# Implementation of the Kanban System to Reduce Work in Process Inventory at Company X

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**Abstract.** Company X is a make-to-order (MTO) and engineer-to-order (ETO) footwear manufacturing company that experiences frequent production delays despite stable monthly demand from LAF Project. These delays are primarily caused by imbalances in workload between work stations, resulting in significant Work In Process (WIP) accumulation. This condition leads to idle time at downstream stations and inefficient utilization of working time. The imbalance is suspected to arise from differences in processing times between stations and the use of a batch production system of ten pairs per batch. To address these issues, this study applies line balancing, mixed model scheduling, and a Kanban system to improve production flow and control. Line balancing using the Region Approach (RA) method increased line efficiency from 45.33% to 88.39%, reduced the smoothness index from 2.77 to 4.21, and reduced the number of work stations from five to four. Mixed model scheduling produced an optimal production sequence for six shoe models with two color variations and changed the batch size from ten pairs to one pair per sequence. The implementation of a Kanban system with one card per work station successfully eliminated WIP accumulation and maintained a controlled buffer of one pair at each station.

**Keywords:** *Line Balancing, Mixed Model Scheduling, Kanban*.

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## A. Introduction

The footwear industry in Indonesia is experiencing rapid growth and plays a significant role in supporting the national economy. As a labor-intensive sector with a strong export orientation, Indonesia contributes approximately 535 million pairs of shoes to the global market, accounting for about 3.5% of total global footwear exports (11). Company X is a make-to-order (MTO) and engineer-to-order (ETO) manufacturing company engaged in the footwear industry . In carrying out its production process, Company X has several work stations, namely the pattern making work station, the cutting work station, the upper making work station, the sole work station, the inspection work station, and the finishing work station. Company X currently receives regular monthly orders from one brand, LAF Project. Despite consistent demand, the company still often faces delays in completing orders. Based on observations, the main problem is caused by an imbalance in the workflow between stations, which results in a backlog of Work In Process (WIP), particularly between the Cutting–Upper and Inspection–Sole stations. The accumulation of WIP causes material flow to be disrupted, increases waiting time between processes, causes idle time at the Inspection and Finishing stations, and overloads the Upper and Sol stations, which collectively lengthens production lead time and causes delays in order completion.

The accumulation of WIP is thought to be caused by two factors. First , it is thought to be due to differences in capacity or processing time between work stations . Some stations, such as Upper and Sol, have much longer processing times than other stations. Second, the accumulation of WIP is also suspected to be caused by a production system that still uses the batch method, where one batch consists of 10 pairs of shoes . This system means that the transfer of materials to the next process can only be done after one batch is completely finished, thereby slowing down the flow of materials and causing the processes to become increasingly unbalanced.

To overcome production line imbalances, an approach is needed that can balance the workload between stations, organize the production sequence efficiently, and control the flow of materials. The line balancing approach is used to equalize capacity between work stations so that the production rate is more balanced and delays can be minimized (10). In addition, the application of mixed model scheduling is necessary to manage the production sequence of various shoe models simultaneously so that production volume is more evenly distributed and delays can be avoided. To maintain production line balance and control WIP, a Kanban system is implemented that limits production based on cards, so that material flow becomes more controlled, especially for products with consistent monthly demand.

Research on the implementation of Kanban systems in large companies has been widely conducted; however, studies focusing on small-scale companies with irregular operating systems remain limited. Therefore, this study is necessary to examine how the Kanban system can be applied in small companies facing dynamic demand. Previous studies on balancing Kanban implementation have been conducted by Adiansyah and Zaqi (1), Kartini (9), Raharjo, Prasetyaningsih, and Amaranti (14). The similarity between this study and the previous research lies in the use of heuristic methods for production line balancing, followed by the implementation of Kanban on the production line, as well as the common problems addressed, namely work-in-process accumulation between operations and high delay times at workstations.

## B. Method

This research began with information gathering through field studies and literature, followed by problem formulation, goal setting, and data collection. After that, line balancing calculations, production scheduling with a mixed model scheduling, and Kanban system design were carried out. All results were analyzed, then conclusions and suggestions were compiled.

