Redesigning Spring Beds Production Line With Systematic Layout Planning Method and Promodel Simulation

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Abstract

P.T. Alpha Jaya Manunggal Mandiri is a manufacturing company enganged in the furniture sector. In the spring beds production line, several problems occur with the old Layout as high material handling costs. The distance between workstations is far from each other, and alternating process flow made the production less efficient. In creating a new alternative Layout, a systematic layout planning method was used. In creating a new alternative Layout, the first thing to do is to measure the floor area, make production flow, and measure the production standard time to make the flow process chart and operation process chart. After that, the following process is to forecast the product demand for the next year, which would be used on the routing sheet. The routing sheet is used to calculate the number of machines needed to fulfil the product demand. After that, the alternative Layout can be made using the S.L.P. method by making Activity Relationship Chart, Activity Template Block Diagram, Activity Relationship Diagram, and Area Allocation Diagram. After the new alternative Layout is created, the next step is counting the material handling costs and moving moments to find the Layout with minimum material handling costs and moving moments. Then the last step is using the Promodel software to simulate the new alternative Layout and old Layout to find the increase of products that can be made by using a new alternative layout before the new Layout is implemented in the factory.

Keywords
Layout, Material Handling Costs, Promodel, SLP Method, Spring beds

1. Introduction
P.T. Alpha Jaya Manunggal Mandiri is a manufacturing company engaged in the furniture sector to produce cots, bedframes, spring beds, pillows, etc. The production process on each production line has a different layout based on the process flow and based on the material flow pattern. The reason for using a design in the form of serpentine is that the production process flow is longer than the area to overcome the limited space. Poor Layout can hinder the smooth production process and result in an increase in the time required in the production process, an increase in the time needed in the production process, and an increase in the cost of moving materials. P.T. Alpha Jaya Manunggal Mandiri uses a serpentine material flow pattern in it's spring beds production line.

The Layout used at P.T. Alpha Jaya Manunggal Mandiri is a layout based on the process. This flow was used because of flexibility in allocating equipment and plant operators, minimising the risk of stopping production activities, and being very flexible in producing various types of products. In the spring beds production line at P.T. Alpha Jaya Manunggal Mandiri, several problems occur regarding material handling costs. The distance between workstations is far from each other and has an alternating process flow, making it less efficient. Based on the results of the research conducted with Layout at spring beds production line, the following are the objectives in designing new Layout at spring beds production, which are as follows:

a) Designing new Layout for spring beds production line with Systematic Layout Planning method.
b) Reducing material handling costs and moving moments on spring beds production line.
c) Simulating the selected new Layout and the old Layout with promodel software to calculate the increase in total production and average time in the system.

2. Literature Review

2.1 Flow Process Chart (F.P.C.)
F.P.C. is one of the techniques of work study to illustrate the sequence of activities within a process. It is used to record and analyze the activities that make up a process to determine which add value and do not. Activities can be any operation, inspection, storage, transportation, and delay actions carried out by an individual person, a team, a machine, a computer system, or a combination of all (Gilberth, 1921). F.P.C focus primarily on determining the sequence of tasks (Pycraft, 2000). Usually, the information included in the chart is quantity, distance moved, type of work done, and equipment used (Aft, 2000). There are three types of F.P.C, such as (Rastogi, 2010) :

a) F.P.C material or product type that records the changes of the material or product undergoes in location or condition includes operation and transportation.
b) F.P.C. man type that records the activities of a worker or operator.
c) F.P.C. machine type or equipment type that records the manner in which an equipment or machine is used.

2.2 Bill of Material (B.O.M.)
Bill of Material is a listing of the amount of the material required for the production or manufacture of a product, assembly, or subassembly. The information is recorded in a routing file (Anbuvelan, 2005). It qualifies a product and is also useful for charging costs and can be used as a list of materials that must be issued to production or assembly employees. The Bill of Materials lists the number of components, a mixture of several materials and raw materials needed to produce a finished product. A good Bill of Materials should accurately show information about each input, such as a description component, part number, unit of measure, component description, and lead processing time or order. All items and Bill of Materials (B.O.M.) must be uniquely identified and numbered (Apple, 1977).

2.3 Routing Sheet
A routing sheet is a production step that includes components specific with additional details required in operation by the related matters. The routing sheet becomes the backbone of a production process because this routing sheet becomes the backbone of a production process. This routing sheet is a process of re-collecting all data developed by a sequence of operations routing sheet processes often called with operation sheet. This routing sheet is useful for calculating the number of machines required for the production process and finding the machine's capacity (Ramadhan et.al., 2021). After the routing of a component has been established, the detail plan for each operation can be prepared using operations list that specifies in more detail each individual operation. It is usual for an operations list to be prepared for each workstations listed on the routing sheet, although it may occasionally cover a group of machines in a work cell (Scallan, 2003).

2.4 From to Chart (F.T.C.)
The From to chart (F.T.C.) is a conventional technique commonly used for plant layout planning and material transfer in a production process. From to chart is an adaptation of the mileage chart, which is generally found on a road map, so that it shows the total weight of the load. Sometimes, the F.T.C was, referred to as the trip frequency chart or Travel Chart, is a conventional technique commonly used for plant layout planning and material transfer in a production process. This technique is beneficial for conditions where many items flow through an area, such as job shops, machine shops, offices and others (Wignojosoebroto, 2003). The two most common forms are charts that show the distances between departments and charts that show the quantity of material handling trips per day between departments. A F.T.C. differs from an activity relationship chart in this the F.T.C. is relied on a specific layout (Nahmias, 2015).

2.5 Systematic Layout Planning (S.L.P.)
Systematic layout planning is an organized way to conduct layout planning. It consists of a framework of phases, a pattern of procedures, and conventions for identifying, rating, and visualizing the elements and areas involved in a plan. Also referred to as site layout planning is a tool used to arrange a workplace in a plant by locating areas with

high frequency and logical relationships close to each other (Tjusila et.al., 2021, Bagaskara et.al., 2020). Each layout planning is based on these 3 fundamental things (Muther et.al., 2015):
   a) Relationship which is the relative degree of closeness desired or required among things.
   b) Space which is the amount, kind, and shape or configurations of the things being laid out.
   c) Adjustment, which is the arrangement of things into a realistic best fit.

2.6 Software Promodel

Promodel is a windows-based simulation software used to simulate and analyze a system. Software promodel also is a discrete-event simulation technology that is used to plan, design and improve new or existing manufacturing, logistics and other operational systems. Promodel provides a good combination of usage, flexibility and modelling of an actual condition to make it look more realistic (Ramadhan et.al., 2021). During the simulation, an animated representation of the system appears on the screen and after the simulation, performance measures such as resource utilization, productivity, and inventory levels are tabulated and may be graphed for evaluation (Parsaei et.al., 2002).

