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INCREASE EFFICIENCY WITH PRODUCTION MODEL RE-LEYOUT USING ACTIVITY RELATIONSHIP CHART

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Abstract: This thesis contains an analysis to increase efficiency with production model re-layout using activity relationship chart. The research already done at manufacturing making wiring harness located in Balaraja, Tangerang with model carline Toyota Hiace. Based on existing layout, writer defines 21 facilities from beginning process (Pre-Assy) until end process (Inspection). For decide degrees of closeness, writer and stakeholder for the company do brainstorming to formulate 7 criteria for relevance motive table. Based 7 criteria, 21 each facilities can be decided degrees of closeness and mapped out in activity relationship chart. Degrees of closeness each facility can be divided into 6 levels as A (Absolute), E (Especially), I (Important), O (Ordinary), U (Unimportant), and X (Undesirable). Information of degree of closeness become a basis for making new layout more efficiency by using block tamplate but should be adjusted based on layout type production system. Type of layout that suitable is layout by product with improve efficiency from 63% to 65%.

Keywords: Wiring Harness manufacturing, Activity Relationship Chart, Production Layout

INTRODUCTION

PT XYZ are manufacturing company that running at automotive industry with result the result of a vehicle component especially for 4-wheeled vehicle namely wiring harness. Every manufacturing process there is always have target to achieve which is efficiency. Here is table efficiency from PT. XYZ:

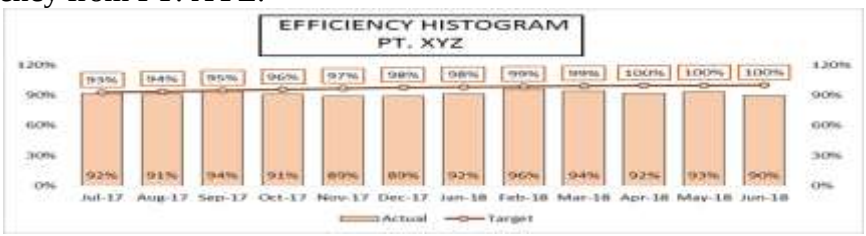
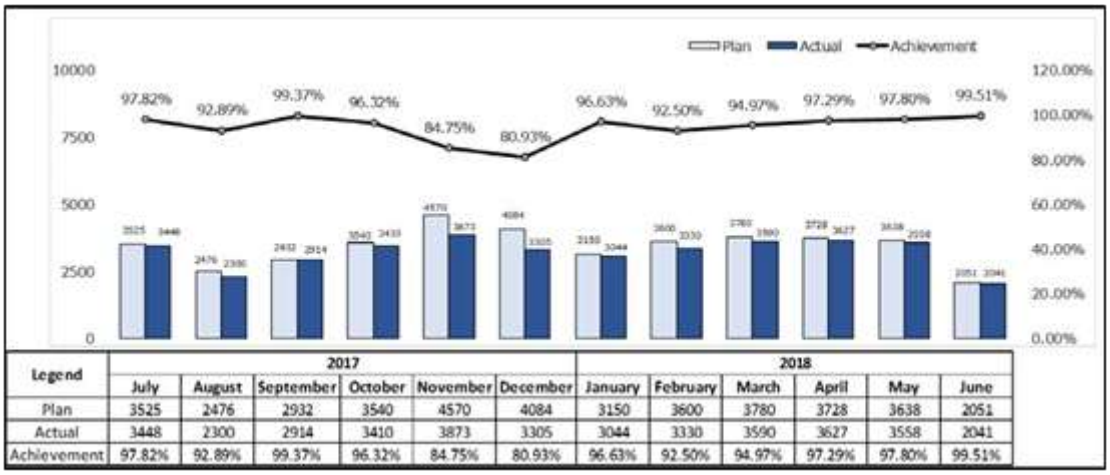


