Improvement of Production Space Layout and Design of Production Assistance

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Abstract

Designing a good layout and having a high efficiency will certainly reduce production costs so as to generate more profits for the company. In PT XYZ, the layout of the machines and departments is still less efficient, which took quite far for the materials to proceed and was also accompanied by the backtracking. According to that statement, the authors do the design a new layout using Activity Relationship Chart, Worksheet, Dimensionless Block Diagram, Activity Relationship Diagram, Area Allocation Diagram, From to Chart, and Material Handling Equipment so, giving the result of a new layout that yields efficiency up to 16% of a type of product. In addition, to support the work of the operator, design tools were carried out using Rapid Entire Body Assessment and Anthropometry methods in making the design of these tools so as to produce a so-called Adjustable Pallet.

Keywords
Activity Relationship Chart, Worksheet, Dimensionless Block Diagram, Activity Relationship Diagram, Area Allocation Diagram,

1. Introduction
PT XYZ which is located on Jalan Mauk Raya KM. 7 Comp. Industri Karet Jaya No. 8 Tangerang is one of the companies engaged in the packaging industry that produces carton packaging or cardboard. PT XYZ produces ready-made cartons used to package products that will be distributed by customers. The carton or cardboard is produced according to customer demand with a variety of types that are quite complex, ranging from various shapes and sizes to the type and thickness of the carton used (Gozali et al. 2012, Hassan et al. 1987, Hamamoto 1999).

Any facilities for the production of machinery, operators and other facilities must be provided in their respective places and production equipment in the factory. Arrangements regarding the layout of factory facilities and work areas is a problem that is often found even cannot be avoided in the industrial world, even for smaller and simpler industries, and can also apply to the existing factory facilities as well as planning facility layout arrangements for new plants. If this arrangement is well planned, it will have a good influence on the efficiency and smoothness of the production process in an industry (Pradana et al. 1984, Kusjak 1987, Fu and Kaku 1997). Based on observations made at PT XYZ, there are several problems that have the potential to disrupt the production process. Problems that occur, one of which is the problem of production layouts that are still less efficient, which causes a buildup of material in a particular process and waiting time between one machine to another. Because the layout arrangement is less efficient, the company will certainly get losses because it takes longer to produce cardboard or carton(Singh 2006, Miller and Gau 1996, Drira and Hajri 2007). The following is a Table 1 of material mileage and time needed to move material in the form of cardboard sheets for small ordinary cardboard types, large ordinary cardboard boxes, small special cardboard boxes and large special cardboard boxes with existing layouts:

Table 1. Material Mileage and Time Needed to Move Material

Product	Distance (m)	Time (seconds)
Ordinary small cardboard boxes	184.8	410.67
Ordinary large cardboard boxes	198	440
Special small cardboard boxes	156	380
Special large cardboard boxes	279	653.34

It should be that with the area of the factory and factory facilities available in the production space layout, it can still be improved to reduce the distance and time of the production process.
Layout problems are not the only problems that occur at PT XYZ. The line production problem is also one of the problems that occur at PT XYZ, including the production process that is less supportive in developing methods of moving goods or Material Handling caused by suboptimal Activity Relationship Charts so that many machines should be closely linked, but in fact, the machines are not near that cause a backtracking process. In addition to these problems, there are fewer ergonomic problems in the production process where the operators are too much activity to lift cartons manually without the help of tools.

The problems above are some of the problems found in the company PT XYZ, and by doing this final project, research is expected to help solve the problems that occur in the company and is expected to help improve the ongoing production process at PT XYZ.

2. Research Method

The research began with direct observations in the PT XYZ production room. After making observations, the problem is formulated based on the problems found. The problem found is that the production space is not well organized, so it interferes with the production activity, especially when transferring material from one post to another post. In addition, the existence of some backtracking found throughout the production process can also cause a decrease in productivity because it requires more time to move the material. For this reason, data collection was carried out in the form of distances between departments and material removal times. The data is then processed and analyzed after the theoretical foundation and methods of Industrial Engineering are applied so that it gets the expected improvement. And the final step is drawing conclusions and suggestions.