### Balancing the Production Line Using the Line Balancing Method

Line balancing aims to determine the appropriate amount of work elements at each workstation, including the optimal placement of machines at each work center, so that all stations have equal capacity. This balancing is done by considering the completion time of each job, machine capacity, and available labor (4). Several methods can be used in line balancing, including analytical, probabilistic, branch and bound, fabrication, and heuristic methods. In this study, the heuristic method is selected because line balancing problems are combinatorial in nature and difficult to solve practically using exact methods. The heuristic approach, first introduced by Fred M. Tonge, was developed to simplify complex combinatorial problems so they can be addressed more easily. This approach aims to produce near-optimal solutions through simple and understandable steps, and although it does not always guarantee an optimal result, it is preferred due to its efficiency and practicality.

### Mixed Model Production Scheduling

When a manufacturing company transitions from monthly or weekly scheduling to daily production, the Just In Time (JIT) approach can be implemented through a uniform daily production schedule with minimal variation in output. Unlike monthly scheduling, which often causes production fluctuations and idle capacity due to equipment and labor constraints, daily scheduling allows multiple products to be produced in small quantities each day while still meeting total monthly demand. This results in a more balanced workload, reduced idle machines and labor, and better utilization of resources. To support this system, Mixed Model Scheduling is commonly applied to minimize lot sizes and determine an optimal daily production sequence that fulfills overall demand efficiently (15).

### Designing the Kanban System

Kanban is a tool used to support the Just In Time (JIT) production system (13), where the term “Kanban” literally means a visual record or signal. The Kanban system functions as an integrated information medium that controls production processes so that products are manufactured in the right quantity and at the right time at each production stage. Typically, Kanban takes the form of a card placed in a rectangular vinyl envelope containing three main types of information: withdrawal information, transportation information, and production information (14). Through this mechanism, Kanban enables information flow both vertically and horizontally, facilitating coordination within the factory as well as between the factory and its external partners.

## C. Result and Discussion

Production line balancing can be performed using several methods, including Ranked Positional Weight (RPW), Region Approach (RA), and Moodie–Young (MY), each employing different strategies to address line balancing problems. In this study, the Region Approach (RA) is selected because the footwear production line has a branched precedence structure and a relatively complex set of work elements. RA prioritizes work elements with no or few predecessors, leading to a more efficient workstation allocation (3). Although previous studies indicate that RA and MY often produce similar line efficiency results, research by Alexandra (2) shows that RA yields a lower smoothness index than MY, indicating better workload balance. In contrast, the RPW method focuses solely on positional weights based on the longest processing path, without considering predecessor relationships.

After production line have been balanced, production scheduling is carried out using a mixed model scheduling method that takes into account shoe model variations without involving shoe sizes due to inconsistent demand for sizes. Scheduling begins with calculating the daily demand for each model, determining the cycle time based on the results of line balancing, and calculating the inverse cycle time ratio to determine the minimum number of units in a sequence. The production sequence is determined to even out production volume and minimize setup time between models.

And the last, the Kanban system is designed by creating production Kanban cards that contain information on product type and production quantity, both for upstream and downstream work stations. The number of Kanban cards is determined based on production requirement calculations, taking into account the cycle time and capacity of the work stations. The flow of Kanban cards between work stations is then designed to control the flow of materials, limit excessive production, and reduce the accumulation of Work In Process (WIP). The research calculation details can be seen below.

### Current Line Balancing Calculations

The first step is to create a precedence diagram. A precedence diagram is created for the shoe production process to determine the dependencies between processes, whether a particular process can only begin once its predecessor has been completed, or whether the process can proceed even if its predecessor has not been completed (8). The precedence diagram for the shoe manufacturing process can be seen in Figure 1, and a description of the process sequence can be seen in Table 1.

