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Line Balancing Analysis Using Ranked Positional Weight (RPW) Method inThe Part S Seal Packing Production Process

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Abstract

PT BESQ Sarana Abadi is a manufacturing company that produces spare parts made from rubber, this company supplies spare parts for large companies such as PT Hino and PT Toa Galva Industri. In conducting cooperation, this company must meet the requirements set by the partner company, where one of the assessment factors is the efficiency of the production trajectory. Efficiency in productivity determines how the company's reputation. The strategy that companies can do to improve efficiency is to carry out production planning and continuous supervision. The problem faced by PT BESQ Sarana Abadi is the delay in producing spare parts. The production delay is caused by the imbalance of the production line between workstations in the production process. One of the tools that can be used to streamline production time is Line balancing. The purpose of this line balancing is to prevent bottlenecks, keep the line smooth, and increase production efficiency. The method used in this research is ranked Position Wight, which results in an increase in line efficiency from 59.64% to 68.17% and reduces idle time or waiting time from 4594.172 seconds to 3171.144.

Keywords: line balancing, Bottlenecks, Time Study, Workstation

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I. INTRODUCTION

The rapid development of technology requires industries in Indonesia to innovate, one of which is to run a production system effectively and efficiently, using operators and a minimal number of machines but can produce high production output *to* compete with the many new companies that have emerged[1]. The manufacturing industry is an industry that absorbs a lot of human resources and *opens* many jobs [2].

PT BESQ Sarana Abadi is a manufacturing company that produces spare parts made from rubber, this company supplies spare parts for large companies such as PT Hino and PT Toa Galva Industri. In conducting cooperation, this company must meet the requirements set by the partner company, where one of the assessment factors is the efficiency of the production trajectory. Efficiency in productivity determines how the company's reputation. The strategy that companies can do to improve efficiency is to carry out production planning and continuous supervision. This should be the company's concern because efficiency is one of the important factors to compete with other companies, because it can attract partners to work with the company. The problem faced by PT BESQ Sarana Abadi is the delay in producing spare parts. The production delay is caused by the imbalance of the production line between workstations in the production process. One of the tools that can be used to streamline production time is line balancing.

Line balancing is a method to balance the assignment of several work elements from an assembly line to workstations to minimize the number of workstations and minimize the total idle time at all workstations at a certain output level. The purpose of this line balance is to prevent bottlenecks, keep the line running smoothly, and increase production efficiency [3].

The purpose of this research is to optimize the production line at PT BESQ Sarana Abadi based on cycle time and Precedence Diagram, to increase the efficiency of the production line and minimize the waiting time for each station. The research was conducted starting from measuring working time and comparing the efficiency level of the old production line with the new production line. The same thing was done by [4], the application of line balancing using the ranked position weight method which can produce an efficiency of 89.29% and a balance delay of 10.71%.

A. Line balancing

Line balancing is an analysis used to calculate the balance of production time by dividing the workload between processes in a balanced manner so that there is no idle process due to waiting too long for products from the previous process. According to [5] the main purpose of line balancing is as a tool that makes each workstation efficient and balances the existing line so that all stations in the line as much as possible have the same operating time. The result of applying Line Balancing is minimizing idle time to achieve work time efficiency at workstations[6].

B. Ranked Position Weight Method (RPW)

In this method, workstations are arranged based on work weights. The arrangement is done from the weight of the largest workstation and the last is the workstation with the smallest weight[4]. This method is used because it is considered better than other methods. The stages of the Ranked Positional Weight (RPW) Method are:

1. Calculate the position weight of each task, which is the weight of a task plus the weight of the next tasks.
2. Sort the tasks according to the positional weight, from largest to smallest.
3. Place the largest weighted task into a station without violating the precedence constraint and the station time does not exceed the cycle time.
4. Perform the placement until all tasks are assigned to a workstation.