3. Results and Discussion

Based on the results of observations and data processing, there are several machines that have the same function but have a placement that can be said to be quite distant namely those are:

1. Cutting roller machine with cutting plong machine that has the same function, which is to cut and form a pattern or indentation of the product.
2. The stitching machine with the glue machine has the same function, which is to glue the piece of cardboard that has a pattern and mould, so the cardboard will look more shaped in accordance with what has been ordered by the customer.
3. Pond butterfly machine with pond roller machine, both machines have the same name, but for pond roller machine, this machine is to make cuts in special-shaped cardboard but has a large size, for example, cardboard guitar instrument. Meanwhile, the pond butterfly machine has the same function as a rolling pond machine, but this machine can only make pieces on specially shaped cardboard that has a small size, such as cardboard of pizza food.

By using the analyzes above, the layout of PT XYZ has 13 departments where the departments are Receiving, Shipping, Office, Raw Material Storage, Finish Good Storage, Warehouse, Printing, Cutting, Flatbed Trimmer/Pond, Stitching/Glue, Binding Machine, Restroom, and Press and Water Treatment. To better know the closeness between departments, the Activity Relationship Diagram becomes the choice to find out the closeness between departments by using equations.

$$N=\frac{n(n-1)}{2} \qquad (1)$$

$$N=\frac{13(13-1)}{2}$$

$$N=78$$

With the following information:
N : Amount of closeness between departments
n : The number of departments

After getting the results of the number of relationships between departments, the next step is to calculate the number of proximity codes for each department, with the following percentage in Table 2:

Table 2. Table Percentage of Proximity between Departments.

Code	Percentage
A	5%
E	10%
I	15%
O	25%
U and X	45%

So, the closeness between departments is obtained from the codes in Table 3 and Table 4:

Table 3. Table of Amounts of Proximity between Departments.

Code	Amount of closeness
A	4
E	8
I	12
O	20
U	46
X	2

Table 4. Table of Department Proximity Reasons

Number	Reason
1	For a better path
2	Material from the current product through these two departments
3	Lane for operator

After calculating the amount of closeness between these departments and the reasons for the qualitative closeness of each department, an Activity Relationship Chart can be obtained which is used to determine the closeness of each department as follows in Figure 1:

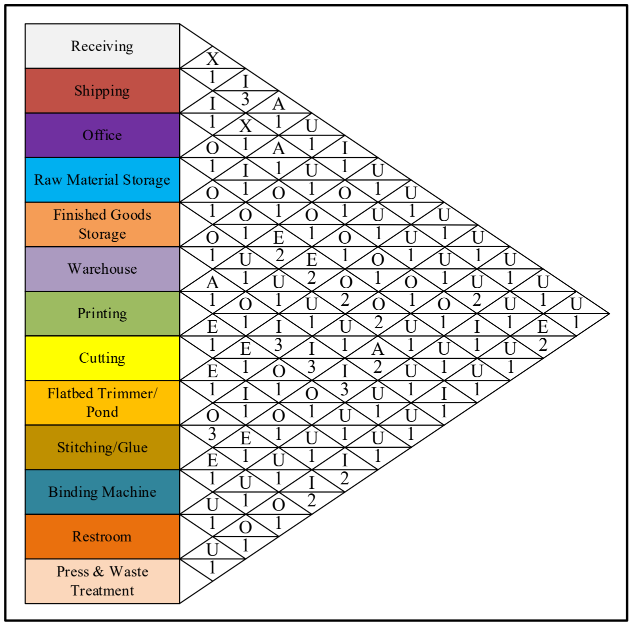

Figure 1. Activity Relationship Chart Diagram.

