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Reducing Waste of Material Transport in Manufacturing Facility using Systematic Layout Planning and Simulation Approach

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Operations Research (OR) is one of the popular managerial decision science tools to improve productivity. One of OR applications is layout planning. A good layout planning can reduce the distance between departments which can improve the number of throughputs. This research is based on a case company of Azka Pratama SME which is sponge slipper manufacturer in Yogyakarta, Indonesia. This company has a problem in material handling among the departments which impacts on a low number of throughput and long production time. The objective of this study is to improve the design of facility layout so that the waste of material handling time can be minimised. This research developed ARC and CRAFT method to redesign the facility layout, then simulation method was employed to simulate and analyse the proposed layout designs. The results showed that Craft method could reduce the distance of 53.76% and material handling time about 37.13% from the current system. Then, the throughput increased by 2.39%. On the other hand, through the ARC method, the distance and time can be reduced by 34.39% and 26.52%, respectively. Then, the throughput could be improved by 3.75%.

Keywords: relayout; waste of transportation; ARC; CRAFT; simulation

I. INTRODUCTION

One of the sciences concerned within evaluating manager decisions is operations research. Summing up, operations research discusses about the problem of how to gain means and use resources in the most effective way taking into account surrounding limitations. As an example is production area, a good area is an area there is minimal waste of transportation.

The development of hotels has been increasing lately in Yogyakarta. This allows competition between hotel services to prove that the hotel has satisfactory service standards. The quality of a good flip sponge certainly gives added value to a service at the hotel. The sandals sponge industry has the role of being a producer and supplier of products to meet the demands of various hotels, this condition encourages companies to have the right strategy in increasing the amount of production and making efficiency in every production activity. A good layout of all production facilities in a factory is the basis for making work operations more effective and efficient as well as maintaining the work success of an industry (Wignjosoebroto, 2009). Efficiency in utilising existing resources is the principle that all companies want both manufacturing and services because efficient use of resources will reduce costs and production time (Pranata *et al.*, 2016).

Small and Medium Enterprises (SME) AZKA PRATAMA is a company that produces comfortable and quality sponge slippers. These sponge slipper products also often become souvenir in some wedding events. SME AZKA PRATAMA located at Jalan Joho Blok VI No.26 RT 07/60 Condongcatur, Depok, Sleman, D.I. Yogyakarta. The following stages of the production process of sponges are initially raw materials, namely sponges of liver and furring fabrics taken from the warehouse. The sponge sheets will go through the process of finishing with furring cloth using latex glue, after which the sponge glue will be measured and cut to length. The cutout will be printed into 2 parts sandals (cup & sol) using a pound machine, the flip cup section will be screened according to

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consumer demand and the cup edge is given a list. Meanwhile, the soles are processed by the final sewing which will be sewn with the finished cup slipper.

Increasing number of hotels certainly increases the number of demand for SME AZKA PRATAMA. A good layout contributes to increasing the amount of production, but this company has a problem with material flow in the form of waste of time due to the flow distance from the warehouse to the measurement and glueing department and the cup sewing department to the insole sewing department ± 50 m far enough. Material flow has a total distance of 1,437.90 m with a time of 249 seconds/frequency which means that 22.71% is used for the material movement of the total production time. Therefore, it is necessary to improve the layout to reduce waste using the ARC and CRAFT methods and simulate with Software Arena to analyse the total production.

The ARC method is often stated in "qualitative" assessments and tends to be based on subjective considerations. This map is used to show the relationship between activities and their reasons, as information to determine the design of the next area, and location of activities (Wignjosoebroto, 2009). The CRAFT method is to exchange the location of activities in the initial layout to find better problem solving based on the flow of material. Subsequent ex-changes lead to a layout that approaches minimum costs (sub-optimum) (Apple, 1990). Software Arena is a SIMAN block-based simulation platform and is equipped with the addition of many functional modules, full structure visualisation and model parameters, better input and output analysis, control and animation facilities, and output reporting. Arena has been widely used both in industry and academia (Altiok & Melamed, 2007).