Figure 1. Monthly Efficiency PT. XYZ from July 2017 until June 2018

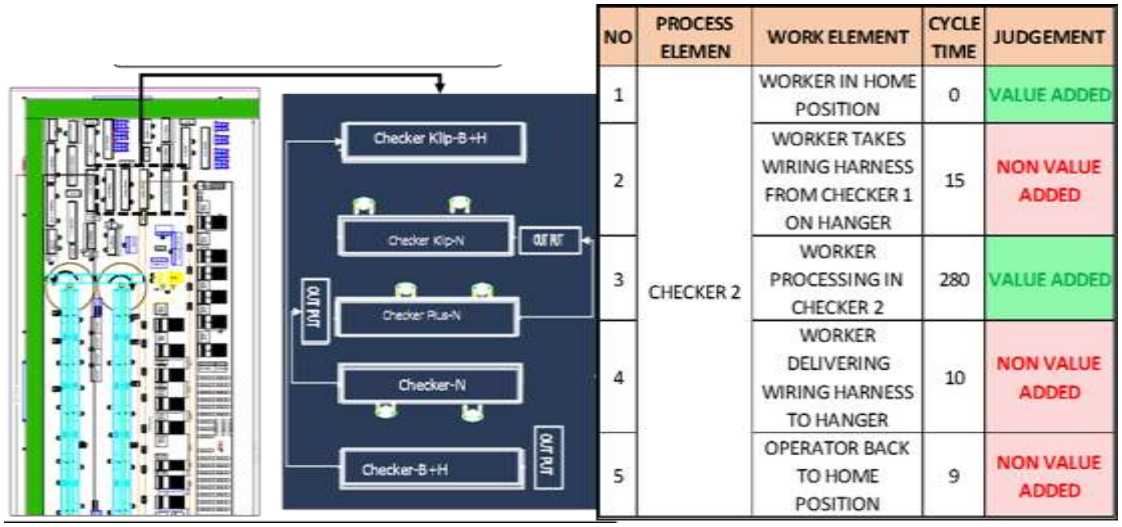
From the data it can be concluded efficiency has not reached target that had already been fixed every month. Effect from target efficiency not achieve is package output are not achieve too. The following this data achievement output packing for highest model Carline Hiace based on Higher UMH (Unit Man hours) in PT. XYZ July 2017 until June 2018:



Legend	2017						2018					
	July	August	September	October	November	December	January	February	March	April	May	June
Plan	3525	2476	2932	3540	4570	4084	3150	3600	3780	3728	3638	2051
Actual	3448	2300	2914	3410	3873	3305	3044	3330	3590	3627	3558	2041
Achievement	97.82%	92.89%	99.37%	96.32%	84.75%	80.93%	96.63%	92.50%	94.97%	97.29%	97.80%	99.51%

Figure 2. Monthly Packing output of Carline Toyota Hiace from July 2017 until June 2018

From the charts above, it can be conclude that the conditions of achievement output still below 100% production output and could meet the needs. From the chart we can see higher plan production output, the level achievement of output is getting smaller. This is because manufacturing process still not optimum and *loss time* happens in several process. For study case in inspection area, moving process for WIP (Work in Process) goes not effective and efficient because moving not hand-to-hand.



NO	PROCESS ELEMEN	WORK ELEMENT	CYCLE TIME	JUDGEMENT
1	CHECKER 2	WORKER IN HOME POSITION	0	VALUE ADDED
2		WORKER TAKES WIRING HARNESS FROM CHECKER 1 ON HANGER	15	NON VALUE ADDED
3		WORKER PROCESSING IN CHECKER 2	280	VALUE ADDED
4		WORKER DELIVERING WIRING HARNESS TO HANGER	10	NON VALUE ADDED
5		OPERATOR BACK TO HOME POSITION	9	NON VALUE ADDED

Figure 3. Illustration of Work in Process movement in the Inspection area

Based in description above, writers interested to have research increase efficiency with production model re-layout using activity relationship chart (ARC) in PT. XYZ with analyze MUDA process that may occurs.

LITERATURE REVIEW

Facility Layout Planning

Facility Layout Planning can be defined as procedures for arrangement factory facilities in order to support manufacturing process. According to Heru (2015), in general meaning, facility layout planning is arranged workspace and all production facilities for best economic for production operation, safety and comfortable that can improve moral and work performance. Work in arrangement facility layout planning also need to pay attention to security and convenience of workers on carrying out his job. According to Rika (2008) there are 4 kind of layout based on production system, there are:

1. Layout by Product
2. Layout by Process
3. Fixed position Layout
4. Group Technology Layout

After determinate of these type of layout, next is to determinate production process flow in production process. According to Samsudin (2014), production process flow are defines as a stream of necessary to move production item from beginning process until finish process. Some production process flow in common is straight line, U-shape, circular line, S-shape, and corner of odd.

ARC (Activity Relantionship Chart)

Activity relantionship Chart is a mapping that developed by Richard Muther in Faisol (2013) that system for analyze level of relation or relatedness of activity from one facility and other. The technique was invented by Richard Muther required a tools to signify degree of closeness in every facilities.

Table 1. Degree of Importance table

Code	Colour	Degree of Importance
A	Red	Absolute
E	Orange	Especially
I	Green	Important
O	Blue	Ordinary
U	White	Unimportant
X	Brown	Undesirable

Code from table above help to symbolizes degree of closeness in every facility by specifically and standardize. For reason to election code can be taken by each activity in facility and company policy. Generally, according to Apple in Purnomo (2004) reason for closeness divided into 3 criteria (Production Criteria, Employee Criteria and Information Criteria).

