Optimization of Assembly Process in the Production Line to Increase Productivity with the Line Balancing Method in the Indonesian Automotive sector

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Abstract

The development of the industry forces the performance of manufacturing companies to be managed according to high standards at all levels such as cost, quality, and speed. Strong performing companies will generate growth in various aspects of global competitiveness. which ultimately affects performance in development, investment, trust from shareholders, In Indonesia the manufacturing industry has a very important role in economic development and contributed to national income by 22% in 2016 (Bank Mandiri 2018) and is also the second-largest car manufacturing industry in Southeast Asia. The biggest challenge today is a company not only competing with competitors who are different but also with the same group in various countries and even making alliances to maintain competitiveness carried out by Hyundai - KIA, Renault-Nissan-Mitsubishi, etc, To gain the trust of top management so that they are given new model or technology, on their production systems around the world including manufacturers in Indonesia, this is done so that companies are competitive, one of which is in terms of optimizing the number of workers. The purpose of this research is to improve performance in terms of the production line at the assembly line at an automotive factory in Indonesia by using several actual data collection methods Line Balancing using the Yamazumi chart and calculation by Moodie Young The results of this research contribute to the literature in the automotive sector. but in various other sectors.

Keywords
Automotive Industry, Assembly Lines balancing, Moodie Young and Design Standard Time Ratio DSTR

1. Introduction
The development of the Automotive industry from time to time experiences developments that force the performance of manufacturing companies to be managed according to high standards at all levels – cost, quality, speed, flexibility, reliability, delivery (Florin 2019), to be able to generate higher profitability and profit than average competitors, lower cost structure, better productivity, high-quality products which are the heart of the company's performance (Porter 1985) and become one of the basic things that are of concern to many interests, including owners, employees, suppliers, investors to generate profits. goods or services that compete competitively in the global market (Brigham and Houston 2004), to gain customers earlier than their competitors (Reza et al. 2019).
The automotive industry in Indonesia continues to grow. The emergence of a new model, the differentiation of vehicle prices, and other vehicle brand make the automotive industry more competitive. (Furaida et al. 2018),and industry very important role in economic development contributing to national income and an attractive place for foreign investors to invest capital to be used as a production base (Ministry of Industry and Trade 2020), and the number of vehicles in Indonesia increases significantly from year to year (Irhami and Farizal 2021) based on data for 2021, the Indonesian car manufacturing industry regionally in Southeast Asia occupies the second position under Thailand which controls about 50% of car production in the region and ranks -20 in ASIA, as shown in Table 1.

Table 1. Total Production of Motor Vehicles in the World Period 2015 -2020

No	Region / Countries	Year (Unit)					
		2015	2016	2017	2018	2019	2020
	World	90,780,583	95,057,929	97,302,534	95,634,593	91,786,861	77,621,582
1	China	24,503,326	28,118,794	29,015,434	27,809,196	25,720,665	25,225,242
3	Japan	9,278,321	9,204,590	9,693,746	9,728,528	9,684,298	8,067,557
5	India	4,160,585	4,519,341	4,782,896	5,174,645	4,516,017	3,490,000
6	South Korea	4,555,957	4,228,509	4,134,913	4,028,834	3,950,617	3,506,774
11	Thailand	1,915,420	1,944,417	1,988,823	2,167,694	2,013,710	1,427,074
20	Indonesia	1,098,780	1,177,389	1,216,615	1,343,714	1,286,848	691,286
21	Malaysia	614671	513,445	460140	564800	571632	485186
31	Vietnam	50,000	236,161	236,161	237,000	250,000	NA

One way to maintain competitiveness in costs can be done by optimizing costs such as producing with a minimum of human resources which according to research provides 22% of the total production costs other than materials in motor vehicle assembly (Cole A 2020). DSTR (Design Standard time ratio) is one of the index parameters to show the ratio of added value in all operations and can be used to compare company productivity at the global level (Sawassalung & Chutima 2017). DSTR is an indicator in measuring resource efficiency by comparing the ratio of actual time versus design standard time,