Activity Relationship Diagrams are very useful for planning and analyzing activity relationships between each department. As a result, the data obtained will then be used to determine the location of each department based on the Activity Relationship Diagram. Basically, this diagram explains the relationship between material flow patterns and the location of each supporting department to its production department. After getting the closeness between the departments of the Activity Relationship Chart diagram, the next step is to create a worksheet for each department to make it easier to interpret the data and to become the basic data for the formation of dimensionless block diagrams (Table 1) and Table 5

Table 5. Table of Department Proximity Reasons.

Activity	A	E	I	O	U	X
Recieving	4		3, 6		5, 7, 8, 9, 10, 11, 12, 13	2
Shipping	5	13	3	7	6, 8, 9, 10, 11, 12	1, 4
Office			1, 2, 5, 12	4, 6, 7, 8, 9, 10, 11	13	
Raw Material Storage	1	7, 8		3, 5, 6, 9, 10	11, 12, 13	2
Finished Good Storage	2, 11		3, 13	4, 6	1, 7, 8, 9 ,10 , 12	
Warehouse	7		1, 9, 10, 11	3, 4, 5, 8	2, 12, 13	
Printing	6	4, 8, 9		2, 3, 10, 11	1, 5, 12, 13	
Cutting		4, 7, 9	10, 13	3 ,6, 11	1, 2, 5, 12	
Flatbed Trimmer / Pond		7, 8, 11	6, 13	3, 4, 10	1, 2, 5, 12	
Stitching / Glue		11	6, 8	3, 4, 7, 9, 13	1, 2, 5, 12	
Binding Machine	5	9, 10	6	3, 7, 8, 13	1, 2, 4, 12	
Restroom			3		1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 13	
Press & Waste Treatment		2	5, 8, 9	10, 11	1, 3, 4, 6, 7, 12	

With data that has been arranged more systematically in a worksheet, a Dimensionless block diagram can be easily created. From the data that has been grouped in a worksheet and then entered into a template activity. Where each template explains the relationship between departments. The template on a Dimensionless block diagram is intended to explain the relationship between production process activities between one department to another, and with a note that the scale for the extent of each department does not need to be considered (Figure 2).

In the preparation process, Dimensionless block diagrams are arranged based on the code listed in the Worksheet table. In the code U (Unimportant) is not counted because it is considered not to give any effect on one activity to the other departments.

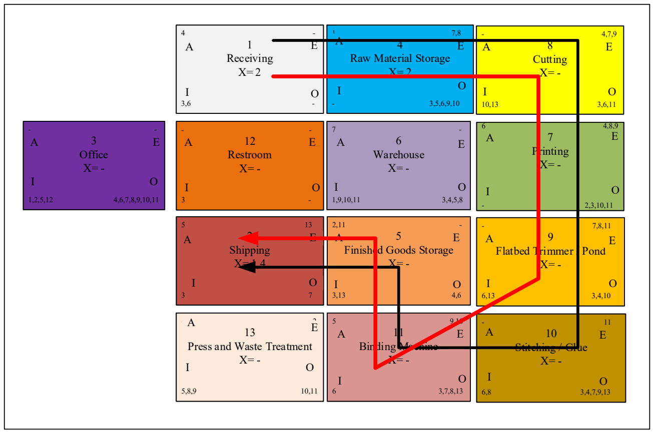

Figure 2. Dimensionless Block Diagram.

After the dimensionless block diagram, the next step is to create an activity relationship diagram that serves to provide a more specific picture of the relationship between departments supported through the activity relationship chart and the dimensionless block diagram where the activity relationship chart does not have the location of each department, and on the dimensionless block diagram there is no specific relationship between one department to another so that activity relationship diagram provide more detailed information, but the size of each block or department have been overlooked (Figure 3).