3. Methods

In creating a new Layout on the spring beds production line, the steps in creating a new layout using the S.L.P. method. The following are the stages methods of creating a new Layout:
   a) Performing a layout analysis on the spring bed production line at P.T. Alpha Jaya Manunggal Mandiri.
   b) Calculating spring beds production time by calculating cycle time, normal time, and standard time of spring beds production.
   c) Making the flow process chart of spring beds production based on the standard time of spring beds production.
   d) Making the Bill of Material in the production of spring beds based on the level of each material.
   e) Forecasting demand of spring beds products for the next year using software Q.M. for windows V5.
   f) Making a routing sheet of the spring beds production process for next year based on the number of product requests.
   g) Making multi-product process chart in spring beds production.
   h) Determining the actual number of machines required in the production of spring beds.
   i) Creating from chart inflow and from chart outflow to determine the relationship between workstations.
   j) Making a priority scale between workstations based on the chart created.
   k) Creating a new layout on a spring beds production line using the Systematic Layout Planning (S.L.P.) method.
   l) Comparing the alternative new Layout with the old Layout based on the moment of movement and material handling costs.
   m) Simulating the new Layout and the old Layout using Promodel Software.
   n) Comparing the total amount of production and average time in the system from the Promodel simulation.
   o) Implementing the new Layout on the spring beds production line.

The methods of creating a new Layout are formed into a flowchart. The flowchart for creating a new Layout can be seen in Figure 1.
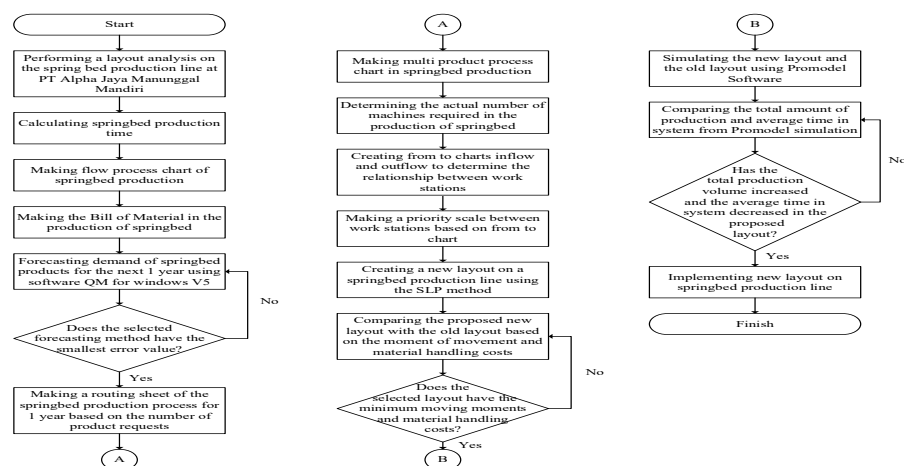
Figure 1. Flowchart Creating New Layout

4. Data Collection

4.1 Initial Layout
The initial Layout of the production floor of P.T. Alpha Jaya Manunggal Mandiri can be seen in Figure 2.
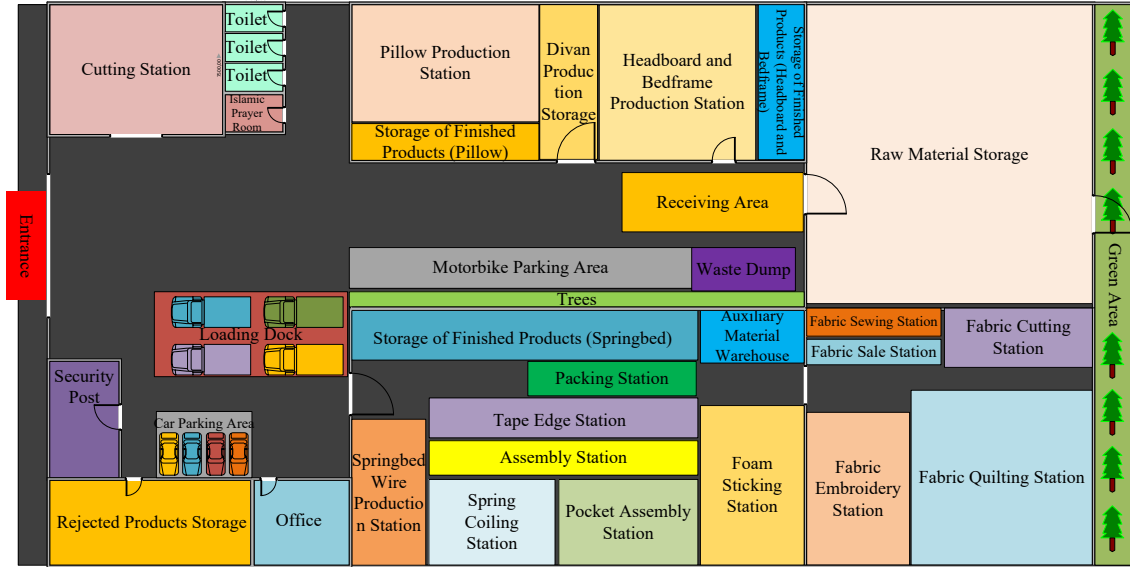

Figure 2. Initial Layout P.T. Alpha Jaya Manunggal Mandiri

4.2 Floor Area
Based on data collection on the spring beds production floor of P.T. Alpha Jaya Manunggal Mandiri, researchers obtained data on the area production floor is 1824,578 m^2. The following is the area data of each department at the spring beds production line of P.T. Alpha Jaya Manunggal Mandiri, which can be seen in Table 1.

Table 1. Floor Area of Spring Beds Production P.T. Alpha Jaya Manunggal Mandiri

Department	Department Area
Floor Production	499.281
Raw Material Storage	823.257
Auxiliary Material Warehouse	184.21
Storage of Finished Products	317.83
TOTAL AREA WITHOUT ROADS	1824.578
Allowance	20%
TOTAL AREA WITH ROADS	2189.494

4.3 Production Flow
The flow of the spring beds production process in P.T. Alpha Jaya Manunggal Mandiri can be seen in Figure 3.
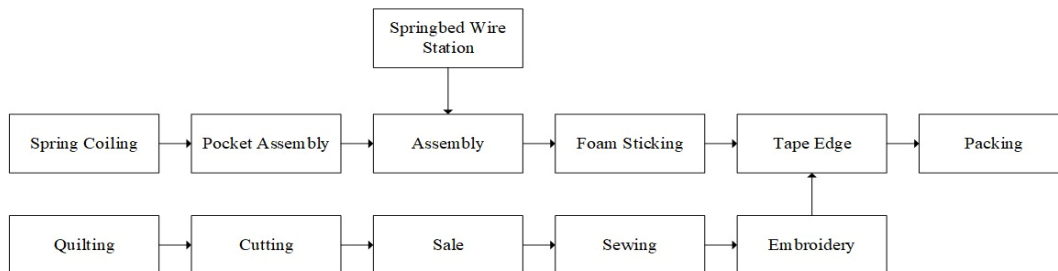

Figure 3. Spring Beds Production Flow

The production flow for the springbed frame start from the spring coiling machine to pocket assembly machine and then continue to the assembly station. In the springbed assembly station the springbed wire and springbed frame were assembled and then continue moving to the foam sticking station and then into the tape edge station. The springbed fabric were move from the quilting station to the cutting station to the sale station and sewing station and finally go to embroidery station which then move to tape edge process and then finally go to packing station.

