# Line Balancing and Investment Cost Analysis of Sewing Departement at PT XYZ using Ranked Position Weight Method

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## Abstract

PT. XYZ is a company operating in the garment and textile industry in the city of Solo. In the Sewing division, there are busy work stations and idle times, then high waiting times and idle operators due to irregular workloads, so the concept of line balancing needs to be implemented to achieve company goals. The aim of this research is to determine the optimal number of work stations. The research method used is a qualitative data method, with data collection techniques using field research and observation. Based on the calculations that have been carried out in calculating the ranked positional weight, it is known that in the production line process, line 2A style MS LS Sewing Division has a takt time value of 94 seconds. After improvements were made to the production line with Line Balancing, which originally had 60 work stations, it became 35 work stations. The results for line efficiency, namely 80%, indicate that the ratio in making a series of assembly activities in the work station has a good percentage. Then the results obtained in the balance delay state that in organizing work assembly activities in the work station it is 20% while in the smoothness index the results obtained are 138.83 seconds

## Keywords
Line Balancing, Takt Time, and Work Station

## 1. Introduction
The manufacturing industry is an industry or business that processes goods raw or semi-finished goods become finished goods by using assistance with tools, production machines, operators, structured management, and others so on with a large production scale. The manufacturing industry consists of: various types, one of which is the textile industry.

In the problems that often occur in the production process, the authors overcome the problem of searching for educated paths in the company so the production trajectory method is used that uses the method of positional weight rating (RPW) is one of the heuristic solutions to solve combinatoric problems that try to find solutions. Based on the problem as explained before, it causes bottlenecks at the work station which causes an imbalance in the production line. In completing this conversation, the production line balance is used using the Rank Position Weight (RPW) method. This settlement is done in order to increase the productivity of the production process.

Unbalanced production lines result in bottlenecks. Bottleneck is a condition where several work stations do the full process and several other work stations are idle because they are waiting for input from the previous work station. To minimize bottlenecks it is necessary to design a balance of production lines. However, the weakness of the design of the production line balance today is that the efficiency of the balance of the trajectory is not optimal. The general method used to optimize the efficiency of the production line is the Ranking Positional Weights (RPW) method. This method uses an allocation system for a number of machines allocated in a work station. The workings of this method are to calculate the weight of each machine and operator contained in the system. The weights are sorted from the largest to the smallest

The most crucial problem in assembly lines is distributing the operations that need to be done in a balanced way between workstations, considering one or more purposes, under some constraints. This problem is considered the assembly line balancing problem. Assembly line balancing problem, assuming that the processes required for the production of the product, the durations of the processes, and the priority relations between the processes are known; It is based on the rearrangement of the assembly line in order to distribute the workload equally among the stations on the line. The purpose of assembly line balancing is to distribute the workload equally to the stations on the assembly line.

## 2. Literature Review

The idea of assembly line balancing was first mentioned in Bryton's master's thesis published in 1954. In his study, Bryton accepted that the number of workstations was fixed, giving equal times to all workstations and that workmen moved between workstations. Assembly line balancing problems have been tried to be solved by using many methods in the literature. These methods; It is possible to collect them under three headings: classification according to the problem, classification according to the solution approach, and classification according to the processing time. If it is desired to consider classification methods according to the solution approach, they are examined in 3 groups as heuristic methods, analytical methods and simulation techniques. Solving the problem in analytical methods takes time. Mathematical programming, branch-and-bound algorithm, dynamic programming, position weight technique are some of these methods. In heuristic methods, a better and more valid solution can be reached quickly and with less computation.

Rank positional weight method (RPWM) Developed by Helgeson and Birnie in 1961. It is a frequently used method among the heuristic methods in the literature in solving assembly line balancing problems. The position weight of each task is obtained by adding up all subsequent task times, including itself. The point to be considered here is that the task with a high position weight is selected in the first assignment process.