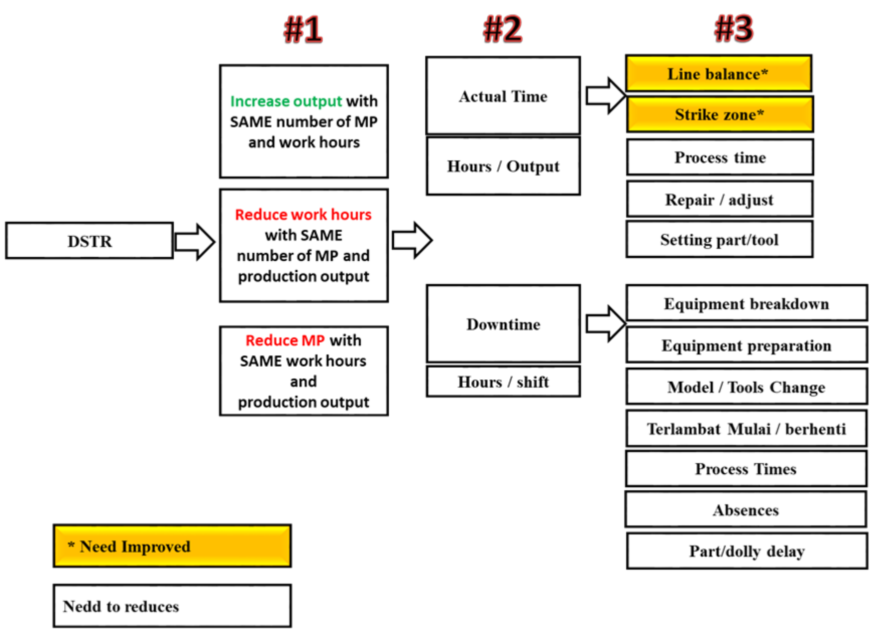


Figure 1. How to Increase DSTR Productivity

One way that can be done to increase efficiency is to balance lines by arranging work elements into work stations so that a good work time balance is obtained by reducing "waste" such as waiting times, process unbalances, repair time, because defects/production defects, unnecessary movement of people in the assembly process.

2. Literature

The history of the development of production lines in the automotive sector

Mass production was first developed in the 19th century, which was originally developed in the Ford car industry by Hendry Ford, but in the past, the production system itself consisted of several stages, divided into 3 periods. stages (Womark et al. 1997), (i). Craft Period (Craft Production), (ii) Mass Production Period (Mass production), and (iii) Lean Manufacturing.

2.1 Assembly Process on Production Lines in the Automotive Industry

Most products are processed by assembly or *assembly*. Products consist of several parts or components that are put together into a single unit called the *assembly*. Assembly lines are divided into two categories, namely manual and automated (Rachmawaty. 2018).

a. Manual Assembly Lines, is a production line consisting of a series of *workstations* where assembly tasks are carried out by human workers as shown in Figure 2.

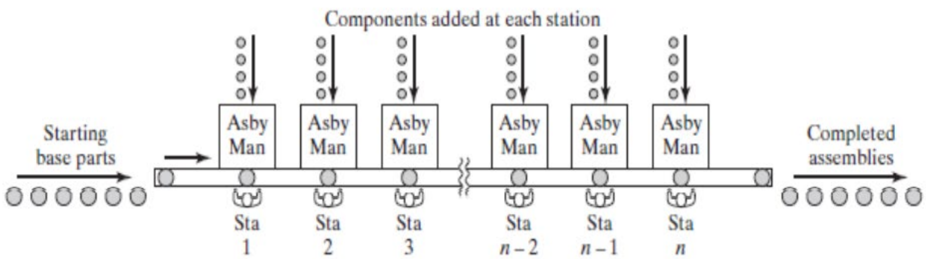


Figure 2. Assembly Line Manual (Source: Groover, 2014)

b. Automated Assembly Lines and the Automated Assembly Process, a series of assembly operations automatically combine several components into a single unit. Several types of *automated assembly systems* are depicted in Figure 3.

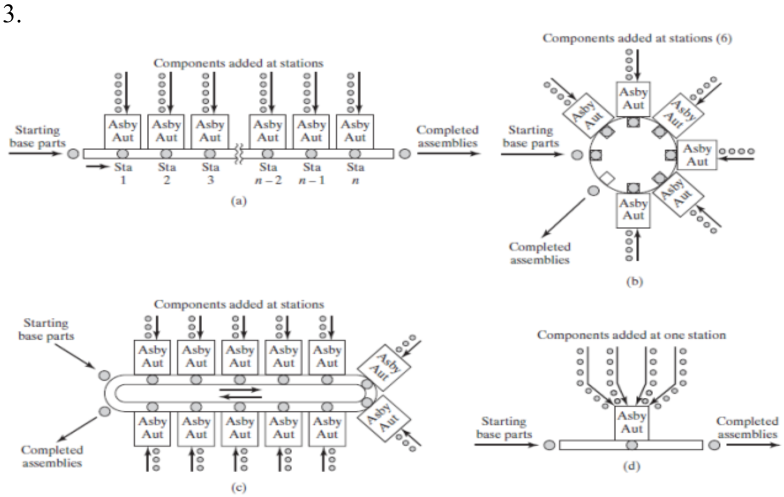


Figure 3. Automated Assembly Line (Source: Groover, 2014)

