

Karakuri Kaizen Design to Reduce Work Time at the Packing Station

Yusuf Mauluddin *, Bagas Fardiansyah

Industrial Engineering, Institut Teknologi Garut, Garut, 44151, Indonesia

* Corresponding Author: yusuf.mauluddin@itg.ac.id

ARTICLE INFO

Article history

Received January 15, 2025
Revised September 22, 2025
Accepted October 4, 2025

Keywords

Cycle time reduction;
Food industry;
Kaizen;
Karakuri;
Packing station.

ABSTRACT

This study investigates production bottlenecks at the packing station of PT Anta Boga Pangan Nusantara, where manual operations resulted in prolonged cycle times and reduced efficiency. The research aims to design and implement a Karakuri Kaizen-based Lean Mover to minimize work time and enhance process performance. A quantitative approach was employed, involving direct observation, time measurement, and process analysis. The implementation of the Lean Mover successfully reduced the cycle time from 158.08 seconds to 24.74 seconds, outperforming the target takt time of 27 seconds. These findings demonstrate that low-cost, energy-efficient mechanical systems can effectively eliminate non-value-added activities, balance operator workloads, and improve productivity in food industry operations. The novelty of this study lies in the application of Karakuri Kaizen within the food manufacturing sector, a field rarely explored in previous research, thereby extending its applicability beyond conventional industrial settings. The study contributes theoretically by providing empirical evidence of Karakuri Kaizen's effectiveness in optimizing manual operations in resource-constrained environments, and practically by offering an ergonomic, sustainable, and affordable alternative to high-cost automation systems.

This is an open-access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



1. Introduction

In the era of globalization and increasingly fierce industrial competition, the performance of manufacturing companies is largely determined by high work productivity and efficiency (Kittidecha et al., 2024). Companies must produce optimal output with minimal input while ensuring effective and efficient use of resources. Optimal production efficiency allows the fulfillment of production targets with minimal time and cost and the reduction of waste without sacrificing product quality (Pescoe & Shejwal, 2021). One of the crucial challenges in achieving this efficiency is identifying and eliminating bottlenecks, which are points in the production flow where the production rate slows down and limits the overall system capacity (Tan et al., 2023). Bottlenecks significantly impact throughput, work-in-process, and production lead times, causing work backlogs, resource wastage, and potential delivery delays (Kalbhor et al., 2018). Therefore, addressing bottlenecks is essential in improving production efficiency (Evelyn Agustin et al., 2025).

The packing station is often the source of bottlenecks in the manufacturing process. As the final stage of production, this station plays an important role in ensuring that products reach consumers quickly and efficiently. Common problems at the packing station involve prolonged cycle times

resulting from repetitive and complex manual tasks (Dini Wahyuni et al., 2019), excessive operator movements that cause fatigue and potential injuries (Monoarfa et al., 2021), potential human errors that result in rework and delays (Daelima et al., 2013), and suboptimal layouts that waste time and effort (Redantan, 2021; Widiwati et al., 2025). These problems, if ignored, can reduce the operational efficiency and profitability of the company. Various solutions have been implemented to overcome the bottleneck problem at the packing station, ranging from bottleneck analysis and application of Lean Manufacturing principles that focus on identifying and eliminating waste in the process to overcome bottlenecks (Musa, 2024), analyzed bottlenecks on the production line in a textile factory with the Kaizen method (Kurnianingtias et al., 2019), analyzed bottlenecks and charging costs in pile making at spinning work stations by recommending the addition of tools and operators to overcome them (Setiawan et al., 2015), balancing workload between stations and increasing production capacity to reduce bottlenecks with a line balancing approach (Daelima et al., 2013), reducing cycle time and unnecessary operator movements by implementing Karakuri Kaizen (Pogowonto & Amrina, 2020).

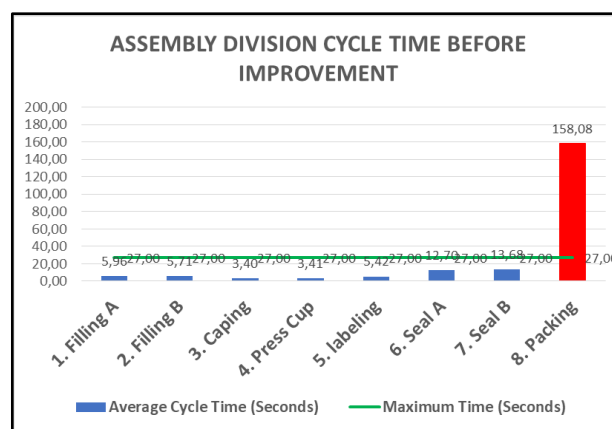


Fig. 1. Cycle time data of chili sauce product 135gr Assembly

As seen in Fig. 1, Although various studies have highlighted the application of lean manufacturing and kaizen to reduce cycle times, most remain limited to conventional approaches or high-cost automation technologies. The research gap lies in the lack of studies emphasizing simple mechanical solutions based on Karakuri Kaizen, particularly in the food industry, which faces resource constraints and a high demand for efficiency (Matindana & Shoshiwa, 2025).