The steps applied in the rank positional weight method technique are as follows: Step 1: A priority relationship diagram is drawn. Step 2: Position weight (position weight) is calculated for each task. The position weight of a task is the sum of the time required to perform that task and the duration of the tasks that follow that task. Step 3: Tasks are sorted by position weight from largest to smallest. Step 4: The task with the highest position weight is selected and assigned to the workstation. Step 5: After the task with the highest position weight is assigned to the workstation, the task with the highest position weight is selected among the remaining tasks and assigned to the station considering the following constraints. a) The reserved jobs list is checked. If tasks with no predecessor are assigned, go to b; if not, go to step 6. b) The durations of the tasks are compared to the unused time of the station. If the duration of the task to be assigned is less than the unused time, the assignment is made and the unused time of the station is recalculated and step 5 is repeated, if it is greater than the unused time, step 6 is passed. Step 6: The process continues until the assignment to the station is selected, checked, and, if possible, until two conditions are met: a) All work items are assigned. b) There are no tasks that meet the priority requirement and the unassigned time requirement. Step 7: The task with the highest position weight that is not assigned is assigned to the next station, and the first six steps are repeated. Step 8: Assignment continues until all tasks are assigned to the workstations. After the implementation of all these steps, the assembly line balancing problem is solved.

## 3. Methods

The research begins with an initial identification phase, which includes field studies, literature reviews, problem identification, problem formulation, research objectives determination, and research method selection. This phase is conducted through observations and interviews with employees and operators in the Sewing department at PT XYZ.

Observations and interviews are carried out for one month to understand the production line and identify the peoduction flow in the Sewing department, particularly in the 2A line.

In terms of research objectives, this research is called action research. Action research is a study conducted to obtain practical findings / for the purposes of making operational decision. The type of data used in this research is primary data. The data is a time-cycle data of the working element production process of the style MS LS in line 2A. The working element cycle time that will be completed by the ranked positional weight method is the data on the average time of the working element cycle of the style MS LS. There are 60 operating elements.

## 4. Data Collection

Data gathering methods and research tools are essential for undertaking data collection. The following data collection methods were used in this study.

**Table 1**. Data Process Activity and Cycle Time

| No | Process Activity | CT | No | Process Activity | CT |
|---|---|---|---|---|---|
| 1 | Gambar i/lining collar band | 13,80 | 31 | Overlock III inside pocket k/k | 31,80 |
| 2 | Heming collar-band (non-fuse linning) | 28,20 | 32 | Copot+pasang pocket solid | 100,80 |
| 3 | Blabar collar-band (non-fuse) | 33,00 | 33 | Copot+pasang button 2pcs pocket | 6,40 |
| 4 | Gunting+balik+press ujung collar pakai mesin | 11,60 | 34 | Botton sew crossstitching | 15,60 |
| 5 | Srik collar-band 4mm | 20,00 | 35 | Blabar pasang flap pocket k/k | 81,00 |
| 6 | Der+gandeng+gunting+balik panil collar | 54,40 | 36 | Stik flat pocket 5mm k/k | 27,60 |
| 7 | Stik krah tengah collar 1mm | 18,40 | 37 | Button hole | 41,40 |
| 8 | Button hole | 6,20 | 38 | Button sew crossstiching | 54,40 |
| 9 | Blabar+kepras flap pocket k/k | 36,20 | 39 | Gosok/cetak 4 sisi lapisan label besar | 27,20 |
| 10 | Balik flap pocket k/k | 22,40 | 40 | Pasang label besar 4 sisi | 53,80 |
| 11 | Stik flap pocket JR II k/k | 62,00 | 41 | Pasang label 4 sisi | 30,60 |
| 12 | Gosok flat pocket jadi k/k | 12,00 | 42 | Pasang lapisan label pada back yoke | 71,20 |
| 13 | Botton hole | 12,20 | 43 | Buka pleat k/k+belah back yoke | 25,20 |
| 14 | Manjangi s,cuff k/ (linning non-fuse) | 26,60 | 44 | Stik back yoke JR I | 26,60 |
| 15 | Gambar cuff k/k | 17,60 | 45 | Gosok back yoke | 8,60 |
| 16 | Blabar+kepras hexa s,cuff k/k | 40,60 | 46 | Join shoulder+sortir k/k | 34,00 |
| 17 | Balik +press hexa s,cuff k/k | 16,80 | 47 | Stik shoulder JR I k/k | 29,00 |
| 18 | Stik hexa s,cugg 4mm k/k | 35,80 | 48 | Blabar+stik+panil pasang collar+jpt label+size | 111,40 |
| 19 | Gosok cuff jadi k/k | 14,20 | 49 | Overlock III armhole | 47,40 |
| 20 | Botton hole | 12,20 | 50 | Overlock III ujung slevee k/k | 38,40 |
| 21 | Botton sew crossstitching | 15,20 | 51 | Pasang armhole c,stitch k/k | 50,60 |
| 22 | Cetak split tempel k/k | 6,40 | 52 | Stik armhole JR I k/k | 37,20 |
| 23 | Pasang slevee binding+potong k/k | 30,40 | 53 | Blabar side seam L/S k/k | 42,20 |
| 24 | Pasang slevee placket+tres+potong k/k | 74,00 | 54 | Pasang care label | 10,60 |
| 25 | Botton hole | 11,80 | 55 | Stike side seam L/S+sortir k/k | 108,20 |
| 26 | Botton sew crossstitching | 23,20 | 56 | Overlock III klim bottom | 26,80 |