Type of Assembly Line The type of assembly line can be seen from the utilization side of the assembly line, it can be categorized into two types. Among them are (i) One-sided Assembly Line with the characteristic of using only one side of the line and is a form of simpler than *line balancing problem* (Rachmawaty 2018).and, (ii) Two-sided Assembly Line, wherein this model, each operator works on the opposite side of the same line, they perform the tasks assigned by each station with the same individual product. Tasks are performed according to a specific sequence of task operations and may have limitations on the direction of operation (Tuncel and Aydin. 2013) as shown in Figure 4 and figure 5.

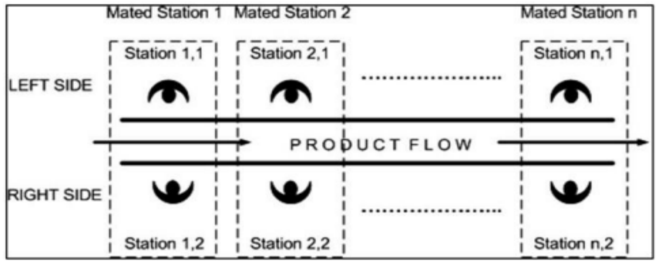


Figure 4. Two Side Assembly Line (Source: Tuncel & Aydin,2014)

In the Automotive Industry, the assembly of four-wheeled vehicles themselves will generally consider configurations in terms of manual or automatic depending on the process to be carried out, the following is a general description of the car manufacturing process in the automotive industry.

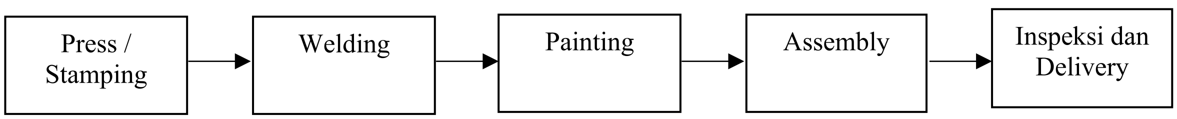


Figure 5. Illustration of the Car Assembly Process (Source: Sawassalung & Chutima 2017)

2.3 Waste in Production Systems

Systematically, *lean* is the reduction or elimination of *waste*. *Waste* can be interpreted as waste or is also referred to as activities that do not add value to the *output of* a company or organization. Shigeo Shingo identifies eight types of *waste* (*eight wastes*) (Hines and Taylor 2000) in (Leksic et al. 2020) consists of Overproduction, Over Processing. Waiting / Idle Time. Unnecessary Motion, Unnecessary Inventory. defect, transportation, and Non-utilized talent (Man Power).

2.4. Problems in the Automotive Industry in Indonesia

The automotive industry is one of the mainstay sectors that has a significant contribution to the national economy and this sector has contributed an investment value. 99.16 trillion IDR with a total production capacity of 2.35 million units per year and absorbs direct labor. as many as 38.39 thousand people. There are 22 units of four-wheeled or more motorized vehicle industrial companies in Indonesia and this will increase to 26 units of companies with a total investment value of 10.05 trillion IDR with a production capacity of 9.53 million units per year and absorbs a workforce of up to 32 thousand people. And have a far-reaching impact on the more than 1.5 million people who work along the industry value chain. In 2019, However, the national automotive industry is still facing various kinds of big challenges (Kemenperin,2019), one of which is

1. The capabilities of existing human resources in the entire supply chain of international standard products as well as being globally competitive.

2.5. Overcoming the Challenges of the Automotive Industry

It takes many parties to face the challenges of the national automotive industry in the global arena. In addition, the government is obliged to ensure that the manufacturing business climate and environment are conducive, developing infrastructure that supports smooth logistics mobility as well as the export-import process of goods. Developing the domestic process raw material industry for the automotive industry by facilitating investment (Gaikindo 2020).