The novelty of this research lies in the application of a Lean Mover design based on Karakuri Kaizen at a packing station in the food industry. This study differs from that of Pogowonto & Amrina (2020), which focused on general manufacturing sectors, as it emphasizes a low-cost, energy-efficient solution to address bottlenecks in food production. The urgency of this research is further underscored by market demands for sustainable production efficiency under limited investment capacity. The objective of this study is to design and implement a lean mover to reduce cycle time at the packing station and to evaluate its effectiveness using a quantitative approach. The contributions of this research are twofold: (1) practically, it provides an alternative lean solution that is simple, energy-efficient, and applicable to the food industry as well as other sectors facing similar challenges; and (2) theoretically, it strengthens the literature on Karakuri Kaizen applications by offering empirical evidence within the food production context, which has rarely been addressed in previous studies.

2. Method

This research was conducted at PT Anta Boga Pangan Nusantara using a quantitative approach. The methodological framework was based on the Karakuri Kaizen concept, as illustrated in Fig. 2, which presents the research flowchart and implementation stages. Karakuri Kaizen is an approach that integrates simple mechanical mechanisms with the principle of continuous improvement (Bukhori et al., 2023). According to Rembulan and Maratama (2022), it improves production efficiency by

utilizing basic mechanisms without relying on electrical power or advanced technology, thereby reducing waste and increasing productivity. This method is part of the broader Kaizen philosophy, which emphasizes low-cost, energy-efficient, and environmentally friendly solutions (Famila Dwi Winati, 2021). In industrial and manufacturing contexts, Karakuri Kaizen refers to the development and application of simple mechanical devices (Zein et al., 2018) that exploit inclined planes and gravitational forces (Gursoy Ozcan, 2022), without requiring external energy sources such as electricity or compressed air, to optimize processes, minimize waste, enhance efficiency, and lower costs (Herwanto et al., 2017).

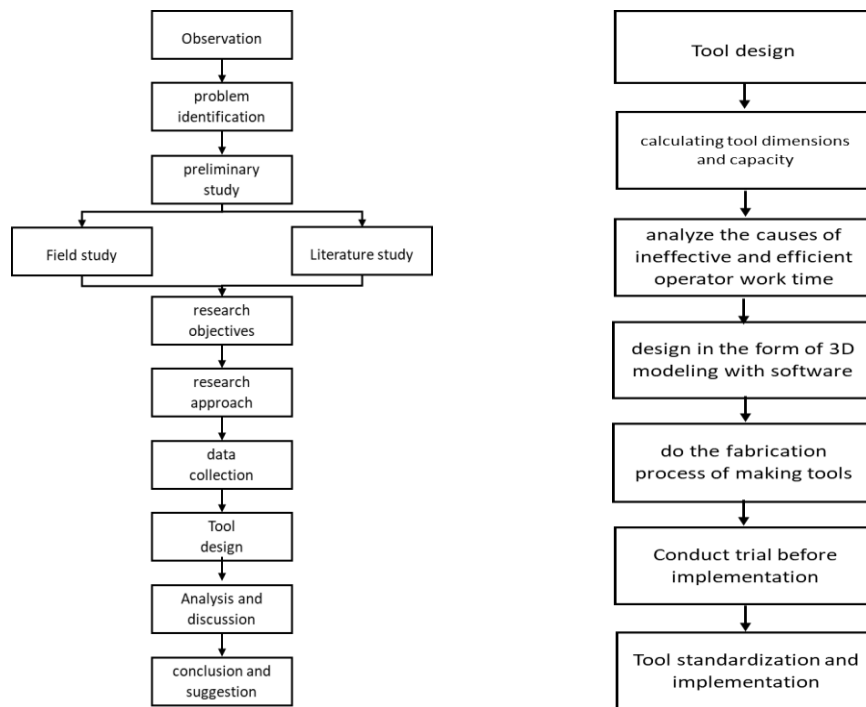


Fig. 2. Research Flowchart and Stages of Karakuri Kaizen

Previous studies have demonstrated the effectiveness of Karakuri Kaizen in diverse applications. Imansuri et al. (2024) reported a 10.99% reduction in cycle time for the Cup Lower Pump Wire Press machine, from 10.10 seconds to 8.99 seconds. Nugroho et al. (2021) showed that production capacity targets could be improved through efficient material-handling design. Herwanto, et al. (2017) combined Karakuri Kaizen with ergonomic anthropometry to design handling tools that reduced operators' physical workload. Madisa et al. (2019) applied Karakuri Kaizen to workstation design, resulting in a 5.8% increase in productivity and improved ergonomics. Similarly, Prasetyawan et al. (2020) found that the use of Karakuri Kaizen-based assistive devices improved process accuracy to 95%, eliminated product defects, and reduced electrical energy consumption by 45%.

