cycle) due to the complexity of the preparation process and the need to retrieve materials from multiple locations. A recap of the Delivery area's cycle time is presented in Table 2.

The highest cycle time in the Delivery area was observed in the delivery activity to Customer 2, at 7.6 minutes/cycle, due to the longer poly-box pick-up location. A recap of the cycle time area of the Brake Assy/Drum in Hat is presented in Table 3. The highest cycle time in the BA/DIH area was observed in the activities of Supply Child Part DIH (21.0 minutes/cycle) and Supply Child Part BA (18.0 minutes/cycle), due to the complexity of filling components of various types from multiple storage locations.

3.2 Data Processing and Workload Analysis Results

The results of converting cycle time to workload per shift using Equations (1) to (4) are presented in Table 4.

Table 1: Recap of the time cycle area finish good

No.	Operator	Line	Packaging Type	Average Cycle Time (minutes/cycle)
1	Operator A	Line 1	Polybox (2 units)	5.2
2	Operator A	Line 1	Pallet	7.1
3	Operator A	Line 3	Polybox (2 units)	4.3
4	Operator A	Line 3	SGMW Pallet	3.9
5	Operator A	Line 3	Carton Box	17.0
6	Operator B	Line 2	Polybox (2 units)	5.0
7	Operator B	Line 2	Pallet	7.0
8	Operator B	Line 4	Polybox (1 unit)	5.8
9	Operator B	Line 4	Polybox (2 units)	5.1
10	Operator B	Line 4	HPM Pallet	3.9
11	Operator B	Line 4	Carton Box	17.0

Table 2: Cycle time area delivery recap

No.	Operator	Customer	Average Cycle Time (minutes/cycle)
1	Operator C	Customer 1	6.5
2	Operator C	Customer 2	7.6
3	Operator C	Customer 3	4.6
4	Operator C	Customer 4	5.0
5	Operator C	Customer 5	7.0
6	Operator C	Customer 6	5.1
7	Operator C	Customer 7	2.1
8	Operator D	Customer 8	2.8
9	Operator D	Customer 9	4.7
10	Operator D	Customer 10	5.9
11	Operator D	Customer 11	5.1
12	Operator D	Customer 12	2.1
13	Operator D	Customer 13	2.1
14	Operator D	Customer 14	2.1
15	Operator D	Customer 15	2.1
16	Operator D	Customer 16	4.7

Table 3: Cycle time measurement results in the brake assembly/drum in hat (BA/DIH) area

No.	Operator	Sub-Area	Activity	Average Cycle Time (minutes/cycle)
1	Operator E	BA	Supply Empty Box	2.37
2	Operator E	BA	Supply Plate	8.0
3	Operator E	BA	Supply Child Part 1	5.2
4	Operator E	BA	Supply Child Part 2	18.0
5	Operator F	DIH	Supply Empty Box	2.4
6	Operator F	DIH	Supply Plate	7.2
7	Operator G	DIH	Supply Child Part	21.0

Table 4: Total workload/shift recap per area

Area	Operator	Regular Work (min)	Irregular Work (min)	Total Workload per Shift (min)	Utilization (%)	Status
FG	Operator A	559.6	16.1	575.7	120.0%	Overload
FG	Operator B	542.3	13.0	555.3	115.7%	Overload
Delivery	Operator C	839.5	10.0	849.5	177.0%	Overload
Delivery	Operator D	987.3	10.0	997.3	207.8%	Overload
BA/DIH	Operator E	305.6	47.6	353.2	73.6%	Normal
BA/DIH	Operator F	243.0	71.4	314.4	65.5%	Underload
BA/DIH	Operator G	337.3	48.0	385.3	80.3%	Normal

3.3 *Yamazumi* Chart and Workload Gap Analysis

Based on Table 4 and the Yamazumi Chart visualization, the analysis of the workload gap between operators in each area was as follows:

Area Finish Good

Both operators experienced overload with utilization of 120.0% (Operator A) and 115.7% (Operator B). The workload gap between the two of them, at 20.4 minutes/shift, indicates a relatively even distribution. However, the combined total workload of 1,131 minutes/shift exceeds the capacity of two operators (960 minutes/shift), so redistributing activities between operators cannot fundamentally resolve the overload. The main cause of overload is the high production volume of Line 3, which produces 54 cycles/day and contributes 308.0 minutes/shift to Operator A's load.