The previous research about relayout facilities was carried out by Primasari (2014) with the ARC method and CRAFT software assistance to solve the layout problems in Rafi Furniture, obtained the results of minimal material displacement distance and time, in-creased output and total minimisation of MHC. Research using the CRAFT method and WinQSB V2.0 software were also carried out by Wahyuni and Safitri (2014), the results of the proposed improvement in facility layout are obtained by moving the area of the facility according to the flow of material transfer process. Haq and Antara (2015) conducting research about relayout facilities using the From-To Chart method and ARC analysis in running UA-FLP to solve layout problems at UD Supra Dinasti Denpasar, GMP results were obtained and new layout proposals from UA-FLP modelling were able to reduce material mileage. Combining the CRAFT method with the Graph method has also been done by Ningtyas *et al.* (2015), and the alternative results of the Graph layout method give the minimum material handling cost. Another study using the CRAFT algorithm method is done by Yuliana to solve the problem of facilities layout in K-Store, Krakatau Junction. Obtained a reduction in the total distance of 15.65 m to be more optima (Yuliana *et al.*, 2016). Pranata and Wigati (2016) conducted a study with the ARC method and CRAFT algorithm with WinQSB software to solve layout problems at PT Mitra Precision Plastindo. Obtained a better new layout design with a small total cost. Whereas Faishal *et al.* (2017) has conducted research using the MULTIPLE method and a simulation approach with ProModel 6.0 software to solve layout problems in the food industry. The results of the second scenario of the 3 improvement scenarios provided the largest increase from the others even though they require more expensive investment. The research was conducted by Iskandar and Fahin (2017) with the ARC and ARD methods to solve layout problems at Mercedes-Benz Indonesia PT. Obtained distance results and more efficient costs for the production process. Dewa *et al.* (2018) combines the ARC, ARD and Flexsim Chart software simulations, so that the layout can be obtained by exchanging and bringing the work station closer so that there is a 38% decrease in MHC. Hidayat *et al.* (2016) Facility Layout Redesign With Quantitative And Qualitative Method On Printing Industry, and from the results of these studies able to reduce the total distance by 13.98%. Felecia *et al.* (2017) relayout library facility layout design for digital native generation. as the result, new library facility layout will be more suitable to meet digital native generation needs. The implication of this adjustment is additional investment in new facilities and repositioning current layout.

II. MATERIALS AND METHOD

The stages of the research that will be carried out are:

A. Preliminary Study

This study includes preliminary observations and literature studies which can be explained as follows:

1. Literature study

Deeper learning activities concerning theories can add insight and become references in conducting research.

2. Initial observation

This observation is a deeper learning activity concerning the target object of the study and concerning the problems that exist. Data obtained in the form of company conditions, production processes, and other information.

B. Problem Identification

The initial stage is to observe the real conditions that occur in eight to find out how the system is going on in the company. Then proceed with understanding the problems that occur based on carried out observations.

C. Problem Formulation

The results of the problem identification process. Research topics and identification of problems that have been obtained, are used as a reference in determining the success rate of a study.

D. Data Collection

Steps are taken to obtain the data needed in research, which supports the success of the research. The data collected in this study are initial layout, area of the company, production system, flow chart, sequence of production processes, employee salaries, employee work schedules, production time, allowance time.

E. Data Processing

The stages in processing in this study are as follows:

1. Calculate production capacity

The working system of this company is bulk, so the production capability of each employee is different. Calculation of production capacity is obtained from working hours per day reduced by the time the employee allowances are divided by the processing time, then multiplied by the number of working days.

2. Calculate the total movement

The frequency of the flow of material transfers is needed to calculate the amount of production, the amount of material needed and the capacity of transportation equipment so that it can know how much the load of transportation.

3. Calculate the distance between department

The distance between departments can be calculated after determining the department's centre point. Distance calculation uses a rectilinear method where distance is measured following a straight line between departmental center points.