The data used in this research are primary data, obtained through direct observation of work activities at the packing station. As seen in Fig. 2, Time measurements were conducted using stopwatch techniques to capture cycle times accurately. The data were analyzed using descriptive and comparative methods. Efficiency calculations were carried out by comparing cycle times before and after the implementation of the Karakuri Kaizen Lean Mover design. Data validity was ensured through repeated measurements at different time intervals to confirm consistency. A before-and-after comparison method was applied to evaluate the effectiveness of the improvement, focusing on cycle time reduction and operator workload. Statistical calculations were also conducted to determine efficiency gains and to verify whether the improvements met the targeted takt time. These methods ensured the reliability and validity of the findings, thereby providing a rigorous basis for interpreting the results.

3. Results And Discussion

The results and discussion of this study discuss the steps in applying the Karakuri kaizen method (Herwanto et al., 2017). The stages that are passed include:

3.1. Calculating tool dimensions and capacity

This calculation is very important to ensure that the designed tool can function properly in the work environment and according to the needs of the production process. The data required includes:



Fig. 3. Product dimensions of 135-gram sauce

The product Fig. 3, used for research is the 135-gram variant of Sauce, which is part of the design of the packing process aids. The product uses PET (Polyethylene Terephthalate) material, which has transparent, lightweight, and water-resistant properties, making it suitable for use as food packaging. The dimensions of the product are 16.5 cm high and 4 cm in diameter, which have been adjusted as part of the tool design to suit the needs of the packing process. The total weight of the product is 152 grams, which consists of the packaging bottle weighing 17 grams and the product contents (sauce) weighing 135 grams. This product data was considered to ensure that the tool designed was suitable for the product's characteristics.

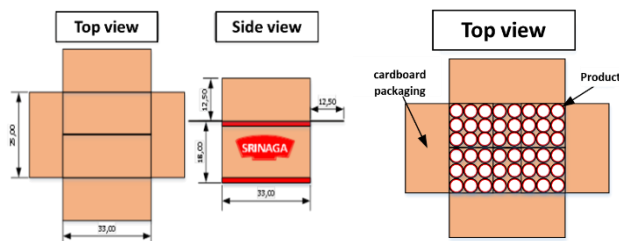


Fig. 4. Cardboard packaging

Cardboard packaging Fig. 4, uses corrugated cardboard material (corrugated cardboard), which provides optimal strength to protect medium-weight goods. This packaging has dimensions of 18 cm high, 32 cm long, and 23 cm wide, adjusted to support the design of tools in the packaging process. In terms of organization, the cardboard can accommodate 48 sauce products arranged in a standing order, with an additional partition in the middle to keep the products stable and safe during storage.

The layout of the division is shown in Fig. 5, used as data in designing the karakuri kaizen tool. The data that can be taken from the layout. The selected operator Fig. 6 is in the seal A, B, and Packing processes. There are operators of the Seal A and B processes because the process is the most influential in hampering the efficiency of the packing process. Hence, bottlenecks occur at the packing workstation. The posture height of the three operators is 170 cm on average.

Tool Drive Mechanism, the tool drive mechanism in *karakuri kaizen* in the manufacture of packing process accelerator tools used, namely: (a) Gravity. this drive mechanism is used to shift the

position of cardboard packaging, utilizing gravity to other positions, such as positions down and tilted down. (b) Lever, this drive mechanism is used as a component to increase the force applied when moving the position of the cardboard packaging. (c) Pulley, this drive mechanism is used to change the direction of the force or to reduce the effort required to lift the load on the cardboard packaging that has been filled with the product (Ludwika et al., 2024).

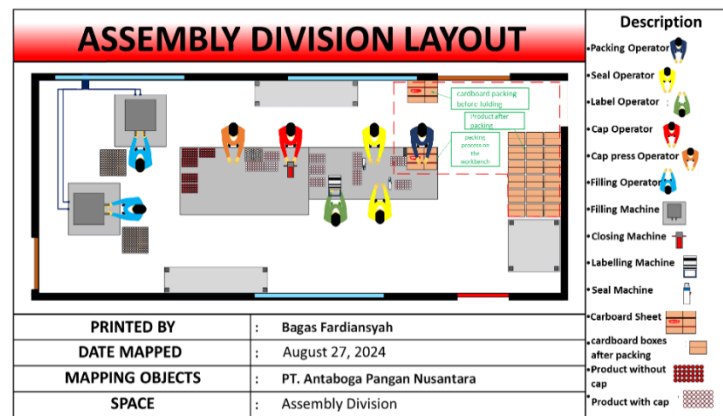


Fig. 5. Layout of the assembly division

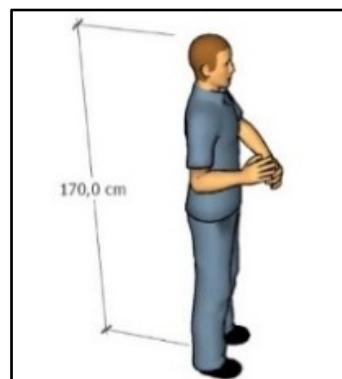


Fig. 6. Operator dimensions

Hinge, this drive mechanism is used for rotational transfer or linear movement in the position of cardboard *packing*. The data needs to determine the dimensions and capacity of the tool. Then, the tool capacity is obtained based on product size, cardboard packaging, assembly division layout, and operator anthropometry (Puthussery & Secco, 2024). The designed tool can accommodate 8 units of cardboard packaging filled with 135 chili sauce products, seven empty cardboard packaging that have been formed, and 40 unfolded cardboard packaging.

