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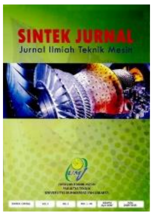

LINE BALANCING ANALYSIS BY USED RANK POSITIONAL WEIGHT (RPW) (CASE STUDY: PART BODY S11038Z PROCESS)

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ABSTRACT

The purpose of this paper is to determine the number of proposed work stations based on Rank Positional Weight and to find out the results of the comparison between the initial work station conditions and the proposed work station conditions. The method used in optimizing Line Balancing is the Rank Positional Weight (RPW) method by calculating the amount of processing time, Balance Delay, Smoothness Index, the largest track efficiency, and station efficiency. The results of the comparison between the initial work station conditions and the proposed work station conditions using the RPW method in the total production process time of the S11038Z section from the initial conditions of 1060.23 seconds after analysis using the RPW method obtained a shorter processing time of 970.23 seconds or reduced by 90 seconds. The balance delay in the initial condition was 67.6% with the RPW method, the result was that the balance delay was better, namely 62.9%. The smoothness index in the initial conditions is 1059.79 to 857.88. The tracking efficiency increased by 4.7%, from 32.4% to 37.1%. The efficiency of the biggest workstations also increased, from 489 seconds to 399 seconds.

Keywords: *Track Balance; Line Balancing; RPW; Balance Delay; Smoothness Index; Track Efficiency*.

1. INTRODUCTION

A flow-oriented production assembly line the system where the work station performs serially or line synchronized operations. Sequentially because they are moved along the line usually by several people type of transportation system, eg. conveyor belt [1].

In the implementation of a work activity process, it is necessary to have a method that will be able to increase productivity, namely by replacing existing work methods by considering the factors that affect the work activity [2,3]. Another way can be done is by optimizing the workforce and machines, especially the production section [4,5].

One of the factors that greatly affect the productivity of the company is the production line [6,7]. They said the efficiency of the production line between several related work stations greatly affects productivity. The higher the line efficiency, the better the material flow between stations, so that the delay (*delay time*) can be avoided.

Based on observations and interviews with production employees and production planning (PPIC) in Surya Toto Corp, it was found that there was a problem of ineffective labor and production machines, resulting in a bottleneck at one of the production stations, especially in the section of polishing factory 5 which was a result of delays in the previous processing, namely the process machining. To achieve work efficiency, the bottleneck must be minimized, one way is to balance the number of operators and the speed of the existing machines. **So** in this paper will determine the number of proposed work stations based on Rank Positional Weight and find out the results of the comparison between the initial work station conditions and the proposed work station conditions.

2. METHODS

2.1. Production Process Concept

Definition and types of the production process according to the definition of a production process is a method, method, and technique to create or increase the use of goods and services by using resources (labor, machines, materials, funds) existing [8]. production is one of the most important parts of a manufacturing company that deals with the transformation of various inputs into outputs (products) according to the specified quality standards. meanwhile, what is meant by the production process is a series of steps used to transform these inputs into outputs [9,10].

2.2. Line Balancing

Line balancing is the assignment of task elements from an assembly line to work stations to minimize the number of work stations and minimize the total price idle time at all stations for a level of output certain. General requirements that must be used in a balanced production trajectory are minimizing idle time and minimizing balance delay [11].

2.3. Ranked Positional Weight (RPW)

The RPW solution is one of the more efficient ways of assigning job elements to stations than the other methods. In the RPW method, you can set the cycle time and then calculate the work stations required for the production line or vice versa. this matter cannot be performed in any other line balance method [12]. RPW method is a combined method between the Large Candidate Ruler Region Approach methods. The RPW value is a calculation between the work element and the position of each work element in the precedence diagram. The steps of the RPW method are as follows [13]:

a. Creating a precedence diagram or network diagram of the OPC;
b. Calculating cycle times;
c. Creating a path matrix based on precedence diagrams;
d. Calculate the position weight of each operation which is calculated based on the total time of the operation and the operations that follow it;
e. Sort the operations from the largest to the smallest operating weight;
f. Counts the minimum number of work stations;
g. Make a flow diagram for the minimum work station and then load the operation on the work station starting from the largest to the smallest operating weight, with the criteria that the total operating time is less than the desired cycle time;
h. Carry out trial and error to get the highest track efficiency;
i. Calculates the balance delay trajectory.