4.4 Operation Process Chart

Operation Process Chart (O.P.C.) determines the spring beds production process at P.T. Alpha Jaya Manunggal Mandiri. Operation Process Chart (O.P.C.) of spring beds production can be seen in Figure 4.
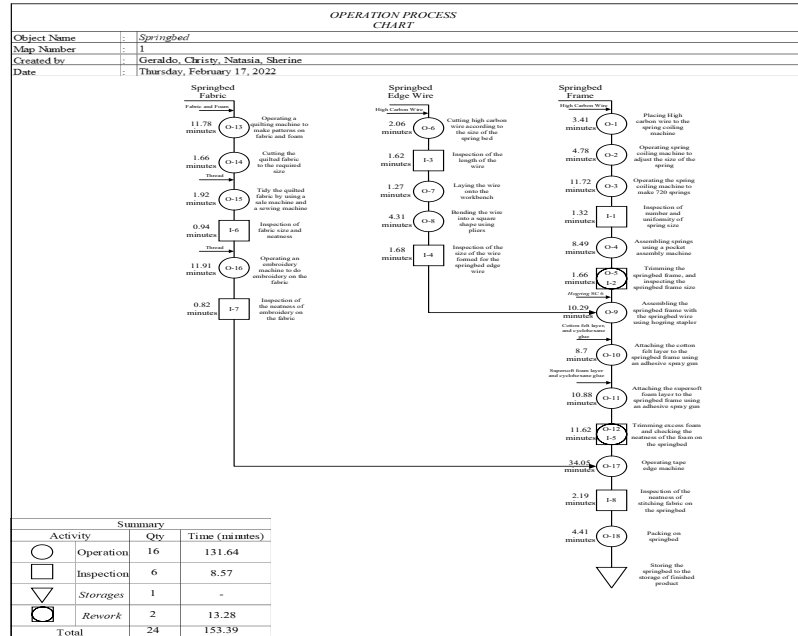

Figure 4. Operation Process Chart

4.6 Product Demand

The forecasting for product demand year 2022 uses the quadratic method because this method has the smallest error value of any other method. Forecasting was done using software Q.M. for Windows V5. The demand for the spring beds can be seen in Table 2.

Table 2. Demand of Spring beds Product

Number	Month	Total (Pieces)
1	January (2022)	1409
2	February (2022)	1434
3	March (2022)	1435
4	April (2022)	1445
5	May (2022)	1434
6	June (2022)	1462
7	July (2022)	1450
8	August (2022)	1479
9	September (2022)	1510
10	October (2022)	1523
11	November (2022)	1526
12	December (2022)	1547
Total Request		17654

5. Results and Discussion

5.1 Numerical Results

In creating a new Layout for the spring beds production line, it is necessary to calculate the number of machines needed based on the product demand forecast from Table 3. In calculating the number of machines, researchers used a routing sheet. The routing sheet of spring beds production can be seen in Table 3.

Table 3. Routing Sheet of Spring beds Production

Operation	Activity Name	Machine Name (Tool)	Standard Time (minutes)	Machine Set-up Time (minutes/days)	Scrap Percent (%)	Expected Amount	Prepared Amount	Reliability (%)	Amount After Reliability	Efficiency (%)	Amount After Efficiency	Theoretical Machine Capacity/Days	Theoretical Machine Amount/Days
						Springbed Frame							
O-1	Placing high carbon wire to the spring coiling machine	Spring Coiling Machine	3.4	5	0%	71.10249	71.10249	95%	74.84473	95%	78.78393	139.70588	0.56393
O-2	Adjusting the size of the spring which made using spring coiling machine	Spring Coiling Machine	4.8	30	5%	67.54737	71.10249	95%	74.84473	95%	78.78393	93.75000	0.84036
O-3	Making 720 springs	Spring Coiling Machine	12.9	15	5%	64.17000	67.54737	95%	71.10249	95%	74.84473	36.04651	2.07634
I-1	Inspection of number and uniformity of spring size	Spring Coiling Machine	2.0	0	0%	64.17000	64.17000	95%	67.54737	95%	71.10249	240.00000	0.29626
O-4	Assembling springs using a pocket assembly machine	Assembly Pocket Machine	8.3	20	3%	62	64.17000	95%	67.54737	95%	71.10249	55.42169	1.28294
O-5	Trimming the springbed frame	Assembly Pocket Machine	2.4	0	0%	62.2449	62	95%	66	95%	68.96942	200.00000	0.34485
I-2	Inspecting the springbed frame size							95%		95%			
O-9	Assembling the springbed frame with the springbed wire using hogring stapler	Workbench 3	10.2	0	2%	61.00000	62.24490	95%	65.52095	95%	68.96942	47.05882	1.46560
O-10	Attaching the cotton felt layer to the springbed frame using an adhesive spray gun	Workbench 4	8.800	0	0%	61.00000	61.00000	95%	64.21053	95%	67.59003	54.54545	1.23915
O-11	Attaching the supersoft foam layer to the springbed frame using an adhesive spray gun	Workbench 4	10.8	0	0%	61	61.00000	95%	64.21053	95%	67.59003	44.44444	1.52078
O-12	Trimming excess foam	Workbench 4	11.800	0	2%	59.37500	61	95%	64	95%	67.13212	40.67797	1.65033
I-5	Checking the neatness of the foam on the springbed							95%		95%			
O-17	Operating tape edge machine	Workbench 5	33.1	15	4%	57.00000	59.37500	95%	62.50000	95%	65.78947	14.04834	4.68308
I-8	Inspection of the neatness of stitching fabric on the springbed	Workbench 5	2.3	0	0%	57.00000	57.00000	95%	60.00000	95%	63.15789	208.69565	0.30263
O-18	Packing on springbed	Workbench 6	4.5	0	0%	57	57.00000	95%	60.00000	95%	63.15789	106.66667	0.59211
						Springbed Edge Wire							
O-6	Cutting high carbon wire according to the size of the spring bed	Workbench 2	3.000	1	2%	115.15152	117.50155	95%	123.68584	95%	130.19562	159.66667	0.81542
I-3	Inspection of the length of the wire	Workbench 2	2.1	0	0%	115.15152	115.15152	95%	121.21212	95%	127.59171	228.57143	0.55821
O-7	Laying the wire onto the workbench	Workbench 2	1.4	0	0%	115.15152	115.15152	95%	121.21212	95%	127.59171	342.85714	0.37214
O-8	Bending the wire into a square shape using pliers	Workbench 2	4.400	1	1%	114.00000	115.15152	95%	121.21212	95%	127.59171	108.86364	1.17203
I-4	Inspection of the size of the wire formed for the springbed edge wire	Workbench 2	2.4	0	0%	114.00000	114	95%	120.00000	95%	126.31579	200.00000	0.63158
						Spring bed							
O-13	Operating a quilting machine to make patterns on fabric and foam	Quiting Machine	12.4	20	5%	64	67	95%	70.65787	95%	74.37671	37.09677	2.00494
O-14	Cutting the quilted fabric to the required size	Workbench 1	1.7	0	3%	62	64	95%	67.12498	95%	70.65787	282.35294	0.25025
O-15	Tidy the quilted fabric by using a sale machine and a sewing machine	Sale Machine and Sewing Machine	2.3	7	3%	60	62	95%	65.11123	95%	68.53814	205.65217	0.33327
I-6	Inspection of fabric size and neatness	Sale Machine and Sewing Machine	1.6	0	0%	60	60	95%	63.15789	95%	66.48199	300.00000	0.22161
O-16	Operating an embroidery machine to do embroidery on the fabric	Embroidery Machine	10.7	20	5%	57	60	95%	63.15789	95%	66.48199	42.99065	1.54643
I-7	Inspection of the neatness of embroidery on the fabric	Embroidery Machine	1.3	0	0%	57	57	95%	60.00000	95%	63.15789	369.23077	0.17105