3.2. Analysis of the causes of ineffective and inefficient operator time

After calculating the dimensions and capacity of the equipment, the next step is to analyze the causes of ineffective and inefficient operator time. This analysis is done by identifying sources of waste in the operator's workflow at the packing station, such as unnecessary movements, waiting time, or non-ergonomic work positions. As for the work activities obtained, the packing operator requires a completion process, as seen in Table 1.

The results of this analysis showed that the packing operator had excessive work elements, so changes to the work process needed to be made. The excess work element in question is the 8th process element, namely, inserting 48 product units into cardboard packaging, which is the most extended process element and takes 93.2 seconds. So, the results of the analysis of the causes of ineffective and efficient operator time are obtained because these process elements include essential process elements

in the packing process, so the things that are done to be effective and efficient without eliminating the process elements are sharing these work elements with Seal A and Seal B operators, sharing these elements can equalize the operator load.

Table 1. Packing process work activities

No	Process	Time (seconds)	Time (minutes)
1	take the cardboard sheet	2.66	0.04
2	Laying and forming the cardboard sheets into a box	4.67	0.08
3	folding the front of the cardboard	3.91	0.07
4	folding the back of the cardboard	4.24	0.07
5	folding the left side of the cardboard	3.34	0.06
6	folding the Right side of the box	3.78	0.06
7	holding and applying duct tape	8.09	0.13
8	loading 48 units of product into the boxes	93.2	1.55
9	folding the front cardboard box	3.77	0.06
10	folding the back of the box	3.96	0.07
11	folding the left cardboard box	3.8	0.06
12	folding the Right cardboard box	3.82	0.06
13	holding and applying duct tape	8.2	0.14
14	lifting product-filled boxes	3.41	0.06
15	moving the product-filled boxes	7.23	0.12
Time per cycle		158.08	
Number of products per cycle		48	

Based on these element changes, the packing operator only focuses on work elements, including: (a) The process of taking cardboard packaging, (b) Forming the cardboard packaging into a perfect shape, (c) Give the operator seal A and seal B to be filled with products that have been sealed, (d) Products that have been packaged are then moved to the packing operator and packaged again to be stored in the storage warehouse. So, the change in the work process above can reduce the packing station work process time, and the operator's time becomes effective and efficient.

3.2. Designing in 3D Modeling

After completing the needs analysis, the Karakuri tool design will be designed in 3D modeling using SketchUp 2020 engineering design software. This stage allows a more precise visualization of the Karakuri solution, ensuring that all elements of the tool function properly before production. With 3D modeling, the design is obtained in the form of shown in the Fig. 8.

The three-dimensional modeling of the Karakuri Lean Mover illustrates the integration of several key components. Component A is used to store folded cardboard, while Component B serves as the queue for pre-assembled boxes. Component C transfers product-filled boxes to the final process, whereas Component D functions as both a transfer and sealing unit. In addition, Component E accommodates product-filled boxes before they are moved to the next stage.

3.4. Performing the fabrication process of tool prototyping

After the tool design is finalized in 3D, the next step is to carry out the tool's fabrication process or physical prototyping. The fabrication stage involves making the components of the Karakuri tool according to the established design. Depending on the design tool, this process can involve several production techniques, such as cutting, assembling, and welding components.



Fig. 7. Prototype karakuri Lean Mover

The design, as shown in Fig. 7, was compared with the prototype at a 1:2.22 scale. The Karakuri prototype design focused on basic functions because the main principle of Karakuri is efficiency and energy saving. The materials used for the prototype were inexpensive and easy to obtain, namely PVC pipes and wood. The prototype was developed to test whether the tool could function according to the initial concept.