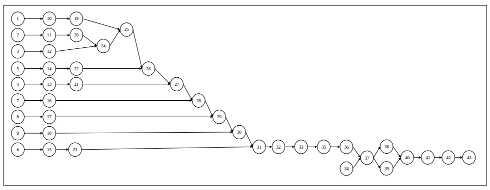

**Figure 1 .** Shoe Production Precedence Diagram

 https://doi.org/10.29313/bcsst.v1i1.23068

**Table 1 .** Current Line Balancing Performance

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| 1 | Drawing pattern 1 onto the upper material | 1 | 10.9 | 0.18 | **0.18** |
| | Draw pattern 2 onto the upper material | 2 | 30.0 | 0.5 | **0.68** |
| | Draw pattern 3 onto the upper material | 3 | 13.5 | 0.23 | **0.91** |
| | Drawing pattern 4 onto the upper material | 4 | 10.7 | 0.18 | **1.09** |
| | Drawing pattern 5 onto the upper material | 5 | 10.1 | 0.17 | **1.2** |
| | Drawing pattern 6 onto the upper material | 6 | 9.3 | 0.15 | **1.4** |

**Table 2 .** Current Line Balancing Performance

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| 1 | Drawing pattern 7 onto the upper material | 7 | 10.3 | 0.17 | **1.58** |
| | Drawing pattern 8 onto the upper material | 8 | 10.8 | 0.18 | **1.76** |
| | Drawing pattern 9 onto the upper material | 9 | 11.2 | 0.19 | **1.95** |
| 2 | Cut pattern 1 based on the lines | 10 | 394.1 | 6.57 | **6.57** |
| | Cut pattern 2 based on the lines | 11 | 56.3 | 0.94 | **7.5** |
| | Cutting pattern 3 based on the lines | 12 | 64.4 | 1.07 | **8.58** |
| | Cut out pattern 4 (2) based on the lines | 13 | 50.4 | 0.84 | **9.42** |
| | Cut pattern 5 (2) based on the lines | 14 | 34.0 | 0.57 | **9.9** |
| | Cut pattern 6 based on the lines | 15 | 29.3 | 0.49 | **10.48** |
| | Cut pattern 7 based on the lines | 16 | 20.2 | 0.34 | **10.81** |
| | Cut pattern 8 based on the lines | 17 | 24.9 | 0.41 | **11.23** |
| | Cutting pattern 9 based on the lines | 18 | 28.3 | 0.47 | **11.7** |
| | Cutting pattern 1 | 19 | 56.9 | 0.95 | **12.65** |
| | Pattern 2 | 20 | 31.0 | 0.52 | **13.16** |
| | Pattern 4 (2) | 21 | 12.3 | 0.20 | **13.37** |
| | Pattern 5 (2) | 22 | 16.5 | 0.27 | **13.64** |
| | Pattern 6 | 23 | 12.1 | 0.20 | **13.84** |
| | Sew pattern 2 with pattern 3 (SA1) | 24 | 20.3 | 0.34 | **14.18** |
| | Sewing SA1 with pattern 1 (SA2) | 25 | 12.0 | 0.2 | **14.38** |
| | Sewing SA2 with pattern 5 (2) (SA3) | 26 | 40.4 | 0.67 | **15.06** |

 ISSN: XXXX-XXXX

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| | Sewing SA3 with pattern 4 (2) (SA4) | 27 | 40.7 | 0.68 | **15.73** |
| | Sewing SA4 with pattern 7 (SA5) | 28 | 12.1 | 0.20 | **15.94** |
| | Sewing SA5 with pattern 8 (SA6) | 29 | 12.0 | 0.20 | **16.14** |
| | Sewing SA6 with pattern 9 (SA7) | 30 | 13.4 | 0.22 | **16.36** |
| | Sewing SA7 with pattern 6 (SA8) | 31 | 35.2 | 0.59 | **16.95** |
| | Glue the inside of SA8 with foam (SA9) | 32 | 11.4 | 0.19 | **17.14** |
| 3 | Checking SA9 | 33 | 98.4 | 1.64 | **1.64** |
| 4 | Attaching the midsole to the shoe last | 34 | 28.6 | 0.48 | **0.48** |
| | SA9 | 35 | 16.6 | 0.28 | **0.75** |
| | Glue the inside of SA9 with hardening material (Chemical Sheet) | 36 | 46.7 | 0.78 | **1.53** |
| | Pulling the SA9 | 37 | 323.3 | 5.39 | **6.92** |
| | Glueing the pulled SA9 | 38 | 28.1 | 0.47 | **7.39** |
| | Glueing soles that have been oven-dried | 39 | 23.0 | 0.38 | **7.77** |
| | Attaching SA9 with outsole (ASS) | 40 | 92.1 | 1.54 | **9.31** |
| | Shoe pressing | 41 | 69.3 | 1.16 | **10.46** |
| | Removing the shoelast from the shoe | 42 | 36.3 | 0.61 | **11.07** |
| 5 | Finishing and inspecting shoes (finished goods) | 43 | 411.4 | 6.86 | **6.86** |