| | | | | | |
|---|---|---|---|---|---|
| 27 | Jahit laid on JR II -non fuse | 36,80 | 57 | Plipit bottom hem bulat | 71,40 |
| 28 | Bikin boxsplit pakai alat JR I | 17,00 | 58 | Buka flui +pasang cuff k/k | 72,40 |
| 29 | Lipat ujung pocket | 26,20 | 59 | Button sew crossstiching | 23,20 |
| 30 | Gosok/cetak pocket hexa | 36,80 | 60 | Bartack | 54,40 |

Based on the data table 1, regarding actual process time observation data used in this practical work research. The process time was obtained from direct measurements using a stopwatch with repeated observations and measurements five times. The production process on the assembly line consists of 60 work operations. The following is data on the operational process time for line 2A of the Sewing Department for MS LS style production at PT XYZ.

## 5. Results and Discussion

### 5.1 Normal Time and Standard Time

**Table 2**. Normal Time and Standard Time

| Process Activity | Adj | Normal Time | Standard Time | Process Activity | Adj | Normal Time | Standard Time |
|---|---|---|---|---|---|---|---|
| Gambar i/lining collar band | 1,1 | 15,18 | 16,87 | Overlock III inside pocket k/k | 1,08 | 34,34 | 38,16 |
| Heming collar-band (non-fuse linning) | 1,08 | 30,46 | 33,84 | Copot+pasang pocket solid | 1,05 | 105,84 | 117,60 |
| Blabar collar-band (non-fuse) | 1,11 | 36,63 | 40,70 | Copot+pasang button 2pcs pocket | 1,1 | 7,04 | 7,82 |
| Gunting+balik+press ujung collar pakai mesin | 1,16 | 13,46 | 14,95 | Botton sew crossstitching | 1,08 | 16,85 | 18,72 |
| Srik collar-band 4mm | 1,1 | 22,00 | 24,44 | Blabar pasang flap pocket k/k | 1 | 81,00 | 90,00 |
| Der+gandeng+gunting+balik panil collar | 1,08 | 58,75 | 65,28 | Stik flat pocket 5mm k/k | 1 | 27,60 | 30,67 |
| Stik krah tengah collar 1mm | 1,08 | 19,87 | 22,08 | Button hole | 1,06 | 43,88 | 48,76 |
| Button hole | 1,1 | 6,82 | 7,58 | Button sew crossstiching | 1,03 | 56,03 | 62,26 |
| Blabar+kepras flap pocket k/k | 1,11 | 40,18 | 44,65 | Gosok/cetak 4 sisi lapisan label besar | 1,08 | 29,38 | 32,64 |
| Balik flap pocket k/k | 1,1 | 24,64 | 27,38 | Pasang label besar 4 sisi | 1,08 | 58,10 | 64,56 |
| Stik flap pocket JR II k/k | 1,05 | 65,10 | 72,33 | Pasang label 4 sisi | 1,08 | 33,05 | 36,72 |
| Gosok flat pocket jadi k/k | 1,1 | 13,20 | 14,67 | Pasang lapisan label pada back yoke | 1,05 | 74,76 | 83,07 |
| Botton hole | 1,1 | 13,42 | 14,91 | Buka pleat k/k+belah back yoke | 1,06 | 26,71 | 29,68 |
| Manjangi s,cuff k/ (linning non-fuse) | 1,11 | 29,53 | 32,81 | Stik back yoke JR I | 1,06 | 28,20 | 31,33 |
| Gambar cuff k/k | 1,16 | 20,42 | 22,68 | Gosok back yoke | 1,1 | 9,46 | 10,51 |
| Blabar+kepras hexa s,cuff k/k | 1,11 | 45,07 | 50,07 | Join shoulder+sortir k/k | 1,11 | 37,74 | 41,93 |
| Balik +press hexa s,cuff k/k | 1,1 | 18,48 | 20,53 | Stik shoulder JR I k/k | 1,06 | 30,74 | 34,16 |
| Stik hexa s,cugg 4mm k/k | 1,06 | 37,95 | 42,16 | Blabar+stik+panil pasang collar+jpt label+size | 1,05 | 116,97 | 129,97 |
| Gosok cuff jadi k/k | 1,1 | 15,62 | 17,36 | Overlock III armhole | 1,08 | 51,19 | 56,88 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Botton hole | 1,1 | 13,42 | 14,91 | Overlock III ujung slevee k/k | 1,08 | 41,47 | 46,08 |
| Botton sew crossstitching | 1,08 | 16,42 | 18,24 | Pasang armhole c,stitch k/k | 1,03 | 52,12 | 57,91 |
| Cetak split tempel k/k | 1,1 | 7,04 | 7,82 | Stik armhole JR I k/k | 1,06 | 39,43 | 43,81 |
| Pasang slevee binding+potong k/k | 1,11 | 33,74 | 37,49 | Blabar side seam L/S k/k | 1,06 | 44,73 | 49,70 |
| Pasang slevee placket+tres+potong k/k | 1,08 | 79,92 | 88,80 | Pasang care label | 1,1 | 11,66 | 12,96 |
| Botton hole | 1,1 | 12,98 | 14,42 | Stike side seam L/S+sortir k/k | 1 | 108,20 | 120,22 |
| Botton sew crossstitching | 1,08 | 25,06 | 27,84 | Overlock III klim bottom | 1,08 | 28,94 | 32,16 |
| Jahit laid on JR II -non fuse | 1,11 | 40,85 | 45,39 | Plipit bottom hem bulat | 1,08 | 77,11 | 85,68 |
| Bikin boxsplit pakai alat JR I | 1,08 | 18,36 | 20,40 | Buka flui +pasang cuff k/k | 1,02 | 73,85 | 82,05 |
| Lipat ujung pocket | 1,08 | 28,30 | 31,44 | Button sew crossstiching | 1,1 | 25,52 | 28,36 |
| Gosok/cetak pocket hexa | 1,08 | 39,74 | 44,16 | Bartack | 1,08 | 58,75 | 65,28 |

The following is a calculation of line efficiency, balance delay, idle time, smoothness index before line balancing. To calculate line efficiency, balance delay, idle time, smoothness index, and line throughput, cycle time values are needed. Cycle time is the same as the longest task time (Stevenson, 2018). Based on the table 2 above, the cycle time value obtained is 129.97 seconds.

- *Line Efficiency*

$$Line\ Efficiency = \frac{\sum_{i=1}^{k} STi}{(K)(CT)} x100\%$$

$$Line\ Efficiency = \frac{2525,85}{(60)(129,97)} x100\%$$

$$Line\ Efficiency = 32\%$$

- *Balance delay*

$$D = 1 - Line\ Efficiency$$

$$D = 1 - 32\%$$

$$D = 68\%$$

- *Smoothness Index*

$$SI = \sqrt{\sum (STmax - STi)^2}$$

$$SI = \sqrt{511117,32}$$

$$SI = 714,92$$

From the results of these calculations it is known that line efficiency on line 2A style MS LS is 32% with a balance delay of 68%, where this value shows that the efficiency of the production line is not yet efficient and there is still a lot of idle time which can result in bottlenecks so that the production target will be difficult to achieve.