Table 2. Reason for Degree of Closeness

Clasification	Explanation
Relatedness of Production	Order of Work flow
	Using same equipment
	Using same checksheet
	Using same room
	Noise, dust, vibration, smell, etc.
	Facilitate moving goods
Relatedness of Worker	Use the same operator
	the importance of relating
	Degree of employment relations
	Normal travel path
	ease of supervision
	carry out similar work
	employee favored
	employee transfer
	employee disruption
Relatedness of Information	use the same notes or files
	working paper relationship degree
	using the same communication tool

WorkSheet

According to Rika (2008), uses worksheet is easy to see the design of an activity or facility with each other. Result of mapping worksheet can be used to determine new layout through Activity relantionship diagram (ARD) and composed in Area allocation Diagram (AAD).

Block Tamplate & ARD (Activity Relantionship Diagram)

The next step after design worksheet is establishment block template. According to Purnomo (2004), Block tamplate is a template that inform level of relationship between other facilities. The objective is to design more easily identify links any existing facilities.

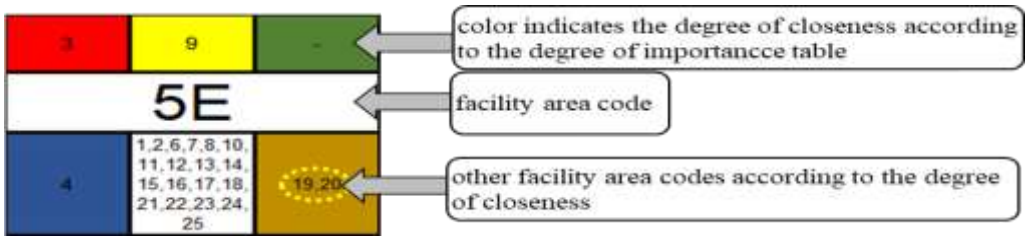


Figure 4. Sample Block Template

Next step is design using block template called activity relationship diagram aimed to ease controlling the design process, so the activity can be adjacent or far apart from each other. Determining ARD need to be considered some factor there are:

- Process flow, material and tools

- ARC and part material flow
- *Worksheet*

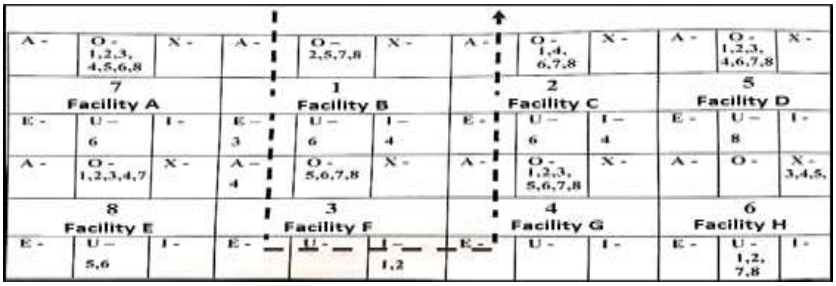


Figure 5 Sample Activity Relationship Diagram

AAD (Area Allocation Diagram)

According to Rika (2008), AAD is a template area that arranged based on ARD who was an image of final layout but does not contain facilities. AAD give adjustment if process design in ARD still not quite right. Otherwise, adjustment is not could break the level of degree that already been prepared from ARC before.

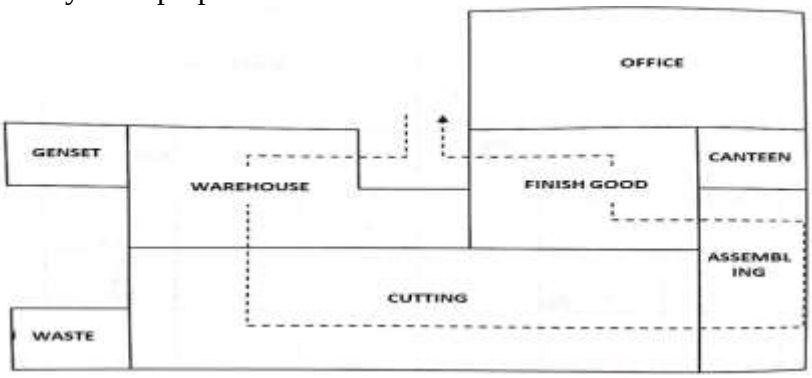


Figure 6. Sample of Area Allocation Diagram

RESEARCH METHODS

The steps in the research are divided into two stage. The first stage is for research preparation and the second stage is the stage of collect, processing and conclusion. The steps above are described in figure 7. The method of solving the problem is as follows:

