JKIE (Journal Knowledge Industrial Engineering) Vol. 8, No. 3, December 2021, pp. 215-223

http://jurnal.yudharta.ac.id/v2/index.php/jkie

JKIE

Journal Knowledge Industrial Engineering

E-ISSN: 2541-4461 | P-ISSN: 2460-0113

Application Of Track Balance And Re-Layout Proposed Using Heuristic Methods And Activity Relationship Chart In The Integrating Process: A Case Study in PT.HAI

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Article Info

Article history

Received : November 17, 2021

Revised : November 28, 2021

Accepted : December 13, 2021

Published : December 26, 2021

Keywords:

ARC;

Efficient;

Line balance;

RPW

A B S T R A C T

PT HAI is an animal feeding ration manufacturing industry. The initial stage in the animal feed production process begins with the breeding process, but has a long cycle time due to uneven workloads at work stations, as well as the placement of work stations that are far apart causing idle time. Ranked Positional Weight is one of the line balancing methods by sorting the positional weights at each work station, to minimize balancing delay and work station. Activity Relationship Chart is a simple technique in planning the layout of facilities based on the degree of activity relationship. Calculations that have been done obtained the results: cycle time = 129 minutes, work station = 2, efficiency = 18%, balance delay = 3.6%, and smoothing index = 370 minutes. The results of the ARC method are changing the location of the finished product warehouse into a raw material warehouse which can eliminate 2 processes thereby reducing cycle time, so that the results of the heuristic method after re-layout are obtained: cycle time = 129 minutes, work station = 2, efficiency = 21% , balance delay = 3.1%, and smoothing index = 327 minutes

DOI: https://doi.org/10.35891/jkie.v8i3.2754

1. Introduction

Changes in work techniques, manufacturing processes, human resource capabilities are the impact of the application of industry 4.0 which has the basic principle of increasing efficiency at each work station in the manufacturing process (Fudianto & Munir, 2017) (Herdiani & Syafarudin, 2019). Steps in realizing increased efficiency at work stations by eliminating stages that do not provide added value, thus making the manufacturing process chain leaner and achieving high value added products with the best quality.

Quality is the level of feasibility of a product by the customer whether it meets or exceeds what is expected. A good manufacturing process will produce good output as well. Manufacturing companies that want to remain consistent with the quality of their products will increase efficiency at work stations in the production process (Syafa'at & Wahid, n.d.)(Arianty, 2015)(Arif & Abdul, 2019).

PT HAI is one of the animal feed ration manufacturing industries that produces chicken feed, fish feed and shrimp feed which in the production process begins with the process of mating. The mating process in animal feed production has a long cycle time caused by the uneven workload at the work station, causing a balance delay. Placement of work stations that are not close to each other also results in idle time because it takes time for the transportation process from one work station to another, so improvements are needed to minimize cycle time and layout changes to realize good cycle times and minimize idle time (Wahid & Chumaidi, 2015)(Alfriansyah et al., n.d.).

Balance delay and idle time in the process of inputting can be minimized by balancing the production line (line balancing) and rearranging the layout of the process flow of the process. Line balancing is a strategy to equalize the workload at each work station and reduce idle time and excess work capacity at other work stations (Dewi et al., 2020). The goal of implementing line balancing is to make high work trajectories efficient so that an even work trajectory is obtained. One of the track balance methods is the Ranked Positional weight method, which is to sort the positional weights to equalize the workload at each work station. Improvements to the layout of the inputting process flow can be completed using the ARC (Activity Relationship Chart) method. The ARC method is a simple technique in planning the proposed rearrangement at PT. HAI, especially at the work station for the process of inking. The following is the data on the processing time of the process at PT. HAI:

Tabel 1. Calculation results directly at PT. HAI

Node	Process Operation	Time (minute)
1	Weighing trucks entering the factory area	1,5
2	Truck enters the sampling area	0,7
3	First raw material sampling	4,5
4	Quality control	90
5	Raw materials move to the silo area	1,5
6	Raw materials move to the raw material warehouse	2,5
7	Unloading of raw materials in the raw material warehouse	29
8	Taking the second raw material sample at the raw material warehouse	14,5
9	Unloading raw materials in silos	3,5
10	Sampling of the second raw material in the silo	1,8
11	Processing	25,4
	Quantity (cycle time)	174,9

2. Literature Review

Line balancing is the distribution of a number of jobs at each work station that are interconnected in one production line. The work station has a time that is not more than the cycle time and the work station. The function of line balancing is to balance a path. The main objective of path balancing is to minimize idle time on the path determined by the operation with the longest cycle time.