### 5.2 *Precedence Diagram*

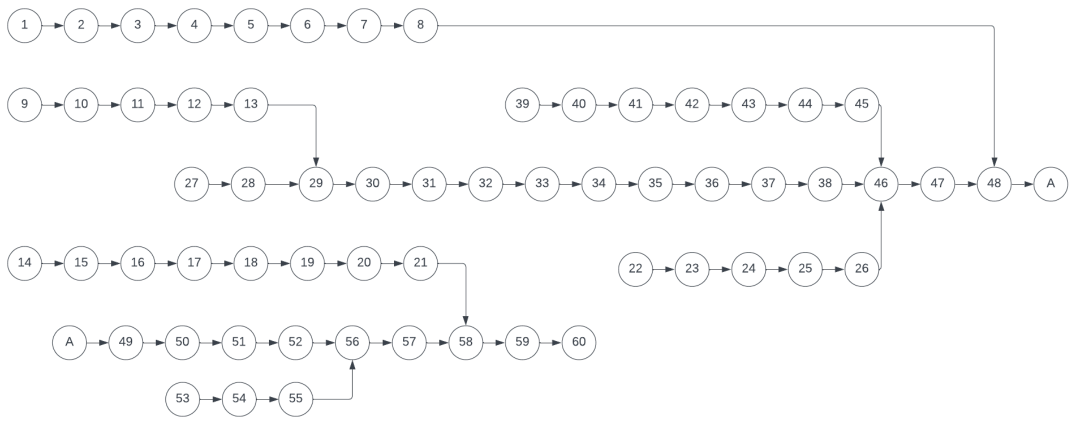


Figure 1. Precedence Diagram

### 5.3 Identify the Root Cause of Low Efficiency Using Fishbone Diagrams

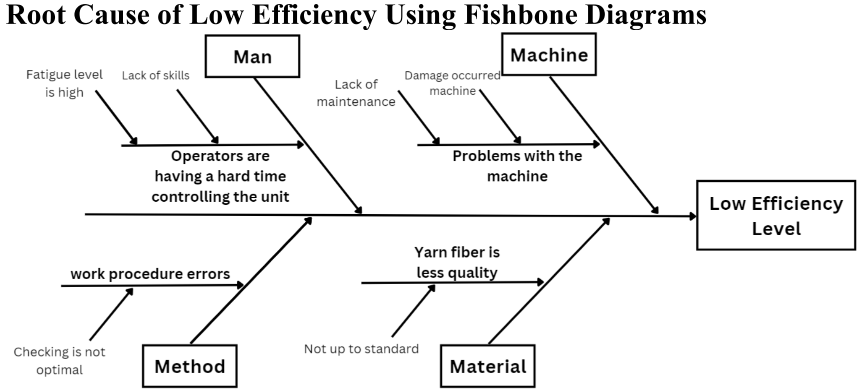


Figure 2. Fishbone Diagram

The figure 1 and 2 above explains the identification of problems from the low efficiency of line 2A of the Sewing Department producing the MS LS style at PT XYZ using the Fishbone Diagram

### 5.4 Proposed Improvements

Before grouping operations at stations, it is necessary to calculate the minimum number of stations theoretically and takt time. The following is the formula and calculation of the minimum number of stations theoretically and takt time (Table 3). The minimum number of work stations is obtained using the following calculations

$$Takt\ time = \frac{Net\ time\ available\ per\ day}{Production\ rate\ per\ day}$$