2.4. Application of Line Balancing with the RPW Method

The manufacturing line of manufacture (ALM) has been used with success in the manufacturing industry. In ALM, these are different workstations that are placed on different lines and workers, machines, or robots at different workplaces in sequence. The complete product will appear off the line after passing through all work stations. One of the methods known as RPWM [14], has been used in balancing manufacturing lines in the industry.

For the relative importance of the various elements of the job, each element is assigned a "weight" that defines its importance relative to the others. Weights are defined as the sum of the operating time required for the element and the total operating time required for all elements to replace the elements [15]. Subject to work station priorities, storefronts are assigned according to weight; A job station with a higher weight will start working sooner than one with a lower weight.

In used the RPW method can be found the optimum balance delay for each type of ARM product from 60.46% to 20.5488% with a production of 113.50 units/day to 116 units/day, and also work efficiency from 60.50% to 78.4511%, with 7 workstations [16].

Indrawan minimizing the bottleneck of the production process using the method, it was line balancing found that the increase in work efficiency of the production line was 47.56% from 39.99% to 87.55%. And the balance delay can be reduced by 47.56% from 60.01% to 12.45%. With effective work stations on the polyester yarn production process line as many as 3 work stations. By increasing the production output by 37 tons / month from 400 tons / month to 437 tons / month [17].

2.5. Measurement Methods and Techniques

The initial stage in this research is the identification stage, where the stage is carried out by making direct observations to identify problems at the research location. From the problems that have been identified, then formulate the problem and set research objectives. Then literature and field studies are carried out to support the research so that the research runs well and correctly.

The second stage is data collection, which consists of actual TX432SD product demand data, part routing S11038Z data, and product structure (BOM) data. Product demand data is used as a reference for identifying problems that occur. Routing data to get the work process sequence, the length of time for the making process part S11038Z, and determine the position weight from highest to lowest and product cycle time.

The next stage is the data processing stage, including the calculation of the machine cycle time for each unit of product as in shown table 1. To calculate the cycle time, it is obtained by cycle time for dividing each process by the number of machines used, then the total result of the entire process is added. Next is to create an Operation Process Chart (OPC) initial conditions as an illustration of the sequence of the S11038Z part production process. Making a Precedence Diagram as a continuation of the previous process so that the process flow can be clearer as in Figure 1. The data which is processed further is calculating cycle time, balance delay, smoothness index, and track efficiency.

The last stage of this research is analysis and conclusion. This analysis is a descriptive description of the results of the research conducted, including cycle time, total processing time, balance delay, smoothness index, track efficiency, and largest workstation efficiency. From the results of this study, it can be seen the amount of processing time that needs improvement, and then conclusions can be drawn about the balance of the largest workstation and recommendations for improvements to improve processing time efficiency and track balance so that delivery delays do not occur.

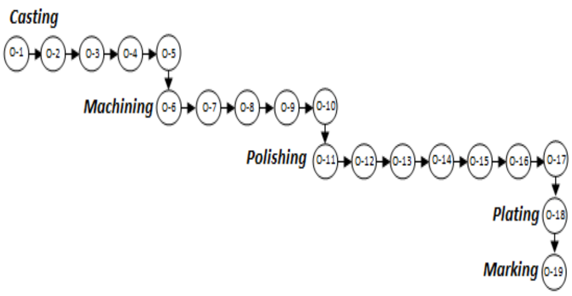

Figure 1. Precedence Diagram

3. RESULTS AND DISCUSSION

3.1. Cycle Time

This research begins by calculating the cycle time of the product with the following calculations:

a. Average production target per month (January-December 2017) = 1760 units.
b. Production yield per day = 1760/20 days = 88 units per day.
c. Working hours per day are 2 shifts (1 shift = 8 hours).

$$CT = \frac{P}{Q} \quad (1)$$

$$CT = \frac{(2x8x60x60)}{88}$$

$$= \frac{57600}{88} = 654.54\ second$$

Data cycle time of the machine by the machine used to process *parts* S11038Z proposal in Table 1.

