

Reducing waste in the convection industry by lean six sigma and DMAIC implementation approach

Muhammad Faishal ^{1*}, Ratih Dewita Krisna ², and Khoirunnisa Maharani ³

¹Department of Industrial Engineering, Universitas Ahmad Dahlan, Yogyakarta, Daerah Istimewa Yogyakarta, Indonesia

Abstract. Convection industries are always required to improve quality. The ABC convection industry faces several problems in the production process, such as waste product defects of up to 10%, waste over-processing, and transportation waste. This research aims to reduce the occurrence of waste in The ABC production process. The method used in this research is Lean Six Sigma and the DMAIC approach (define, measure, analyze, improve, and control), which have been proven to reduce waste. In the DMAIC stages, the fishbone diagram is used in the analysis stage to find the root of the problem, while the 5W+1H method is used in the improvement stage to provide recommendations for improvement. The improvements implemented include re-layout the sewing workstation, installing a partition on the sewing table, and adding tools such as material measuring stickers and grouping patterns based on models at the patterning and cutting workstations. The workstation space was moved to the same building to eliminate transportation waste. After the improvement, the sigma level calculation results showed an increase of 10%, from a sigma level of 3.5 to 3.9 sigma.

1 Introduction

The circular economy plays a crucial role in attaining the Sustainable Development Goals (SDGs), particularly in promoting responsible consumption and production (SDG 12). Among the various strategies employed is the reduction of waste in the production process [1]. Reducing waste in an industry will not only improve the economy (SDG 12) but will also improve sustainable communities (SDG 11) [2]. The garment industry is one of the industries that satisfies people's needs regarding clothing needs and continues to experience development. However, increasingly, there has been an increase in imported garment products from various other countries and this has caused many domestic garment industries to decide to go out of business [3]. The development of the business world has brought business people into very tight competition. Business actors must be able to survive in retaining and winning consumers, as well as being able to offer various advantages for the

* Corresponding author: muhammad.faishal@ie.uad.ac.id

products being marketed [4]. A production process that pays attention to quality will produce products that are free from damage. This can avoid waste and inefficiency so that production costs per unit can be reduced and product prices can become more competitive. Quality improvements to the production process must be carried out continuously to minimize product defects [5]. Therefore, there is a need for quality control, so that the products produced are always in standard condition [6].

The ABC convection industry is a home industry in the city of Purwakarta which operates in the convection sector. The products produced by this convection are various products such as Babydoll dresses, Mia Tunik, Dania Blouse, Curve Babydoll and Fuji pants. Based on observations conducted, The ABC convection industry production activities are not free from waste. The large number of defective products that exist at several stages of production activities, such as at work stations for patterning and cutting, sewing and attaching buttons to clothes. One of the production errors in The ABC convection industry is an error during cutting so that one roll of material cannot be used. This means the company requires additional production costs to replace materials with new ones so that it can produce according to customer demand. This research aims to find out how to reduce defective products, eliminate layout inefficiencies, reduce overprocessing waste that occurs due to defective products, propose improvements and implement proposed improvements.

The product that will be used as a research object is Mia Tunik. This product was chosen because it is the most widely produced with an average production of 3,072 pieces/month. These products will be sold in available offline stores and using the ecommerce platform, namely Shopee. In this research, it is carried out with the Lean Six sigma theory which is one of the alternatives in the principles of quality control [7] and is a breakthrough in the field of quality management using the DMAIC stage [8,9].

2 Material and Methods

This research uses the DMAIC (Define, Measure, Analyze, Improve, and Control) method as problem solving to reduce waste on the convection production floor in order to increase the Sigma value. The Define stage, is to identify waste in the Mia Tunic production process by making Value Stream Mapping and identifying the types of defects produced in the production process, as well as making SIPOC diagrams. In the second stage or measure, will measure or process the data that has been obtained by calculating with the applicable formulas and provisions. After knowing what waste occurs, the number of defective products and the amount of production in one period, then make Value Stream Mapping and calculate the sigma level value of the defect [7].

In the third stage or analyze, an analysis is carried out on what causes waste by using a fishbone diagram. By brainstorming with the convection to analyze the causal factors, so that it will get a way out to reduce existing problems. Then pour into the fishbone diagram so that it can find and analyze the factors that cause problems in the convection. After knowing the root cause of the problem seen from the fishbone diagram, then enter the fourth stage, namely improve. At this stage, suggestions will be given regarding improvements regarding the problems that exist in the convection using the 5W + 1H method. At this stage, all proposed improvements will also be implemented at The ABC convection industry.