$$Takt\ time = \frac{28800}{305} = 94 \text{ detik}$$

$$N_{min} = \max\ (n_{min}; n_{probable})$$

$$n_{min} = \sum_{i=1}^{n} \frac{ti}{c}$$

$$n_{min} = \frac{2525{,}85}{94}$$

$$= 27 \text{ station}$$

Table 3. Sorting position weights from largest to smallest

| Elemen | No | Operasi | WB | Proses yg Mendahului | Bobot Operasi | WB Cumulative | WB Stasiun |
|---|---|---|---|---|---|---|---|
| 1 | 9 | Blabar+kepras flap pocket k/k | 44,65 | - | 1323,14 | 72,02 | 72,02 |
| | 10 | Balik flap pocket k/k | 27,38 | 9 | 1295,76 | | |
| 2 | 11 | Stik flap pocket JR II k/k | 72,33 | 10 | 1223,43 | 72,33 | 72,33 |
| 3 | 27 | Jahit laid on JR II -non fuse | 45,39 | - | 1214,25 | 74,96 | 74,96 |
| | 12 | Gosok flat pocket jadi k/k | 14,67 | 11 | 1208,76 | | |
| | 13 | Button hole | 14,91 | 12 | 1193,85 | | |
| 4 | 28 | Bikin boxsplit pakai alat JR I | 20,40 | 27 | 1193,85 | 51,84 | 51,84 |
| | 29 | Lipat ujung pocket | 31,44 | 13, 28 | 1162,41 | | |
| 5 | 30 | Gosok/cetak pocket hexa | 44,16 | 29 | 1118,25 | 82,32 | 82,32 |
| | 31 | Overlock III inside pocket k/k | 38,16 | 30 | 1080,09 | | |
| 6_7 | 32 | Copot+pasang pocket solid | 117,60 | 31 | 962,49 | 158,06 | 79,03 |
| | 39 | Gosok/cetak 4 sisi lapisan label besar | 32,64 | - | 960,13 | | |
| | 33 | Copot+pasang Button 2pcs pocket | 7,82 | 32 | 954,67 | | |
| 8 | 34 | Button sew crossstitching | 18,72 | 33 | 935,95 | 91,10 | 91,10 |
| | 40 | Pasang label besar 4 sisi | 64,56 | 39 | 895,57 | | |
| | 22 | Cetak split tempel k/k | 7,82 | - | 872,82 | | |
| 9_10 | 41 | Pasang label 4 sisi | 36,72 | 40 | 858,85 | 143,59 | 71,79 |
| | 35 | Blabar pasang flap pocket k/k | 90,00 | 34 | 845,95 | | |
| | 1 | Gambar i/lining collar band | 16,87 | - | 837,05 | | |
| 11_12 | 23 | Pasang slevee binding+potong k/k | 37,49 | 22 | 835,33 | 185,07 | 92,53 |
| | 36 | Stik flat pocket 5mm k/k | 30,67 | 35 | 815,28 | | |
| | 2 | Heming collar-band (non-fuse linning) | 33,84 | 1 | 803,21 | | |
| | 42 | Pasang lapisan label pada back yoke | 83,07 | 41 | 775,79 | | |
| 13 | 37 | Button hole | 48,76 | 36 | 766,52 | 48,76 | 48,76 |
| 14 | 3 | Blabar collar-band (non-fuse) | 40,70 | 2 | 762,51 | 55,65 | 55,65 |
| | 4 | Gunting+balik+press ujung collar pakai mesin | 14,95 | 3 | 747,56 | | |
| 15 | 24 | Pasang slevee placket+tres+potong k/k | 88,80 | 23 | 746,53 | 88,80 | 88,80 |