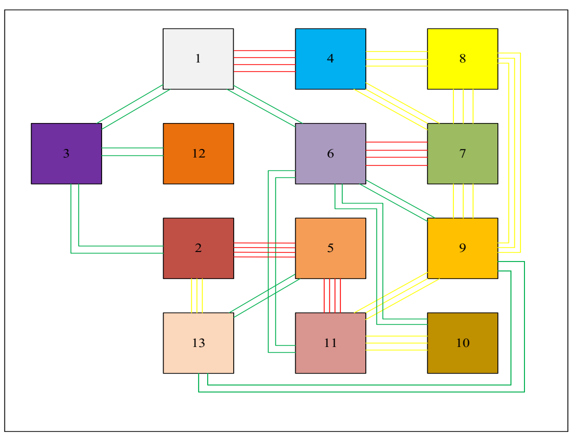

Figure 3. Activity Relationship Diagram.

Next is to use the Area Allocation Diagram, which serves as a place to organize each department in the production room. This arrangement is a continuation of the dimensionless block diagram where in dimensionless block diagrams, there is no size from each department, so the allocating diagram area is very useful so that each department that has been arranged can occupy a place in accordance with the order of production or sequence of interests between departments. Below are some pictures of the area allocating diagram for the production layout at PT XYZ, where the area allocating diagram is useful as a reference for making layouts so that the available layouts also become several layouts so that the best-proposed layouts will be selected for PT XYZ. The area allocating diagram itself has also gotten allowance from each machine and also the department that the allowance has been calculated based on the comparison between the machine and the product that will be processed with the machine. Following is a table of allowances from each machine and also a picture of the area allocating diagram in Table 6.

Table 6. Table of Allowances at Each Department.

Mesin	Jumlah	Ukuran		Luas	Allowance	Keb. Ruang	Total Allowance
		P	L				
Printing Machine	1	10	4	40	300%	120	157,8
Printing Machine	1	6,3	2	12,6		37,8	
Pond Butterfly Machine	2	2,8	2,6	7,28	400%	29,12	101
Pond Gilas Machine	1	4,65	2,3	10,695		42,78	
Cutting	3	3,4	1,45	4,93	500%	24,65	171,3
Gilas Cutting	1	3,1	3,3	10,23		51,15	
Plong	3	2,8	1,1	3,08		15,4	
Glue	1	4,3	1,9	8,17	400%	32,68	68,68
Stitching	6	1,5	1	1,5		6	
Press	1	1,2	1,4	1,68	800%	13,44	107,52
Binding	1	1,1	1,5	1,65	300%	4,95	4,95

The table above shows the length, width and broad of each machine that manufactures cardboard boxes at PT XYZ. Each of these machines has an allowance as a space for the operator to make cardboard cartons. Each department has different broad requirements because the allowance is determined based on the size of the material that is being processed. Based on the allowance table in table 6, an area allocation diagram is then made that showing in more detail the area required for each department, as shown in Figure 4.

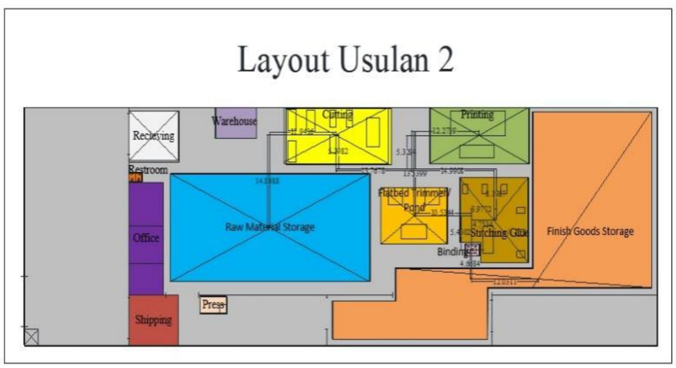

Figure 4. Final Layout Proposal 2.

