

Implementing Kaizen through a Lean RACE Model: A Case Study

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Abstract

In this case study, we conducted a Kaizen implementation to eliminate waste in a quick shipping area of a manufacturing facility. Based on Toyota's seven types of waste, specific wastes in the system are identified, and the improvement opportunities are specified. The lean RACE (Reduce, Accelerate, Consolidate, Enhance) model is then implemented to identify improvement targets in four directions: Reduce non-value-added activities to decrease interruption in the flow, Accelerate value-added activities to improve throughput and lead time, Consolidate value-added processes into fewer steps in order to shorten the value stream, and Enhance the value added through the processes to improve customer satisfaction and employee welfare such as the ergonomics of work and safer work environment. Based on the collected data, a numerical study is conducted through simulation modeling to verify the benefits of the Kaizen plan. The use of the RACE model, in this case, has projected results of reduction in transportation waste, less handling of work in process, and less waiting which leads to reduction in cycle time and increased throughput.

Keywords

Lean manufacturing; Kaizen; Continuous improvement; Lean RACE model

1. Introduction

In today's competitive market, it is essential to reduce waste and continuously pursue perfection in order to maintain a competitive edge. Kaizen (Continuous Improvement) is a Japanese philosophy, which means continual and incremental improvement [1]. Kaizen is an ongoing effort that lasts as long as the process lasts, and it is one of the main pillars of Lean. It goes hand in hand with other lean concepts such as Just in Time (JIT). Scholars and practitioners proposed Kaizen to be one of the main reasons why western firms had not fully benefited from related Japanese concepts such as Just in Time (JIT) [2].

One of the main challenges that faces Kaizen events or projects is how to identify improvement opportunities. Generally, waste refers to all elements of production that only increase cost without adding value. They can be identified based on Toyota's classic seven types of waste: overproduction, waiting, transportation, over processing, inventory, motion, and defects [3]. An eighth waste was added later which addresses the underutilized human talent. Reducing the non-value added activities improves the organization's competitive position [4]. Value is created if internal waste is reduced, as the wasteful activities and the associated costs are reduced, increasing the overall value proposition for the customer [5]. With Kaizen events, changes are introduced to deal with issues that limit the firm's ability to deliver value [6]. However, not all improvement opportunities would be identified or considered during a Kaizen event. A structured way to evaluate the opportunities is desired.

In this case study, we used Kaizen, i.e., continuous improvement approach, to improve the performance of logistics of a manufacturing facility. Specifically, we follow a Lean RACE (Reduce, Accelerate, Consolidate, Enhance) model to investigate improvement opportunities [7]. As shown in Figure 1, the Lean RACE model aims to not only reduce the non-value added activities but also enhance the value creation process, which is sometimes under-emphasized in Kaizen events. While most Kaizen initiatives stop after identifying and removing or reducing the non-value added activities, Lean RACE model pushes the improvement effort further by searching opportunities in other directions. First, the model seeks to accelerate the value added to ensure a quick delivery. Next, consolidate value-added activities to shorten the cycle time and therefore, shorten the lead time. Shorter cycle time results in a smaller work-in-process

that not only reduces the capital tied up, but also leads to an uncluttered plant floor [8]. The last option of the Lean RACE model is to enhance the value of the product or service for the customer. Customers can be external customers and/or internal customers. Improvements to meet external customer perceptions, without equivalent improvements for internal customers would almost certainly generate a negative reaction among the internal customers [9]. After opportunities in the four distinct directions are identified, the benefits and drawbacks should be evaluated using a Force Field Analysis to balance the trade off before finalizing the Kaizen plan.

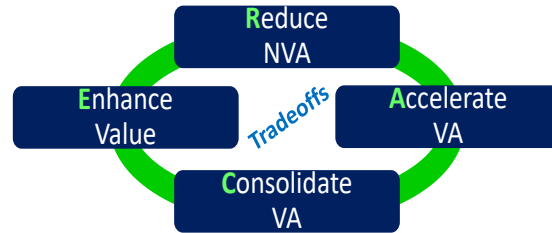


Figure 1: The Lean RACE Model of Four Potential Improvement Directions [7]

The remainder of the paper is organized as follows. Section 2 gives an overview of the system being evaluated and give a detailed description of the shop floor. In Section 3, the Kaizen implementation is explained by showing how the four categories of the Lean RACE model were used in this project. Section 4 explains the simulation model used to verify the improvement of Kaizen implementation. Section 5 summarizes the results and findings.

