Balancing the production line using the ergonomic approach

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Abstract. Track balance is a process of balancing production lines at a series of work stations (machinery and equipment) that need to be carried out in the product manufacturing process. This aims of this research is to form and balance the work risks allocated to each work station. If the track balance is not carried out it can lead to inefficiencies and reduce the level of flexibility of the production floor. Job Rotation (JR) is a method for designing jobs where staff learn work skills from various parts and by making changes to tasks, fatigue resulting from repetitive work tasks will be eliminated. In principle, the Region Approach method seeks to charge first to operations that have a large preliminary responsibility. Through the research conducted, the optimum trajectory is obtained using the region approach and job rotation methods where the method can produce optimum work center and can reduce the risk of excessive work. Region approach trajectory, as many as 7 work stations. In addition, the efficiency of the production line where there is an increase in efficiency of 10.56% in the region approach trajectory. Then the balance delay decreased by 10.07% in the region approach trajectory, and a decrease in the smoothing index by 298.90 in the region approach trajectory. Based on the results of the calculation of work risk using the RULA method, the results of the calculation of work risk on the work elements of each work center where the results obtained by the reduction of work elements and the addition of work elements are carried out so that the work risks at each work center are balanced, and can reduce injuries when work. Production line on the proposed condition with a cycle time of 2304 seconds and there are 7 work stations. The known value of balance delay is 18.62%, efficiency is 81.76% and smoothing index is 2015.74.

1. Introduction
Track balance is a process of balancing production lines at a series of work stations (machinery and equipment) that need to be carried out in the product manufacturing process. This aims to form and balance the work risks allocated to each work station. If the track balance is not carried out it can lead to inefficiencies and reduce the level of flexibility of the production floor. Job Rotation (JR) is a method for designing jobs where staff learn work skills from various parts and by making changes to tasks, fatigue resulting from repetitive work tasks will be eliminated. The importance of JR has long been recognized in almost every company setting throughout the world. The Region Approach method was developed by Bedworth and this method divides the precedence diagram in several regions vertically, and in each region there is no dependency between work operations. In principle, the Region Approach method seeks to charge first to operations that have a large preliminary responsibility.

2. Method
This research was conducted at XYZ company uses the Research method as follows:
2.1. Research steps

The steps taken in conducting this research are as follows.

- **Rating Factor**
  Rating is a process during measurement of time in which the researcher compares the performance (speed and tempo) of the operator during observation with the observer's personal concept of normal performance. Rating factor is applied to the selected time to obtain normal time.

- **Allowance**
  The normal time of an operation has no allowance. The time available is only the time that is needed by the operator to carry out a job in the normal tempo.

- **Time of work element for each station**
  Time measurement is used to determine the time needed for workers who are trained and have certain qualifications who work in a normal business to carry out specific tasks or jobs. Time measurement is used to measure work, where the result of time measurement is the time when someone who does a job and trained for the job with a normal or standard tempo. Such time is referred to as standard time in operation.

- **Precedence Diagram**
  Precedence Diagram is a graphical description of the order of work operations, as well as dependence on other work operations whose purpose is to facilitate the control and planning of activities related to it.

| Work Station | Work Element | Process | Number of Operators |
|--------------|--------------|---------|---------------------|
| I            | 1            | Taking wood raw materials from the warehouse | 1 |
|              | 2            | Constructed wood raw materials by forklifts |  |
|              | 3            | Cut the ends of wood |  |
|              | 4            | Mashed wood with a planner machine | 2 |
|              | 5            | Arranged wood on a pallet | 1 |
|              | 6            | Moved wood to Grade Station | 1 |
| II           | 7            | Timber extraction and preparation | 1 |
|              | 8            | Cut with Saw Mill | 1 |
|              | 9            | Classified wood according to grade | 1 |
|              | 10           | Arranged wood on a pallet |  |
|              | 11           | Moved wood to the Finger Joint station | 1 |
| III          | 12           | Arrangement of wood on the glue conveyor | 1 |
|              | 13           | Cut and glued the wood ends with a Finger Joint machine | 1 |
|              | 14           | The wood is connected on the conveyor | 1 |
|              | 15           | Wooden joints are arranged on the Finger Joint machine |  |
|              | 16           | Pressing wood joints with Finger Joint machines | 2 |
|              | 17           | Arranged wooden connections on a pallet |  |
3. Result and discussion