3.1 Ergonomic Data Processing

From the data in Table 7, Table Dimensions of operator elbow height, the average height of operator elbows obtained which is 102.35 cm, with an example calculation as follows:

$$\bar{X} = \frac{\sum Xi}{N}$$

$$\bar{X} = \frac{2047}{20}$$

$$\bar{X}=102.35$$

The obtained is 102.35 because the tools that will be designed so that each operator working on the stitching machine can be used, the standard deviation for the tools is to use the P50 percentile, which is because when using the P1 percentile, the operator who has the highest elbow height at PT XYZ will be more bent when taking the product that will be input into the stitching machine, as well as when using the P99 percentile, the operator who has the shortest elbow height at PT XYZ will be difficult to reach, or it can be said that both are less effective and efficient to use. Therefore, the P50 percentile is used so that P50 =, then P50 = 102.35.

3.2. Layout Data Processing Analysis

Based on the results of the layout that has been made, the results of the analysis of the distance from the initial layout with the two layouts are as follows in table 7:

Table 7. Table Comparison of Distances from Results of Large Special Cardboard Layout

Large Special Cardboard Comparison					
Layout awal		*Layout* usulan 1		*Layout* usulan 2	
Urutan	Jarak (meter)	Urutan	Jarak (meter)	Urutan	Jarak (meter)
Raw Material – Cutting Gilas	75	Raw Material – Cutting Gilas	34,5	Raw Material – Cutting Gilas	26,8
Cutting Gilas – Printing	54	Cutting Gilas – Printing	24,3	Cutting Gilas – Printing	36
Printing – Pond Gilas	80,4	Printing – Pond Gilas	45,9	Printing – Pond Gilas	25,5
Pond Gilas – Binding	69,6	Pond Gilas – Binding	21,4	Pond Gilas – Binding	15,9
Binding – Finish Good Storage	15	Binding – Finish Good Storage	34,6	Binding – Finish Good Storage	16,6
Total	294	Total	160,7	Total	120,8

After analyzing the results of the comparison between the three layouts, the best layout is the layout of the second proposal, which has the shortest production line, which is for ordinary cartons with a moving distance of 166.1 meters, then for special cartons, the moving distance is 120.5 meters. Therefore, the second proposed layout was chosen as the new layout for PT Perdana Mega Jaya. Based on the layout that has been selected and the speed of the operators that have taken by means of a sample test that is 0.45 so that the resulting comparison of the time the operator runs to move raw materials is as follows in Table 8:

Table 8. Time Comparison Results Table

Initial *layout*		***layout* proposals**	
Type	Time (seconds)	Type	Time (seconds)
Ordinary small cardboard boxes	410.67	Ordinary small cardboard boxes	369.12
Ordinary large cardboard boxes	440	Ordinary large cardboard boxes	369.12
Special small cardboard boxes	380	Special small cardboard boxes	266.67
Large special cardboard boxes	653.34	Large special cardboard boxes	266.67

With a comparison of the transfer time of raw material production as in the table, each process of making cardboard boxes in PT XYZ produces efficiencies of in Table 9:

Table 9. Table Layout Efficiency Results

Type	**Efficiency**
Ordinary small cardboard boxes	11%
Ordinary large cardboard boxes	8%
Special small cardboard boxes	11%
Large special cardboard boxes	16%

From the above Table 9 , it can be concluded that the proposed layout can improve efficiency in the form of a reduction in time, which can increase productivity in producing cardboard cartons. The increase in efficiency of the best production time is for large special cardboard boxes with an efficiency level of 16%. To find out the production time required in the initial layout and comparison with the proposed layout, which has an efficiency of 16%, it can be noted in Table 10 below.

Table 10. Calculation of the Total Time of Making Large Special Cardboard with Initial Layout.