[1]

C. RPW Method Calculation

There are calculations used in the application of the RPW method:

1. Cycle Time

Cycle time (CT) is the maximum time limit allowed from each workstation. Cycle time is obtained from the amount of time available divided by the number of products that can be produced [7].

$$Cycle\ time = \frac{\sum X_{in}}{N} \quad (1)$$

2. Normal Time

Normal time is working time that has considered the adjustment factor, which is the average cycle time multiplied by the adjustment factor [7].

$$Normal\ Time = CT\ X\ Rating\ Factor \tag{2}$$

3. Standard Time

Standard time is the time required by humans to complete a job completely. Standard time has considered aspects of operator work speed and the leeway needed by operators [7].

$$Standard\ Time = Normal\ Time\ \times \frac{100\%}{100\% - Allowance} \tag{3}$$

II. Research Method

The data sources used in this research are the results of data processing consisting of:

1. Cycle time data of production process to get efficiency value with RPW method.
2. Operation time data to get Ratting value and value in a process with RPW method.
3. Analyzing the calculation of the value of a process in finishing to produce a balancing line by maximizing.

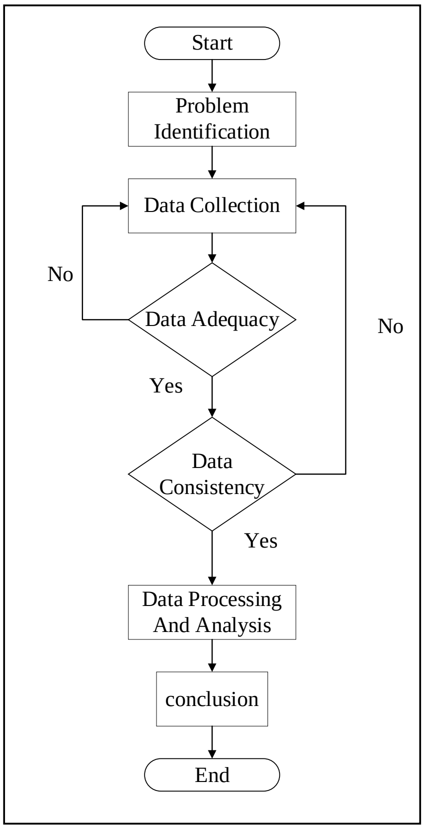

Fig. 1. Reserch Method

The research was conducted with a process that includes data collection, data processing, and balance analysis on the part S Seal Packing production line at PT BESQ Sarana Abadi using the ranked position weight method. After data collection is sufficient, the data that has been obtained is used to create a precedence diagram and processed in accordance with the provisions of line balancing using the ranked positional weight method to produce a line balance on an efficient production line.

III. Results and Discussion

The research begins with identifying problems in the company, then collecting data on the production process operations. From the data that has been collected, data sufficiency and data uniformity tests are carried out. The data sufficiency test uses a confidence level of 95% and an accuracy of 5%, the data is said to be sufficient if N' is less than N (20). Then the data that has been considered sufficient is tested for data uniformity using an accuracy level of 5%. Data is said to be uniform if there is no data that crosses the upper control limit or lower control limit.