3 Results and Discussion

3.1 Define

The purpose of define is to identify the process to be improved [10]. At this stage, it can be identified that there are several wastes in the production stage of Mia Tunic at The ABC

convection industry. The waste in question is an ineffective layout, transportation waste from the iron work station to the packaging work station which is 20 meters away, overprocessing waste due to less careful sewing and the presence of defective products in the production as shown in Table 1.

Table 1. Number of waste defect & overprocessing in 3 month

Month Period	Total Production (Unit)	Product Overprocessing (unit)	Total Defect (unit)	Percentage %
1	3534	242	321	9%
2	3798	328	371	10%
3	2235	198	266	12%

In the define stage, a SIPOC diagram is also made to find out and identify each point regarding suppliers, inputs, processes, outputs, and customers involved in a production process as show in Figure 5 in Supplementary [11].

3.2 Measure

The purpose of measuring is to conduct and develop a data collection plan that can be carried out at the process and/or output level [12]. At this stage, measuring work time, testing the homogeneity data and testing the sufficientcy data obtained from taking data on the cycle time of the Mia Tunic production process. The data homogeneity test is carried out to determine whether the measured data is similar and comes from the same system. [13] as show in Table 2.

Table 2. Homogenity and sufficient Test

	Cutting (sec)	Sewing (sec)	Finishing (sec)	Iron (sec)	Packaging (sec)
Total	1170	28033	1495	3580	756
Average	45	1078	58	138	29
UCL	45.00	1133.31	64.66	144.36	35.19
LCL	45.00	1023.07	50.34	131.02	22.96
	Homogen	Homogen	Homogen	Homogen	Homogen
$\sum X$	1170	28033	1495	3580	756
$\sum X^2$	52650	30233405	86105	493062	22086
$(\sum X)^2$	1368900	785849089	2235025	12816400	571536
N'	0	0.6684198	1.6285943	0.63323474	2.749287
N	26	26	26	26	26
	Sufficient	sufficient	sufficient	sufficient	sufficient

The results of the test show that the data is uniform and sufficient so that it can be used as data for making Value Stream Mapping [14]. The purpose of Value Stream Mapping is to identify all types of waste in all production processes so that improvements can be made in an effort to reduce waste [15]. The following is current stage of the Value Stream Mapping of Mia Tunic product as shown in Figure 1.

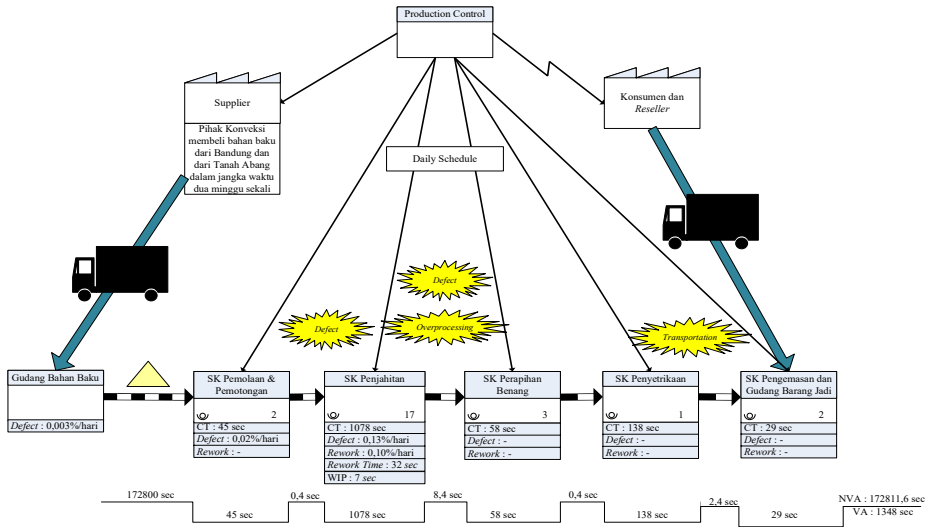


Fig. 1. Current Value Stream Mapping

At this stage, the calculation of defects per million opportunities (DPMO) and determining the sigma level is also carried out [16]. DPMO is a unit that shows the chance of defects for every one million events [17]. DPMO is one of the process capability assessments to measure how good a production process as show in Table 3