Proses	Raw Material	M1	Cutting	Cumulative Time	M2	Printing	Cumulative Time	M3	Pond	Cumulative Time	M4	Binding	Cumulative Time	M5	Finished Goods
Batch			T1			T2			T3			T4			
1		166,67		166,67											
			409,76	576,43	120,00										
2		166,67		743,10		388,00	1084,43	178,67							
			409,76	1152,87	120,00				942,40	2205,50	154,67				
3		166,67		1319,54		388,00	1660,87	178,67				408,54	2768,71	33,33	
			409,76	1729,30	120,00				942,40	2781,94	154,67				2802,04
4		166,67		1895,97		388,00	2237,30	178,67				408,54	3345,15	33,33	
			409,76	2305,74	120,00				942,40	3358,37	154,67				3378,48
5		166,67		2472,41		388,00	2813,74	178,67				408,54	3921,58	33,33	
			409,76	2882,17	120,00				942,40	3934,81	154,67				3954,91
						388,00	3390,17	178,67				408,54	4498,02	33,33	
									942,40	4511,24	154,67				4531,35
												408,54	5074,45	33,33	
															5107,78

Table 11. Calculation of the Total Time of Making Large Special Cardboard With Proposed Layout.

Proses	Raw Material	M1	Cutting	Cumulative Time	M2	Printing	Cumulative Time	M3	Pond	Cumulative Time	M4	Binding	Cumulative Time	M5	Finished Goods
Batch			T1			T2			T3			T4			
1		59,56		59,56											
			409,76	469,32	80,00										
2		59,56		528,88		388,00	937,32	56,67							
			409,76	938,65	80,00				942,40	1936,39	35,33				
3		59,56		998,21		388,00	1406,65	56,67				408,54	2380,26	36,89	
			409,76	1407,97	80,00				942,40	2405,72	35,33				2417,15
4		59,56		1467,53		388,00	1875,97	56,67				408,54	2849,59	36,89	
			409,76	1877,30	80,00				942,40	2875,04	35,33				2886,48
5		59,56		1936,86		388,00	2345,30	56,67				408,54	3318,91	36,89	
			409,76	2346,62	80,00				942,40	3344,37	35,33				3355,80
						388,00	2814,62	56,67				408,54	3788,24	36,89	
									942,40	3813,69	35,33				3825,13
												408,54	4257,56	36,89	
															4294,45

An example of calculating the processing time for each machine in the above table uses the cycle time data in Table 10 Furthermore, the cycle time is multiplied by the number of cardboard productions, which is 1,000 units divided into five waves because the maximum capacity of the pallet, which is the material transferring media is 200 stacks of cartons. Then, the material removal time is calculated by dividing the material transfer distance in Table 11, so that results are obtained in units of seconds.

$$\text{Akhir-Awal}=N$$

$$\frac{N}{\text{Awal}}\times 100\%$$

$$5107{,}78-4294{,}45=813.33$$

$$\frac{813.33}{5107{,}78}\times 100\%=16\%$$

As shown in Table 11 above, obtained a total production time of 5107.78 seconds in the initial layout. Meanwhile, to carry out the same production process, the proposed layout takes 4294.45 seconds, which means there is a reduction in the production time of 0.8 seconds per unit.

3.3. Analysis of Ergonomic Data Processing

By using anthropometry data where the average elbow height of the production operator is 102.35 cm, the design of tools to help operators of the stitching machine is obtained as follows in Figure 5 and Figure 6:

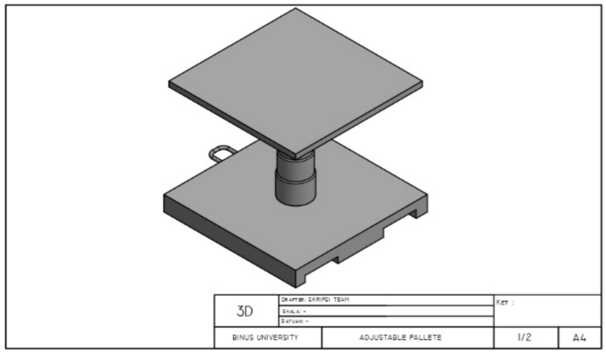

Figure 5. Adjustable Pallet 3D.