4. Calculate the total distance

After calculate the distance between departments and the frequency of material flow, the total distance travelled during the production process can be calculated.

5. Establish Ftom To Chart (FTC)

The to-map is done by changing the basic data into data that is ready to be used on the map, followed by making a matrix according to the number of activities.

6. Calculate Material Handling Cost (MHC)

Based on the distance between the department at the initial production facility, the amount of material flow (frequency/period) and MHC per time, the total MHC can be known by multiplying the distance, and MHC per time.

7. Calculate the production time

Before doing the simulation from the results of the improvement in the layout of system, data fitting is needed to get the right type of data distribution at each processing time.

Processed data will be used to design facility layout using

the ARC method and the CRAFT method:

i. Design layout ARC method

This design is to get the layout according to the order of the flow of materials according to the degree of relevance so that the layout is in the order of production.

ii. Design layout CRAFT method

This design includes items into the QS version 3.0 program to get a minimum MHC layout.

F. Layout Simulation

Simulation models that have been designed and developed can analyse production output from selected alternative layouts making it easier to see improvements in production when implemented.

G. Analysis and Discussion

The results of the calculation will be analysed and compared to the results of the two methods and coupled with the real condition which gives the smallest MHC, the shortest distance, and the greatest efficiency according to the techniques and methods used in this study.

H. Conclusion

Based on the results of data analysis that has been obtained, the conclusions obtained and provide advice for the company to the final results of this research as information and information.

III. RESULT AND DISCUSSION

The data needed to process data with the ARC and CRAFT method is the layout of the company's existing conditions. As follows the layout of the existing company:

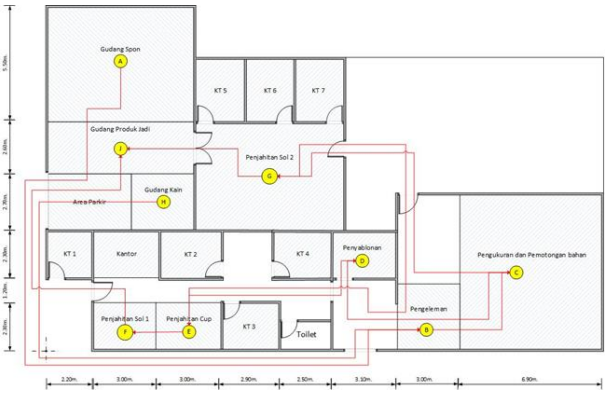

Figure 1. Existing Layout

A. Production Capacity

Employee production capacity is obtained from working hours per day minus the time of employee allowance in each department divided by the processing time, then multiplied by the working day.

$$\left(\frac{working\ hours\ per\ day - allowance\ time}{processing\ time}\right) \times working\ days$$

Table 1. Production Capacity

Dept. Code	Operator Code	Capacity
B	Opt. 10	213
	Opt. 11	230
	Opt. 12	230
C	Opt. 10	743
	Opt. 11	795
	Opt. 12	809
D	Opt. 4	6.989
	Opt. 5	6.809
E	Opt. 9	11.276
F	Opt. 8	990
G	Opt. 13	1.027
	Opt. 14	984
	Opt. 15	1.047
	Opt. 16	1.213
	Opt. 17	1.264
	Opt. 18	1.133

B. Frequency

The frequency of this displacement is obtained from the number of units that are divided by the capacity of the

conveyance. The number of units moved is obtained from observations on the company. Transport capacity is obtained from the volume of transport equipment and the volume of units moved (Ningtyas *et al.*, 2015).