Table 3 DPMO Calculation before improvement

Steps	Action	Before
1	Number of product	9567
2	Number of defect product	955
3	Failure level = step (2)/ step (1)	0.0998
4	Number of CTQ	4
5	Probability of failure rate = step(3)/step(4)	0.02495
6	DPMO = step (5) * 1.000.000	24955.57
7	DPMO to sigma level	3.46 = 3.5

3.3 Analyze

This step is to analyze the cause-and-effect relationship of various factors that exist and are studied to find out the dominant factors that need to be controlled [18]. At this stage aims to analyze the waste that occurs during the production process of Mia Tunik products by using tools in the form of causal diagrams (fishbone) to find out and group the causes based on certain problems [19] so that the causes of problems that occur in The ABC convection industry can be known. based on brainstorming between owners and workers in convection. In the case of The ABC convection industry, there are several wastes, namely waste of over processing, transportation and waste of defective products. Defective products here are products that have unsewn parts, loose threads, cutting errors, and dirty materials. As show in Figure 6 and 7 in supplementary

3.4 Improve

3.4.1 Improvement Action Plan

Improve stage, a corrective action plan is made using the 5W + 1H method to find out the problems that occur in detail as an improvement stage that supports the production process [20]. In achieving these goals, an improvement plan and target are made using the 5W + 1H concept (What, Why, Where, When, Who, How) [21]. At this stage, Brainstorming discussions were held with the head of the convection and staff, so that the results of the improvement action plan were obtained as shown in table 4.

Table 4. Improvement Action Plan by 5W+1H

No	Root cause	What (Action)	Why	How	Where	When	Who			
1.	Inefficiency in the sewing workstation layout	Relayout the sewing workstation	Inefficiency causing product throwing	1. improving the new layout at the sewing station with the ARC method	Sewing station	M1	Student			
				2. Implementation the new layout		M3-M6		Student, staff		
2.	There are many product defects, rework, errors in pattern cutting	Create SOPs in each production process	No work standart	1. <i>Brainstorming</i> with Head and staff to create SOP	Office	M2	Student, head and staff			
				2. Conduct SOP socialization to employees		All station		M3	Head of staff	
				3. Implementation of SOPs in each production process		All Station		M3-M6	All	
3.	Material stuck to the bottom of the sewing machine	Sealing the bottom of the sewing table	The baffle will prevent the material being processed from entering under the table.	1. The process of measuring the table and purchasing plywood	Sewing Staiun	M2	Student			
				2. Cutting the plywood according to the table size				Cutting area	M2	Student
				3. The process of installing the bulkhead on the table				Sewing statiun	M2	Student
				4. Bulkhead marker on the workbench	Sewing statiun	M2-M6	Sewing staff			

No	Root cause	What (Action)	Why	How	Where	When	Who
4	Inefficient patterning and cutting process	Installing material measuring stickers and grouping product model patterns	Simplify the work of SK patterning and cutting employees with floor gauges and product pattern grouping.	1. Designing measurement stickers for the floor in the patterning and cutting decree.	Cutting area	M2	Student
				2. Make product pattern group name tags	Cutting area	M2	Student
				3. Printing stickers and name tags	Cutting area	M2-3	Student
				4. Applying tools	Cutting area	M3-M6	All

3.4.2 Layout Planning using Activity Relationship Chart (ARC)

At this stage, a new layout of the convection is also made and proposed to the convection. ARC is a map that is organized to determine the level of importance between objects and shows some objects that must be brought closer to other object activities [9,22]. The benefit of ARC is to find out which work process flows are closely related so they need to be brought closer [23]. Based on the results of data processing with the ARC method, a proposed layout of sewing machines at the sewing workstation at the new The ABC convection industry can be obtained. In this new layout, there is a transfer of space for the finished goods warehouse so that there is no transportation waste from the ironing workstation to the finished goods warehouse. But this has not been implemented because there is no approval from the owner of the convection. The proposed new layout is shown in Figure 9 in supplementary.

3.4.3 Improvement Implementation

Improvement is applied to the problems experienced by The ABC convection industry. This application is based on the results of brainstorming and interviews with convection parties using the 5W + 1H method (What, Why, Where, When, Who, How) so that there is an application of proposed improvements for twenty days. Some of the proposed improvements applied to The ABC convection industry such as the application of table dividers at the sewing station, the installation of name tags and pattern stickers at the cutting station, the application of new work standards to all workers. Figure realization of improvement implementation as shown in Figures 10, 11, and 12 in supplementary.