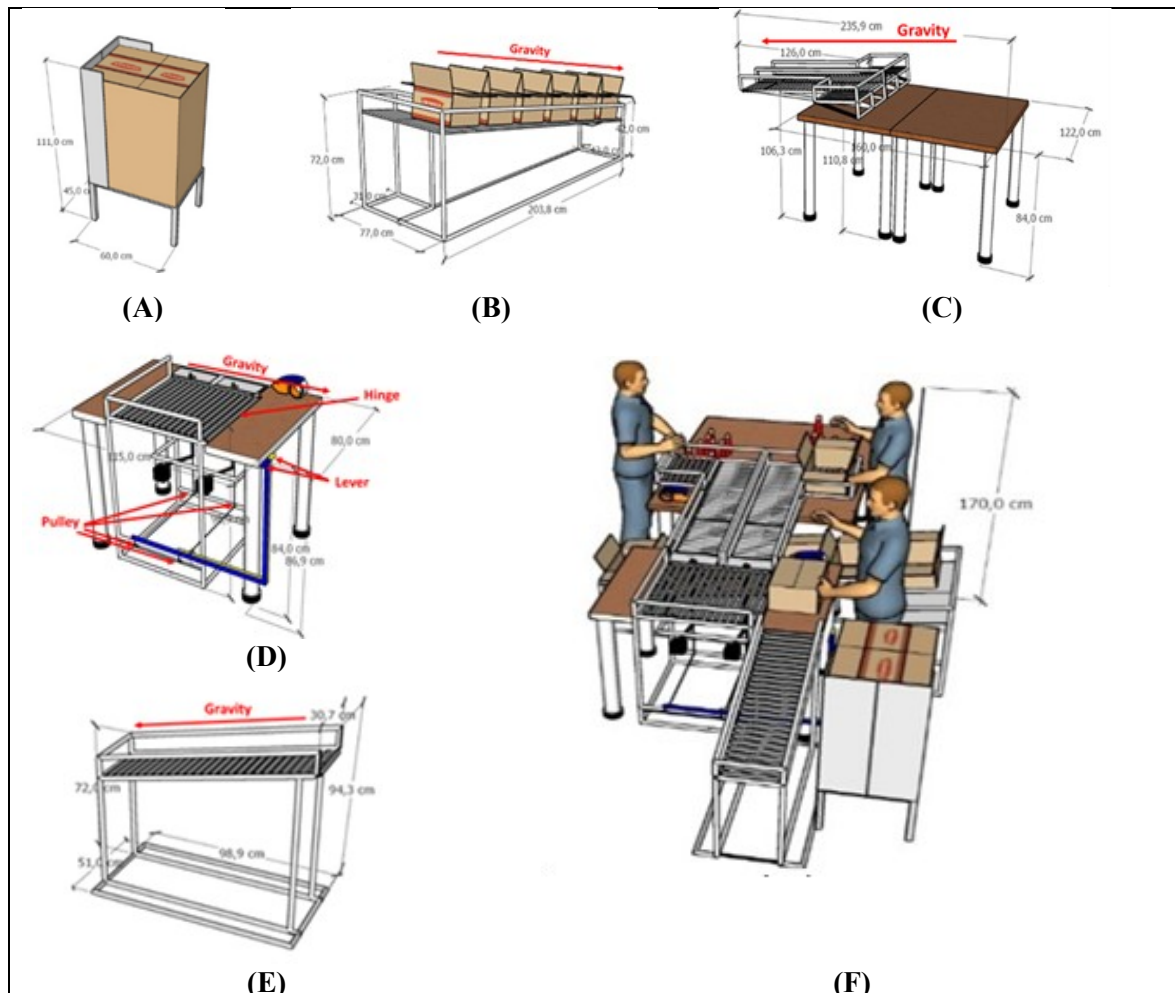


Fig. 8. Karakuri Lean Mover and Component 3D Modeling

3.5. Conducting trials before implementation

After the tool was completed, a trial was conducted to verify its functionality and its ability to reduce work time. The results demonstrated a significant reduction in cycle time. Based on the motion

study of the Karakuri LeanMover prototype, the cycle time decreased from 158.08 seconds to 24.74 seconds, which is below the takt time of 27 seconds, representing an improvement of 109.08%. Therefore, the application of the Karakuri Kaizen method in developing material handling aids with the LeanMover tool proved effective in eliminating bottlenecks and enhancing efficiency at the packing workstation.

3.6. Tool standardization and implementation

The final step is to standardize and implement the Karakuri Kaizen tool. After the trial is successful and the tool functions as expected, a standard operating procedure (SOP) will be made to integrate the use of the tool into the production process formally. The results of the standardization of these tools in the form of left-hand, right-hand maps for the packing process workstation operators are described in Table 2.

Table 2. Right-hand left-hand map

No	Left hand	Time (Seconds)	Code	Code	Time (Seconds)	Left hand	Components used
1	picks up the cardboard sheet at Karakuri component A forming the cardboard sheet	1,33	RE	RE	1,33	take the cardboard sheet in Karakuri component A	
2	into a box in karakuri component D	2,35	P	P	2,35	form the cardboard sheet into a box in karakuri component D	Karakuri D
3	folding the front cardboard in karakuri component D	2,12	A	A	2,12	folding the back of the cardboard in the karakuri D component	Karakuri D
4	fold the left side of the cardboard in karakuri component D	1,89	A	A	1,89	folding the Right cardboard in the karakuri D component	Karakuri D
5	Shut up	0,86	H	RE	0,86	take the duct tape dispenser on the karakuri component D	Karakuri D
6	point to the center of the cardboard	1,32	P	P	1,32	directs the duct tape dispenser to the center of the cardboard	Karakuri D
7	hold and apply duct tape	4,97	H	U	4,97	pulls and cuts the duct tape dispenser	Karakuri D
8	storing the cardboard in Karakuri Model B	0,94	RE	RE	0,94	storing the duct tape dispenser	Karakuri B
9	Presses Karakuri lever DD	1,72	U	RE	1,72	picking up the duct tape dispenser	Karakuri C dan D
10	aims at the center of the cardboard	1,33	P	P	1,33	directing the duct tape dispenser to the center of the cardboard	Karakuri D
11	holding and taping the duct tape	4,98	H	U	4,98	pull and cut the duct tape dispenser	Karakuri D
12	Pushing the product into Karakuri B	0,93	M	M	0,93	storing the duct tape dispenser	Karakur I E
Cycle time (seconds)					24,74		
Takt time (maximum time)					27		
Number of products per cycle					48 pcs		