Table 2. Frequency

From	To	Production Capacity	Transport Capacity	Frekuensi (riil)
A	B	673	30	23
H	B	673	100	7
B	C	5.869	900	7
C	D	6.900	600	12
C	F	990	320	4
C	G	6.668	960	7
D	E	5.638	520	11
E	F	990	320	4
E	G	6.668	960	7
F	J	990	320	4
G	J	6.668	900	8

C. The Distance between Department

The distance between departments is measured from the centre of the department to the next department on the X and Y axes (Wignjosoebroto, 2009). From the calculation of the centre point can be calculated the distance between work stations. In this study the distance between work stations is calculated using the rectilinear formula.

$$dij = |xi-xj| + |yi-yj| \quad (1)$$

Calculation of distance between departments in the existing layout based on the coordinates of the centre point is presented in Table 3.

Table 3. Material Transfer Distance

From		To		Distance (m)
A	Gudang Spon	B	Pengeleman	26,95
H	Gudang Kain	B	Pengeleman	18,25
B	Pengeleman	C	Pengukuran & Pemotongan Spon	7,10
C	Pengukuran & Pemotongan Spon	D	Penyablonan	8,90
C	Pengukuran & Pemotongan Spon	F	Penjahitan Sol 1	22,05
C	Pengukuran & Pemotongan Spon	G	Penjahitan Sol 2	17,25
D	Penyablonan	E	Penjahitan Cup	11,95
E	Penjahitan Cup	F	Penjahitan Sol 1	3
E	Penjahitan Cup	G	Penjahitan Sol 2	11,20
F	Penjahitan Sol 1	J	Gudang Produk Jadi	8,85
G	Penjahitan Sol 2	J	Gudang Produk Jadi	8,45

D. The Total Distance

Based on the calculations in Table 2. about the frequency of material displacement and Table 3. about the distance of material displacement, the total distance taken during the production process activities can be determined. The total total distance in the existing layout is 1,437.90 m.

E. Material Handling Cost (MHC)

This Material Handling Cost (MHC) uses per unit time because the company does not provide wages for material grinding activities that occur. MHC results per month in existing layouts are presented in Table 4.

Table 4. MHC per unit time

Dari	Ke	Kode Operator	Gaji/Bulan (Rp)	Hari Kerja	Waktu Kerja/Hari (jam)	Total OMH/dtk (Rp)	Total OMH/dtk (Rp)	OMH/Bulan (Rp)
A	B	Opt. 10	Rp 1,200,000.00	12	6.50	Rp 4.27	Rp 4.27	Rp 61,333.33
		Opt. 11	Rp 2,500,000.00	26	7	Rp 3.82	Rp 3.82	Rp 118,650.79
		Opt. 12	Rp 2,500,000.00	26	7	Rp 3.82	Rp 3.82	Rp 118,650.79
H	B	Opt. 10	Rp 1,200,000.00	12	6.50	Rp 4.27	Rp 4.27	Rp 17,230.77
		Opt. 11	Rp 2,500,000.00	26	7	Rp 3.82	Rp 3.82	Rp 33,333.33
		Opt. 12	Rp 2,500,000.00	26	7	Rp 3.82	Rp 3.82	Rp 33,333.33
B	C	Opt. 10	Rp 1,200,000.00	12	6.50	Rp 4.27	Rp 4.27	Rp 2,512.82
		Opt. 11	Rp 2,500,000.00	26	7	Rp 3.82	Rp 3.82	Rp 4,861.11
		Opt. 12	Rp 2,500,000.00	26	7	Rp 3.82	Rp 3.82	Rp 4,861.11
C	D	Opt. 4	Rp 3,400,000.00	30	9	Rp 3.50	Rp 3.50	Rp 16,370.37
		Opt. 5	Rp 2,000,000.00	26	10	Rp 2.14	Rp 2.14	Rp 8,666.67
C	F	Opt. 8	Rp 1,500,000.00	26	8	Rp 2.00	Rp 2.00	Rp 4,583.33
C	G	Opt. 16	Rp 1,500,000.00	26	10	Rp 1.60	Rp 6.01	Rp 27,353.40
		Opt. 17	Rp 2,000,000.00	26	10.50	Rp 2.04		
		Opt. 18	Rp 2,000,000.00	26	9	Rp 2.37		
D	E	Opt. 9	Rp 2,000,000.00	30	10	Rp 1.85	Rp 1.85	Rp 5,500.00
E	F	Opt. 8	Rp 1,500,000.00	26	8	Rp 2.00	Rp 2.00	Rp 625.00
E	G	Opt. 16	Rp 1,500,000.00	26	10	Rp 1.60	Rp 6.01	Rp 45,953.70
		Opt. 17	Rp 2,000,000.00	26	10.50	Rp 2.04		
		Opt. 18	Rp 2,000,000.00	26	9	Rp 2.37		
F	J	Opt. 8	Rp 1,500,000.00	26	8	Rp 2.00	Rp 2.00	Rp 3,750.00
G	J	Opt. 13	Rp 1,500,000.00	26	8.50	Rp 1.89	Rp 7.07	Rp 14,705.88
		Opt. 14	Rp 2,000,000.00	26	8	Rp 2.67		
		Opt. 15	Rp 2,000,000.00	26	8.50	Rp 2.51		
Total Ongkos *Material Handling*							Rp 68.30	Rp 522,275.75