Table 1. Calculation of Cycle Time Machine Each Unit Products (Proposed)

Op	Description	Machine	*CT*	Tot Machine	*Ct / Unit*
O-1	Print*Core*	Machinery Naniwa(Core)	120	1	120
O-2	Coating Brass	Machine LPDC	107	1	107
O-3	Cutting	Machine *Cutting*	25	1	25
O-4	*Shot Blast*	Machine *Shot Blast*	16.7	1	16.7
O-5	Eliminate *Dabo*	Machine *GrindingCasting*	20	1	20
I-1	Inspection*part*	*Sigmat Digital*	20	1	20
O-6	Making	Machine *GnuttiThread*	13.6	1	13.6
O-7	Process	Machine *WashingWashing*	25	1	25
O-8	discharge process*Kiriko*	Machine *Air Blowing*	15	1	15
O-9	Process	Machine *Leak TestLeak Test*	24	1	24
O- 10	Cleaning	Machine *AlkalineDirt*	75	1	75
I-2	inspection*Part*	*Sigmat Digital*	20	1	20
O-11	*Berto*	**Robot Machine 1**	**291**	2	145.5
O-12	*Berto*	**Machine *Abrasive* # 240**	**85**	2	42.5
O-13	*Berto*	**Machine *Abrasive* # 400**	**105**	2	52.5
O -14	*Buffing*	**Machines *Buff* Manual**	**45**	2	22.5
O-15	*Buffing*	**Machines *BuffMepsa***	**116**		1116
I-3	examination of a n*part*	Visual (eye)	20	1	20
O-16	Coating Nickel and *Chrome*	Engineering *Plating*	2460	56	43.93
I-4	Examination *Part*	Visual (eye)	20	1	20
O-17 I-5	Provision *brand* TOTO and inspection of *parts*	Machine *Marking*	26	1	26
	TOTAL		**3649.3**		**970.23**

3.2. Determining the Number of Work Stations

a. Total processing time = 970.23 seconds
b. Cycle time = 654.54 seconds

$$\text{Kmin} = \frac{\sum \text{ti}}{\text{C}} = \frac{970.23}{654.54} = 1.48 \approx 2 \text{ station} \quad (2)$$

Based on the above calculation, a minimum of 2 work stations is obtained. So that the track balancing can be done using the RPW method. Calculation on weighting position can be seen in Table 2.

Table 2. Position Weight Calculation Results with the RPW Method (Proposed)

Station	Op	Information	*Ct / Unit*	Weight Position	Total Time Station
1	O-1	Print *Core*	120	1060.23	308.7
	O-2	Brass Plating	107	940.23	
	O- 3	Cutting	25	833.23	
	O-4	*Shot Blast*	16.7	808.23	
	O-5	Removing*Dabo*	20	791.53	
2	I-1	Checking *part*	20	771.53	172.6
	O-6	Making	13.6	Thread7 51.53	
	O-7	Washing process	25	737.93	
	O-8	Process of removing *kiriko*	15	712.93	
	O -9	Leak test process	24	697.93	
	O-10	Cleaning dirt	75	673.93	
	I-2	Check *part*	20	598.93	
3	O-11	*Berto*	**145.5**	**578.93**	**399**
	O-12	*Berto*	**42.5**	**433.43**	
	O-13	*Berto*	**52.5**	**390.93**	
	O-14	*Buffing*	**22.5**	**338.43**	
	O-15	*Buffing*	**116**	**315.93**	
4	I-3	examination *part*	20	199.93	89.93
	O-16	Coating Nickel and *Chrome*	43.93	179.93	
	I-4	examination *part*	20	136	
	O-17 I-5	Provision *brand* TOTO and inspection *part*	26	116	
		TOTAL TIME			**970.23**

Example of calculation:

Weight of RPW Element$_n$ = $\sum$ Processing time element - Processing time of element$_{n-1}$

Weight RPW Element$_1$ = (120 + 107 + 25 + 16.7 + 20 + 20 + ... + 20) - 0 = 1060.23

Weight RPW Element$_2$ = (120 + 107 + 25 + 16.7 + 20 + 20 + ... + 20) - 120 = 940.23

Based on the results of the position weight calculation using the RPW method, the initial conditions in the 5factory fitting have 5 work stations namely Casting, Machining, Polishing, Marking, and Plating. By using line balancing with the RPW method, the number of stations was obtained to be 4 with the longest station time of 399 seconds, namely at station 3 (station polishing).

3.3. Balance Delay

Calculating the balance delay

$$BD = \frac{N.CT - Ti}{N.CT} \times 100\% \quad (3)$$

$$BD = \frac{(4x\ 654.54) - 970.23}{(4\ x\ 654.54)}\ x\ 100\%$$

$$= 0.629\ x\ 100\% = 62.9\%$$

Based on the above calculations, the value obtained *balance delay* is obtained in this condition. proposal of **62.9%**.

3.4. Smoothness Index

Calculating the smoothness of production

$$SI = \sqrt{\sum (CT\text{-}ST)^2} \quad (4)$$

$$SI = \sqrt{735956.61}$$

$$= 857.88$$

Based on the above calculations, the value is obtained *smoothness index* under the proposed condition of 857.88.

3.5. Track Efficiency

Calculating the track efficiency

$$EL = 100\% - BD \quad (5)$$

$$EL = 100\% - 62.9\%$$

$$= 37.1\%$$

3.6. Work Station Efficiency

The results of workstation efficiency calculations can be seen in Table 3.

Table 3. Proposed Work Station Efficiency Calculation Results

Station	Operation Charging	Time for Station	Greatest Stations Time	Work stations efficiency
1	O-1,O-2,O-3,O-4,O-5,I-1	308.7	**399**	77.37 %
2	O-6,O-7,O-8,O-9,O-10,I-2	172.6		43.26%
3	O-11,O-12,O-13,O-14,O-15,I-3	**399**		100 %
4	O-16,I-4,O-17,I-5	89.93		22.54 %

The results of improvements from the S11038Z production process can be seen in Table 4.

Table 4. Comparison of Repair Results

Num	Item	Before	After	Gap
1	Cycle time	654.54	654.54	0
2	Number of process time	1060.23	970.23	90
3	*Balance Delay*	67.6 %	62.9 %	4.7 %
4	Smoothness Index	1059.79	857.88	201.91
5	Line efficiency	32.4 %	37.1 %	4.7 %
6	The efficiency of the greatest work station	489	399	90

4. CONCLUSIONS

Based on the results of the analysis with the RPW method and discussion of the data that has been processed using related methods, it can be concluded that: The number of proposed work stations is 4 stations, with different loading for each station from initial conditions. By using the RPW method, the operating loadings are obtained at each work station, namely: station one consists of O-1, O-2, O-3, O-4, O-5, I-1, station two consisting of O-6, O -7, O-8, O-9, O-10, I-2, station three consists of O-11, O-12, O-13, O-14, O15, I-3, and station four consists of O-16, I-4, O-17, I-5.

The results of the comparison between the initial work station conditions and the proposed work station conditions using the RPW method, the cycle time of the production process per day is 654.54 seconds. Total processing time for the S11038Z part in initial conditions is 1060.23 seconds, after analysis using the RPW method is obtained a shorter processing time of 970.23 seconds or a decrease of 90 seconds.

Suggestions that the author can give to companies related to the Final Project analysis are to improve the smooth operation of production which previously experienced delivery delays, especially insection *polishing5*, the company should use the RPW method so that the trajectory can be more balanced and production can flow smoothly so that orders can be obtained. fulfilled by the smooth flow of the production process. To get a better work station track performance, the company should conduct training *multi-skill* insection *polishing* 5 for employees to be ready to be placed anywhere with high work stations and optimization of machine capacity.

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