From the routing sheet, the number of machines can be calculated. The number of machines needed for the spring beds production can be seen in Table 4.

Table 4. Number of Machines Needed

Number	Tool / Machine	Tool / Machine Description	Total of Theoretical Machines	Total of Actual Machines
1	Quilting Machines	Quilting Machines	2.00494	3
2	Sale Machine	Sale Machine	0.33227	1
3	Embroidery Machine	Embroidery Machine	1.14643	2
4	Spring Coiling Machines	Spring Coiling Machines	2.07634	3
5	Assembly Pocket Machines	Assembly Pocket Machines	1.28294	2
6	Sewing Machine	Sewing Machine	0.22161	1
7	Workbench 1	Scissors, Cutter, Ruler	0.25025	1
8	Workbench 2	Plier, High carbon wire	1.17203	2
9	Workbench 3	Hog ring gun, Hog ring gun SC 6	1.4656	2
10	Workbench 4	Adhesive gun sprayer, Cyclohexane glue	3.94821	4
11	Workbench 5	Tape edge, Thread, Protective Tape	4.68308	5
12	Workbenchs 6	PE plactic, scissors	0.53211	2

5.2 Graphical Results

The new alternative Layout was created using the S.L.P. method. The Layout was created by making A.R.C. to figure out the closeness between workstations. After that S.L.P. method continues by making the Activity Template Block Diagram a template containing activity centres and the level of relationship between each workstation. Then create the Activity Relationship Diagram, which is the diagram of the relationship between workstations based on a priority scale table. Then the last one is making the Area Allocation Diagram a global layout that describes the relationship between work stations on a spring beds production line with the actual floor area size scale. The Activity Relationship Chart for the company can be seen in Figure 5.
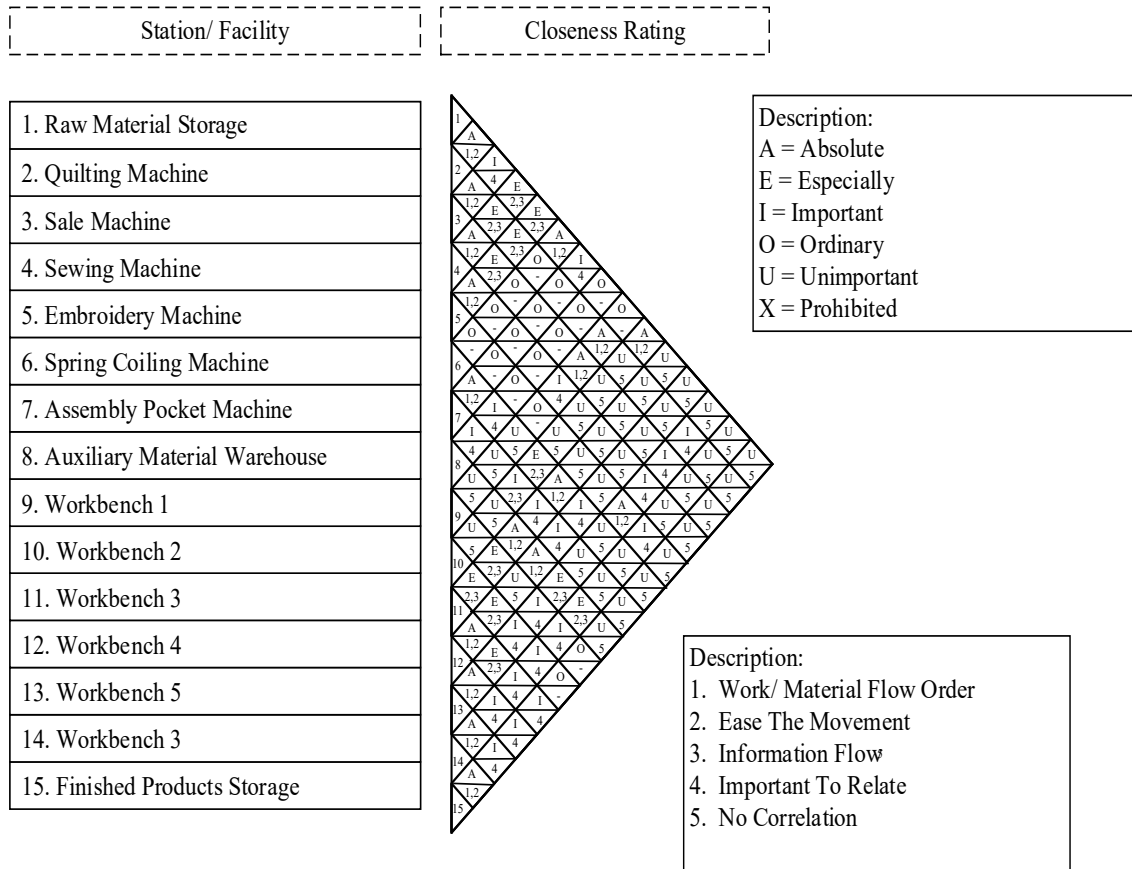

Figure 5. Activity Relationship Chart

The S.L.P. method continues from the Activity Relationship Chart by making the Activity Template Block Diagram. The Activity Template Block Diagram was created based on the Activity Relationship Chart. The activity Template Block Diagram can be seen in Figure 6.