ARC (Activity Relationship Chart) is a simple technique in planning the rearrangement of facilities or departments from one department to another based on the degree of activity relationship. Richard Muther in his book entitled "Systematic Layout Planning (Botom cahners books, 1973)" developed the basic rationale in an Activity Relationship Chart. Basically the Activity Relationship Chart is almost the same as from to chart, except that the Activity Relationship Chart has a more qualitative analysis process. In the Activity Relationship Chart the numbers of weight or volume and distance of displacement in the from to chart are replaced with letter codes that indicate the degree of relationship between activities qualitatively and numerical codes that indicate the reason for choosing the code.

The inspection process is the first step in the animal feed production process, where raw materials are distributed or stored in silos and separated from particles that are not needed in the next process to be made into finished products.

3. Methodology

The location of this research is carried out at Pt HAI which is located at the PIER industrial area Jl. Kraton Industri Raya No. 04, Kraton District, Pasuruan Regency, East Java 67151. The time of the research was carried out for approximately five weeks, to be precise, starting from November 02, 2020 to December 02, 2020, with the research diagram as follows:

Pengendalian kualitas produksi unit plate heat exchanger (phe) pada proses welding koneksi dengan pendekatan pdca untuk meningkatkan performansi cycle time.

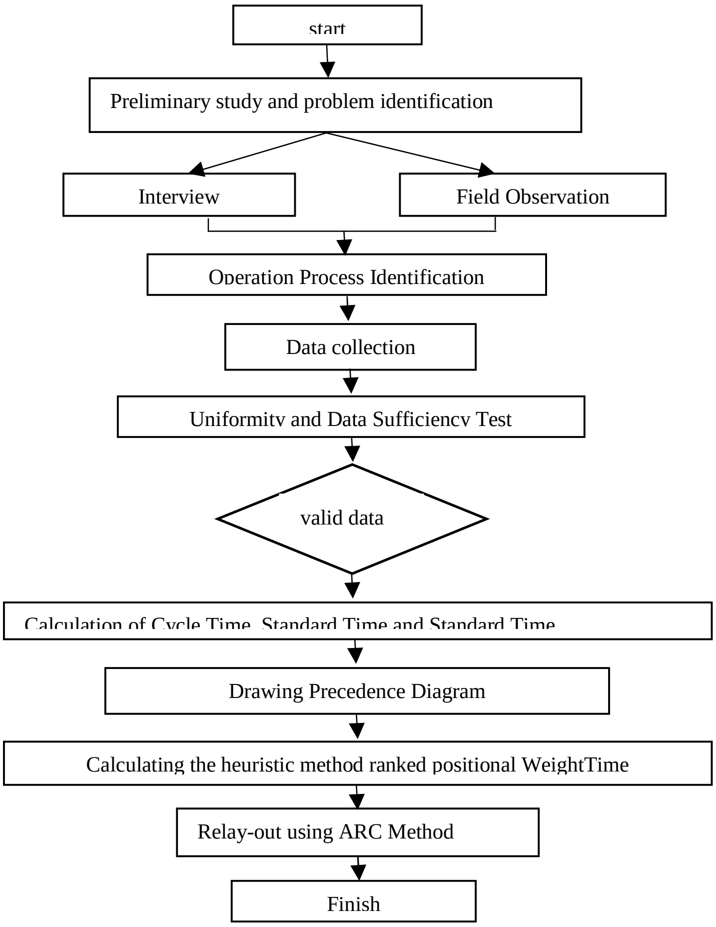

Figure 1. research flow chart

4. Results and Discussion

The data adequacy test in this study uses a 95% confidence level (k) = 2, and an accuracy level (s) = 5%, using the following formula:

$$N' = \left(\frac{2/0{,}05\sqrt{N\sum X^2 - \left(\sum X\right)^2}}{\sum x} \right)^2$$

Data is considered sufficient if N'< N, N = 10

Data uniformity test, data is considered uniform if the data does not exceed the upper and lower limits that have been determined by the following formula:

$$R' = \left(\frac{\sqrt{N\left(\sum X^2\right) - \left(\sum X\right)^2}}{N^2} \right) \quad \begin{matrix} BKA = \bar{X} + 2(R) \\ BKB = \bar{X} - 2(R) \end{matrix}$$

Based on the above formula, the results of the data adequacy and uniformity tests that have been carried out are as follows:

Table 2. Test for Sufficiency and Uniformity of Data

No	Work Operation	X'	Data Sufficiency Test			Data uniformity test		
			N	N'	Description	BKA	BKB	Description
1	Weighing trucks entering the factory area	90,9	10	1.18	enough	95,86	85,94	uniform
2	Truck enters weighing area	42,8	10	3,11	enough	46,58	39,02	Uniform
3	First raw material sampling	269,2	10	4,96	enough	299,18	239,22	Uniform
4	Quality Control				4,400			
5	Raw materials move to the silo area	92	10	0,87	enough	96,28	87,72	Uniform
6	Raw materials move to the raw material warehouse	152	10	0,32	enough	156,28	147,72	Uniform
7	Unloading of Raw Materials in the raw material warehouse	29	10	0,92	enough	30,4	27,6	Uniform
8	The second raw material sampling at the raw material warehouse				870			
9	Raw Material Unloading in Silo	208,1	10	0,23	enough	213,1	203,1	Uniform
10	Sampling of the second raw material in the silo				108			
11	Pressing Process	1.525,8	10	1,031	enough	1.530,08	1.521,52	uniform
Cycle Time		174,9	Minute					

Performance Rating

The results of measuring the performance rating at PT HAI using the Westing House System's Rating system obtained results of +0.08 so that P (Performance Rating) = (1 + 0.08) = 1.08 = 108%, meaning that the operator's speed when doing work is considered to be working above the normal limit or working.

Allowance

The calculation of the allowance that has been carried out at PT HAI, obtained a result of 24. Based on the above calculations, the cycle time, standard time and standard time for each work operation can be seen in the following table:

Table 3. cycle time, standard time and standard time

Work Operation	WS	WN	WB
1	1,5	1,62	2
2	0,7	0,756	1
3	4,5	4,86	6
4	90	97,2	128
5	1,5	1,62	2
6	2,5	2,7	4
7	29	31,32	41
8	14,5	15,66	21
9	3,5	3,78	5
10	1,8	1,944	3
11	25,4	27,432	36
Amount	174,9	188,9	249

Precedence Diagram

The next step is to determine the approximate amount of raw materials to be copied/year:

=(25 working days x 19.5 working hours x 60)/128=228 units

WS=(∑Available time)/(units to be produced)

=(25 working days x 19.5 working hours x 60 minutes)/(228 units)

=129 Minutes

P-ISSN: 2460-0113 I JKIE (Journal Knowledge Industrial Engineering) I E-ISSN: 2541-4461
DOI: https://doi.org/10.35891/jkie.v8i3.2754 I Vol. 8, No. 3, December 2021, pp. 215-223

The longest operating time is 128 minutes and the desired actual cycle time is 129 minutes, so the actual cycle time used is 129 minutes.

RPW (Ranked Positional Weight) Method

The first step in solving the problem is by using the position weight method, namely by using a precedence matrix based on the network and the amount of operating time and can be seen in the following table 4:

Table 4. precedence matrix based on network and operating time

Operating Time	Positional	Weight
1	2+1+6+128+2+41+21+4+5+3+36	249
2	1+6+128+2+41+21+7+5+3+36	247
3	6+128+2+41+21+7+5+3+36	246
4	128+2+41+21+4+5+3+36	240
5	2+41+21+36	112
6	4+5+3+36	47
7	41+21+36	98
8	21+36	57
9	5+3+36	44
10	3+36	39
11	36	36

The next stage is to sort the operating weights and calculate the number of work stations needed, the positions can be seen as follows:

Table 5. priority order and work station

Priority Order	Operation	Operation Time	Position Weight
1	1	2	249
2	2	1	247
3	3	6	246
4	4	128	240
5	5	2	112
6	7	4	47
7	8	41	98
8	6	21	57
9	9	5	44
10	10	3	39
11	11	36	36

Number of Workstations= (∑Available time)/(Cycle time)= 249/129=1.93=2 workstations. Next, grouping into work stations based on their respective groups and calculating efficiency is shown in the following table:

Table 6. grouping into work stations

<table>
<tr><th>Work Station</th><th>Work Operation</th><th>Operation Time</th><th>Efficiency</th></tr>
<tr><td rowspan="5">1</td><td>1</td><td>2</td><td>2%</td></tr>
<tr><td>3</td><td>6</td><td>5%</td></tr>
<tr><td>5</td><td>2</td><td>2%</td></tr>
<tr><td>6</td><td>4</td><td>3%</td></tr>
<tr><td>7</td><td>41</td><td>32%</td></tr>
</table>

