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Production Track Balance Design To Minimize Bottleneck

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ABSTRACT

PT. Socfin Indonesia Kebun Tanah Belih is a company engaged in rubber processing with crumb rubber products. In the production process there is a bottleneck problem. Aims to get an improvement in the balance of the production line so as to increase production output. The right problem solving method is the Ranked Position Weight method, Theory of Constraints, and the Simulated Annealing Algorithm. RPW is used to calculate the actual production line performance. The results obtained indicate that there is an imbalance in the path, then an analysis of the causes of the problem is carried out using the TOC method. The results of the cause of problems at the work station and the reduction of the time of the work elements are obtained, so that the smoothing index value is obtained as a path balance parameter. The smoothing index value is then used as the initial solution in the Simulated Annealing Algorithm. The parameters of the Simulated Annealing Algorithm include cycle time, initial temperature of 1000C, 17 iterations, and steady state termination at N value of 3. The search for new solutions is carried out by iterating by combining work elements based on precedence diagrams and zoning constraints. The iteration stops when N is 3, meaning that the iteration has been rejected three times in a row. The best solution is obtained in iteration 10 with a value of 110.39. By using the Simulated Annealing Algorithm method, the efficiency value is increased by 9.36%, the balance delay value decreases by 9.36% and the smoothing index decreases by 94.18.

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1. INTRODUCTION

Production line balancing focuses on improving line efficiency, which aims to increase productivity. Path balancing uses a balancing approach to assigning work elements from the production line to the work station to minimize the number of work stations and minimize the total idle time at all stations for a certain level of output.

PT. Socfin Indonesia Kebun Tanah Besih is a company engaged in the processing of SIR 3CV and SIR 10 rubber with crumb rubber products. Rubber production results are used by foreign companies engaged in manufacturing to produce products that require crumb rubber as raw materials. The production process of PT. Socfin Indonesia Tanah Besih Plantation is continuous with U.S. material flow pattern. PT. Socfin Indonesia Kebun Tanah Besih has 10 work stations, work station I (sorting), work station II (chopping I), work station III (rinsing), work station IV (chopping II), work station V (chopping III), work stations VI (chopping IV), work station VII (box filling), work station VIII (cooking), work station IX (cooling), and work station X (packaging).

The company experienced problems in the production process, namely bottlenecks at work stations III, V, and VIII. The bottleneck is caused by the production capacity at work stations III, V, and VIII which is smaller than the company's production capacity. Production capacity can be seen in Table 1.

Table 1. Production capacity

Work Station	Work Station	Capacity (Kg/day)	Production (Kg/day)	Capacity	Differen ce
III	Flushing	11,000	15,120		-4.120
V	Chopping III	13,200	15,120		-1,920
VIII	cooking	14,300	15,120		-820

Machine capacity that is smaller than production capacity causes an imbalance of time at work stations in the production process. The time of work stations experiencing bottlenecks can be seen in table 2.

Table 2. Bottleneck Work Station Time

Work Station	Work Station	Available Time (Second)	Time Required (Second)	Difference
III	Flushing	62.857.14	71,280	-8,422.86
V	Chopping III	75,428.57	77,760	-2,331.43
VIII	cooking	81,714.29	86,400	-4,685.72

Based on Table 2. it can be seen that there are three work elements experiencing bottlenecks, namely at work station III (rinsing), work station V (chopping III), and work station VIII (cooking). From the calculation results, it can be seen that there is an imbalance problem because the time required is greater than the available time, meaning that the work station cannot produce according to the predetermined production target and as a result there is an accumulation of raw materials.

Research conducted by Much. Djunaidi and Angga in the Body Bus assembly process showed that there was a track balance problem in the production process. The researcher implements the Theory of Constraint (TOC) and can reduce the occurrence of bottlenecks, increasing the work efficiency of the production line.[2]Another research conducted by Moh. Husen using the Simulated Annealing method in static job shop scheduling to minimize makespan time. The results showed that the use of the Simulated Annealing heuristic method can be used to minimize the completion time.

To solve the bottleneck problem at work stations, the Theory of Constraints (TOC) method and Simulated Annealing Algorithm are used. TOC is a technique for solving a problem in a production line that focuses on improving system performance. TOC tries to identify the constraints in the system and exploits to improve the overall output of the system. The Simulated Annealing Algorithm is an algorithm used to find an approach to the optimum solution of a problem.