3.5 Control

At this stage, verification is carried out whether improvements have been made properly and will improve the process and control so that improvements are made continuously to approach the best Six Sigma level. At this stage, Value Stream Mapping is made, the calculation of the percentage of defective products and the calculation of the sigma level after the improvement. So that it can be seen whether there is a change for the better after the implementation of the proposed improvements at The ABC convection industry.

Value Stream Mapping after improvement is for comparison with the process before improvement. Value-added time is reduced due to a reduction in time in the production process at the patterning and cutting work stations. After the improvement, there is an

installation of tools in the form of fabric measuring stickers so that operators can more easily and more quickly measure the length of the fabric used for processing. Then there is a grouping of patterns so that operators find it easier to find the pattern to be used. Value Stream Mapping future state as show in Figure 2.

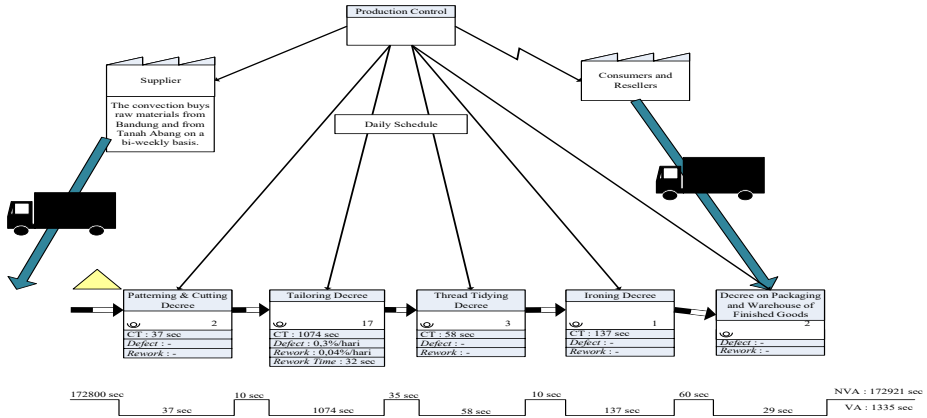


Fig. 2. Value Stream Mapping Future State

After the improvement, the author took defect product data with a total of 8 production days during the two months with a total of 509 Mia Tunic products produced. In that period, there were 14 unsewn defect products, 2 loose threads, no errors in cutting, and finally 3 dirty materials. The total product defects of Mia Tunic products produced in that period were 19 pieces. Table 5 shows the number of defective products after improvement at The ABC convection industry.

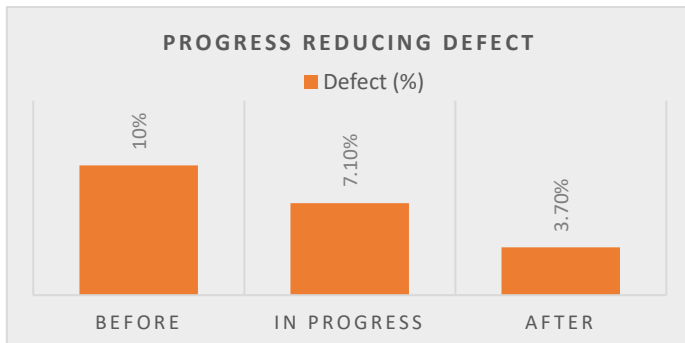


Fig. 3. Comparison Chart of Defect Percentage

At this stage, defects per million opportunities (DPMO) are also measured and sigma levels are determined. This is done to determine the change in value whether the production process is better than before improvement. Table 5 DPMO and sigma level calculations before and after

In the calculation of the sigma level during and after improvement, it has increased from the sigma level before improvement. Before the improvement, the sigma level was at 3.3 while during the improvement period it was at 3.5 and in the period after the improvement it was at 3.7. However, this figure is still far from the 6 sigma value, so continuous improvement is still needed until it approaches the 6 sigma value.

Table 5. Comparison DPMO level

Steps	Action	Before	After
1	Number of product	9567	509
2	Number of defect product	955	19
3	Failure level = step (2)/ step (1)	0.0998	0.037
4	Number of CTQ	4	4
5	Probability of failure rate = step(3)/step(4)	0.02495	0.0093
6	DPMO = step (5) * 1.000.000	24955.57	9332.03
7	DPMO to <i>sigma level</i>	3.46 = 3.5	3.85 = 3.9

In connection with the improvements that have been made and the increase in Sigma value, a standardization is made which aims to prevent waste as before and prevent a decrease in the sigma value from the level that has been achieved after improvement. this is in line with the concept of green management which is in line with SDG 12[24]. In the ABC convection industry, there is no SOP that standardizes the process at each stage of production. Therefore, SOP standardization is made at each workstation in the ABC convection industry so that there are standards and similarities in the production performance of each worker. The sewing stage and the patterning and cutting stage are the stages that have many cases of defective products.