There are two line balancing criteria considered in this study, namely Line Efficiency (LE) and Smoothness Index (SI), which are used to determine whether the flow is good or not (7). The time used in the line balancing calculation is the time used to produce one unit of shoes. The time data used must be uniform and sufficient (16). The calculation of the current line balancing performance is as follows:

1. Line Efficiency (LE)
   The CT used is obtained from $ST_{(max)},$which is 17.14 minutes
   with k = 5 SK
   $$LE = \frac{\sum_{i=1}^{k} ST_i}{CT \times k} x\ 100\% \quad ...(1)$$
   $LE = \frac{1,95+17,14+1,64+11,07+6,86}{17,14 \times 5}$ x 100% = 45.43%
   Note:
   LE = Line Efficiency
   $ST_i$= Station time from Work Station i
   k = Total Work Stations
   CT = Cycle Time
2. Smoothness Index (SI)
   $$SI = \sqrt{\sum_{i=1}^{k} (ST_{max} - ST_i)^2} \quad ...(2)$$

$$SI = \sqrt{\begin{matrix}(17{,}14-1{,}95)^2+(17{,}14-17{,}14)^2+(17{,}14-1{,}64)^2+\\(17{,}14-11{,}07)^2+(17{,}14-6{,}86)^2\end{matrix}}$$
$$= 24.77$$

Description:
SI = Smoothness Index
$ST_{max}$ = Maximum station time
$ST_i$ = Station time from station i
k = Total Work Stations

**Production Line Balancing Results Using the Line Balancing Method**

The Region Approach (RA) method was chosen because it is capable of handling branched precedence structures and complex work elements by scheduling work elements that have no or few predecessors at an early stage, thereby making the division of work stations more efficient. This method divides the precedence diagram into several vertical regions with the rule that there are no sequential operations within a single region. The application of RA results in changes to the precedence diagram arrangement, where several work elements, including work element 34, which has no predecessor, can be placed at the initial work station compared to the previous condition. The rearranged precedence diagram can be seen in Figure 2, and the rearrangement of the work element and work station sequence using the RA method can be seen in Table 2.