2. RESEARCH METHOD

Judging from the research method, the research is categorized as action research. Action research is a research conducted to obtain practical findings/for operational decision making purposes.

Because the aim is to make operational decisions in order to develop new skills or new approaches, this research is less likely to contribute to science.

The methods used in collecting data, namely:

a. Observation method to obtain time data of each station's work elements, rating factorand allowances.

b. Documentation method for obtain work element data, precedence diagrams, and zoning constraints.

c. Interview method to find out the obstacles that occur on the production floor.

3. RESULTS AND DISCUSSIONS

3.1 Analysis of Data Sufficiency Test

In this study, data collection was carried out 10 times on each work element using a stopwatch. The confidence level used in this study is 95% with a value of 1.96 and an accuracy level of 5% to determine whether the data is sufficient (can be represented as a sample). In work element 1, the result is the value of N > N' (10>9.96). Based on the calculation results, 31 work elements have a value of N > N', which means that all time data is sufficient.

3.2 Data Uniformity Test Analysis

The data uniformity test uses a 95% confidence level with a value of 1.96 and an accuracy level of 5%. Based on the results of calculations on work element 1, the average value is 29.10, with BKA 33.94 and BKB 24.26. It states thatall observational data fall within the range between BKA (Upper Control Limit) and BKB (Lower Control Limit) so that the data is said to be uniform to set standard time.

3.3 Zoning Constraint Analysis

Allocating work elements at work stations that hinder or require the grouping of certain work elements at certain stations. For work elements 1 to work elements 24 are wet process work elements and work elements 25 to 31 work elements are dry process work elements.

3.4 Actual Track Balance Analysis

The following is a precedence diagram of the actual path.

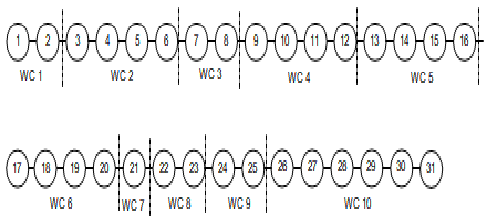

Figure 1. Actual Precedence Diagram

Bottlenek work stations occur at work station III, work station V, and work station VIII. The actual track has 10 work stations with a balance delay value of 22.95%, an efficiency value of 77.05%, and a smoothing index value of 204.57. The performance value obtained shows that there is an imbalance in the path. A perfect balance is characterized by an efficiency value close to 100%, a smoothing index and a balance delay value that is close to 0. These values indicate that it is necessary to balance the production line using Theory of Constraint and Simulated Annealing.

3.5 Analysis of Theory of Constraints

There were five obstacles that were found to cause bottleneck work stations using the Theory of Constraints method, namely:

a. Constraints of different raw material suppliers.
b. The maintenance schedule is not according to the SOP.
c. The operator does not deftly rinse the lumb.
d. Lumb caught in the blade.
e. Box related to the dryer.

The Theory of Constraints method is used to analyze the existing constraints. The constraints of different raw material suppliers at work station V cannot be avoided because they are beyond the control of the company. Constraints at station III are operators who are not nimble in rinsing the lumb resulting in the production process being hampered. Operation bottlenecks can be balanced by providing operator training. The problem at work station V is the lumb that often gets stuck in the blade on the extruder machine. This can be overcome by changing the type of blade that is more resistant to all types of raw materials. The obstacle at work station VIII is that the Standard Operation Procedure that has been set by the company has not received a good response. The Standard Operation Procedure (SOP) at the company stipulates that maintenance for dryer machines is carried out once a week, but in real conditions on the production floor it is not applied. This causes the box to often get stuck when it will be inserted into the dryer. Boxes that are related can be avoided by providing socialization or training to operators how to operate the dryer in accordance with the Standard Operating Procedure (SOP).