2. System Descriptions

The system being evaluated in this case study is a quick shipping area of a manufacturing facility. The products are essentially the same, but they differ in the way they are being shipped. As shown in Figure 2, there are eight different shipping methods used in this process, which are represented as A through H. A product travels on a conveyor belt to the shipping area and is diverted to the appropriate outlet based on the shipping method.

A camera is installed at the beginning of the conveyor to read the barcode of the product. A signal is then sent to the correct gate to divert the product to the proper outlet. The product then is carried in trays to a final processing table before being shipped out. There are also two extra outlets (i.e., I and J) to catch any failure in reading by the camera, which makes the total number of outlets on the conveyor 10. Each product type is gathered in a separate gaylord that can hold up to 500 pieces. Once a gaylord is full, a worker pulls it to the covering station, where a plastic bag is placed on top of the gaylord to protect the product from being damaged while waiting for shipping.

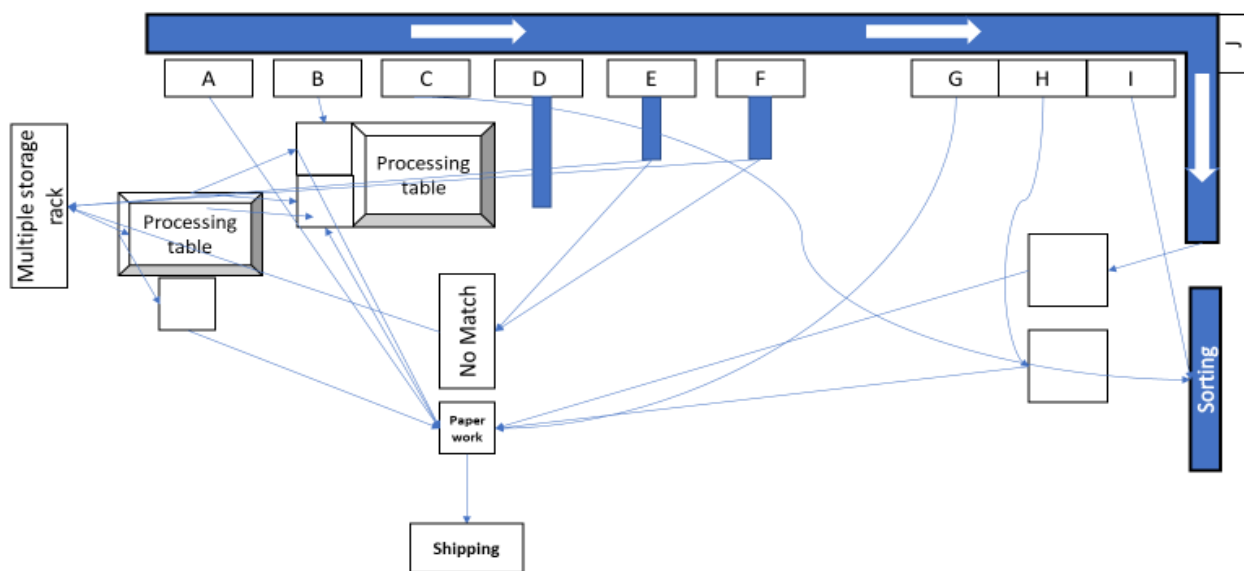


Figure 2: Shop floor map before Kaizen

The shipping methods of the ten outlets are as follows:

- **Gate A:** Once the camera at the beginning of the conveyor belt reads the barcode of the product and recognizes it as a shipping method A product, a signal is sent to the gate A to divert the product. The product then falls into the proper gaylord. Next step is covering the full gaylord, and then the worker transports it to the staging area to be shipped.
- **Gate B:** Product B is collected in a smaller container once it leaves the conveyor belt. Then it will be manually transported to a bigger gaylord that contains products C, D, and E. Once the gaylord is full, a worker will transport it to the covering station and then to the shipping area.
- **Gate C:** Occasionally, the camera fails to read the barcode off of a product due to various reasons. One of the possible reasons is that the barcode is smudged and unreadable. Another reason is that sometimes the products ride on top of each other while being transported on the conveyor belt, resulting in obscuring the barcode. Therefore, the management decided to dedicate this gate to catch those types of products. The no-read products are collected in a gaylord and are transported manually to a smaller sorting machine. After being sorted properly, the products are being manually transported to the proper gaylord to be merged with the rest of that type.
- **Gate D:** The products shipped via this method will be collected in a small container that can hold up to 30 pieces. Once the container is filled, a worker will transport it to a nearby table where the products are placed in shipping envelope and then placed into a gaylord. Once the gaylord is full, a worker will transport it to the covering station then to shipping.
- **Gate E:** Products shipped via this method are shipped in multiple pieces. Once a product comes off of the conveyor belt, it is collected in a small container that holds up to 30 pieces. A worker goes through the container and manually sort the pieces to make sure that all pieces of an order are there. If all pieces are there, the tray is then taken to a holding area, waiting to be further processed. Once a worker is available, the products are manually placed into a single envelope and then placed in a gaylord. Once the gaylord is full, a worker transports it to the covering station then to shipping. If not all pieces of an order are there, the product is placed in a different tray and is held at a different rack, called No Match rack. If the shift changes and still there is no match for the product, the product is being terminated and reproduced.
- **Gate F:** This shipping method is very similar to the previous one. The only difference is that products are shipped via a different vendor. Products shipped via this method are shipped in multiple pieces. Once a product comes off of the conveyor belt, it is collected in a small container that holds up to 30 pieces. The rest of the process is identical to Gate E.
- **Gate G:** Products shipped via this method are collected in a gaylord, and once it is full, a worker transports it to the covering station and then to the shipping area.
- **Gate H:** Products shipped via this method are collected in a small tray that holds up to 30 pieces, and once it is full, it will be manually transported to a pallet that can hold up to 60 trays. Once the pallet is full, a worker pulls it to the covering station and then to the shipping area.
- **Gate I:** This gate is another no-read gate. The purpose of it is to capture whatever the previous gates failed to divert. Products are collected in a gaylord and are transported manually to a smaller sorting machine. After being sorted properly, the products are being manually transported to the proper gaylord to be merged with the rest of that type.
- **Gate J:** Products shipped via this method are collected in a small tray that holds up to 30 pieces. Once it is full, it will be manually transported to a pallet that can hold up to 60 trays. Once the pallet is full, a worker pulls it to the covering station and then to the shipping area.

Unnecessary transportation and extra handling of WIP and ergonomically unsafe work environment are the main complains from the shop floor about the process. These issues resulted in a cluttered shop floor and consequently low morale among workers.

3. Identifying Kaizen Opportunities

The Lean RACE model is utilized to identify and eliminate Muda (waste). The four categories of the model served as guidelines throughout the Kaizen project.

Reduce: We started with reducing the non-value added activities. Transportation was the most dominant type of waste existed in this process. Unnecessary handling of the products was one of the main issues. Therefore, the first step was to eliminate the needless handling by rearranging the gates on the conveyor belt where they are closer to the subsequent

steps. Gate F should be moved up along the conveyor belt and becomes the first gate on the line. By doing so, we eliminated 13 meters of WIP transportation from where the gate was to the storage rack. The storage racks for match and no match were brought together to eliminate the need to transport the WIP for another 6 meters. Gate E was also moved up in the line to be the second gate. The same goes to this gate when it comes to cut down needless transportation of the WIP. Gate B was moved down to be the third gate. Also, the processing table for products coming of gate B and gate D was moved down the line as well, so it will be close to both gates to minimize WIP handling and transportation. Gate A was moved down the line to be the fourth gate. Gate D was moved down the line to be the fifth gate and on the other side of the processing table to minimize WIP handling and transportation waste. Gate G moved up the line to be the sixth gate. Gate C was combined with gate I and moved down to be the eighth gate. Gates H and J to stay as seventh and ninth gates respectively.

Accelerate: The next step is to find opportunities to accelerate the process. As mentioned earlier, once a gaylord is full, a worker will transport it to the covering station to cover it with a plastic bag. We deemed this step as a value-added activity as it protects the product from being damaged. Once a gaylord is covered, it will then be transported to the staging area and wait to be shipped. To improve this step, we moved this step to be done after a gaylord is being staged for shipping instead of it being in the middle of the shop floor.