Figure 6. Activity Template Block Diagram

The Activity Relationship Diagram can then be made from the Activity Template Block Diagram. The Activity Relationship Diagram was created based on the Activity Template Block Diagram worksheet. The Activity Relationship Diagram was created in 2 different posititon so the alternative Layout can be made in 2 forms with different positions using the S.L.P. method. The Activity Relationship Diagram can be seen in Figure 7.

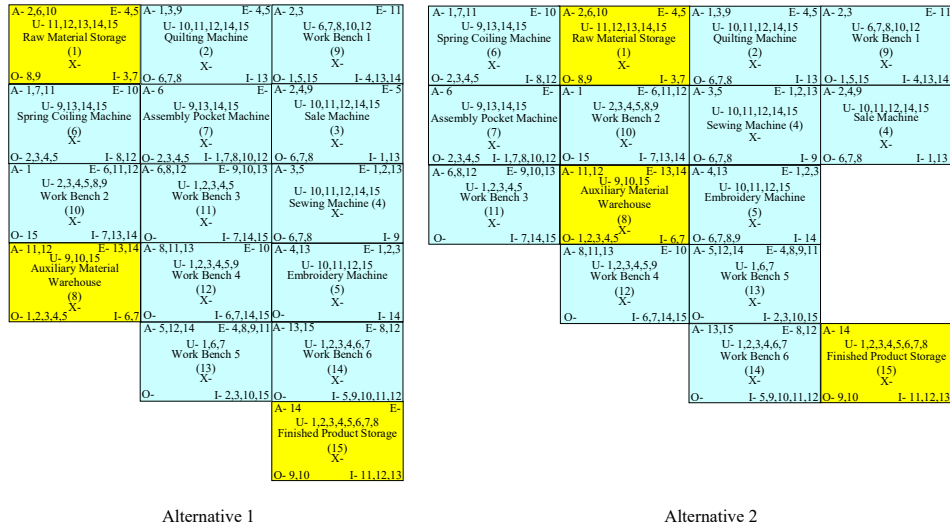Alternative 1   Alternative 2

Figure 7. Activity Relationship Diagram

After making the Activity Relationship Diagram, the S.L.P. method continues by making Area Allocation Diagram from the two forms of alternative Layout. The Area Allocation Diagram can be seen in Figure 8.
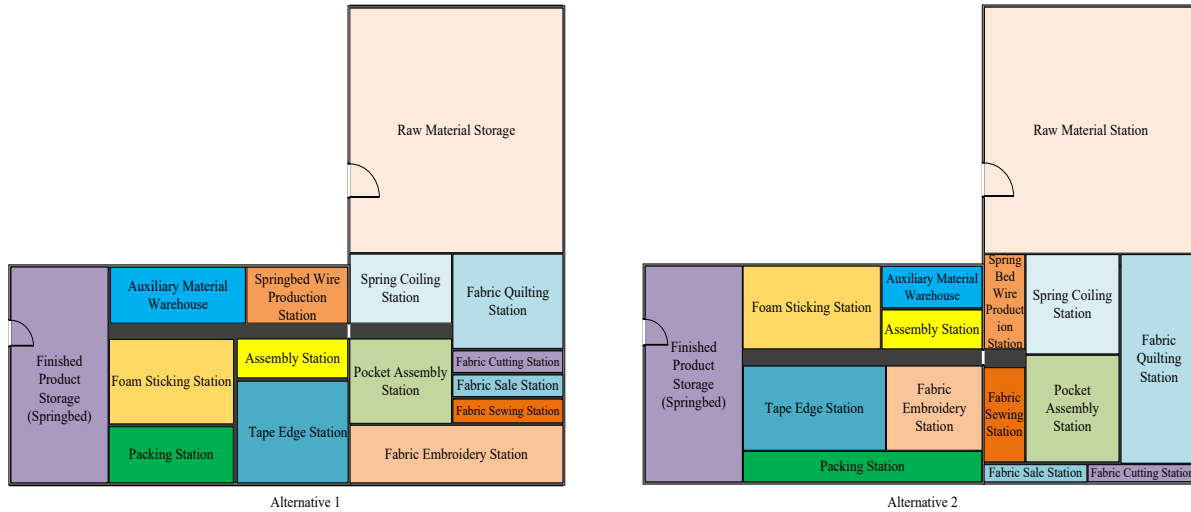
Figure 8. Area Allocation Diagram

After making the Area Allocation Diagram, the final step of the S.L.P. method was creating the new alternative Layout. The alternative Layout was built in 2 forms that can be seen in Figure 9.
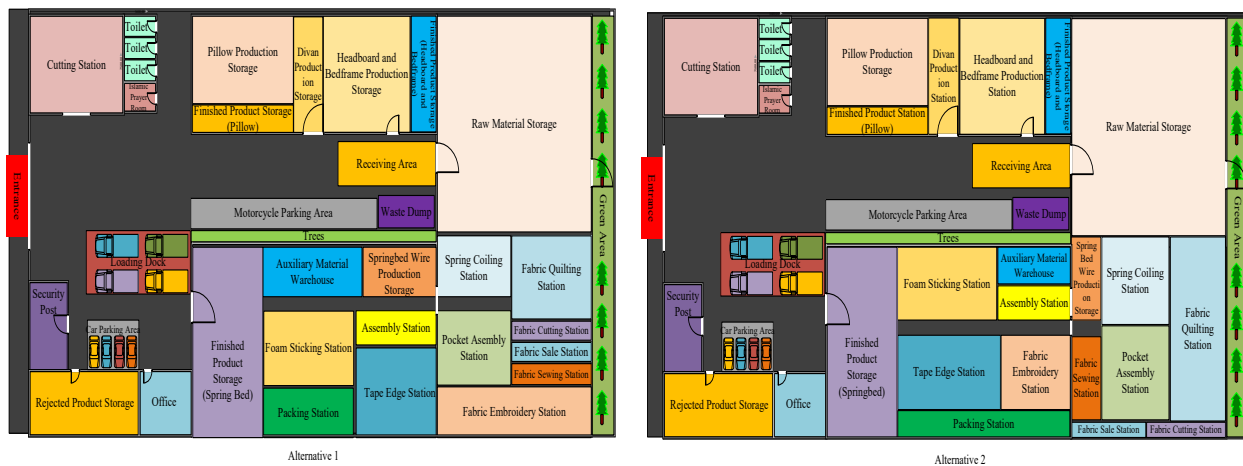
Figure 9. New Alternative Layout

5.3 Material Handling Cost

From the alternative Layout that has been made, the calculation of material handling costs and moving moments is carried out to select the new Layout with minimum material handling costs and moving moments. The calculation of material handling costs on the old Layout can be seen in Table 5, material handling costs on the alternative Layout 1 can be seen in Table 6, and material handling costs on the alternative Layout 2 can be seen in Table 7.