2.6. Line Balancing

Line balancing is an analysis that calculates the balance of a series of machines and tools useful in making a product. The assembly line is divided into several workstations which are usually carried out by people and several operators and may be carried out using various types of tools (Gupta & Starr 2014). The main purpose of *line balancing* is to obtain a smooth production flow to obtain high utility. (Slack et al. 2010). thus causing inefficiency of work on work elements (Sitorus et al. 2020). As shown in Figure 6 there is an inequality in working time at each station,

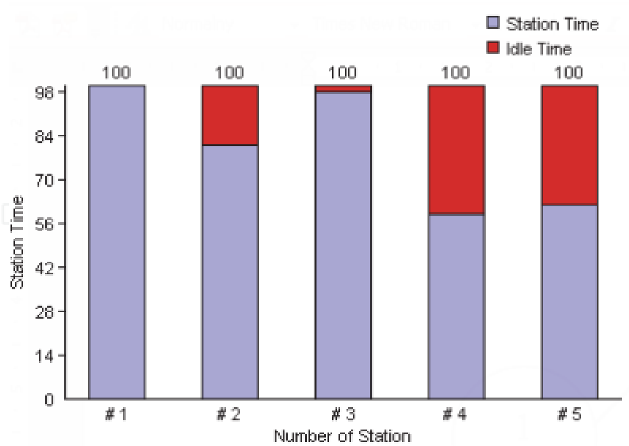


Figure 6. Phenomena in Line Balancing (Grzechca,2011)

Line balancing can be interpreted as *Assembly Line Balancing Problem* ALBP (Rachmawaty 2018): several previous studies on *assembly line balancing* with a *two-sided assembly line* (Tuncel & Aydin 2014) would be more suitable to use Yamazumi because the process of assembling four-wheeled vehicles in parallel. Work Station Efficiency (LE) is the ratio of operating time (c) to the largest workstation operating time (Ws). Workstation efficiency is also achieved by determining the division of tasks at each workstation based on a list of work elements and the amount of *cycle time* and improving the division of tasks (Grzechca 2011).

$$\text{LE} = \frac{\sum_{i=1}^{K} STi}{c-K} \,.\, 100\ \% \quad \text{or} \quad LE_{STi} = \frac{ST1}{c}.100\%$$

Dimana
K – Total number statiun
c - Cycle time
STmax - maximum station time ,

3. Methodology

The methodology in this study uses field data quantitatively, some of the data also refers to secondary data issued by recognized related agencies. The Data is taken using randomize after which the results are averaged, a yamazumi chart is made, in this line balancing method using Moodie young with the object of research in the four-wheeled automotive industry in Indonesia with the basic reason of previous research focusing more on the garment industry in several countries

4. Data Collection

The actual cycle time is taken by using one of three principles, namely the randomize method by taking data randomly 2 times and then averaging it, this aims to make the data taken to be valid (Montgomery 2013) following table 2 The product that will be assembled on the assembly line is a four-wheeled vehicle that has several large sub-assy components consisting of several parts so that it becomes a whole product unit by Operation Chart Diagram of the vehicle assembly process on the assembly line, Figure 7-8 and table 3 is Actual Time each WorkCenter.

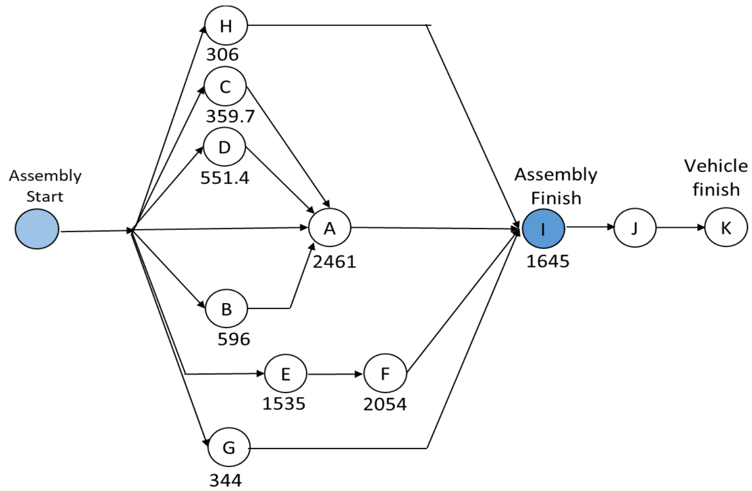


Figure 7. Operation Chart Diagram of the vehicle assembly process on the assembly line