Consolidate: We also combine the two gates so that the no-read gate can catch all the non-read products. Since non-read is inevitable in this process, it is essential that the non-read products are being caught and sorted to make sure that they are shipped the proper way. However, having two non-read gates is not justifiable. Therefore, we combined the two gates into one gate which is located towards the end of the line. In this way, the no-read gate can catch all the non-read products and will be close to the sorting machine to reduce transportation.

Enhance: Lastly, we further improve the process ergonomically. In this case study, it was also found that the worker who transports products coming off of gate J has to pick up a small size tray that can hold up to 30 pieces and weighs between 15 to 20 lbs and then turns 180 degrees to place it on the shipping pallet. This process is not only time consuming but also has an inherent risk of back injury induced by the ergonomically incorrect motion. Therefore, we recommended to employ a robotic arm that can perform the same task with no risk of injuring the worker. In this way, the worker can be freed to perform another task on the line in a way that will further improve the performance of the process.

The improvement opportunities are summarized in Table 1, categorized by the four directions: R-A-C-E. The shop floor map after the Kaizen improvement project is implemented is shown in Figure 3.

Table 1: Summary of Improvement Plan

Reduce	Reduce transportation and handling of WIP to reduce the cycle time
Accelerate	Accelerate transportation of gaylord to the shipping area
Consolidate	Combine the two no-read gate into one gate and place it closer to the subsequent process
Enhance	Adding a robotic arm to enhance the ergonomics of the workplace

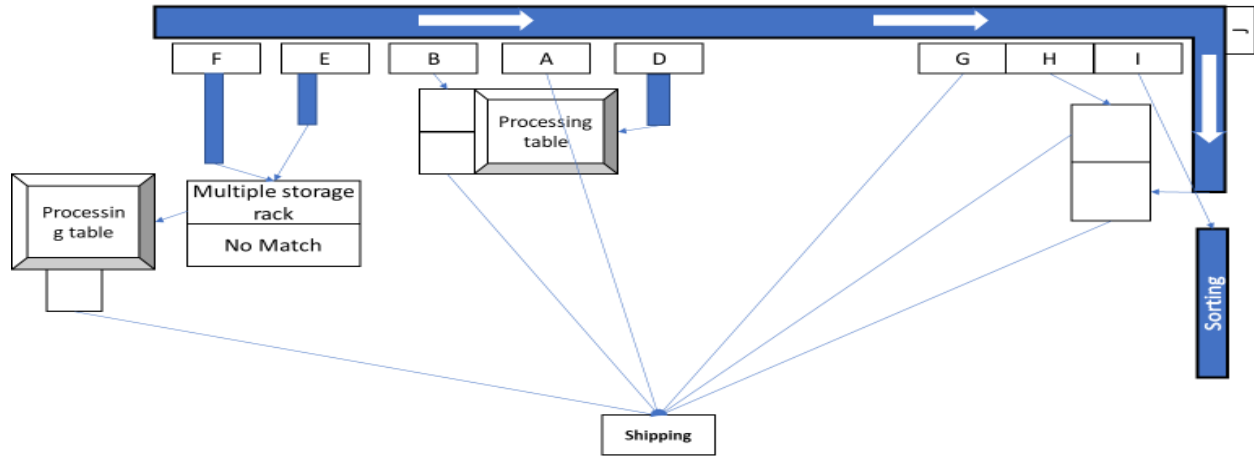


Figure 3: Shop floor map after Kaizen

4. Validation through Simulation:

After the Kaizen opportunities were identified by the project team, the expected improvement is validated by a simulation study. Simulation software Arena was used to model the system and verify if there exists significant improvement of the system by comparing the before and after Kaizen performances. Due to confidentiality issues, the parameters used in this simulation model are approximates of the actual parameters. Based on the two-period, 8-hour run of the simulation model, we find out the results of the simulation are reasonably close to the actual performance metrics. The performance metrics of the before and after Kaizen implementation are summarized in Table 2.

Table 2: Performance Metrics

Metric	Before	After	Improvement (%)
Number of gaylord shipped	19	24	26.315
Average waiting time	1.51 minute	1.232 minute	18.41
Total transportation distance	83 m	48 m	42.16

The simulation results showed a reasonable improvement after Kaizen. The three main key performance indicators (KPIs) of interest are the production rate, waiting time and the total transportation distance of WIP.