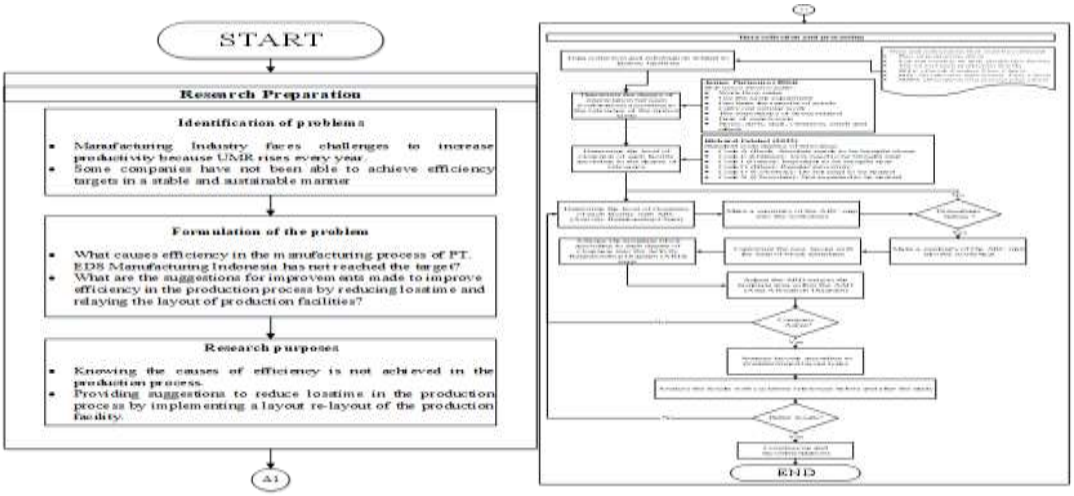


Figure 7. Research Method Framework

FINDINGS AND DISCUSSION

Collecting facility data in Total Requirement Sheet

Table 3. Total Requirement Sheet Carline Hiace

No	Code	Facility Name	Facility Size (Meters)				
			Width	length	Large	Qty	Total
1	A	Pre-Assy Machine	2.8	7.5	21.00	7	147.00
2	B	Twist Machine	3.3	6.8	22.44	1	22.44
3	C	Bonder Machine	3.9	4.5	17.55	2	35.10
4	D	Rychem	3.6	2.4	8.64	2	17.28
5	E	Haibara Computer	1.3	2.9	3.77	1	3.77
6	F	Kanban Store (Pre-Assy)	0.9	4.4	3.96	1	3.96
7	G	Circuit Store	1.6	0.8	1.28	70	89.60
8	H	Sub Assy	3.5	2.1	7.35	14	102.90
9	I	Air-Bag	3.8	2.2	8.36	1	8.36
10	J	Torque	2.8	0.9	2.52	3	7.56
11	K	Conveyor	5.2	34	176.80	2	353.60
12	L	Material Supply	1	1.6	1.60	11	17.60
13	M	Kanban Store (Final Assy)	1	1.6	1.60	1	1.60
14	N	Grommet Injection	1.2	1	1.20	3	3.60
15	O	Shiage 1	1.5	2.8	4.20	3	12.60
16	P	Checker Arus	1.2	4.4	5.28	4	21.12
17	Q	Checker Clip + Fuse	1.2	4.4	5.28	5	26.40
18	R	Shiage 2	1.4	2.6	3.64	4	14.56
19	S	Visual Inspection	1.4	4.4	6.16	4	24.64
20	T	Packing Area	2	4.3	8.60	2	17.20
21	U	Hanger Output	1.5	0.6	0.90	7	6.30
Grand Total							937.19

First step for optimize layout analysis need to collect data of any facilities that used in Total Requirement Sheet. Every Facility written code to help next step of analysis and also measured either length, width, and number of needs any facility.

Determine the degree of the relationship

For determining the rate of interest between facilities, every code and color determined based on the number of criteria chosen in accordance with their needs.

Table 4. Degree of importance table

ARC Relevance Information Table			
No	Interest level	Code	Information
1	Absolute	A	Number of connection reasons >= 5
2	Especially	E	Number of connection reasons = 4
3	Important	I	Number of connection reasons = 3
4	Ordinary	O	Number of connection reasons = 2
5	Unimportant	U	Number of connection reasons = 1
6	Undesirable	X	Number of connection reasons = 0

The number criteria and assessment of degrees of interest conducted by brainstorming together with stakeholder in the company (Production Department, Project Preparation Department and Engineering Department). For the result, there are will be chosen 7 from 18 relevance motive that explained earlier.

Table 5. Reason for Degree of Closeness

Relevance Motive Table	
No	Reason
1	Order of Work flow
2	Using same equipment
3	Facilitate moving goods
4	carry out similar work
5	the importance of relating
6	ease of supervision
7	carry out similar work

There are 210 combination from the result of analysis, for A code (Absolute) 9 relations, E code (Especially) 14 relations, I code (Important) 19 relations, O code (ordinary) 31 relations, U code (Unimportant) 137 relation and X code (Undesirable) 0 relation.

Degrees of closeness mapping with ARC

After determining the degree of closeness, any facility next is mapped out 210 combination from degree of closeness in one map namely activity relationship chart with writing code of nearness in the map.