4 Conclusion

The ineffectiveness of the sewing workstation layout at The ABC convection industry carried out a relay layout to eliminate the ineffectiveness. The relay layout process is carried out using the ARC (Activity Relationship Chart) method so that there is no collision and throwing of goods in the sewing process. The existence of transportation waste from the ironing work station to the packaging workstation, it is proposed to move the workstation space and transfer the function of the rest room, which is not too used. In the problem of defective products, several improvements were made, including the creation of SOPs (Production Operational Standards) at each work station, the installation of partitions on the sewing table, and installation of tools at the patterning and cutting work stations in the form of sticking material measuring stickers on the floor and grouping material patterns. After the improvement, there is a decrease in the percentage of defective products from 10% to 3.7% and the sigma value has increased from 3.5 to 3.9

References

1. M. Geissdoerfer, P. Savaget, N. M. P. Bocken, and E. J. Hultink, The Circular Economy – A new sustainability paradigm?, *J. Clean. Prod.* **143**, 757 (2017). <https://doi.org/10.1016/j.jclepro.2016.12.048>
2. J. Kirchherr, D. Reike, and M. Hekkert, Conceptualizing the circular economy: An analysis of 114 definitions, *Resour. Conserv. Recycl.* **127**, 221 (2017). <https://doi.org/10.1016/j.resconrec.2017.09.005>
3. A. Y. Ramdhani, I. A. T. Munikhah, R. W. Arini, and A. Saepullah, Peningkatan Performansi Proses Produksi Konveksi dengan Software Simulasi Flexsim 2019, *J. TRINISTIK J. Tek. Ind. Bisnis Digit. Dan Tek. Logistik* **1**, 58 (2022). <https://doi.org/10.20895/trinistik.v1i1.712>
4. Abdurrahim, H. Tannady, D. Ekowati, W. Nawarcono, and A. Budi Pratomo, Analysis