Table 5. Material Handling Costs Old Layout

From	To	Distance (m)	Material	Material Handling	Amount to be moved	Unit	Unit Load	Frequency / Day	Moving Moments (m)	Material Handling Cost (USD)	Material Handling Cost per day (USD)	Material Handling Cost per week (USD)
Raw Material Storage	Spring Coiling Machine	16.00	High Carbon Wire	Carlift	2.375	Pieces	1	2.38	38.08	0.24	9.02	45.1
Spring Coiling Machine	Assembly Pocket Machine	2.50	Spring	Hand Pallet	41040	Pieces	720	57	142.5	0.02	2.85	14.25
Assembly Machine	Work Bench 3	2.00	Springbed Frame	Hand Pallet	57	Pieces	1	57	114	0.02	2.28	11.4
Raw Material Storage	Work Bench 2	19.00	High Carbon Wire	Carlift	1	Pieces	1	1	19	0.24	4.5	22.5
Work Bench 2	Work Bench 3	2.50	Springbed Wire	Hand Pallet	114	Pieces	15	7.6	19	0.02	0.38	1.9
Work Bench 3	Work Bench 4	3.50	Springbed Frame	Hand Pallet	57	Pieces	1	57	199.5	0.02	3.99	19.95
Auxiliary Material Warehouse	Work Bench 4	2.00	Cotton Felt Layer and Supersoft Foam Layer	Hand Pallet	456	Pieces	6	76	152	0.02	3.04	15.2
Work Bench 4	Work Bench 5	2.50	Springbed	Hand Pallet	57	Pieces	1	57	142.5	0.02	2.85	14.25
Raw Material Storage	Quilting Machine	8.00	Fabric and Foam	Hand Pallet	6	Rolls	2	3	24	0.02	0.48	2.4
Quilting Machine	Work Bench 1	1.50	Quilting Fabric	Hand Pallet	3	Rolls	2	1.5	2.25	0.02	0.05	0.25
Work Bench 1	Sale Machine	1.00	Quilting Fabric	Hand Pallet	228	Pieces	8	28.5	28.5	0.02	0.57	2.85
Sale Machine	Sewing Machine	0.50	Quilting Fabric	Hand Pallet	228	Pieces	8	28.5	14.25	0.02	0.29	1.45
Sewing Machine	Embroidery Machine	2.50	Quilting Fabric	Hand Pallet	57	Pieces	8	7.13	17.825	0.02	0.36	1.8
Embroidery Machine	Work Bench 5	5.50	Embroidery Fabric	Hand Pallet	57	Pieces	10	5.7	31.35	0.02	0.63	3.15
Work Bench 5	Work Bench 6	1.50	Springbed	Hand Pallet	57	Pieces	1	57	85.5	0.02	1.71	8.55
Work Bench 6	Finished Product Storage	2.50	Springbed	Hand Pallet	57	Pieces	1	57	142.5	0.02	2.85	14.25
Total		73.00							1172.76		35.85	179.25

Table 6. Material Handling Costs Alternative Layout 1

From	To	Distance (m)	Material	Material Handling	Amount to be moved	Unit	Unit Load	Frequency / Day	Moving Moments (m)	Material Handling Cost (USD)	Material Handling Cost per day (USD)	Material Handling Cost per week (USD)
Raw Material Storage	Spring Coiling Machine	3.00	High Carbon Wire	Carlift	2.375	Pieces	1	2.38	7.14	0.24	1.69	8.45
Spring Coiling Machine	Assembly Pocket Machine	2.50	Spring	Hand Pallet	41040	Pieces	720	57	142.5	0.02	2.85	14.25
Assembly Machine	Work Bench 3	3.50	Springbed Frame	Hand Pallet	57	Pieces	1	57	199.5	0.02	3.99	19.95
Raw Material Storage	Work Bench 2	6.50	High Carbon Wire	Carlift	1	Pieces	1	1	6.5	0.24	1.54	7.7
Work Bench 2	Work Bench 3	2.50	Springbed Wire	Hand Pallet	114	Pieces	15	7.6	19	0.02	0.38	1.9
Work Bench 3	Work Bench 4	1.50	Springbed Frame	Hand Pallet	57	Pieces	1	57	85.5	0.02	1.71	8.55
Auxiliary Material Warehouse	Work Bench 4	1.50	Cotton Felt Layer and Supersoft Foam Layer	Hand Pallet	456	Pieces	6	76	114	0.02	2.28	11.4
Work Bench 4	Work Bench 5	1.50	Springbed	Hand Pallet	57	Pieces	1	57	85.5	0.02	1.71	8.55
Raw Material Storage	Quilting Machine	3.00	Fabric and Foam	Hand Pallet	6	Rolls	2	3	9	0.02	0.18	0.9
Quilting Machine	Work Bench 1	1.00	Quilting Fabric	Hand Pallet	3	Rolls	2	1.5	1.5	0.02	0.03	0.15
Work Bench 1	Sale Machine	1.00	Quilting Fabric	Hand Pallet	228	Pieces	8	28.5	28.5	0.02	0.57	2.85
Sale Machine	Sewing Machine	1.00	Quilting Fabric	Hand Pallet	228	Pieces	8	28.5	28.5	0.02	0.57	2.85
Sewing Machine	Embroidery Machine	1.50	Quilting Fabric	Hand Pallet	57	Pieces	8	7.13	10.695	0.02	0.21	1.05
Embroidery Machine	Work Bench 5	8.50	Embroidery Fabric	Hand Pallet	57	Pieces	10	5.7	48.45	0.02	0.97	4.85
Work Bench 5	Work Bench 6	1.50	Springbed	Hand Pallet	57	Pieces	1	57	85.5	0.02	1.71	8.55
Work Bench 6	Finished Product Storage	2.00	Springbed	Hand Pallet	57	Pieces	1	57	114	0.02	2.28	11.4
Total		42.00							985.79		22.67	113.35