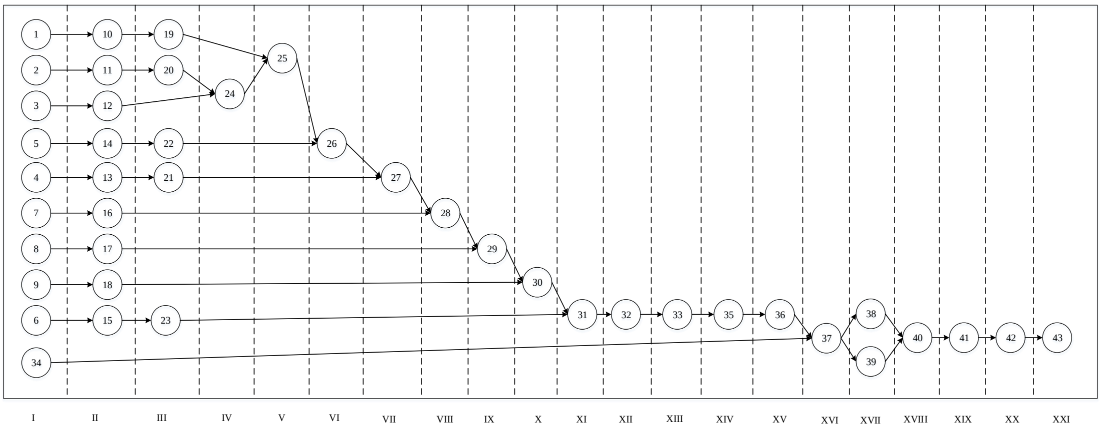


**Figure 2 .** Precedence Diagram Using the RA Method

**Table3 .** Line Balancing Performance Using the RA Method

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| 1 | Drawing pattern 1 onto the upper material | 1 | 10.9 | 0.18 | **0.18** |
| | Drawing pattern 2 onto the upper material | 2 | 30.0 | 0.5 | **0.68** |
| | Draw pattern 3 onto the upper material | 3 | 13.5 | 0.23 | **0.91** |
| | Drawing pattern 4 onto the upper material | 4 | 10.7 | 0.18 | **1.09** |
| | Drawing pattern 5 onto the upper material | 5 | 10.1 | 0.17 | **1.2** |
| | Drawing pattern 6 onto the upper material | 6 | 9.3 | 0.15 | **1.4** |
| | Drawing pattern 7 onto the upper material | 7 | 10.3 | 0.17 | **1.58** |
| | Drawing the 8 pattern onto the upper material | 8 | 10.8 | 0.18 | **1.76** |

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| | Drawing pattern 9 onto the upper material | 9 | 11.2 | 0.19 | **1.95** |

**Table4 .** Line Balancing Performance Using the RA Method

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| | Attaching the midsole to the shoelast | 34 | 28.6 | 0.48 | 2.43 |
| | Cut pattern 1 based on the lines | 10 | 394.1 | 6.57 | **9** |
| | Cutting pattern 2 based on the lines | 11 | 56.3 | 0.94 | **9.94** |
| | Cutting pattern 3 based on the lines | 12 | 64.4 | 1.07 | **11.01** |
| | Cut pattern 4 (2) based on the lines | 13 | 50.4 | 0.84 | **0.84** |
| | Cut pattern 5 (2) based on the lines | 14 | 34.0 | 0.57 | **1.41** |
| | Cut pattern 6 based on the lines | 15 | 29.3 | 0.49 | **1.89** |
| | Cut pattern 7 based on the lines | 16 | 20.2 | 0.34 | **2.2** |
| | Cut pattern 8 based on the lines | 17 | 24.9 | 0.41 | **2.65** |
| | Cut pattern 9 based on the lines | 18 | 28.3 | 0.47 | **3.12** |
| | Pattern 1 | 19 | 56.9 | 0.95 | **4.07** |
| | Pattern 2 | 20 | 31.0 | 0.52 | **4.58** |
| | Pattern 4 (2) | 21 | 12.3 | 0.20 | **4.79** |
| | Pattern 5 (2) | 22 | 16.5 | 0.27 | **5.06** |
| 2 | Sewing pattern 2 with pattern 3 (SA1) | 24 | 20.3 | 0.34 | **5.6** |
| | Sewing SA1 with pattern 1 (SA2) | 25 | 12.0 | 0.20 | **5.8** |
| | Sewing SA2 with pattern 5 (2) (SA3) | 26 | 40.4 | 0.67 | **6.47** |
| | Sewing SA3 with pattern 4 (2) (SA4) | 27 | 40.7 | 0.68 | **7.15** |
| | Sewing SA4 with pattern 7 (SA5) | 28 | 12.1 | 0.20 | **7.35** |
| | Sewing SA5 with pattern 8 (SA6) | 29 | 12.0 | 0.20 | **7.56** |
| | **Sewing SA6 with pattern 9 (SA7)** | **30** | **13.4** | **0.22** | 7.78 |
| | Sewing SA7 with pattern 6 (SA8) | 31 | 35.2 | 0.59 | **8.36** |
| | Glueing in SA8 with foam (SA9) | 32 | 11.4 | 0.19 | **8.56** |
| | Checking SA9 | 33 | 98.4 | 1.64 | **10.19** |
| | Cutting SA9 | 35 | 16.6 | 0.28 | **10.48** |
| 3 | Bonding SA9 with hardener | 36 | 46.7 | 0.78 | **0.80** |
| | Pulling SA9 | 37 | 323.3 | 5.39 | **6.32** |

| Work Station | Work Element Description | Work Element | Standard Time (Seconds) | Standard Time (Minutes) | Cumulative Standard Time |
|---|---|---|---|---|---|
| | Glueing the pulled SA9 | 38 | 28.1 | 0.47 | **6.8** |
| | Glueing soles that have been oven-dried | 39 | 23.0 | 0.38 | **7.2** |
| | Attaching SA9 with outsole (ASS) | 40 | 92.1 | 1.54 | **8.77** |
| | Shoe pressing | 41 | 69.3 | 1.16 | **9.96** |
| | Removing the shoelast from the shoe | 42 | 36.3 | 0.61 | **10.58** |
| 4 | Finishing and inspecting shoes | 43 | 411.4 | 6.86 | **6.86** |