Area Delivery

The overload condition is much more critical at utilization levels of 177.0% (Operator C) and 207.8% (Operator D). The gap of 147.8 minutes/shift indicates a considerable imbalance, mainly due to assigning Customer 10 to Operator D, resulting in 74 cycles/day because of a combination of high shipping volume (889 pcs/day) and limited packaging capacity (1 pcs/polybox). The combined total workload of 1,846.8

JOMAse | Received: 30-June-2026 | Accepted: 30-July-2026 | [(70) 2: 171-176]
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minutes/shift indicates an acute need for additional operators and work system improvements. In addition, abnormal conditions were observed, including pushing poly-boxes with sticks due to a jammed chute, which was categorized as waste and not included in the standard workload.

Area BA/DIH
All operators were below the available time, but the maximum gap of 70.9 minutes/shift among Operator G (385.3 minutes) and Operator F (314.4 minutes). Operator F had the lowest utilization at 65.5%, with an idle time of 165.6 minutes/shift, indicating underutilized capacity. This area was the most feasible candidate for managing work.

3.4 Analysis of Balancing Job Area Brake Assy /Drum in Hat

Based on the results of the workload analysis, a balanced job scenario was designed through redistributing activities from Operator E to Operator F. Activity evaluation was conducted based on four key criteria: functional feasibility, proximity to the target area, receiving operator capacity, and potential impact on production process continuity. These criteria were assessed to determine the operational suitability of each activity within the existing production system.

The Supply Empty Box BA activity was chosen because it met all criteria: it was simple and required no special skills, it was located close to Operator F's duty area, Operator F had a considerable idle time (165.6 minutes/shift), and it had no direct impact on the supply of critical components. Supply Plate and Supply Child Part activities were not selected because they required specialized knowledge of the different component types and storage locations across sub-areas. The results of the workload comparison before and after balancing are presented in Table 5.

The evaluation of the effectiveness of balancing jobs using Equation (5) resulted in a gap reduction of Operators E–F of 72.2% and a gap reduction of Operators G–F of 35.0%. The full results of the evaluation are presented in Table 6. This balancing scenario reduced the gap for Operators E–F by 72.2%, from 38.8 minutes to 10.8 minutes/shift, and the gap for Operators G–F by 35.0%, from 70.9 minutes to 46.1 minutes/shift. All operators remain below the available time of 480 minutes/shift after redistribution. These findings are in line with [9], which shows that implementing the *Yamazumi* Chart as a balancing tool can effectively reduce the workload gap between operators. The total combined post-balancing idle time of 387.1 minutes/shift opens up further optimization opportunities through cross-area job balancing.