A. Production Process

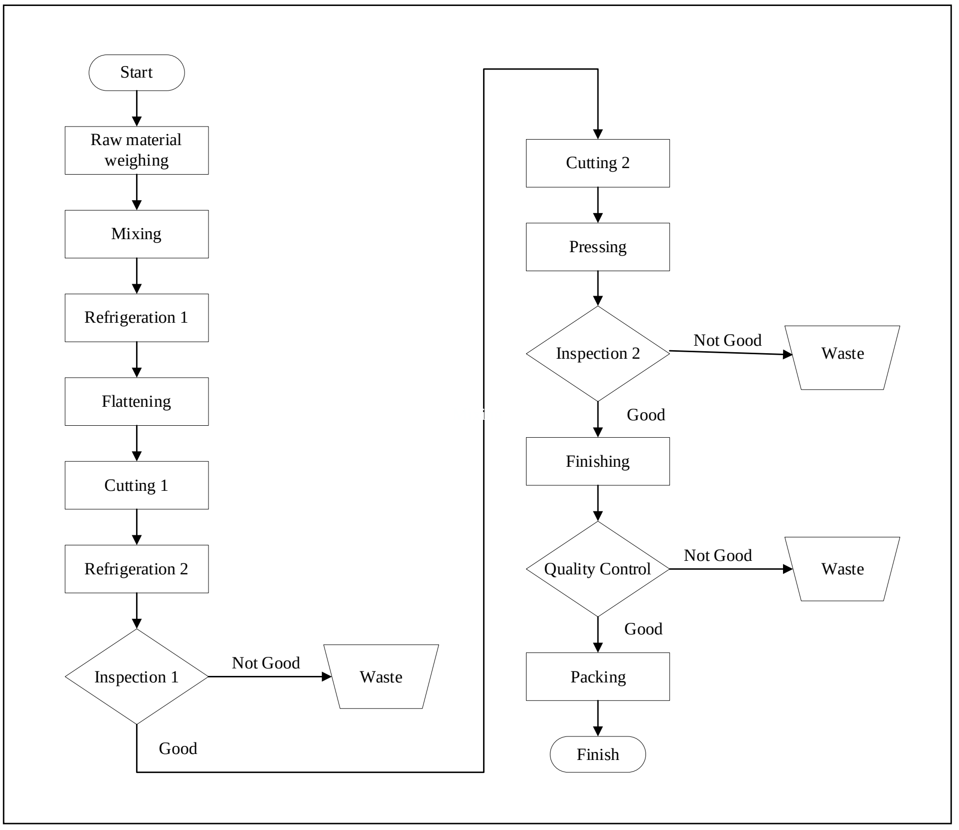

Fig. 2. Production Proces Chart

The production process begins with weighing raw materials and some additional chemicals that are adjusted to the specifications of the parts to be produced. The raw material is then inserted into the kneader machine for mixing with a predetermined temperature and time according to specifications, after completion of the mixing process the material enters the cooling process 1 so that the temperature becomes lower and can be moved to be flaked using an openmill machine. After this process, the raw material has become a compound or half-cooked rubber in the form of long sheets which are then cut in the cutting process 1 into smaller compounds.

Compound before proceeding to the next process must be tested first to ensure compliance with specifications, compound that meets the standards will enter the next process, namely cutting 2, in the process of cutting 2 compound is cut and weighed to adjust the weight of 1 Shoot pressing process of the type of product to be produced. The next process is that the compound that has been adjusted in quantity is pressed or printed according to the shape of the part being produced, after completing the printing process, parts that are not suitable will become waste because they cannot be used anymore, while suitable parts enter the finishing process. In this process, unwanted rubber residue from the pressing process is cut, then the part is checked to ensure compliance with company standards. The last process is packaging, in this process the shape and quantity are adjusted to the client's request.

B. Time Study

Observations of operating time were carried out as many as 20 trials on each operation, the operating time data can be seen in table 1.

Table I. TIME STUDY

Symbol	Average	Rating Factor	Normal Time	Allowance	Standard Time
O-1	142,996	1,12	160,15552	44	285,992
O-2	703,552	1,06	745,76512	44	1331,723429
O-3	625,512	1,05	656,7876	10	729,764
O-4	679,464	1,11	754,20504	47	1423,028377
O-5	28,7	1,05	30,135	49	59,08823529
O-6	804,77	1,03	828,9131	20	1036,141375
O-7	615,35	1,11	683,0385	25	910,718
O-8	11,364	1,11	12,61404	33	18,82692537
O-9	560,61	1,05	588,6405	30	840,915
O-10	49,97	1	49,97	28	69,40277778
O-11	4,214	1,04	4,38256	22	5,618666667
O-12	5,28	1,06	5,5968	28	7,773333333
O-13	54,88	1,01	55,4288	22	71,0625641
Total	**4286,662**	**13,8**	**4575,63258**	**402**	**6790,054683**

C. Cycle Time

Cycle time is the maximum time of operation in one workstation. Cycle time can be found by knowing the number of working hours available and the number of products that can be produced. In the production process part S Seal Packing has a working hour of 7 hours or equal to 25200 seconds per shift and can produce 2823 pcs parts per shift. the following is the calculation of cycle time in the part S Seal Packing production process.

$$Cycle\ time = \frac{\sum X_{in}}{N}$$

$$Cycle\ time = \frac{25200}{2823}$$

$$Cycle\ time = 8{,}92\ s$$

From these calculations the results of the calculation of cycle time produce a smaller value than the largest operating time, namely in the flaking process with a comparison with the cycle time is 8.92 <.1423.028 The results of this calculation cannot be decreased so that the cycle time is taken from the largest process time, namely 1423.028 seconds.