3.1. Time calculation
In this study a 95% confidence level and a 5% accuracy level were used. If the confidence level is 95% then \( k = 1.96 \). Accuracy rate of 5% is equal to 0.05. Data collection was carried out as much as 5 times the observations for each work element in the production floor using the help of a stopwatch in the study. Data sufficiency test is conducted to find out whether the amount of data that has been collected is sufficient (can represent the population as a sample). In work element 1, the result is \( N > N' (5 > 0.21) \) so that in work element 1, the data is sufficient with the number of observations made 5 times, and testing for the whole work element. Based on the calculation results, the entire data is sufficient because the value of \( N > N \) for all work elements. Data uniformity test on each element is in the upper control limit and lower control limit so that it can be concluded that the data is uniform. The normal time with a rating factor in element I is 339.02 with a rating factor of 1.15, where the rating factor obtained is based on the...
results of each operator's work. Standard time with allowance is obtained to find out the standard time that exists in each work element.

3.2. Path with the region approach method
On the trajectory using the region approach method, there are 38 work elements arranged into 8 work stations. In table 2 it can be seen that the number of stations using the region approach method is as follows:

| Work Station | Work Operation | Time Work Station |
|--------------|----------------|-------------------|
| I            | 1,2,3,4,5,6    | 1578              |
| II           | 7,8,9,10,11    | 1399              |
| III          | 12,13,14,15,16,17 | 2183             |
| IV           | 18,19,20,21    | 1350              |
| V            | 22,23,24,25    | 2213              |
| VI           | 26,27,28,29    | 1384              |
| VII          | 30,31,32,33    | 1313              |
| VIII         | 34,35,36,37    | 1186              |

Then the precedence diagram with the region approach method can be seen in Figure 1.

The production line is in the initial condition with a cycle time of 1670 seconds and there are 28 working elements. The known value of balance delay is 79.73%, efficiency is 20.26% and smoothing index is 2879.23.

3.3. Track balance with job rotation
After obtaining the work risks of each work element using the RULA method, the calculation of work risk is performed again based on the results obtained where the work elements 5, 6, 9, 11, 16, 20, and 28 experience excessive work risks with a score of 7, displacement work elements carried out by looking at the work risks of each work station so that existing work stations can have the same work risks.

| Work Station | Work Element | Process | Number of Operators |
|--------------|--------------|---------|---------------------|
| I            | 1            | Taking wood raw materials from the warehouse | 1 |
|              | 2            | Constructed wood raw materials by forklifts | 1 |
|              | 3            | Cut the ends of wood | 1 |
|              | 4            | Mashed wood with a planner machine | 1 |
|              | 5            | Arranged wood on a pallet | 1 |
|              | 6            | Moved wood to Grade Station | 1 |
II

7 Timber extraction and preparation
8 Cut with Saw Mill
9 Classified wood according to grade
10 Arranged wood on a pallet
11 Moved wood to the Finger Joint station
12 Arrangement of wood on the glue conveyor
13 Cut and glued the wood ends with a Finger Joint machine
14 The wood is connected on the conveyor

III

15 Wooden joints are arranged on the Finger Joint machine
16 Pressing wood joints with Finger Joint machines
17 Arranged wooden connections on a pallet
18 A wooden connection to the Molding station was carried
19 Arranged wooden joints on molding machines
20 Smoothed wood connections with molding machines
21 Arranged wooden connections on a pallet
22 Taken to the Laminating station by Hand Lift