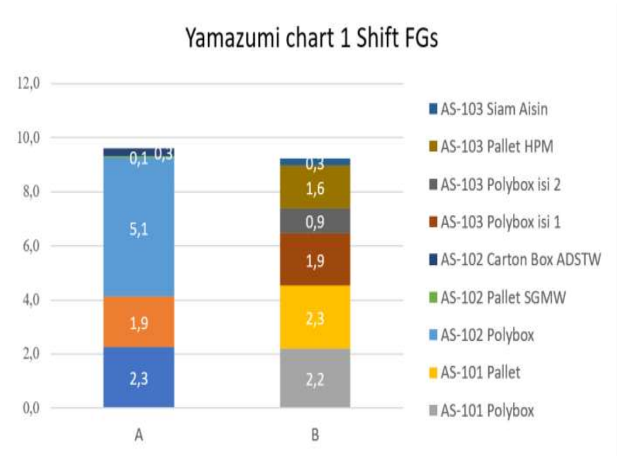

Figure 1: *Yamazumi* chart 1 shift area finish good

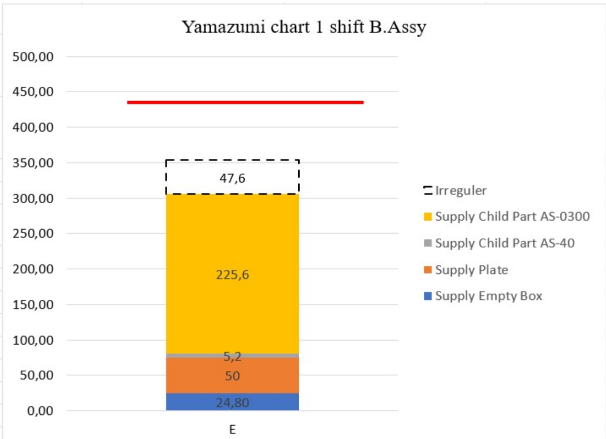

Figure 3: *Yamazumi* chart 1 shift area brake assembly

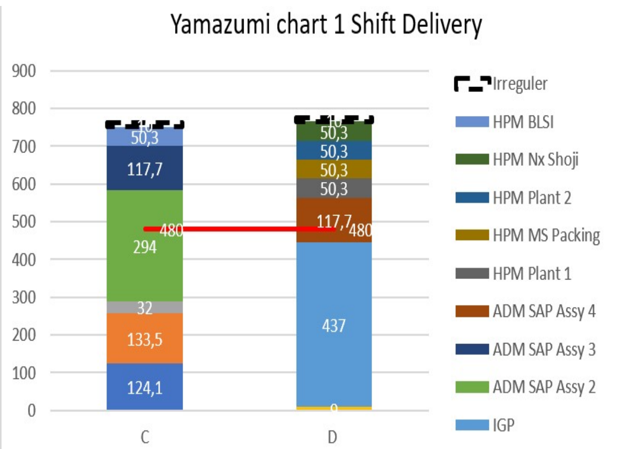

Figure 2: *Yamazumi* chart 1 shift area delivery

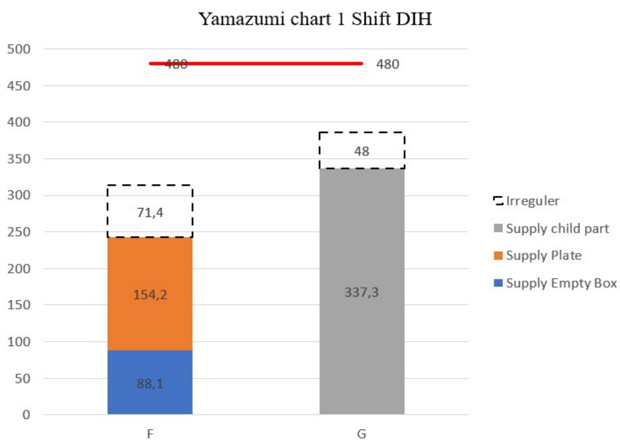

Figure 4: *Yamazumi* chart 1 shift area drum in hat

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Table 5: Workload comparison before and after balancing job implementation

Operator	Before (minutes)	After (minutes)	Delta (minutes)
Operator E	353.2	328.4	-24.8
Operator F	314.4	339.2	+24.8
Operator G	385.3	385.3	0

Table 6: Evaluating the effectiveness of managing work

Indicator	Before	After	Improvement
Operator Gap E–F (minutes)	38.8	10.8	↓ 72.2%
Operator Gap G–F (minutes)	70.9	46.1	↓ 35.0%
Operator Gap G–E (minutes)	32.1	56.9	↑ 77.3%
Operator E Utilization (%)	73.6%	68.4%	↓ 5.2%
Operator F Utilization (%)	65.5%	70.7%	↑ 5.2%
Operator G Utilization (%)	80.3%	80.3%	-
Operator E Idle Time (minutes)	126.8	151.6	+24.8
Operator F Idle Time (minutes)	165.6	140.8	-24.8
Operator G Idle Time (minutes)	94.7	94.7	-