3.6 Analysis of Path Balance Improvement Using the Simulated Annealing Algorithm Method

The application of the proposed improvement is carried out using the simulated annealing algorithm method. There are 5 steps in this method. In the first step, determining the initial solution by determining the Smoothing Index value of 126.49 as the initial solution. Determine the control parameters, namely the initial temperature of 100oC, the reducing factor for the control temperature value (F) of 0.95, the number of iterations 17 times, and the iteration stop with a value of N=3. The second step is carried out to generate new solutions by doing iterations. The iteration is carried out 17 times by merging work elements into work stations according to zoning constraints. The third stage is the evaluation of a new solution, where each iteration is evaluated by comparing the value of the initial solution with the new solution. The fourth stage is the termination of the iteration which is carried out if the iteration has been carried out as many as the number of iterations specified in the control parameters. From the calculation results, it was found that iterations 13 to 17 were rejected successively so that iterations had to be stopped because they were already in a steady state. The fifth stage is the selection of the best solution, the criteria for the best solution are seen from the smoothing index value which is getting closer to 0. Iteration 10 was chosen as the best solution with a smoothing index value of 110.39. From the calculation results, it was found that iterations 13 to 17 were rejected successively so that iterations had to be stopped because they were already in a steady state. The fifth stage is the selection of the best solution, the criteria for the best solution are seen from the smoothing index value which is getting closer to 0. Iteration 10 was chosen as the best solution with a smoothing index value of 110.39. From the calculation results, it was found that iterations 13 to 17 were rejected successively so that iterations had to be stopped because they were already in a steady state. The fifth stage is the selection of the best solution, the criteria for the best solution are seen from the smoothing index value which is getting closer to 0. Iteration 10 was chosen as the best solution with a smoothing index value of 110.39.

The following is a precedence diagram of the selected production path in the 10th iteration which has the lowest smoothing index value, namely:

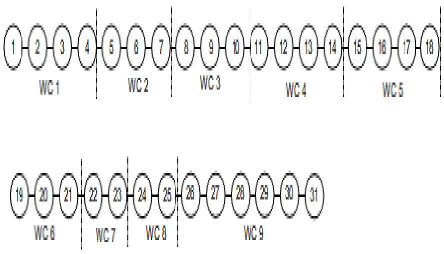

Figure 2. Precedence Diagram Repair

Improvements are made in accordance with the objectives to be achieved, namely reducing bottlenecks. Based on the results of improvements to the working time grouping with a cycle time of

200 seconds with a total of 9 work stations, balance delay of 13.59%, efficiency of 86.41% and smoothing index of 110.39.

3.4 Production Line Balancing Performance Parameter Analysis

In determining the best improvement between the actual condition and after the improvement design analysis can use performance parameters so that it can be applied to the company. The comparison of the parameters of the production line balancing results used is the smoothing index value.

4. CONCLUSION

The actual production line has 10 work stations with a balance delay value of 22.95%, an efficiency value of 77.05%, and a smoothing index value of 204.57. This situation indicates that there is an imbalance in the path. Work stations that experienced production line imbalance occurred at work station III, work station V, and work station VIII.

Constraints that cause bottleneck work stations using the Theory of Constraint (TOC), namely the constraints of different raw material suppliers at work station V cannot be avoided because they are outside the company's control. The obstacle at station III is the operator who is not nimble in rinsing the lumb. Operations that experience bottlenecks can be balanced by providing training to the operator. The problem at work station V is the lumb that often gets stuck in the blade on the extruder machine. This can be overcome by changing the type of blade that is more resistant to all types of raw materials. The problem at work station VIII is that the box is often involved when it will be inserted into the dryer.

Improvements to the production line balance using the Simulated Annealing Algorithm resulted in a working time grouping with a cycle time of 200 seconds with a total of 9 work stations, a balance delay of 13.59%, an efficiency of 86.41% and a smoothing index of 110.39. There are 5 steps in this method. The first step is to determine the initial solution in the form of a smoothing index value of 126.49. The second step is to iterate 17 times to get a new solution. The third step is to evaluate the new solution by comparing the value of S and the value of the probability of acceptance. The fourth step is determining the iteration stop (steady state). The fifth step is the selection of the best solution, the criteria for the best solution are seen from the smoothing index value which is getting closer to 0.

The track balance is categorized as good if the balance delay and smoothing index are close to 0 and the efficiency is close to 100%. In repairing the track using the Simulated Annealing Algorithm, the production line has increased the efficiency value by 9.36%, decreased the balance delay value by 9.36% and decreased the smoothing index value by 94.18. Then the production path is declared to be better than the actual production path.

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