Table 3. Actual Time each Work Center

Code	Work Center	No of Station	Cycle Time (s)	Line Effesiensi (LE)
A	Trim Line	54	2461	94.96%
B	Dashboard	9	589.36	68.21%
C	Supply Parts RH Trim	5	359.76	74.95%
D	Supply Parts LH Trim	9	551.40	63.82%
E	Engine Line	18	1535.44	88.86%
F	Chassis Line	26	2054.31	82.32%
G	Supply Parts RH Final	4	344.58	89.73%
H	Supply Parts LH Final	5	306.15	63.78%
I	Final	46	1645.58	95.99%

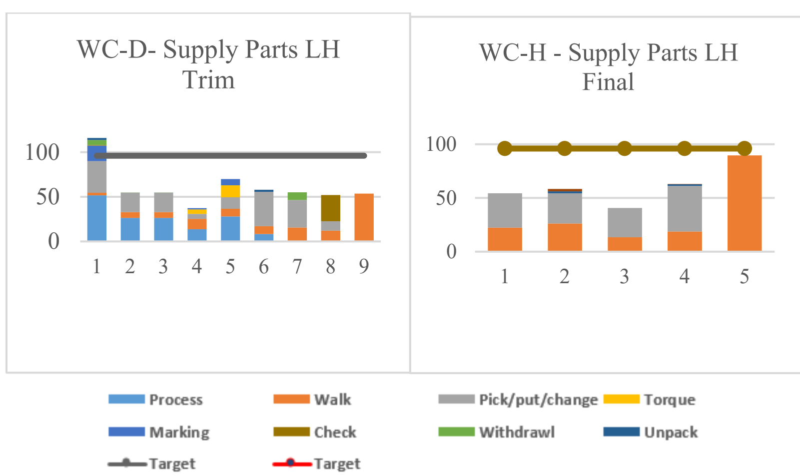


Figure 8. Yamazumi Chart Process WC D-H

5. Result and Discussion

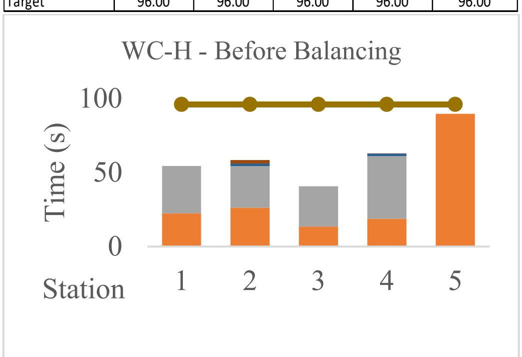
From the results of the existing data, line balancing is carried out by moving work to the previous and subsequent stations, when viewed from the tables 4-6 it is found that 1 station can be removed from 3 stations in 2 work centers and increase LE to 78.6% in WC-H and 86.4% in WC-H WC-B.

Table 4. WorkCenter after Balancing

Code	Work Center	No of Station	Cycle Time (s)	Line Effesiensi (LE)
A	Trim Line	54	2461	94.96%
B	Dashboard	7	589.36	86.4%
C	Supply Parts RH Trim	5	359.76	74.95%
D	Supply Parts LH Trim	9	551.40	63.82%
E	Engine Line	18	1535.44	88.86%
F	Chassis Line	26	2054.31	82.32%
G	Supply Parts RH Final	4	344.58	89.73%
H	Supply Parts LH Final	4	306.15	78.6%
I	Final	46	1645.58	95.99%

Work Element	1	2	3	4	5
Process	0.00	0.00	0.00	0.00	0.00
Walk	22.42	26.21	13.47	18.82	89.68
Pick/put/change	31.98	28.09	27.22	42.37	0.00
Torque	0.00	0.00	0.00	0.00	0.00
Marking	0.00	0.00	0.00	0.00	0.00
Check	0.00	0.00	0.00	0.00	0.00
withdrawl	0.00	1.81	0.00	1.57	0.00
Unpack	0.00	2.30	0.00	0.22	0.00
TOTAL	54.40	58.41	40.69	62.98	89.68
Target	96.00	96.00	96.00	96.00	96.00