The results of this research concerning workload balancing were consistent with recent international studies on lean manufacturing and human-centered production systems. The workload imbalance reduction of 72.2% showed that redistribution of tasks with the real workload measurement can successfully improve the workload equity without extra manpower or workstation redesign. This was in agreement with earlier studies reporting the *Yamazumi* Chart as an effective visual tool for identifying workload imbalances and supporting systematic redistribution of tasks to improve operational performance [10]. Moreover, balancing material supply activities by taking into account operator capacity, task characteristics and travel distance has been proven to reduce unnecessary operator movement while keeping production efficiency [11]. The balancing strategy proposed in this study was based on the same principles. A low complexity and non-critical activity (Supply Empty Box) was reallocated to an underutilized operator to improve workload distribution while keeping production continuity. Additionally, the studies on human-centered balancing have pointed to the importance of considering workload equalities together with productivity goals in balancing decisions, which further supports the practical effectiveness of the proposed approach for a more balanced workload distribution [12].

Although the study was carried out on a single automotive component manufacturing company, the developed framework can be generalized to other manufacturing environments with repetitive material handling activities and standardized operational procedures. Standardized Work was a systematic basis for documenting work elements, establishing baseline cycle times and supporting continuous improvement across various production systems [13]. Similarly, the *Yamazumi* Chart was well known as an effective lean tool to detect workload imbalance and facilitate task redistribution in various manufacturing environments, irrespective of production layout or product characteristics [10]. Thus, the combination of Standardized Work Type 3, Workload Analysis, and the *Yamazumi* Chart can be presented a practical and portable method for evaluating workload distribution and formulating balancing strategies grounded in real operational data. However, the specific balancing solutions should be customized to each manufacturing environment taking into account factors such as production volume, product mix, facility layout, workforce configuration and operational constraints as these factors highly affect the effectiveness of workload balancing strategies [14-17].

3.5 Repair Recommendations

Area Finish Good

(1) Optimization of operator movement routes to reduce transportation waste, especially in the supply activities of the Line 3 poly-box, which has a frequency of 54 cycles/day; (2) Rearrangement of the staging area by placing the material closer to the point of use; (3) Evaluate the need for additional operators if overload still occurs after optimization.

Area Delivery

(1) Review of customer distribution between operators based on actual workload, especially related to Customer 10, which contributes 43.7% of the total workload of Operator D; (2) Handling the root of the problem of a stuck chute that causes abnormal activity; (3) Evaluation of the need for additional operators considering the total combined workload reached 1,846.8 minutes/shift.

Area BA/DIH

(1) Implementation of the balancing job scenario that has been designed; (2) Periodic post-implementation workload monitoring; (3) A study of advanced balancing work with MH operators in other areas to take advantage of idle time of 387.1 minutes/shift.

4. CONCLUSION

Based on the research results, the following conclusions can be drawn. First, SW Type 3-based work time measurement successfully produced standard cycle times for all MH activities across the FG, Delivery, and BA/DIH areas, serving as the first formally documented work standard for these three areas. Second, the Workload Analysis and *Yamazumi* Chart analyses showed overload conditions in the FG area (utilization 115.7–120.0%) and the Delivery area (utilization 177.0–207.8%), as well as a workload imbalance in the BA/DIH area, with a maximum gap of 70.9 minutes/shift. Third, the most feasible balancing job scenario is the redistribution of Supply Empty Box BA activities from Operator E to Operator F, which has been proven to reduce the gap between Operators E–F by 72.2% and the gap between Operators G–F by 35.0%, with all operators remaining below the available time of 480 minutes/shift. Fourth, improvement recommendations include route optimization and staging area arrangement for the FG area; review of customer distribution and handling of chute jams for the Delivery area; and implementation of balancing jobs and periodic workload monitoring for the BA/DIH area.

The scientific contribution of this study is the integration of the Standardized Work Type 3, Workload Analysis and *Yamazumi* Chart into a practical framework for Material Handling workload balancing. In practice, the framework offers a data-driven approach for manufacturers to identify the workload imbalance and to develop feasible balancing strategies.

However, the study was limited to a single automotive component manufacturer and stable production conditions. Future work should validate the proposed framework in other manufacturing environments and include ergonomic factors and dynamic production conditions.

ACKNOWLEDGEMENTS

The author would like to thank PT. XYZ for the opportunity and data support during the implementation of this research. The author also expresses sincere gratitude to the engineering and operational teams for their valuable assistance, cooperation, and support throughout this study.

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