Based on line balancing calculations using RA and cycle time determined based on the prime number factor of the total station time, which is 13 minutes. The production line performance obtained was a line efficiency of 74.86% and a smoothness index of 7.35. The performance of the production line can still be improved by changing the cycle time, because when using a cycle time of 13, there is still a significant difference in station time. Therefore, a cycle time of 11.01 was used. The following is a description of the performance calculation using CT = 11.01

3. Line Efficiency (LE)
   The cycle time used is 11.01
   with k = 4 SK

$$LE = \frac{\sum_{i=1}^{k} ST_i}{CT \times k} \text{ x } 100\% \quad \dots (3)$$

LE = $0\frac{11{,}01+10{,}48+10{,}58+6{,}86}{11{,}01 \times 4}$ x 100% = 88.39%

4. Smoothness Index (SI)

$$SI = \sqrt{\sum_{i=1}^{k} (ST_{max} - ST_i)^2} \quad \dots (4)$$

$$SI = \sqrt{(11{,}01 - 11{,}01)^2 + (11{,}01 - 10{,}48)^2 + (11{,}01 - 10{,}58)^2 + (11{,}01 - 6{,}86)^2}$$

= 4.21

Based on the results obtained, it can be seen that the line balancing method using the Region Approach (RA) method can increase the LE value, which was initially only 45.43% to 88.39%, and the SI value, which was initially 24.77, decreased to 4.21. These results show a significant improvement in the performance of the shoe production line.

**Mixed Model Production Scheduling Results**

Scheduling using Mixed Model Scheduling is a way to determine the minimum units to be sequenced in one production run. The order of products should be arranged to achieve single-unit production, unless there are production constraints that require larger lot sizes. Some manufacturing equipment with fixed setup times may limit lot sizes by forcing the production of a fixed number of units at a time (15). This explanation is consistent with the case faced by Company X, where there is a machine with a fixed setup time, namely a sewing machine, where the setup involves threading the machine according to the color of the product to be produced, in this case black and white. Therefore, the sequence must be based on the color of the product, and production lots cannot be single units but must be of a certain size.

Based on the scheduling that have been made, it was found that in 1 day, 3 pairs/models of shoes can be produced, so the production batch can be made into 3 pairs/models of shoes. Therefore, the production sequence based on Schniederjans' theory has a total of 72 alternative sequences, as shown in Table 3, where A is the Black Sagan product, B is White Sagan, C is Black Tom Tom, D is

White Tom Tom, E is Black Wynn, and F is White Wynn.