Table 7. Material Handling Costs Alternative Layout 2

From	To	Distance (m)	Material	Material Handling	Amount to be moved	Unit	Unit Load	Frequency / Day	Moving Moments (m)	Material Handling Cost (USD)	Material Handling Cost per day (USD)	Material Handling Cost per week (USD)
Raw Material Storage	Spring Coiling Machine	3.00	High Carbon Wire	Carlift	2.375	Pieces	1	2.38	7.14	0.24	1.69	8.45
Spring Coiling Machine	Assembly Pocket Machine	2.50	Spring	Hand Pallet	41040	Pieces	720	57	142.5	0.02	2.85	14.25
Assembly Machine	Work Bench 3	4.50	Springbed Frame	Hand Pallet	57	Pieces	1	57	256.5	0.02	5.13	25.65
Raw Material Storage	Work Bench 2	3.00	High Carbon Wire	Carlift	1	Pieces	1	1	3	0.24	0.71	3.55
Work Bench 2	Work Bench 3	3.00	Springbed Wire	Hand Pallet	114	Pieces	15	7.6	22.8	0.02	0.46	2.3
Work Bench 3	Work Bench 4	1.25	Springbed Frame	Hand Pallet	57	Pieces	1	57	71.25	0.02	1.43	7.15
Auxiliary Material Warehouse	Work Bench 4	1.25	Cotton Felt Layer and Supersoft Foam Layer	Hand Pallet	456	Pieces	6	76	95	0.02	1.9	9.5
Work Bench 4	Work Bench 5	2.00	Springbed	Hand Pallet	57	Pieces	1	57	114	0.02	2.28	11.4
Raw Material Storage	Quilting Machine	3.00	Fabric and Foam	Hand Pallet	6	Rolls	2	3	9	0.02	0.18	0.9
Quilting Machine	Work Bench 1	1.00	Quilting Fabric	Hand Pallet	3	Rolls	2	1.5	1.5	0.02	0.03	0.15
Work Bench 1	Sale Machine	1.00	Quilting Fabric	Hand Pallet	228	Pieces	8	28.5	28.5	0.02	0.57	2.85
Sale Machine	Sewing Machine	1.00	Quilting Fabric	Hand Pallet	228	Pieces	8	28.5	28.5	0.02	0.57	2.85
Sewing Machine	Embroidery Machine	2.00	Quilting Fabric	Hand Pallet	57	Pieces	8	7.13	14.26	0.02	0.29	1.45
Embroidery Machine	Work Bench 5	2.50	Embroidery Fabric	Hand Pallet	57	Pieces	10	5.7	14.25	0.02	0.29	1.45
Work Bench 5	Work Bench 6	1.25	Springbed	Hand Pallet	57	Pieces	1	57	71.25	0.02	1.43	7.15
Work Bench 6	Finished Product Storage	1.75	Springbed	Hand Pallet	57	Pieces	1	57	99.75	0.02	2	10
Total		34.00							979.20		21.81	109.05

5.4 Proposed Improvements

Based on this research, the purpose of a new Layout to produce spring beds at P.T. Alpha Jaya Manunggal Mandiri is high material handling cost. The location between workstations is far from each other, which makes the moving moments of spring beds production line is high. By using the alternative new Layout at P.T. Alpha Jaya Manunggal Mandiri, this new alternative Layout can decrease the material handling costs and also reduce the moving moments during the production process. The summary of the layout design calculation can be seen in Table 8.

Table 8. Summary of Layout Design Calculation

Layout Design	Factory Area (m²)	Distance (m)	Moving Moments (m)	Material Handling Costs per Week
Old Layout	1824.578	73	1172.76	$ 179.25
Alternative Layout 1	1824.578	42	985.79	$ 113.35
Alternative Layout 2	1824.578	34	979.2	$ 109.05

The alternative Layout for alternative 1 and alternative 2, can decrease the moving moments and the material handling costs per week. The material handling costs and moving moments on the spring beds production line was significantly reduced from the alternative Layout. Alternative Layout 1 decreases the material handling costs become $ 113.35 which decreased by 36.76% with moving moments decreased to 985.79 meters which decreased by 15.94%, and decrease the distance for springbed production process to 42 meters which decreased by 42.47%. The alternative layout 2 decrease the material handling costs to $ 109.05 which decreased by 39.16%, decreased the moving moments 979.2 meters which decreased by 16.51%, and decreased the distance for springbed production process to 34 meters which decreased by 53.42%. From the alternative 1 and alternative 2 the decrease of distance, moving moments, and material handling costs. The alternative layout 2 can decrease the distance, moving moments, and material handling costs greater than the alternative layout 1. So the alternative layout 2 was choosen as the new layout for springbed production line.

5.5 Validation

The validation was done using Promodel software to compare the old Layout and the new alternative Layout. The promodel simulation of the old Layout can be seen in Figure 10, and the new alternative Layout can be seen in Figure 11.
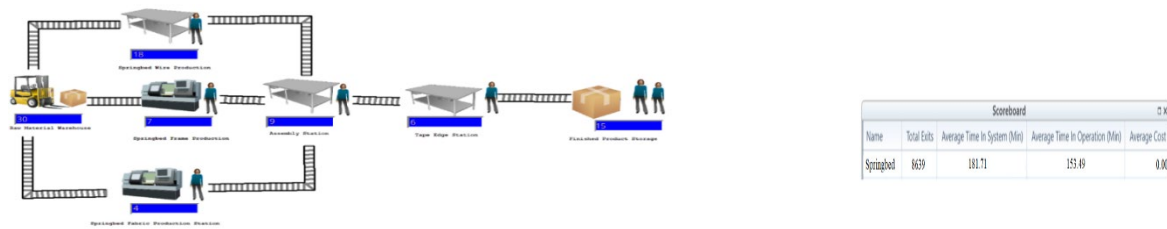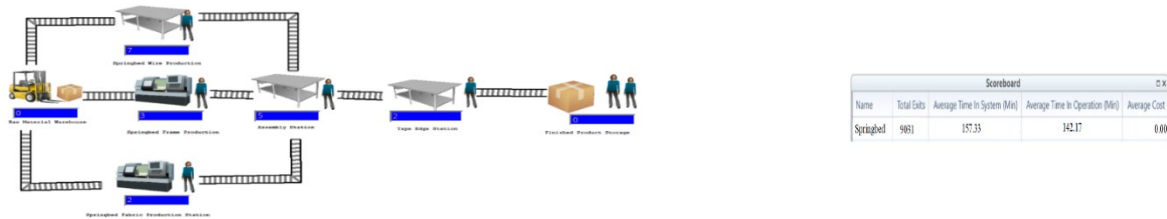
Figure 10. Promodel Simulation Old Layout

Figure 11. Promodel Simulation New Alternative Layout

From the Promodel simulation, the choosen alternative layout reducing the material handling costs, increase the production efficiency by reducing movements and decreasing average production time. By increasing the springbed production efficiency, the total product that can be produced each year have increase by using the new alternative layout. The summary of implementing the new layout for springbed production process can be sen in Table 9.