| 16 | 43 | Buka pleat k/k+belah back yoke | 29,68 | 42 | 746,11 | 68,55 | 68,55 |
| | 25 | Button hole | 14,42 | 24 | 732,11 | | |
| | 5 | Srik collar-band 4mm | 24,44 | 4 | 723,12 | | |
| 17_18 | 44 | Stik back yoke JR I | 31,33 | 43 | 714,78 | 131,94 | 65,97 |
| | 26 | Button sew crossstitching | 27,84 | 25 | 704,27 | | |
| | 38 | Button sew crossstiching | 62,26 | 37 | 704,27 | | |
| | 45 | Gosok back yoke | 10,51 | 44 | 704,27 | | |
| 19_20 | 46 | Join shoulder+sortir k/k | 41,93 | 26, 38, 45 | 662,33 | 129,29 | 64,65 |
| | 6 | Der+gandeng+gunting+balik panil collar | 65,28 | 5 | 657,84 | | |
| | 7 | Stik krah tengah collar 1mm | 22,08 | 6 | 635,76 | | |
| 21_22 | 8 | Button hole | 7,58 | 7 | 628,18 | 171,70 | 85,85 |
| | 47 | Stik shoulder JR I k/k | 34,16 | 46 | 628,18 | | |
| | 48 | Blabar+stik+panil pasang collar+jpt label+size | 129,97 | 8, 47 | 498,21 | | |
| 23_24 | 49 | Overlock III armhole | 56,88 | 48 | 441,33 | 119,54 | 59,77 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 53 | Blabar side seam L/S k/k | 49,70 | - | 426,71 | | |
| | 54 | Pasang care label | 12,96 | 53 | 413,75 | | |
| 25 | 50 | Overlock III ujung slevee k/k | 46,08 | 49 | 395,25 | 78,89 | 78,89 |
| | 14 | Manjangi s,cuff k/ (linning non-fuse) | 32,81 | - | 361,65 | | |
| 26 | 15 | Gambar cuff k/k | 22,68 | 14 | 338,97 | 80,59 | 80,59 |
| | 51 | Pasang armhole c,stitch k/k | 57,91 | 50 | 337,34 | | |
| 27-28 | 52 | Stik armhole JR I k/k | 43,81 | 51 | 293,53 | 164,04 | 82,02 |
| | 55 | Stike side seam L/S+sortir k/k | 120,22 | 54 | 293,53 | | |
| 29 | 16 | Blabar+kepras hexa s,cuff k/k | 50,07 | 15 | 288,89 | 70,61 | 70,61 |
| | 17 | Balik +press hexa s,cuff k/k | 20,53 | 16 | 268,36 | | |
| 30 | 56 | Overlock III klim bottom | 32,16 | 51, 55 | 261,37 | 74,32 | 74,32 |
| | 18 | Stik hexa s,cugg 4mm k/k | 42,16 | 17 | 226,20 | | |
| 31-32 | 19 | Gosok cuff jadi k/k | 17,36 | 18 | 208,84 | 136,19 | 68,09 |
| | 20 | Button hole | 14,91 | 19 | 193,93 | | |
| | 21 | Button sew crossstitching | 18,24 | 20 | 175,69 | | |
| | 57 | Plipit bottom hem bulat | 85,68 | 56 | 175,69 | | |
| 33_34 | 58 | Buka flui +pasang cuff k/k | 82,05 | 21, 57 | 93,64 | 110,41 | 55,20 |
| | 59 | Button sew crossstiching | 28,36 | 58 | 65,28 | | |
| 35 | 60 | Bartack | 65,28 | 59 | 0,00 | 65,28 | 65,28 |