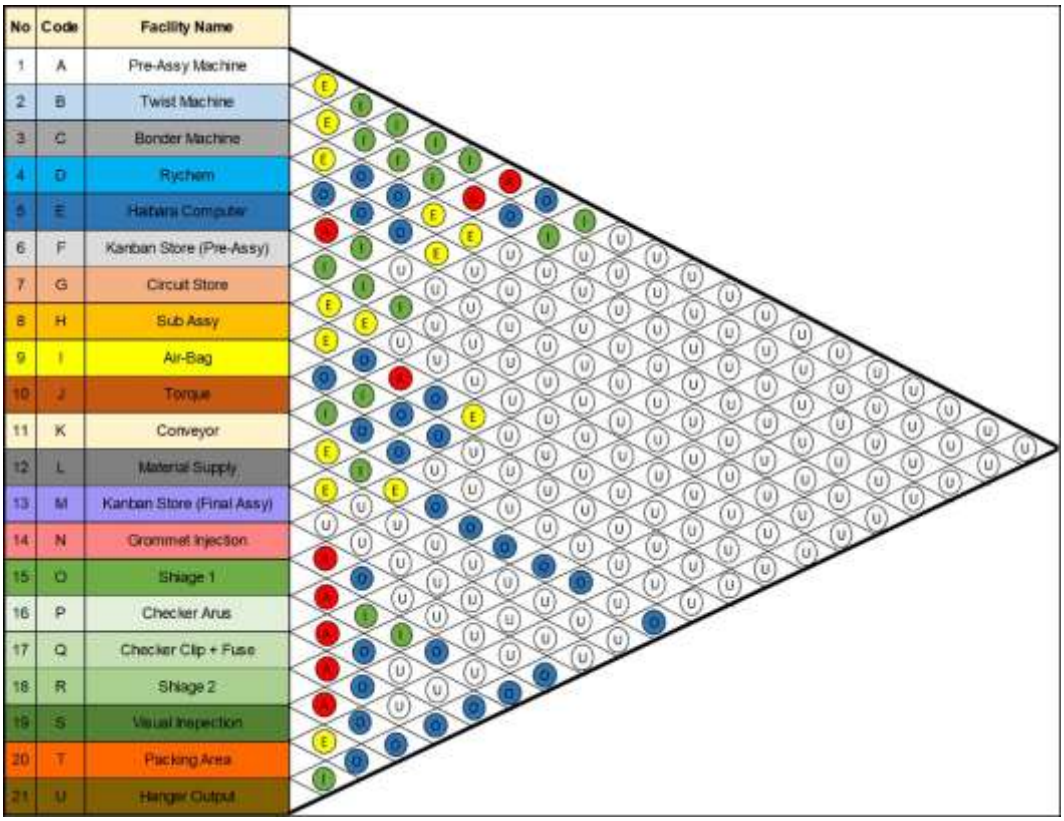


Figure 8. Activity Relationship Chart Toyota Hiace

Summary ARC Mapping to Worksheet

The purpose of making a worksheet is to make a summary for all degrees of closeness based on existing departmental facilities.

Table 6. Worksheet of Degree of Closeness Toyota Hiace

NO	Code	Facility Name	DEGREE OF CLOSENESS					
			A	E	I	O	U	X
1	A	Pre-Assy Machine	7	2	3,4,5,6,9	8	10,11,12,13,14,15,16,17,18,19,20,21	-
2	B	Twist Machine	7	1,3	4,5,6,9	8	10,11,12,13,14,15,16,17,18,19,20,21	-
3	C	Bonder Machine	-	2,4,7,8	1	5,6	9,10,11,12,13,14,15,16,17,18,19,20,21	-
4	D	Rychem	-	3,8	1,2	5,6,7	9,10,11,12,13,14,15,16,17,18,19,20,21	-
5	E	Harbara Computer	6	-	1,2,7	3,4	8,9,10,11,12,13,14,15,16,17,18,19,20,21	-
6	F	Kanban Store (Pre-Assy)	5	-	1,2,7,8,9	3,4	10,11,12,13,14,15,16,17,18,19,20,21	-
7	G	Circuit Store	1,2	3,8,9	5,6	4	10,11,12,13,14,15,16,17,18,19,20,21	-
8	H	Sub Assy	11	3,4,7,9,13	-	1,2,10,12	5,14,15,16,17,18,19,20,21	-
9	I	Air-Bag	-	7,8	1,2,6,11	10,12,13	3,4,5,14,15,16,17,18,19,20,21	-
10	J	Tongue	-	-	11	8,9,12,13	1,2,3,4,5,6,7,14,15,16,17,18,19,20,21	-
11	K	Conveyor	8	12,14	9,10,13	15,16,17,18,19,21	1,2,3,4,5,6,7,14,20	-
12	L	Material Supply	-	11,13	-	8,9,10	1,2,3,4,5,6,7,14,15,16,17,18,19,20,21	-
13	M	Kanban Store (Final Assy)	-	8,12	11	9,10	1,2,3,4,5,6,7,14,15,16,17,18,19,20,21	-
14	N	Grommet Injection	15	11	-	16,21	1,2,3,4,5,6,7,8,9,10,12,13,17,18,19,20,21	-
15	O	Shiage 1	14,16	-	17,18	11,19,21	1,2,3,4,5,6,7,8,9,10,12,13,20	-
16	P	Checker Arus	15,17	-	-	11,14,18,21	1,2,3,4,5,6,7,8,9,10,12,13,19,20	-
17	Q	Checker Clip + Fuse	16,18	-	15	11,19,21	1,2,3,4,5,6,7,8,9,10,12,13,14	-
18	R	Shiage 2	17,19	-	15	11,16,20,21	1,2,3,4,5,6,7,8,9,10,12,13,14	-
19	S	Visual Inspection	18	20	-	11,15,17,21	1,2,3,4,5,6,7,8,9,10,12,13,14,16	-
20	T	Packing Area	-	19	21	18	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17	-
21	U	Hanger Output	-	-	20	11,14,15,16,17,18,19	1,2,3,4,5,6,7,8,9,10,12,13	-