Production rate: Production rate has improved from 19 to 24 gaylord over the two shifts, which represents 26.315% improvement in the production rate. This was a result of a shorter cycle time which was achieved by eliminating unnecessary transportation and handling of WIP.

Waiting time: The total waiting time reduced from 1.51 to 1.232 minute, which represents 18.41% improvement. Before the implementation of Kaizen, the workers spent a lot of time transporting WIP which resulted in a longer waiting time. By rearranging outlets on the conveyor belt, unnecessary transportation of WIP will be eliminated and therefore will free workers to attend value added activities.

Transportation: The biggest improvement was the reduction in total transportation distance of the WIP. From 83 to 48 meter, the total transportation distance decreased by 42.16%.

These results of the simulation study have been reported to the management to finalize the implementation plan. Due to certain constraints, the suggested improvements have not been implemented physically when this paper is completed.

5. Conclusion

Kaizen projects are essential to maintain a competitive edge in any industry. The ever-increasing customers' demands for high quality and on-time delivery are calling for continuous evaluation of processes to find a better way to perform

the same tasks. This paper presents a Kaizen project conducted in a shipping department of a manufacturing company to identify, reduce, and eliminate waste. Lean RACE model was used as a guideline to help search for improvement opportunities in various directions that might have been ignored. Although the suggested Kaizen plan has not been carried out by the manufacturer, a simulation study was conducted to verify the improvement of the Kaizen plan. The results include an increased production rate, reduced average waiting time, and significantly reduced transportation. Additionally, some intangible results of the Kaizen projects will include less cluttered shop floor, safer work environment, and consequently higher morale among workers.

In this study, the Lean RACE model was adopted to broaden the scope of improvements in different directions, especially the Acceleration, Consolidation, and Enhancing, which can easily be overshadowed in projects focusing on lean and waste reduction. Besides the four improvement directions, the Lean RACE model also suggests a Force Field Analysis to evaluate the tradeoffs of different options, although in the studied case, no obvious conflicts were found. The Force Field analysis will be needed for more complicated systems where improvement options are negatively correlated, and simulation modeling will be a valuable tool again to support the what-if analysis of tradeoffs.

Reference

- [1] Palmer, V. S. 2001. "Inventory Management Kaizen." In Proceedings 2nd International Workshop on Engineering Management for Applied Technology. EMAT 2001, 55–56. <https://doi.org/10.1109/EMAT.2001.991311>.
- [2] Berger, Anders. 1997. "Continuous Improvement and Kaizen: Standardization and Organizational Designs." *Integrated Manufacturing Systems* 8 (2): 110–17. <https://doi.org/10.1108/09576069710165792>.
- [3] Ohno, Taiichi. 1988. *Toyota Production System: Beyond Large-Scale Production*. CRC Press.
- [4] Chen, Joseph C., Ye Li, and Brett D. Shady. 2010. "From Value Stream Mapping toward a Lean/Sigma Continuous Improvement Process: An Industrial Case Study." *International Journal of Production Research* 48 (4): 1069–86. <https://doi.org/10.1080/00207540802484911>.
- [5] Hines, Peter, Nick Rich, and Matthias Holweg. 2004. "Learning to Evolve: A Review of Contemporary Lean Thinking." *International Journal of Operations & Production Management* 24 (10): 994–1011. <https://doi.org/10.1108/01443570410558049>.
- [6] Melnyk, Steven A., Roger J. Calantone, Frank L. Montabon, and Richard T. Smith. 1998. "Short-Term Action in Pursuit of Long-Term Improvements: Introducing Kaizen Events." *Production and Inventory Management Journal*; Alexandria 39 (4): 69–76.
- [7] Wan, H., 2014, "Four Aspects of Continuous Improvement in a Value Stream," *Industrial and Systems Engineering Research Conference (ISERC)*, May 31-June 3, Montreal, Canada.
- [8] Lu, S. C. H., D. Ramaswamy, and P. R. Kumar. 1994. "Efficient Scheduling Policies to Reduce Mean and Variance of Cycle-Time in Semiconductor Manufacturing Plants." *IEEE Transactions on Semiconductor Manufacturing* 7 (3): 374–88. <https://doi.org/10.1109/66.311341>.
- [9] Galloway, Les. 1998. "Quality Perceptions of Internal and External Customers: A Case Study in Educational Administration." *The TQM Magazine* 10 (1): 20–26. <https://doi.org/10.1108/09544789810197774>.