- of the Role of Price, Product Variation and Product Quality on Customer Satisfaction of Convection Products, *J. Econ. Bus. Account.* **6**, 1302 (2023)
5. T. Windarti, Pengendalian Kualitas Untuk Meminimasi Produk Cacat Pada Proses Produksi Besi Beton, *J@Ti Undip J. Tek. Ind.* **9**, 173 (2014). <https://doi.org/10.12777/jati.9.3.173-180>
 6. R. Prasetyo and Y. K. Bakhti, Pengendalian Kualitas Produk Pakaian Anak Pada Industri Garment Dengan Metode Seven Tools, *J. Inkofar* **6**, 39 (2022). <https://doi.org/10.46846/jurnalinkofar.v6i1.210>
 7. M. Faishal, E. Mohamad, H. M. Asih, A. A. A. Rahman, A. Z. Ibrahim, and O. Adiyanto, The use of Lean Six Sigma to improve the quality of coconut shell briquette products, *Multidiciplinary Sci. J.* **6**, 1 (2024)
 8. S. Teja, A. Ahmad, and L. L. Salomon, Peningkatan Kualitas Produksi Pakaian Pada Usaha Konveksi Susilawati Dengan Berbasis Metode Six Sigma, *J. Ilm. Tek. Ind.* **10**, 9 (2022). <https://doi.org/10.24912/jitiuntar.v10i1.15949>
 9. M. Faishal, A. Saptari, and H. M. Asih, Relayot Planning to Reduce Waste in Food Industry Through Simulation Approach, *Asia Simul. Conf.* 496 (2017). https://doi.org/10.1007/978-981-10-6502-6_43
 10. Anisha Dian Iswahyuni, Aji Kusumastuti Hendrawan, and Hasan Nur Syamsi, Analisis Quality Control pada Produk Omiland Kasur Bayi Untuk Meminimalisir Produk Cacat di PT. Wahana Kasih Mulia, *Jural Ris. Rumpun Ilmu Tek.* **1**, 115 (2022). <https://doi.org/10.55606/jurritek.v1i1.2091>
 11. B. A. Jaya and M. Mulyono, Analisa Produk Cacat Menggunakan Metode Six Sigma Pada Perusahaan Garmen, *Ultim. Manag. J. Ilmu Manaj.* **14**, 143 (2022). <https://doi.org/10.31937/manajemen.v14i1.2590>
 12. S. Sugiyarto, Pengendalian Cacat Produk PDL Loreng Tni AD Dengan Metode Six Sigma Di PT Sri Rejeki Isman Tbk, *J. Tekst. J. Keilmuan Dan Apl. Bid. Tekst. Dan Manaj. Ind.* **4**, 56 (2020). <https://doi.org/10.59432/jute.v4i1.29>
 13. T. A. Alawiyah, Analisis Pengendalian Kualitas Produk Intimates Bra Fused untuk Meminimalkan Defect dengan Menggunakan Metode Six Sigma Tri Astuti Alawiyah mengalami penurunan kualitas terutama pada produk fusing atau press . Berdasarkan data defect tertinggi pada week 2, *Ilmu Keteknikan I* **2**, (2024)
 14. Ghina Syarifah and Dr. Endang Prasetyaningsih,Ir.,MT, Usulan Perbaikan Waste dan Meningkatkan Kinerja pada Produksi Benang dengan Pendekatan Lean Six Sigma di PT Dhanar Mas Concern I, *Bandung Conf. Ser. Ind. Eng. Sci.* **3**, 150 (2023). <https://doi.org/10.29313/bcsies.v3i1.6165>
 15. N. F. Fatma, H. Ponda, and E. Sutisna, Penerapan Lean Manufacturing Dengan Metode Value Stream Mapping Untuk Mengurangi Waste Pada Proses Pengecekan Material Bahan Baku Ke Lini Produksi, *J. Ind. Manuf.* **7**, 41 (2022). <https://doi.org/10.31000/jim.v7i1.5969>
 16. D. A. Ridho and S. Suseno, Analisis Pengendalian Kualitas Produk Dengan Metode Lean Six Sigma Pada PT. Djohartex, *J. Inov. Dan Kreat.* **2**, 64 (2023). <https://doi.org/10.30656/jika.v2i2.6009>
 17. D. K. Kurnianto, I. R. H. Setyanto, and M. Si, Usulan Perbaikan Kualitas Produk Menggunakan Metode Six, *IDEC 2021 I* (2021)
 18. F. R. A. J. Nugroho, Upaya Perbaikan Kualitas Produk Batik Di Batik Allusnan Menggunakan MetodeSix Sigma Dan New Seven Tools, *J. Cakrawala Ilm.* **1**, 2971 (2022)
 19. B. S. Wijaya, D. Andesta, and E. D. Priyana, Minimasi Kecacatan pada Produk Kemasan Kedelai Menggunakan Six Sigma, FMEA dan Seven Tools di PT. SATP, *J. Media Tek. Dan Sist. Ind.* **5**, 83 (2021). <https://doi.org/10.35194/jmtsi.v5i2.1435>
 20. E. Krisnaningsih and F. Hadi, Strategi Mengurangi Produk Cacat Pada Pengecatan Boiler

- Steel Structure Dengan Metode Six Sigma Di Pt. Cigading Habeam Center, J. Intent J. Ind. Dan Teknol. Terpadu **3**, 11 (2020). <https://doi.org/10.47080/intent.v3i1.796>
21. S. E. Mahardhika and A. Z. Al-Faritsy, Meminimalisir Produk Cacat Pada Produksi Batik Cap Menggunakan Penerapan Metode Six Sigma Dan Kaizen, J. Tek. Ind. J. Has. Penelit. Dan Karya Ilm. Dalam Bid. Tek. Ind. **9**, 464 (2023). <https://doi.org/10.24014/jti.v9i2.23442>
 22. N. F. Azizah, R. A. Apriani, F. M. P, M. Z. Z. A, and F. Aji, Analisis Perancangan Tata Letak Menggunakan Metode Activity Relationship Chart (ARC) dan Computerized Relationship Layout Planning (CORELAP) Pada CV . Tunas Karya, J. Tek. Ind. **9**, 86 (2023)
 23. M. R. Rosyidi, Analisa Tata Letak Fasilitas Produksi Dengan Metode Arc, Ard, Dan Aad Di Pt. Xyz, WAKTU J. Tek. UNIPA **16**, 82 (2018). <https://doi.org/10.36456/waktu.v16i1.1493>
 24. M. Karmagatri, A. Riswanto, H. M. Asih, M. Faishal, A. Munawar, R. T. Evitasari, A. Meilin, and N. Baroroh, MANAJEMEN HIJAU: Teori dan Konsep, *MANAJEMEN HIJAU: Teori Dan Konsep* (PT. Sonpedia Publishing Indonesia, Yogyakarta, 2023)