The results of the study indicate that the implementation of the Karakuri Kaizen LeanMover significantly improved the packing process at PT Anta Boga Pangan Nusantara. Before the intervention, the average cycle time per packing process was 158.08 seconds for 48 units of 135-gram sauce bottles. After the introduction of the LeanMover, the cycle time decreased to 24.74 seconds, which is below the takt time target of 27 seconds, resulting in a production improvement of 109.08%.

Key data were obtained through primary observation and time measurement at the workstation, supported by product specifications, packaging dimensions, operator anthropometry, and workstation layout. The redesigned tool was tested through a prototyping stage using locally available materials and validated through repeated time trials. The results confirmed the tool's ability to reduce excessive motions and rebalance operator workloads between Seal A, Seal B, and packing operators. Fig. 9. is the cycle time of the assembly division after designing the tool, and there is a change in time, namely:

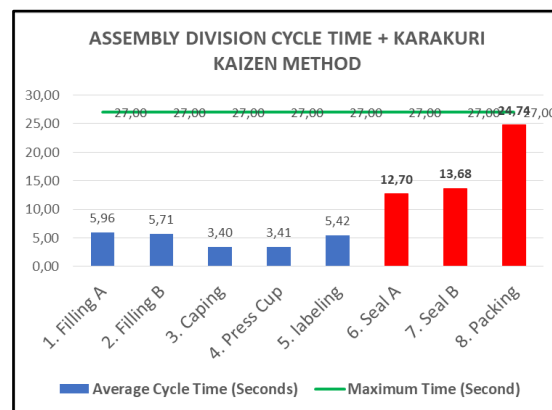


Fig. 9. Cycle time of assembly division & Karakuri Lean Mover

The redesigned process eliminated unnecessary manual handling and distributed workload more evenly, thus improving line balance and removing the bottleneck at the packing station. Overall, the LeanMover prototype achieved its intended purpose of improving productivity while maintaining operator ergonomics and low operational cost.

These results indicate that Karakuri Kaizen provides a practical solution for reducing bottlenecks in manual packing operations. The dramatic decrease in cycle time can be attributed to the elimination of non-value-added activities, better utilization of gravity-based mechanisms, and redistribution of operator tasks. From an ergonomic perspective, the Lean Mover reduced repetitive actions and awkward postures, thereby lowering operator fatigue and improving long-term work sustainability.

Compared to previous studies, the time reduction achieved in this research is greater. For example, Imansuri et al. (2024) reported a 10.99% reduction in cycle time for the Cup Lower Pump Wire Press machine, whereas the current study achieved a reduction of more than 80%. Similarly, Nugroho et al. (2021) showed improvements in production capacity through material-handling design, and Madisa et al. (2019) reported a 5.8% productivity increase from workstation improvements. The present study exceeds these results by demonstrating a drastic cycle-time reduction while also addressing ergonomics and line balancing.

The implication is that Karakuri Kaizen is not only effective in reducing processing time but also provides broader benefits in terms of ergonomics, productivity, and cost efficiency. Unlike high-cost automation, this approach relies on simple mechanical principles such as gravity, pulleys, levers, and hinges, making it particularly suitable for SMEs and food industries with limited resources. The findings also enrich the theoretical development of Karakuri Kaizen by providing empirical evidence in a food industry context, which has rarely been explored in prior research.

4. Conclusion

This study confirmed that the application of the Karakuri Kaizen Lean Mover design significantly reduced cycle time at the packing station, from 158.08 seconds to 24.74 seconds, surpassing the takt time target of 27 seconds. The findings demonstrate that simple, low-cost, and energy-efficient mechanical devices can effectively eliminate bottlenecks, improve productivity, and enhance ergonomics in the food industry. Academically, the research contributes to the development of Karakuri Kaizen theory by providing empirical evidence of its effectiveness in food production, a sector that has rarely been addressed in prior studies. However, the designed Lean Mover still requires further development and testing over an extended period to evaluate the reliability and consistency of its functions in real production conditions. Future research should therefore focus on long-term validation to ensure functional dependability, while also exploring opportunities to integrate Karakuri Kaizen with digital lean tools or Industry 4.0 technologies to enhance its scalability and theoretical contributions to sustainable manufacturing.

Author Contribution: All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

Funding: This research received no external funding.