IV

23 Arranged wooden joints on the laminating machine
24 Pressed into wooden boards
25 Wooden boards arranged on a pallet
26 Taken to the Table Saw station by Forklift
27 Wooden boards arranged on a table saw machine
28 Cut the sides of a wooden board
29 Wooden boards arranged on a pallet
30 Taken to the Sanding station by the Forklift

V

31 Arranged wooden boards on a Sanding machine
32 Smoothed the surface of wooden boards
33 Wooden boards arranged on a pallet
34 Taken to the Packing station by the Forklift
35 Arranged wooden boards
36 Wrapped in wooden boards using plastic
37 Labeled on wooden boards
38 Carried a wooden board using a forklift

Precedence diagram with the job rotation method can be seen in Figure 2.

![Precedence Diagram](image)

**Figure 2.** Precedence diagram.

The production line is in the initial condition with a cycle time of 2506 seconds and there are 7 work stations. The known value of balance delay is 28.13%, efficiency is 72.06% and smoothing index is 2014.02.

### 3.4. Performance Calculation

The results obtained in the region approach method there are 8 work stations with a cycle time of 2304 seconds and there are 8 work stations with a balance delay value of 31.61%, an efficiency of 68.39% and a smoothing index of 2314.64. The results of the job rotation method are 7 work stations with a cycle time of 2506 seconds, a value of balance delay of 28.13%, efficiency of 72.06% and smoothing index of 2014.02.

| Measurement          | Region Approach Pathway | Job Rotation Tracks |
|----------------------|-------------------------|---------------------|
| Work station         | 8                       | 7                   |
| Balance Delay        | 31.61%                  | 28.13%              |
| Track Efficiency     | 68.39%                  | 72.06%              |
| Smoothes Index       | 2314.64                 | 2014.02             |

### 4. Conclusion

1. Production trajectory in the region approach method Forms a sequence of work operations at the work station based on priority operations with the condition that the work station time does not exceed the cycle time, cycle time of 2304 seconds and there are 8 work stations. The known value of balance delay is 31.61%, efficiency is 68.39% and smoothing index is 2314.64.
2. The production trajectory in the Job rotation method has 4 stages, namely by arranging the initial work sequence, calculating work risks, moving workers, and calculating a new work order with a cycle time of 2506 seconds and there are 7 work stations. The known value of balance delay is 28.13%, efficiency is 72.06% and smoothing index is 2014.02.
3. The results obtained in the region approach method there are 8 work stations with a cycle time of 2304 seconds and there are 8 work stations with a balance delay value of 31.61%, an efficiency of 68.39% and a smoothing index of 2314.64. The results of the job rotation method are 7 work stations with a cycle time of 2506 seconds, a value of balance delay of 28.13%, efficiency of 72.06% and smoothing index of 2014.02.
References
[1] Barnes R Motion and Time Study Design and Measurement of Work Seventh Edition.
[2] Miki Maria 2016 Metode Region Approach Untuk Keseimbangan Lintasan.
[3] Mohd Afifuddin 2019 Penerapan Line Balancing Menggunakan Metode Ranked Position Weight (RPW) Untuk Meningkatkan Output Produksi pada Home Industri Pembuatan Sepatu Bola
[4] Rosnani Ginting Lintasan Produksi.
[5] Rosnani Ginting 2007 Sistem Produksi (Yogyakarta Graha Ilmu)
[6] Salih Mohammed Omer 2017 Job Rotation & Impact On Employees Performance An Empirical Study among Employees at Red Sea University Sudan
[7] Sinulingga Sukaria 2013 Metodologi Penelitian 2013 Medan0 USU Press.
[8] SyazwanAizat Ismail The Association between Ergonomics Risk Factors, RULA Score, and Musculoskeletal Pain Among School Children : A Preliminary Result.
[9] Tirajoh, Watson et al 2018 The Effect Of The Benefit Of Job Rotation On Employee Development