F. Design Layout ARC Method

The design of the ARC method layout in UKM AZKA PRATAMA uses the determination of the reasons for determining the degree of relationship that comes from interviews and observations on the condition of the layout of the facilities to be arranged. Map of activity relations can be seen in Figure 2.

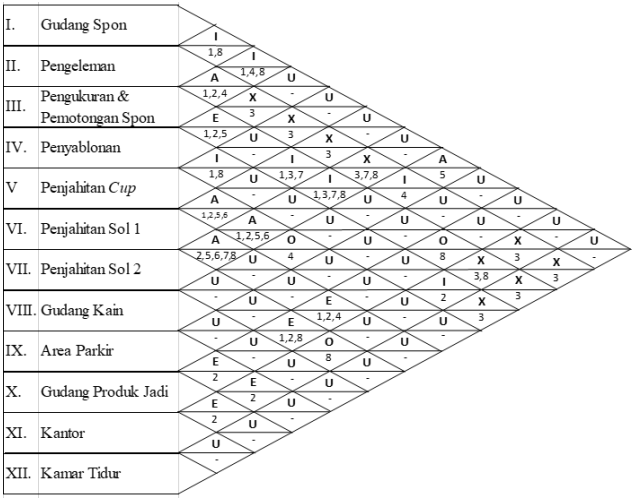

Figure 2. Activity Relationship Chart (ARC)

From ARC it can be seen that this method does 13 changes to reduce waste. These changes occurred in the sponge warehouse and fabric warehouse moving to the rear area because they had to be close to the measurement and materials collection department, the position measurement and cutting department with the glueing department to reduce work disruptions due to the latex glue spraying process, the printing department shifted to manufacture of road access, cup sewing department and sewing of sol 1 must be brought close to the sol 2 sewing department, and the room area becomes 1 area surrounded by a parking area so as to facilitate activities. Layout of the ARC method can be seen in Figure 3.

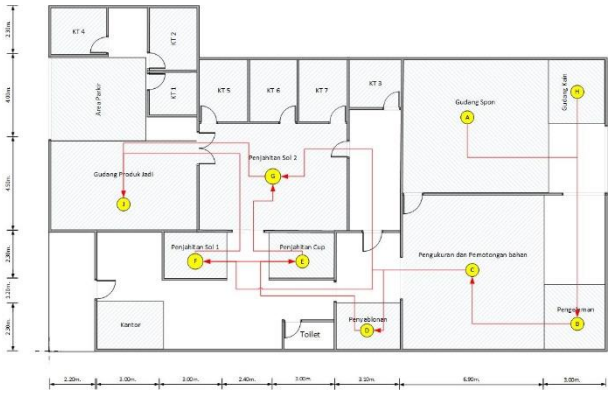

Figure 3. The proposed layout ARC method

1. Total distance from the propose layout ARC method

Based on the calculations in Table 2. about the frequency of material transfers and the distance of new material transfers, the total distance taken during the production process activities can be determined. The total distance in the proposed ARC method layout is 943.45 m which means experiencing a distance savings of 34.39%.