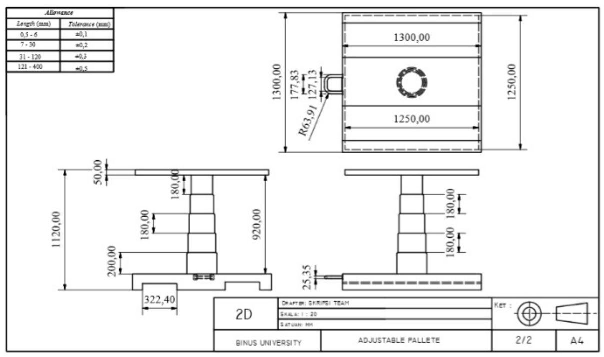

Figure 6. Adjustable Pallet 2D.

Based on the results of data processing in the REBA method, it is known that the process of working on the Stitching machine that is carried out by the operator has a level of risk at the hard level, which means that it immediately requires immediate action. Therefore, to reduce the level of the calculation of REBA in the Microsoft Excel application, a tool called adjustable pallet was made, and the tool has a function to help place the items by the stitching machine. According to the analysis of the motion carried out in the stitching machine, it requires body movements that can exhaust the workers because of repetitive activities, the position of the neck and body bent with high intensity. Because humans have limited physical endurance, this work is not ergonomic and requires tools such as an adjustable pallet (Figure 7).

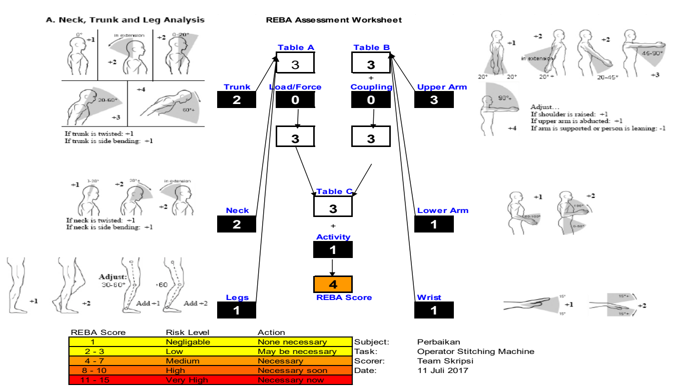

Figure 7. Analysis of REBA after Adding Tools.

After doing the second calculation, after adding an adjustable pallet tool that can eliminate bending and position of the feet and hands because of the function of the tool, this results in a REBA score of 4, which in this process gets a decrease in REBA score.

4. Conclusion and Suggestion

4.1 Conclusion

After making observations, data collection, data processing and data analysis, the following conclusions can be drawn from research at PT XYZ:

1. The best efficient and effective production layout design at PT XYZ is the layout design in Figure 4 .
2. Production productivity efficiency produced by the 2nd proposed layout listed in Table 8, where efficiency of 11% is generated for the type of small ordinary cardboard, an efficiency of 8% for the type of large ordinary cardboard, an efficiency of 11% for special types of small cartons and 16% for large types of special cartons. So that the 2nd proposed production space layout results in better productivity than the initial production space layout.
3. The design tools that can support production activities at PT XYZ are shown in Figure 7, lifting pallet to assist production operators. Where these tools can help the course of production by making operators more supportive of their work which is evident in the proof of REBA that the score is reduced to 4.

4.2 Suggestion

The following are suggestions that can be given to PT XYZ's factory:

1. It is necessary to prepare a special area for Finish Goods to be more organized and make it easier to move finished goods to the shipping area
2. It is necessary to consider replacing equipment or maintenance for equipment that is damaged and old (for example: hand pallet) to facilitate the operator in moving materials.
3. It is necessary to relocate or remove inactive machines from the production area to increase production space so that productivity will increase production.
4. It is necessary to make a large box to hold the remaining pieces of cardboard which can be placed close to the press machine to minimize the need for space to put the remaining pieces of cardboard material so that the environment around the press machine area becomes more organized.

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