	8	21	16%
	9	5	4%
	10	7	5%
	11	36	28%
2	2	1	1%
	4	128	100%
Total		249	198%
Average			18%

Based on the comparison between the initial layout and the proposed layout, there are changes in the weighing area, parking lot, prayer room, temporary storage, raw material warehouse, process building, finished product warehouse, spare parts warehouse, Intake machines, Intake in silos, long shifts in B3 waste disposal and shift in sampling area. The change in the raw material warehouse which was originally a finished product warehouse has a significant effect because it can cut transportation time, namely the process of moving raw materials to the warehouse and the process of moving raw materials to silos, thereby shortening the production cycle time, which will be explained as follows, Calculation of Cycle Time, Normal Time and Standard Time After Re-Layout.

Table 7. Calculation of Cycle Time, Normal Time and Standard Time

Work Operation	WS	WN	WB
1	1,5	1,62	2
2	0,7	0,756	1
3	4,5	4,86	6
4	90	97,2	128
5	29	31,32	41
6	14,5	15,66	21
7	3,5	3,78	5
8	1,8	1,944	3
9	25,4	27,432	36
Amount	170,9	184,572	243

Precedence Diagram after Re-Layout

The next step is to determine the approximate amount of raw materials to be copied/year:

=(25 working days x 19.5 working hours x 60)/128=228 units

WS=(∑Available time)/(units to be produced)

=((25 working days x 19.5 working hours x 60 minutes))/(228 units)=129 minutes

=129 Minutes

The longest operating time is 128 minutes and the desired actual cycle time is 129 minutes, so the actual cycle time used is 129 minutes.

Table 8. Position Weight Calculation After Re-layout

Operation Time	Positional Weight	Weight
1	2+1+6+128+41+21+5+3+36	243
2	1+6+128+41+21+5+3+36	241
3	6+128+41+21+5+3+36	240
4	128+41+21+5+3+36	234
5	41+21+36	98
6	21+36	57

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7	5+3+36	44
8	3+36	39
9	36	36

Table 9. Position Weight Calculation After Re-layout

Priority Order	**Operation**	**Operating time**	**Position Weight**
1	1	2	243
2	2	1	241
3	3	6	240
4	4	128	234
5	5	41	98
6	6	21	57
7	7	5	44
8	8	3	39
9	9	36	36

Number of Workstations
= (∑Available time)/(Cycle time) = 243/129
= 1.88 = 2 Work stations

Table 10. Efficiency Calculation After Re-layout

Work Station	**Work Operation**	**Operation Time**	**Efisiency**
1	1	2	2%
	3	6	5%
	5	41	32%
	6	21	16%
	7	5	4%
	8	3	2%
	9	36	28%
2	2	1	1%
	4	128	100%
Amount		249	190%
Average			21%

Balance Delay

$$D = \frac{n.C - \sum ti}{(n.ti)} \; x\, 100\%$$

$$D = \frac{(2)(129) - 243}{(2)(243)} \; x\ 100\% = 3{,}1\%$$

Smoothing Index Setelah *Re-layout*

$$SI = \sqrt{\sum_{i=1}^{k} (ST max \quad STi)^2}$$

$$SI = \sqrt{106.952} = 327\, menit$$

Table 11 . Comparison of Line Balancing before and after Re-Layout

Line Balancing	Before the Re-Layout	After the Re-Layout	Description
Track Efficiency	18%	21%	Up
Balance Delay	3,6%	3,1%	Down
Smoothing Index	370 Minute	327 Minute	Down

5. Conclusion

The track balance approach using the RPW method in the process of inputting results, namely: cycle time is 129 minutes, 2 work stations, track efficiency is 18%, balance delay is 3.6% and smoothing index is 370 minutes.

b. Proposed improvements to the company's lay-out, especially in the process of relocating weighing areas, parking lots, prayer rooms, temporary storage, raw material warehouses, process buildings, finished product warehouses, spare parts warehouses, intek machines, intek machines in silos, long shifts in B3 waste disposal. and shifting the sampling area. Changes that occur can reduce the cycle time of the processing process in which the processing time of moving raw materials in the raw material warehouse and the time so as to shorten the cycle time of the processing process.

c. Calculation of the RPW method on the process of re-layout after the re-layout, especially on the flow of the process of insertion, obtained the results: the cycle time is 129 minutes, 2 work stations, the efficiency of the track which was originally 18% increased to 21%, the balance delay decreased 3.1% from 3, 6% and the smoothing index fell by 327 minutes from 370 minutes.

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