**Table 5 .** Alternative Sequence Summary

| No | Alternative Sequence | No | Alternative Sequence |
|---|---|---|---|
| 1 | A, C, E, B, D, F | 37 | B, D, F, A, C, E |
| 2 | A, C, E, F, B, D | 38 | B, D, F, E, A, C |
| 3 | A, C, E, D, F, B | 39 | B, D, F, C, E, A |
| 4 | A, C, E, B, F, D | 40 | B, D, F, A, E, C |
| 5 | A, C, E, F, D, B | 41 | B, D, F, C, A, E |
| 6 | A, C, E, D, B, F | 42 | B, D, F, E, C, A |
| 7 | E, A, C, B, D, F | 43 | F, B, D, A, C, E |
| 8 | E, A, C, F, B, D | 44 | F, B, D, E, A, C |
| 9 | E, A, C, D, F, B | 45 | F, B, D, C, E, A |
| 10 | E, A, C, B, F, D | 46 | F, B, D, A, E, C |
| 11 | E, A, C, F, D, B | 47 | F, B, D, C, A, E |
| 12 | E, A, C, D, B, F | 48 | F, B, D, E, C, A |
| 13 | C, E, A, B, D, F | 49 | D, F, B, A, C, E |
| 14 | C, E, A, F, B, D | 50 | D, F, B, E, A, C |
| 15 | C, E, A, D, F, B | 51 | D, F, B, C, E, A |
| 16 | C, E, A, B, F, D | 52 | D, F, B, A, E, C |
| 17 | C, E, A, F, D, B | 53 | D, F, B, C, A, E |
| 18 | C, E, A, D, B, F | 54 | D, F, B, E, C, A |
| 19 | A, E, C, B, D, F | 55 | B, F, D, A, C, E |
| 20 | A, E, C, F, B, D | 56 | B, F, D, E, A, C |
| 21 | A, E, C, D, F, B | 57 | B, F, D, C, E, A |
| 22 | A, E, C, B, F, D | 58 | B, F, D, A, E, C |
| 23 | A, E, C, F, D, B | 59 | B, F, D, C, A, E |
| 24 | A, E, C, D, B, F | 60 | B, F, D, E, C, A |
| 26 | C, A, E, F, B, D | 62 | F, D, B, E, A, C |
| 27 | C, A, E, D, F, B | 63 | F, D, B, C, E, A |
| 28 | C, A, E, B, F, D | 64 | F, D, B, A, E, C |
| 29 | C, A, E, F, D, B | 65 | F, D, B, C, A, E |
| 30 | C, A, E, D, B, F | 66 | F, D, B, E, C, A |
| 31 | E, C, A, B, D, F | 67 | D, B, F, A, C, E |
| 32 | E, C, A, F, B, D | 68 | D, B, F, E, A, C |
| 33 | E, C, A, D, F, B | 69 | D, B, F, C, E, A |
| 34 | E, C, A, B, F, D | 70 | D, B, F, A, E, C |
| 35 | E, C, A, F, D, B | 71 | D, B, F, C, A, E |
| 36 | E, C, A, D, B, F | 72 | D, B, F, E, C, A |

**Kanban System Design Results**

The first step in designing a Kanban system is to create a Kanban card design. Since the Kanban system used is a single card system, the Kanban designed is only a production order Kanban, as shown in Figure 3. The production Kanban card design was created with visual display ergonomics in mind, so that the information presented can be easily, quickly, and accurately understood by operators on the production floor. According to Grandjean (6), an ergonomic visual display must pay attention to the readability, clarity, consistency, and relevance of information. Therefore, this Kanban card is designed with a size of 19.5 cm × 9.5 cm, which is large enough to be seen at a normal viewing distance in the production area.

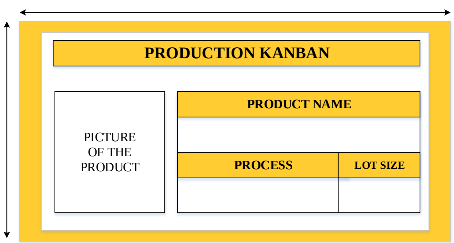


**Figure3 .** Kanban Production Orders

One of the requirements for the Kanban system to operate smoothly is the presence of a certain amount of Work in Process (WIP) in the system. This WIP is generated by issuing a certain number of Kanbans at each work station. The number of Kanbans at one workstation may not be the same as at another workstation due to differences in the nature of the work at different workstations and container capacity limitations (where several units are stored in the same container). The following is an example of the calculation of the number of Kanbans required by Company X at SK 1 for the Sagan Hitam product:

1. Number of Kanbans at SK 1 for the Sagan Hitam Product
   Average demand/day= 2 pairs/day
   Station Time = 23.69 minutes
   Lead Time (L) = $\frac{\text{Station time}}{\text{Kapasitas tersedia per hari}} = \frac{23{,}69 \text{ menit}}{480 \text{ menit/hari}} = 0{,}049$ hari
   Number of Kanbans $\geq \frac{\text{D x L (1+a)}}{\text{c}} \geq \frac{2 \text{ x } 0{,}049\ (1+0)}{1} \geq 0.09 \approx 1$ Kanban

The number of Kanban cards set in this system is one card for each product at each work station. This number is determined by considering several factors, including daily demand, product cycle time, and container capacity. The calculation results show that one card is sufficient to maintain a smooth flow of materials without causing backlogs between processes. The more Kanban cards there are, the more output will be produced, thereby shortening process time and increasing production volume.