D. Initial Production Line

Before using the ranked position weight method to balance the line, it is necessary to know how the condition of the production process and the level of efficiency of the initial line in the company, which will be used to balance the line and comparison. The time used in the calculation of efficiency is the standard time that has been obtained previously through data collection and calculations that have been carried out.

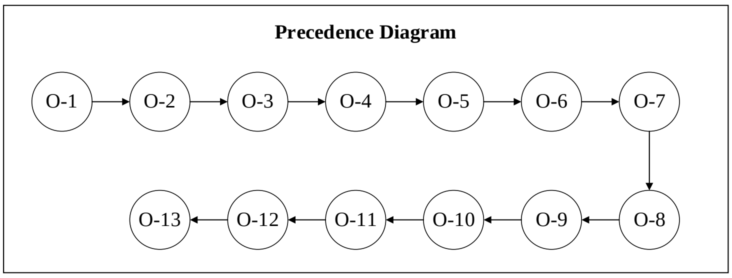

Fig. 3. Precedence Diagram

The production process of the initial line for making part S Seal Packing has 13 operations, where the process sequence cannot be changed because it has no branching process and is in accordance with the rubber processing procedure. The starting line is divided into 8 workstations.

Table II. WORKSTATION EFICIENCY

Workstation	*Operation*	Standard Time (s)	total workstation time	Cycle Time	efficiency (%)
1	O-1	285,992	285,992	1423,028	20%
2	O-2	1331,723	2061,487	1423,028	145%
	O-3	729,764			
3	O-4	1423,028	2518,257	1423,028	177%
	O-5	59,088			
	O-6	1036,141			
4	O-7	910,718	910,718	1423,028	64%
5	O-8	18,826	18,826	1423,028	1%
6	O-9	840,915	910,317	1423,028	64%
	O-10	69,403			
7	O-11	5,619	5,618	1423,028	0%
8	O-12	7,773	78,835	1423,028	6%
	O-13	71,062			

$$Idle\ Time = \left(CT \times \sum Work\ Station\right) - \sum Operatoin\ Time$$

$$Idle\ Time = (1423{,}028 \times 8) - 6790{,}054$$

$$Idle\ Time = 4594{,}172\ \text{Second}$$

Before looking for line efficiency, calculations are made to find idle time or waiting time for all workstations in the part S Seal Packing production process. From the above calculations, the waiting time for all workstations on the initial line is 4594.172335 seconds. After knowing the waiting time, then the line efficiency calculation is carried out by looking for line efficiency and balance delay in the initial line production process.

$$Line\ Efficiency = \frac{\sum Operation\ Time}{(\sum Work\ Station)(CT)} \times 100\%$$

$$Llne\ Efficiency = \frac{6790{,}054}{(8 \times 1423{,}028)} \times 100\%$$

$$Llne\ Efficiency = 59{,}64\%$$

$$Balance\ Delay = 100\% - Line\ Efficiency$$

$$Balance\ Delay = 100\% - 59{,}64\%$$

$$Balance\ Delay = 40{,}36\%$$

From the above calculations the level of efficiency on the initial line (Line Efficiency) is 59.65% and the percentage of waiting time is 40.35%. The initial line efficiency can be improved because each station still has low efficiency, so there are several production processes that can be made into one workstation and divide operations at workstations that have a process time exceeding cycle time, so that it will produce greater efficiency and waiting time for each station can be reduced.

E. Ranked Position Weight Method

The first step in balancing the line using the Ranked Position Weight method is to determine the weight of each operation to determine the order of the production process from the largest operation weight. The weight of the operation can be known by adding the weight of the operation to the weight of the next operations.