- *Line Efficiency*

$$Line\ Efficiency = \frac{\sum_{i=1}^{k} STi}{(K)(CT)} x100\%$$
$$Line\ Efficiency = \frac{2525{,}85}{(35)(129{,}97)} x100\%$$
$$Line\ Efficiency = 80\%$$

- *Balance delay*

$$D = 1 - Line\ Efficiency$$
$$D = 1 - 80\%$$
$$D = 20\%$$

- *Smoothness Index*

$$SI = \sqrt{\sum (STmax - STi)^2}$$
$$SI = \sqrt{19274{,}49}$$
$$SI = 138{,}83$$

## 5.5 Investment Feasibility of Improvement Proposal

a. Production Cost

In designing the improvement proposal, cost assumptions for producing the boxes and shelves are necessary. The following are the production costs used in the creation of boxes and shelves**.**

b. Company Cashflow

The company's cash flow for 5 years with a discount rate of 10% is as follows (Table 4):

Table 4. Cashflow

| **Year** | **Cashflow** |
|---|---|
| 0 | -Rp 180.000.000 |
| 1 | Rp 100.000.000 |

| | |
|---|---|
| 2 | Rp 120.000.000 |
| 3 | Rp 150.000.000 |
| 4 | Rp 130.000.000 |
| 5 | Rp 140.000.000 |

Additionally, the cash flow diagram for the investment proposal over 5 years is as follows (Figure 3).

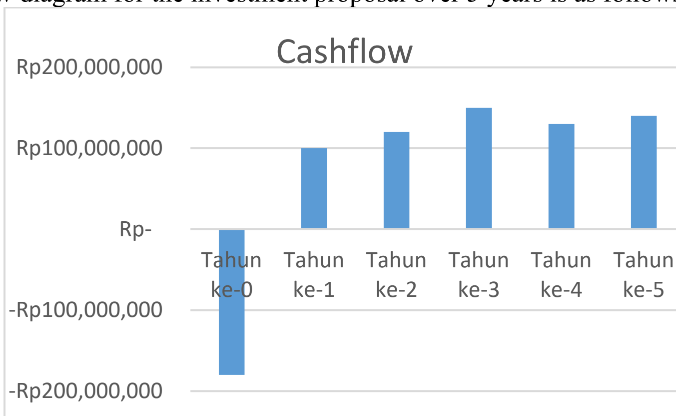


Figure 3. Cashflow Diagram

c. Net Present Value

From the cashflow calculations performed earlier and the Present Value (PV) values obtained from the PVIFA table with a discount factor of 10%, the NPV of the improvement proposal, including boxes and shelves, is as follows. It is known that the NPV of the investment proposal is positive, indicating that the proposed improvement will be profitable for the company in the future (Table 5).