Adjustment the layout with block tamplate

After compiling a summary of the degree of closeness of each facility, the next step is to conduct a simulation to help prepare the proposed layout using a tamplate block. Simulation using tamplate blocks can adjust and place facilities according to the degree of proximity of each so that it becomes a reference for compiling a new layout.

Figure 9 Activity Relationship Diagram Toyota Hiace

Arrange a new layout in AAD

The next step after doing the simulation and get a new layout is to arrange a new layout. Mapping block tamplate arranged according to the degree of closeness to see the new layout mapping by assuming 1 box is equal to 1 meter and the area of each facility refers to the total requirements sheet data.

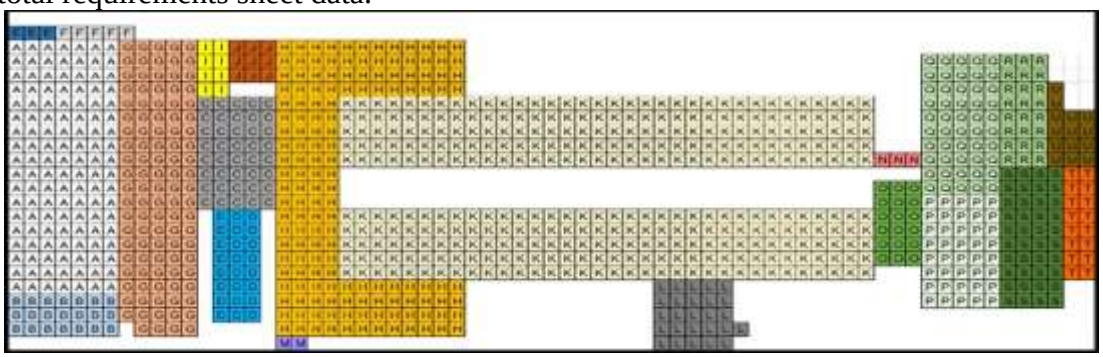


Figure 10 Simulation New Layout Toyota Hiace

After being compiled, layouts are made of the process flow map using an area allocation diagram to see how the product flows and see the allocation of needs of each facility. The following is a map for the area allocation diagram.

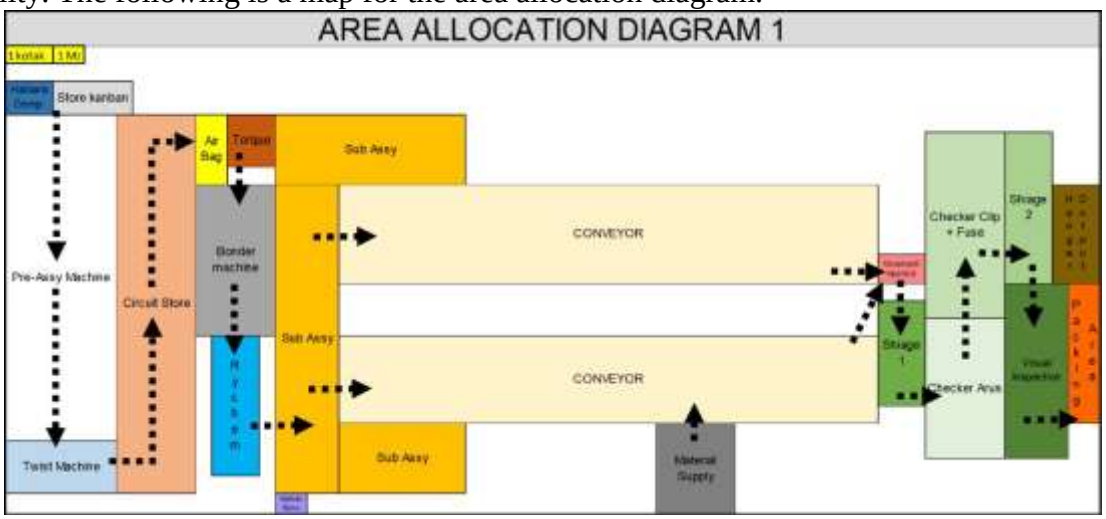


Figure 11 Area Allocation Diagram (1) Toyota Hiace

Arranging the proposed layout according to the type of layout

The next process is to adjust the proposed layout with the type of layout. This is needed to facilitate the production process that is currently running. The type of layout used is layout by product which means the arrangement and number of facilities or equipment are arranged according to the order of each process due to the large production volume. The purpose of this layout is to reduce the process of moving goods by reducing costs or processes that cause waste (MUDA).