Table III. OPERATION WEIGHT

Operation	Weight
O-1	6790,054
O-2	6504,062
O-3	5172,339
O-4	4442,575
O-5	3019,546
O-6	2960,458
O-7	1924,317
O-8	1013,599
O-9	994,7723
O-10	153,8573
O-11	84,4545
O-12	78,835
O-13	71,062

The weight of each operation is used as a reference for preparing the new process sequence. In the production process of part S Seal Packing the sequence cannot be changed, because it must follow the rubber processing method coherently, so the precedence diagram of the new crossn using the Ranked Position Weight method is the same as the initial production line.

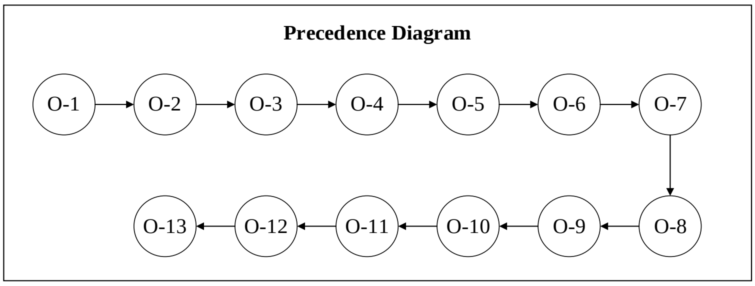

Fig. 4. Precedence Diagram

Line balancing using the Ranked Position Weight method plays a role in organizing workstations and operations within them to improve production line efficiency. In table IV below is the determination of the production line using the Ranked Position Weight method.

Table IV. STATION DRAFTING RPW METHOD

Workstation	Operation	Time (s)	remaining time (s)	task available (Weight)
				O-1
1	O-1	285,992	1137,036	O-2
2	O-2	1331,723	91,304	O-3
3	O-3	729,764	693,264	O-4

Workstation	Operation	Time (s)	remaining time (s)	task available (Weight)
4	O-4	1423,028	0	O-5
5	O-5	59,088	1363,940	O-6
	O-6	1036,141	327,798	O-7
6	O-7	910,718	512,310	O-8
	O-8	18,826	493,483	O-9
7	O-9	840,915	582,113	O-10
	O-10	69,402	512,710	O-11
	O-11	5,618	507,091	O-12
	O-12	7,773	499,318	O-13
	O-13	71,062	428,256	

$$Idle\ Time = \left(Cycle\ Time\ \times \sum Work\ Station\right) - \sum Operation\ Time$$

$$Idle\ Time = (6790{,}054 \times 7) - 1423{,}028$$

$$Idle\ Time = 3171{,}144\ \text{Second}$$

Before looking for line efficiency, calculations are made to find idle time or waiting time for all workstations in the part S Seal Packing production process. From the above calculations, the waiting time for all workstations on the production line with the Ranked Position Weight method is 3171.144 seconds. After knowing the waiting time, then the calculation of line efficiency is carried out by looking for line efficiency and balance delay in the new line production process.

$$Line\ Efficiency = \frac{\sum WOperation\ Time}{(\sum Work\ Station)(CT)} \times 100\%$$

$$Llne\ Efficiency = \frac{6790{,}054}{(7 \times 1423{,}028)} \times 100\%$$

$$Llne\ Efficiency = 68{,}17\%$$

$$Balance\ Delay = 100\% - Line\ Efficiency$$

$$Balance\ Delay = 100\% - 68{,}17\%$$

$$Balance\ Delay = 31{,}83\%$$

The production line of the ranked positional weight method is 68.17% and the balance delay is 31.83%. Thus, the efficiency of the production line has increased significantly compared to the efficiency of the production line in the initial condition.

IV. Conclusion

1. From the calculation of the efficiency of the production line at PT. BESQ Sarana Abadi, it is obtained that the efficiency level on the initial line (Line Efficiency) is 59.65% and the percentage of Balance Dellay is 40.35%.
2. The use of the Ranked Position Weight method can improve the efficiency of the production line, namely all performance indicators show that the production line using the Ranked Position Weight method has a better value, namely, it can reduce idle time or waiting time from 4594.172 seconds to 3171.144 and can increase line efficiency from 59.64% to 68.17%. It can be concluded that the use of the Ranked Position Weight method to balance the line has succeeded in improving line efficiency performance to be more efficient than the initial conditions.

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