Work Element	1	2	3	4	5
Process	0.00	0.00	0.00	0.00	0.00
Walk	22.42	30.12	0.00	18.82	89.68
Pick/put/change	31.98	39.21	0.00	58.47	0.00
Torque	0.00	0.00	0.00	0.00	0.00
Marking	0.00	0.00	0.00	0.00	0.00
Check	0.00	0.00	0.00	0.00	0.00
withdrawl	0.00	1.81	0.00	1.57	0.00
Unpack	0.00	0.00	0.00	0.00	0.00
TOTAL	54.40	71.14	0.00	78.86	89.68
Target	96.00	96.00	0.00	96.00	96.00



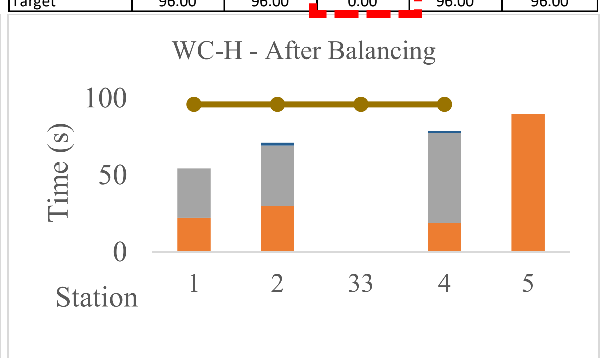
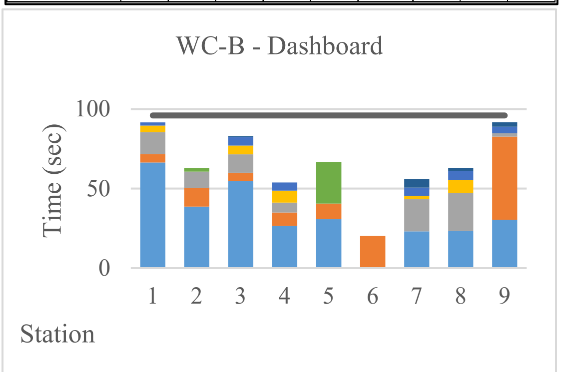


Table 5. Workelement before and balancing

Workelement	1	2	3	4	5	6	7	8	9
Process	66	39	55	27	31	0	23	23	30
Walk	5	12	5	8	10	20	0	0	52
Pick/put/change	14	10	12	6	0	0	20	24	2
Torque	4	0	5	8	0	0	2	8	0
Marking	2	0	5	5	0	0	5	6	4
Check	0	2	0	0	26	0	0	0	0
withdrawl	0	0	1	0	0	0	1	0	1
Unpack	0	0	0	0	0	0	6	2	2
TOTAL	92	63	83	54	67	20	57	63	92
Target	96	96	96	96	96	96	96	96	96

Workelement	1	2	3	4	5	6	7	8	9
Process	66	60	0	59	32	0	23	23	30
Walk	5	12	0	1	17	0	20	0	52
Pick/put/change	14	14	0	11	3	0	20	24	2
Torque	4	0	0	8	5	0	2	8	0
Marking	2	0	0	5	5	0	5	6	4
Check	0	2	0	0	26	0	0	0	0
withdrawl	0	1	0	0	0	0	1	0	1
Unpack	0	0	0	0	0	0	5	0	0
TOTAL	92	88	0	86	88	0	76	61	90
Target	96	96	96	96	96	96	96	96	96



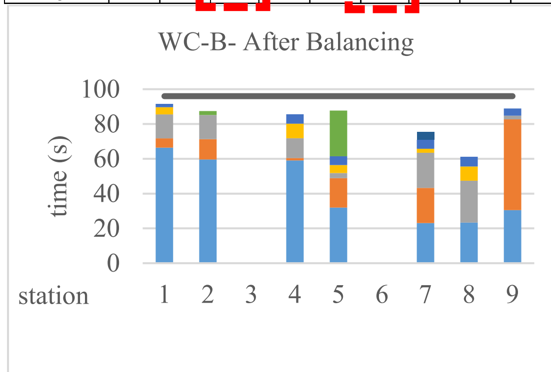


Table 6. Workelement before and after Balance balancing

6. Conclusion

The Line Balancing Method with Moodie Young Calculations can reduce 3 stations from a total of two Workcenters, so it can be said that LE has increased to 78% and 86%, but this paper has several limitations, especially in terms of data, it would be better if in the future using process data not only in the assembly shop but in the previous processes such as stamping, welding, and painting, it is hoped that in the future research with a larger scope will be carried out so that measurements can be more accurate and complete

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Biography

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