Table 5. Net Present Value (NPV)

| **Year** | **Cashflow** | | ***Net Present Value*** | |
|---|---|---|---|---|
| 0 | -Rp | 180.000.000 | -Rp | 180.000.000 |
| 1 | Rp | 100.000.000 | Rp | 86.956.000 |
| 2 | Rp | 120.000.000 | Rp | 90.737.000 |
| 3 | Rp | 150.000.000 | Rp | 98.627.000 |
| 4 | Rp | 130.000.000 | Rp | 74.328.000 |
| 5 | Rp | 140.000.000 | Rp | 69.604.000 |
| **Total PVs** | | | Rp | 420.252.000 |
| **Initial Investment** | | | Rp | 180.000.000 |
| **NVP** | | | Rp | 240.252.000 |

d. Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) calculation is used to determine the efficiency level of an investment. Below is the IRR for the improvement proposal. It is known that the IRR of the investment proposal is acceptable because it yields a rate of 39%, which is higher than the discount rate (10%) (Table 6).

Table 6. Internal Rate of Return (IRR)

| **Year** | **Cashflow** | | ***Net Present Value*** | |
|---|---|---|---|---|
| 0 | -Rp | 180.000.000 | -Rp | 180.000.000 |

| | | |
|---|---|---|
| 1 | Rp 100.000.000 | Rp 86.956.000 |
| 2 | Rp 120.000.000 | Rp 90.737.000 |
| 3 | Rp 150.000.000 | Rp 98.627.000 |
| 4 | Rp 130.000.000 | Rp 74.328.000 |
| 5 | Rp 140.000.000 | Rp 69.604.000 |
| **Total PVs** | | Rp 420.252.000 |
| **Initial Investment** | | Rp 180.000.000 |
| **NVP** | | Rp 240.252.000 |
| **IRR** | | 39% |

e. Payback Period

The payback period calculation is used to determine the time it takes to recover the capital invested in the improvement proposal. Below is the payback period calculation for the improvement proposal (Table 7).

Table 7. Payback Period (PP)

| Year | Cashflow | *Net Present Value* |
|---|---|---|
| 0 | -Rp 180.000.000 | -Rp 180.000.000 |
| 1 | Rp 100.000.000 | Rp 86.956.000 |
| 2 | Rp 120.000.000 | Rp 90.737.000 |
| 3 | Rp 150.000.000 | Rp 98.627.000 |
| 4 | Rp 130.000.000 | Rp 74.328.000 |
| 5 | Rp 140.000.000 | Rp 69.604.000 |
| **Total PVs** | | Rp 420.252.000 |
| **Initial Investment** | | Rp 180.000.000 |
| **NVP** | | Rp 240.252.000 |
| **IRR** | | 39% |
| **Payback Period** | | 2,03 |

So, the payback period for the investment of design improvements is 2.5 years

## 6. Conclusion

The conclusions drawn from the research conducted at PT XYZ are as follows:

1. The causes of low levels of efficiency are identified using a fishbone diagram and divided into four variables, namely man, machine, method and material. These causes consist of unbalanced processing times at each station, interference with the machine, poor object inspection processes, inappropriate work procedures, and poor quality yarn fibers.
2. After line balancing was carried out using the Ranked Positional Weight (RPW) method by sorting and grouping work stations based on position weight, there was an increase in line efficiency calculations, as well as a decrease in the values of balance delay, smoothness index, and total idle time with the number of work operations reduced

from 60 work became 35 work stations and line efficiency was 80% from the previous 32%. Increasing efficiency causes a decrease in total idle time and balance delay, namely total idle time from 5272.15 seconds to 712.69 seconds and balance delay from 68% to 20%.

3. The proposed improvements are considered feasible and can be implemented by PT XYZ. This conclusion is based on The NPV is positive, indicating that the investment in the improvement proposal is acceptable. The IRR is above discount rate, which further supports the feasibility of the improvement proposal. Payback period for estimated 2.03 years, investment in changes to the production process to increase production line efficiency at PT XYZ is useful because it will provide benefits for the company in the future.

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