2. Material handling cost the propose layput ARC method

Calculation of the cost of material handling (MHC) on the design of the facility layout from the ARC method uses a parameter of the operator's speed when transferring material from the existing layout, so that the time of material transfer from the new layout design proposal can be determined. Table 5. presents the speed of material transfer in the existing layout.

Table 5. The speed of Material movement

From	To	Dist. (m)	Time (s)	Speed (m/s)
A	B	26,95	52	0,52
H	B	18,25	48	0,38
B	C	7,10	7	1,01
C	D	8,90	13	0,68
C	F	22,05	22	1
C	G	17,25	25	0,69
D	E	11,95	9	1,33
E	F	3	3	1
E	G	11,20	42	0,27
F	J	8,85	18	0,49
G	J	8,45	10	0,85

Based on data from Table 5. about the speed of material movement and the distance of material movement between new departments, causing savings in displacement time. The calculation of the displacement time uses the parameters of operator speed when moving material so that the proposed layout of the ARC method experiences a time savings of 26.52%, so the total MHC per month is Rp 301,576.53 or experiencing savings of 42.26%.

G. Design Layout CRAFT Method

Processing with the CRAFT method using WinQSB software offers four types of recommendations for alternative layout improvements. Table 6. presents the results of processing WinQSB software for the four types of solutions offered.

Table 6. The WinQSB Result

WinQSB Solutions	Iteration	Total Cost
Evaluate the initial layout only	0	1.486,81
Improve by Exchanging 2 departments	9	817,40
Improve by Exchanging 3 departments	7	1.006,51
Improve by Exchanging 2 then 3 departments	9	817,40
Improve by Exchanging 3 then 2 departments	14	664,83

Based on Table 6. The results of processing CRAFT obtain a solution option that can reduce waste time when moving material. The smallest solution option is on Improve by Exchanging 3 then 2 departments the number of iterations produced to achieve optimal results is 14 iterations with a total cost of 664.83. The proposed layout of the CRAFT method on this solution option makes 9 department changes. Changes occur in the sponge warehouse moving to sewing sol 2 because it has almost the same size, sewing of sol 2 joins together with suturing sol 1. The bedroom area, sewing cup and silk screening shifts and switches position so that the production flow becomes smooth. Office area, the bedroom moves to the back area adjacent to the measuring and cutting area of the material. The glueing area moves to the screen area so that the material flow does not occur when the material is displaced. Figure 4. presents the results of the block layout with the CRAFT method and Figure 5. presents the results of the layout of the layout from the block layout of the CRAFT method.