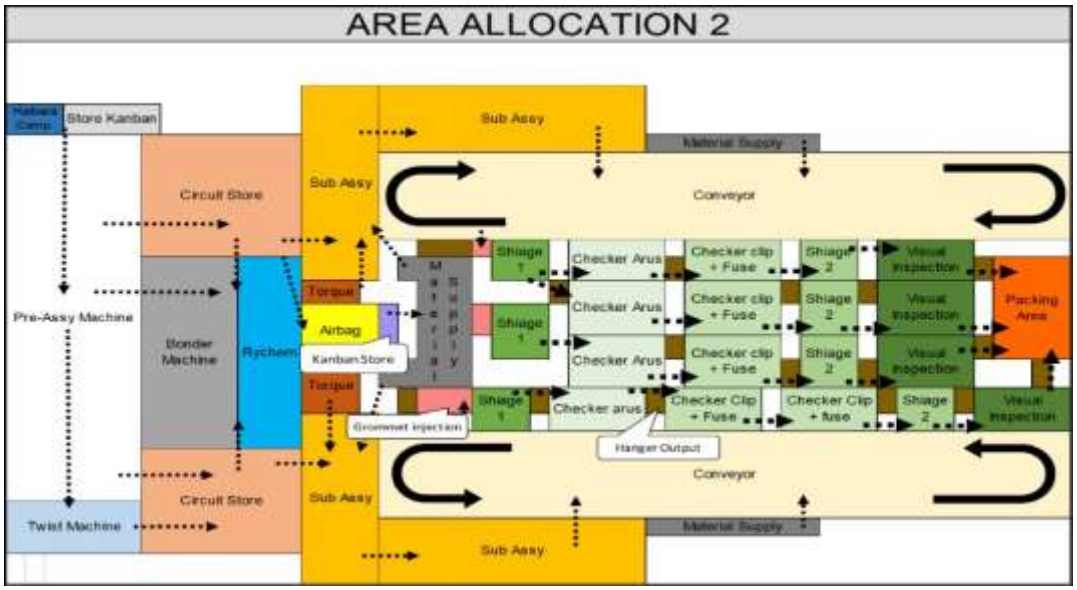


Figure 12 Area Allocation Diagram (2) Toyota Hiace

Compared to the initial layout, the final layout arrangement makes many changes in the Sub Assy, Final Assy and Inspection areas. The following are the biggest changes to the final determination of the production layout of the Hiace carline:

1. In the process of Sub assy the bonder, rychem, air bag and torque facilities are moved to the middle between the circuit store and the Sub-assy facility. This is because the facility is used for both B01 and B02 conveyors on the Toyota Hiace carline. Another consideration is to facilitate control of the stock and minimize the movement of goods during the process.
2. In the Final Assy area, a change in location occurs at the Material Supply facility. Material supply facilities are moved and adjacent to the final sub-assy process to facilitate the WIP (Work in Process) supply process together with the results of the Sub-Assy process raft. In addition, some shelves are needed in the initial process in the Sub-Assy, so it is necessary to place a material supply rack in the middle of the conveyor.
3. In the inspection process, each facility needs to be separated because it has a different pattern. For CV. B01 has E, J and K patterns while for CV. B02 has patterns B, H and N. Therefore, the inspection process is separated according to pattern and arranged straight to facilitate material handling of the finished product.

CONCLUSION AND SUGGESTION

Based on the results of the implementation for the proposed final layout using the Activity relantionship chart method, the change in total layout position is as follows:

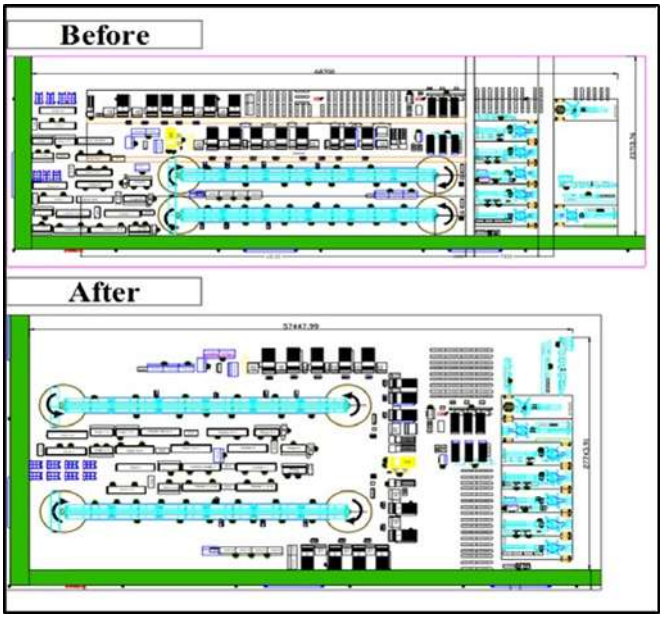


Figure 13 Before and After Re-Layout Production Process

In the latest layout can reduce downtime and reduce the amount with the aim of increasing the efficiency of the production process by moving the area of the store circuit close to pre-assy and moving the inspection area near the final assy area which is placed in the middle of the conveyor. Following is a discussion for each research result after the implementation of the proposed layout.

After making improvements to layout optimization, the downtime comparison before and after the repair has decreased. Especially in the pre-Assy and Final Assy areas.

Table 7 Monthly Downtime Comparison Toyota Hiace

MONTHLY DOWNTIME COMPARISON (Minutes)
CARLINE : TYT HIACE

Responsible	LOSSTIME ITEM	B01			B02		
		Before (April 2019)	After (Agustus 2019)	Balance	Before (April 2018)	After (Agustus 2019)	Balance
PRE-ASSY	NEW OPERATOR IN PA <10 DAYS	0	0	0	0	0	0
	4M CHANGE PA	0	0	0	0	0	0
	ABSENT OPERATORS ARE NOT REPLACED	0	0	0	0	0	0
	TERMINAL PROBLEM	0	0	0	0	0	0
	PROBLEM PART ACCESSORIES	0	0	0	0	0	0
	WRONG WIRE (COLOR / TYPE / SIZE)	0	0	0	0	0	0
	WRONG CUTTING LENGTH	0	11	-11	26	20	6
	PROBLEM BONDER CIRCUIT	0	0	0	43	20	23
	CUTTING PROCESS DELAY	165	16	149	175	39	136
	JOINTING PROCESS DELAY	82	5	77	90	10	80
Total		247	32	215	334	89	245
FINAL ASSY	NEW OPERATOR IN PA <10 DAYS	0	33	-33	0	0	0
	RUMP UP PROCESS (CHANGE SWCT / 4M CHANGE)	0	0	0	17	100	-83
	ABSENT OPERATORS ARE NOT REPLACED	0	93	-93	0	0	0
	MOVE CONVEYOR	0	0	0	0	0	0
	PREPARATION PRODUCTION/CHANGE ASSY	0	0	0	0	0	0
	INITIAL POSITION PROCESS IS NOT HOME POSITION	0	0	0	0	0	0
	QUALITY MEETING	0	0	0	0	0	0
	OVERLOAD JOB	0	0	0	0	0	0
	WITH DIFFICULT PROCESS (FA)	0	11	-11	0	0	0
	QUALITY PROBLEM	202	100	102	71	20	51
	SUB ASSY PROCESS DELAYED	115	0	115	100	0	100
	BIGSUB PROCESS DELAYED	0	0	0	0	0	0
	SETTING PROCESS DELAYED	0	0	0	0	20	-20
	TAPING PROCESS DELAYED	15	30	-15	0	5	-5
Total		332	266	65	188	145	43
GRAND TOTAL		579	299	280	522	234	288

For the calculation of efficiency, it is comparing the output produced with the inputs used in the production system. To calculate the efficiency, PT. XYZ compares the production output in Manhour with the number of Manpower in Manhour. The following is a calculation to get the value of efficiency:

The first thing is to calculate for Output Manhours before (April 2019) with after August 2019) by multiplying each production output by UMH (Unit Man Hours). UMH is the coefficient number obtained from the study of making harnesses to make wiring harness in 1 hour using 1 manpower from the beginning of the process to the end of the process. Each Assy number has a different UMH depending on the level of difficulty in making it.

Table 8 Efficiency Calculation after Reduce Manpower

Total Manpower	April 2018	January 2019	Balance Manpower	Remarks
FA TYT HIACE	72	130	42	1. Adjustment of MP (Man Power) due to decreased loading. 2. MP (Man Power) Circuit Supply Reduction (Before: 4; After: 0)
PA TYT HIACE	63	41	22	1. Adjustment of MP (Man Power) due to decreased loading. 2. Chorobiki & Supply Material MP (Man Power) Reduction (Before: 4; After: 0)
QA TYT HIACE	59	51	8	Decrease Loading

Input MH	49.392	37.296
Output MH	31.120	24.394
Effisiensi	63%	65%

From these results it can be concluded an efficiency increase of 2%. This happened due to a reduction in the standard manpower of the Chorobiki manpower Circuit Supply and manpower by 8 people. In addition, the effect of decreasing loading with reduced manpower can affect efficiency increases. The increase in efficiency is also affected by the decrease in downtime due to quality problems so that it can hamper production reaching the target.

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