Table 9. Summary of Layout Design Calculation

Layout Design	Factory Area (m²)	Distance (m)	Moving Moments (m)	Material Handling Costs per Week	Average Time in System (Minute)	Average Time in Operation (Minute)	Total Production per Year
Old Layout	1824.578	73	1172.76	$ 179.25	181.71	153.49	8639
New Layout	1824.578	34	979.2	$ 109.05	157.33	142.17	9031
Percentage Increase/ Decrease	0%	-53.42%	-16.51%	-39.16%	-13.42%	-7.37%	4.54%

By implementing the new alternative Layout, the total production that can be made is increased from 8639 units each year to 9013 units each year. Total production of the spring beds was incereased by 4.54%, the average time in the system of spring beds production decreased from 181.71 minutes to 157.33 minutes, which lowered the average time in the system by 13.42%. The average time in the operation of spring beds production decreased from 153.49 minutes to 142.17 minutes, which lowered the average time in the operation by 7.37%. The material handling costs decreased from $ 179.25 to $ 109.05 which decreased the material handling costs by 39.16%. The moving moments and distance on springbed production process also decreased. The moving moments decreased from 1172.76 m to 979.2 m which decreased by 16.51%, and the distance decreased from 73 m to 34 m which decreased by 53.42%.

6. Discussion
Layout used on creating the proposed layout is product layout which created using Systematic Layout Planning method (S.L.P.). From the routing sheet the number of machine required with the number of machine available on the factory it's fulfilled. With the new factory layout there were some decrease on the material handling cost, decrease on the moving moments and the distance. Promodel simulation have decrease on the production time and increase the product that can be produce. So it can be known using the new layout could increase the springbed production line productivity.

7. Conclusion

From the new alternative layout created by using Systematic Layout Planning (S.L.P.) Method. The new alternative layout has been made in 2 forms called alternative layout 1 and alternative layout 2. The material handling costs and moving moments on the spring beds production line was significantly reduced from the alternative Layout. Alternative Layout 1 decreases the material handling costs become $ 113.35 with moving moments 985.79 meters, and alternative layout 2 decrease the material handling costs to Rp. $ 109.05 with moving moments 979.2 meters. The choosen Layout was alternative layout 2 because having the least material handling costs per week and the least moving moments. The old layout and chosen alternative layout were simulated using Promodel software. From the simulation, by implementing the new alternative Layout, the total production that can be made is increased from 8639 units each year to 9013 units each year. Total production of the spring beds was incereased by 4.54%, the average time in the system of spring beds production decreased from 181.71 minutes to 157.33 minutes, which lowered the average time in the system by 13.42%. The average time in operation of spring beds production decreased from 153.49 minutes to 142.17 minutes, which lowered the average time in operation by 7.37%. The material handling costs decreased from $ 179.25 to $ 109.05 which decreased the material handling costs by 39.16%. The moving moments and distance on springbed production process also decreased. The moving moments decreased from 1172.76 m to 979.2 m which decreased by 16.51%, and the distance decreased from 73 m to 34 m which decreased by 53.42%.

References

Apple, James M. *Print Layout and Materials Handling.* New York: John Wiley and Sons. (1977).

Aft, L.S. *Work Measurement and Methods Improvement (Engineering Design and Automation)*. Canada: Wiley. (2000).

Anbuvelan, K. (2005). *Management Concepts for Civil Engineer*. New Delhi: Laxmi Publications Pvt Limited.

Bagaskara, K. B., Gozali, L., & Widodo, L. *Redesign Layout Planning Of Raw Material Area And Production Area Using Systematic Layout Planning (SLP) Methods (Case Study Of CV Oto Boga Jaya)*. In IOP Conference Series: Materials Science and Engineering (Vol. 852, No. 1, p. 012122). IOP Publishing. (2020, July).

Gilberth, Frank Bunker. *Process Chart*. U.S.A: American Society of Mechanical Engineers. (1921).

Gozali, L., Widodo, L., Nasution, S. R., & Lim, N. *Planning the New Factory Layout of PT Hartekprima Listrindo using Systematic Layout Planning (SLP) Method*. In IOP Conference Series: Materials Science and Engineering (Vol. 847, No. 1, p. 012001). IOP Publishing. (2020, April).

Heizer, Jay and Barry Render. *Operations Management (Manajemen Operasi).* Jakarta: Salemba Empat. (2001).

Parsaei, H.R., Liggett, H.R., and Lavelle, J.P. *Economic Evaluations of Advance Technologies*. USA: Taylor & Francis. (2002).

Muther, R. and Hales, L. *Systematic Layout Planning*. Marietta: Management & Industrial Research Publications. (2015).

Nahmias, S. and Olsen, T.L. *Production and Operation Analysis*. Waveland Press. (2015).

Niebel, B. W. *Motion and Time Study*. Homewood, Illinois: Irwin. (1988).

Pycarft, M. *Operations Management*. South Africa: Pearson Education. (2000).

Rahman, M. A., Sarker, B. R., and Escobar, L. A., *Peak Demand Forecasting For A Seasonal Product Using Bayesian Approach*, Journal of the Operational Research Society, vol. 62, pp. 1019-1028, 2011.

Ramadhan, D., Widodo, L., Gozali, L., Sukania, I. W., Daywin, F. J., & Doaly, C. O. *Redesigning The Facility Layout With Systematic Layout Planning Method and Lean Manufacturing Approach On The Production Floor At PT. Baruna Trayindo Jaya*.

Rastogi, M.K. *Production and Operation Management*. New Delhi: Laxmi Publications Pvt Limited. (2010).

Reimer, D., and Ali, A., *Engineering Education and The Entrepreneurial Mindset at Lawrence Tech*, *Proceedings of the 3ʳᵈ Annual International Conference on Industrial Engineering and Operations Management*, Istanbul, Turkey, July 3 – 6, 2012, pp. xx-xx.

Robert, William, and Thomas. *Manufacturing Planning and Control for Supply Chain Management*.

Scallan, P. *Process Planning*. Oxford: Elsevier Science. (2003).

Shetty, D., Ali, A., and Cummings, R., *A Model to Assess Lean Thinking Manufacturing Initiatives*, *International Journal of Lean Six Sigma*, vol. 1, no. 4, pp. 310-334, 2010.

Sushil and Martin. *Production and Operations Management Systems*. Florida: C.R.C. Press.

Sutalaksana, Iftikar Z. *Teknik Perancangan Sistem Kerja*. Bandung: ITB. (2006).

Tjusila, A. K., Gozali, L., & Doaly, C. O. *Factory Re-Layout with SLP, CRAFT, CORELAP, Promodel, and FlexSim for Optimization of Material Flow Movement*.

Wahyudi, H., Daywin, F. J., Doaly, C. O., Gozali, L., & Kosasih, W. *REDESIGNING OF FACILITY LAYOUT IN PT. OCEAN CENTRA FURNINDO USING GROUP-TECHNOLOGY, CORELAP AND CRAFT METHOD.*
Wignojosoebroto. *Teknik Analisis untuk Peningkatan Produktivitas Kerja.* Surabaya: Gunawidya. (2000).

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