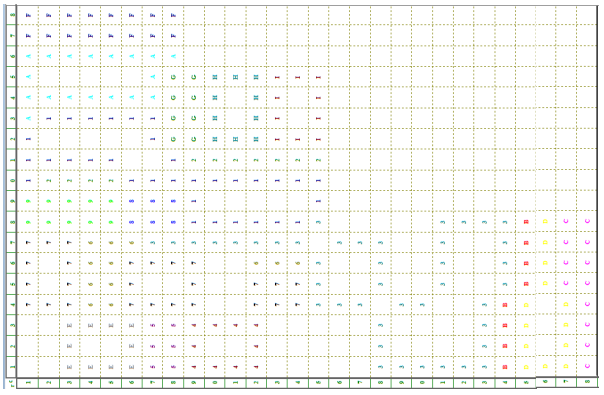

Figure 4. Final Layout

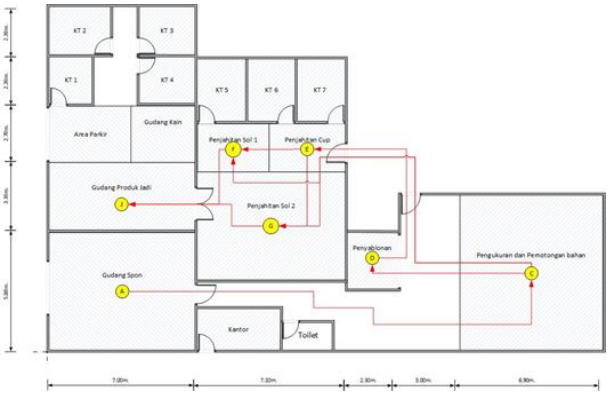

Figure 5. The propose Layout CRAFT method

1. Total distance of alternative CRAFT method layouts

Based on the calculations in Table 2. about the frequency of material transfers and the distance of material movement, the total distance taken during the production process activities can be determined. The total total distance in the proposed CRAFT method layout is 664.82 m, which means experiencing a distance savings of 63.76%.

2. Material handling cost alternative layout methode CRAFT

Calculation of material handling costs (MHC) on the design of facility layout from the CRAFT method also uses operator speed parameters when transferring material from the existing layout. Based on data from Table 5. about the speed of material movement and the distance of material movement between new departments, causing displacement time displacement. The calculation of the displacement time uses operator speed parameters when moving material so that the proposed layout of the CRAFT method has a time savings of 37.13%, so that the total MHC per month is Rp. 144,113.81 or has a savings of 72.41%.

H. Layout Simulation

The results of the proposed layout from processing with the ARC and CRAFT methods will then be simulated using ARENA software so that it is easier to see improvements in production when implemented. Obtained results Increased output of each method. The increase occurred in the proposed layout with the ARC method of 4.19% while the proposed layout with the CRAFT method experienced an increase in output of 2.39%.

I. Implementation Cost

The details of the costs of this renovation are the assumptions and price range in 2018, while the costs to be made for the wall are Rp. 279,000 / meter, the costs to be disassembled for the wall are Rp. 100,000, - / day, costs incurred for the manufacture of roofs of Rp. 250,000 / m2, as well as costs for 2 people the building workforce of Rp. 180,000 / day. The work on renovating the layout will take 2 weeks for each layout proposal, so the total renovation costs to implement the proposed layout from ARC Method is Rp 31,428,900,- and the total cost of renovation to implement the proposed layout from CRAFT Method is Rp 9,437,000,-.

IV. CONCLUSION

AZKA PRATAMA SME is a company that produces comfortable and quality sponge slippers. Currently, they have a problem designing facility layout as there are many wastes of material transport. It affects on long production time and low throughput. Therefore, this study aims to improve the design of facility layout so that the waste of material handling time can be minimised. The Craft method was employed to change the location of Office Area, Gluing Department, Screening Department, Department of sewing sol 1 and sol 2, Rooms 1, 2, 3, and 4. It could reduce the distance of 53.76% and material handling time about 37.13% from the current system. Then, the throughput increased by 2.39%.

On the other hand, the ARC method has improvement in re-designing sponge and fabric warehouses. They moved near to materials measurement and cutting department. Then, materials measurement and cutting department exchanging

positions with glueing department to reduce work disruptions due to the latex glue spraying. Not only those departments, but screen printing department is also shifted for road access, cup and sol 1 sewing department moved to near sol 2 sewing department, and the room area becomes an area that near to parking area to facilitate the activity. Through the ARC method, the distance and time can be reduced by 34.39% and 26.52%, respectively. Then, the throughput could be improved by 3.75%. for the managerial inside in this company the proposed layout of the ARC method is based on the opinion of employees through questionnaires where employee see the need of use to utilise company-owned vacant land around the factory site, so that according to employees this layout from ARC method more comfortable but need a high cost to implementation. while the proposed layout from the CRAFT method resulted the shortest of total distance and lower material handling time and lower implementation costs, so this proposed layout is more applicable than the ARC method.

V. ACKNOWLEDGEMENT

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