After determining the number of Kanbans circulating on the production line, the next step is to design a pull system to be implemented in the company. Currently, the company still uses a push system, where production continues from the initial workstation to the final workstation. The pull system is designed by changing the production flow, which was originally carried out from the earliest workstation. In the pull system, the production process is carried out from the final workstation, which gives production orders to the previous workstations, and so on until the first workstation receives the production order. The production layout is also changed in accordance with the results of the production line balancing, namely by moving the Finishing Workstation to the 2nd floor. The visualization of the production layout using the pull system can be seen in Figure 5.

Before implementing the Kanban system, companies must first prepare buffers at each SK to support the running of the Kanban system. This is because in order to run the Kanban system, there must be buffers whose quantity is controlled by the number of Kanban cards circulating in the production system. Once the buffers at each SK have been prepared, the Kanban system can be implemented. The implementation of this system provides several key benefits, including , reducing overproduction because each station only produces according to the needs of the next process, maintaining smooth production flow because materials move in small lots and continuously, reducing lead time through faster material turnover, and increasing transparency because the number of Kanban cards directly indicates production status and WIP. Visualization of the Kanban system usage and Kanban card flow can be seen in Figure 4.

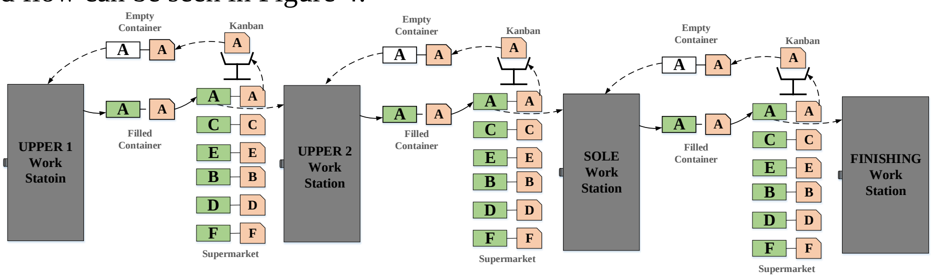


**Figure 4 .** Kanban Cycle

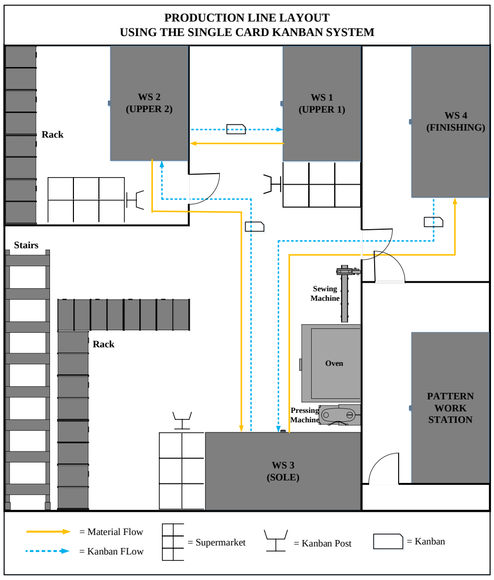


**Figure 5 .** Production Layout and Kanban Card Flow.

## D. Conclusion

The results of the study show that the initial conditions of Company X's production line were not balanced with low efficiency levels, as indicated by a Line Efficiency (LE) value of 45.43% and a Smoothness Index (SI) of 24.77, which caused idle time and Work In Process (WIP) accumulation. The application of the line balancing method using the Region Approach (RA) successfully improved the balance of the production line by increasing the LE value to 88.39% and decreasing the SI to 4.21. In addition, the application of mixed model scheduling produced an optimal production sequence for three types of shoes with two color variations and increased the flexibility of material flow by changing the batch size to one pair per sequence. The implementation of the Kanban system with one card at each workstation proved effective in controlling material flow, eliminating WIP accumulation, and supporting a more organized and responsive pull production system to actual demand.

## Acknowledgement

The author expresses gratitude to Allah SWT for His blessings that enabled the completion of this final project entitled “Implementation of a Kanban System to Reduce Work in Process Inventory at Company X” as a requirement for obtaining a Bachelor of Engineering degree at Universitas Islam Bandung. Sincere appreciation is extended to the author’s family, academic advisors and examiners, lecturers of the Industrial Engineering Program, the management of Company X, and colleagues for their guidance, support, and contributions. The author acknowledges the limitations of this work and hopes it will provide valuable insight, particulasrly in the field of production system improvement.

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