Acknowledgement: This research was supported by Institut Teknologi Garut (ITG), Indonesia, through academic resources and institutional facilities that contributed to the successful completion of this research. The authors declare that no generative AI tools were used in the writing or analysis of this manuscript, except for language editing purposes under author supervision.

Conflicts of Interest: The authors declare no conflict of interest.

Reference

- Bukhori, A. M., Prahasto, T., Haryanto, I., Soedarto, J., 13, N., Tembalang, K., Semarang, K., & Tengah, J. (2023). Analisis Pengaruh Variasi Sudut Kemiringan Feeder Terhadap Waktu Tempuh pada Alat Conveyor LowCost Energy (Karakuri) di PT Dharma Precision Parts. *Jurnal Teknik Mesin S-1*, 11(3), 51–58. <https://ejournal3.undip.ac.id/index.php/jtm/article/view/40069/29603>
- Daelima, V. F., Febianti, E., & Ilhami, M. A. (2013). Analisis Keseimbangan Lintasan untuk Meningkatkan Kapasitas Produksi dengan Pendekatan Line Balancing dan Simulasi. *Jurnal Teknik Industri Untirta*, 1(2), 107–113. <https://jurnal.untirta.ac.id/index.php/jti/article/view/129>
- Dini Wahyuni, Irwan Budiman, Esa Pasaribu, & Jeffrey Panama. (2019). Optimisasi Stasiun Kerja melalui Minimisasi Bottleneck dengan Pendekatan Theory Of Constraint. *Talenta Conference Series: Energy and Engineering (EE)*, 2(3). <https://doi.org/10.32734/ee.v2i3.755>
- Evelyn Agustin, Daniel Marcello, Muhammad Ferdy Setiawan, & Michael Valentino Diamond. (2025). Analisis Bottleneck dan Kapasitas Mesin Untuk Meningkatkan Efisiensi Produksi Cup Plastik di PT “X.” *Journal of Mechanical Engineering*, 2(1), 1–15. <https://doi.org/10.47134/jme.v2i1.3537>
- Famila Dwi Winati. (2021). Peningkatan Kinerja Lini Perakitan Manual dengan Pendekatan Lean-Kaizen. *Industri Inovatif: Jurnal Teknik Industri*, 11(2), 79–89. <https://doi.org/10.36040/industri.v11i2.3647>
- Gursoy Ozcan, A. (2022). Application of Reba and Karakuri Kaizen Techniques To Reduce Ergonomic Risk Levels in a Workplace. *Muhendislik Bilimleri ve Tasarım Dergisi*, 10(4), 1430–1444. <https://doi.org/10.21923/jesd.957691>
- Herwanto, D., Nugraha, A. E., & Laksono, E. R. S. (2017). Perancangan Alat Bantu Untuk Mengatur Cycle Supply Part ke Line Produksi di PT. Toyota Motor Manufacturing Indonesia. *Barometer*, 2(1), 6–11. <https://doi.org/10.35261/barometer.v2i1.595>
- Imansuri, F., Jyestha Soekarno, R., Dahmar Prajoti, H., Syarifudin, A., Anatama Violeta, K., Sumasto, F., & Wulansari, I. (2024). Design of Material Handling Equipment in the Bending Process Using Karakuri

- Kaizen Method: An Analysis of Working Posture. *Jurnal Teknik Industri*, 14(2), 77–89. <https://e-journal.trisakti.ac.id/index.php/tekin/article/view/19411>
- Kalbhor, O., Neve, T., Pachpor, O., Bhoite, N., Deshmukh, A., & Chinchwad, P. (2018). Study of Karakuri Kaizen. *IJSRD-International Journal for Scientific Research & Development*, 6(02), 2321–0613. <https://www.ijssrd.com/articles/IJSRDV6I21545.pdf>
- Kittidecha, C., Chaiklang, A., Saramath, S., Narapinij, P., Phimoolchat, J., Hwanseang, W., Chaowakarnkool, S., Panyarach, W., Sanlad, R., & Lamkam, K. (2024). Productivity improvement of material handling using Karakuri Kaizen hand truck: A case study of Phuwiangwari community enterprise. *RMUTSB Acad. J*, 12(1), 80–92. <https://li01.tci-thaijo.org/index.php/rmutsb-sci/article/view/261404>
- Kurnianingtias, M., Heryadi, A. R., Purwanningrum, D., Astrini, G. Y., Khairunnisa, H., & Sari, L. N. I. (2019). Analisis Penyelesaian Permasalahan Bottleneck pada Lini Produksi di Pabrik Tekstil dengan Metode Kaizen. *Jurnal Rekavasi*, 7(1), 23–30. <https://ejournal.akprind.ac.id/index.php/rekavasi/article/view/3683>
- Ludwika, A. S., Shalehah, M., Mohamad, R. R. A., Oktavia, A. T., Normasari, N. M. E., Tho, N. H., & Rifai, A. P. (2024). Facility Layout Planning of Sheet Metal Working Industry Using Metaheuristics. *Spektrum Industri*, 22(2), 163–178. <https://doi.org/10.12928/si.v22i2.141>
- Madisa, I. M., Taib, M. F. M., & Reza, N. A. (2019). Implementation of Karakuri Kaizen to improve productivity and ergonomics in wire rope industry. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2019(MAR), 2765–2775.
- Matindana, J. M., & Shoshiwa, M. J. (2025). Lean manufacturing implementation in food and beverage SMEs in Tanzania: using structural equation modelling (SEM). *Management System Engineering*, 4(1), 1–14. <https://doi.org/10.1007/s44176-025-00036-3>
- Monoarfa, M. I., Hariyanto, Y., & Rasyid, A. (2021). Analisis Penyebab bottleneck pada Aliran Produksi briquette charcoal dengan Menggunakan Diagram fishbone di PT. Saraswati Coconut Product. *Jambura Industrial Review (JIREV)*, 1(1), 15–21. <https://doi.org/10.37905/jirev.1.1.15-21>
- Musa, C. I. (2024). Peningkatan Kinerja Proses Melalui Analisis Bottleneck dan Prinsip-Prinsip LEARN. *Maximal Journal: Jurnal Ilmiah Bidang Sosial, Ekonomi, Budaya Dan Pendidikan*, 1(6), 281–284. <https://malaqbiipublisher.com/index.php/MAKSI/article/view/110>
- Nugroho, W. I., Karuana, M. R., & Kristiawan, T. A. (2021). Penambahan Alat Bantu Pemindah Produk Menggunakan Pneumatik dan Karakuri pada Mesin Cup Lower Pump Wire Press PT. Mitsuba Indonesia. *Jurnal Rekayasa Mesin*, 16(1), 56. <https://doi.org/10.32497/jrm.v16i1.2516>
- Pescos, & Shejwal, V. D. (2021). Design & Build a Prototype of Two Stage Karakuri Lean Model. *International Journal of Engineering Ang Technoical Research*, 0869(11), 10–12. https://www.erpublication.org/published_paper/IJETR3021.pdf
- Pogowonto, A., & Amrina, U. (2020). Reduction of Cycle Time in Vehicle Engine Assembly Line Using Karakuri Kaizen. *International Journal of Engineering Research and Advanced Technology*, 06(10), 49–57. <https://doi.org/10.31695/ijerat.2020.3657>
- Prasetyawan, Y., Agustin, A. A., & Anggrahini, D. (2020). Simple automation for pineapple processing combining with karakuri design. *IOP Conference Series: Materials Science and Engineering*, 852(1). <https://doi.org/10.1088/1757-899X/852/1/012102>
- Puthussery, S., & Secco, E. L. (2024). Design and Integration of a Robotic Welding Parameterized Procedure for Industrial Applications. *Spektrum Industri*, 22(1), 60–76. <https://doi.org/10.12928/si.v22i1.179>
- Redantan, D. (2021). Meningkatkan Line Efficiency (LE) Dengan Memperbaiki Bottle Neck Dengan Metode Line Balancing di PT. RST. *Sigma Teknika*, 4(2), 267–270. <https://doi.org/10.33373/sigmateknika.v4i2.3635>
- Rembulan, G. D., & Maratama, S. (2022). Perancangan Alat Bantu Dengan Metode Conjoint Analysis Dan Quality Function Deployment (Qfd) Berdasarkan Prinsip Ergonomi. *JIEMS (Journal of Industrial Engineering and Management Systems)*, 15(1), 35–44. <https://doi.org/10.30813/jiems.v15i1.3602>

-
- Setiawan, A. D., Fahlevi, N., Riyanto, B., & Yuniarto, R. (2015). Analisis Bottleneck dan Charging Cost pada Pembuatan Tiang Pancang PT. Wika Beton PPB Boyolali. *Jurnal Karya Teknik Sipil*, 4(1), 56–65. <https://ejournal3.undip.ac.id/index.php/jkts/article/view/8683>
- Tan, K. H., Katayama, H., & Manickavasagam, S. (2023). What is Karakuri Kaizen and How Does It Work? In F. Deschamps, E. Pinheiro de Lima, S. E. Gouvea da Costa, & M. G. Trentin (Eds.), *BT - Proceedings of the 11th International Conference on Production Research – Americas* (pp. 25–32). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-36121-0_3
- Widiwati, I. T. B., Liman, S. D., & Nurprihatin, F. (2025). The implementation of Lean Six Sigma approach to minimize waste at a food manufacturing industry. *Journal of Engineering Research*, 13(2), 611–626. <https://doi.org/https://doi.org/10.1016/j.jer.2024.01.022>
- Zein, M., Nugraha, R. A., Iqbal, M., Prodi, S., Industri, T., Industri, F. R., & Telkom, U. (2018). Perancangan Produk Rasional Material Handling Equipment Pada Proses Manual Palletting Galon Air Mineral Untuk Mengurangi Beban Kerja Operator Rational Product Design of Material Handling Equipment in Mineral Water Manual Palletting Process To Reduce Opera. *E-Proceeding of Engineering*, 5(3), 6809–6819.