PRODUCTIVITY IMPROVEMENT THROUGH THE APPLICATION OF SYSTEMATIC LAYOUT PLANNING TECHNIQUE

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***Abstract**: This research study has been carried out with the aim of developing the appropriate plant layout for a manufacturing organization. The objectives of the research were to study the existing layout of the production line of the studied concern, identifying its strengths and weaknesses and to implement the most effective and optimal layout evaluated by Systematic layout planning technique, in place of the existing layout. The action research approach was adopted to gather the required data. The collected data were incorporated within the different phases of the studied method by detailed study of the layout. Based on strength and weakness of the studied layout three alternative layouts were developed. The alternative layouts along with the existing layout were compared. The best ranked proposed layout was implemented in the studied organization and the affects were listed. The results showed that new proposed plant layout utilizes less space and ultimately increase the productivity.*
Keywords: *Systematic Layout Planning; activity relationship; productivity.*
JEL Classification: *L67*

1. Introduction

To remain competitive in the marketplace manufacturing industries need to focus on improving productivity through systematic and effective layout designing. Plant layout is a technique of locating machines, processes and other services in a systematic and orderly manner within the factory so as to achieve the right quantity and quality of output at the lowest possible cost of

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manufacturing. A good plant layout increase good workflow in production route. It is necessary to design and implement effective layout in a plant from the beginning applying systematic approaches and tools.

Systematic Layout Planning (SLP) [Shubin, J.A., Madeheim, H., 1965] is one of the layout design technique based on a great deal of experience in plant layout design. It provides a kind of facilities planning approach for the analysis of the logistics and non-logistics unit's relationship as the main concern.

In 1961, Richard Muther presented the SLP method. The method has been widely applied since then. He proposed a representation for the intensive work unit operations. This concept developed the layout design from qualitative phase to quantitative phase. Furthermore, Russell D. Meller and Kai-Yin Gau proposed a flow chart method of planar facility layout. Gómez gave a creative idea which introduced the genetic algorithms into the calculation of quantitative facility layout (Li, M., 2010).

Bangladesh Ready Made Garments (RMG) sector is expanding rapidly and it has become the highest garments product exporting country after China. It accounts for over 75% of the country's total export earnings, provides employment almost 5 million people, accounts for over 10% of the country's GDP, and contributes around 40% of Bangladesh's manufacturing output (Rahman, M.A., Hossain, M.S., 2010). Now a day's it is impossible to run a garment manufacturing operation without scientific and professional approach. Among the scientific approaches, layout planning requires more concentration because further re-location or re-design of facilities needs high cost or investment.

An ideal plant layout should provide the optimum relationship among output, floor area and manufacturing process. It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower, and provides for employees' convenience, safety, comfort at work, maximum exposure to natural light and ventilation. It is also important because it affects the flow of material and processes, labor efficiency, supervision and control, use of space and expansion possibilities etc. The layout design has a significant impact on the performance of a production process. Layout design has been an active research area in the past few decades (Meller, R.D., Gau, K.Y., 1996). However, design algorithms for production lines and or workshops are rare and or may not be adequate to solve a real design problem (Peters, B.A., Yang, T., 1975). Existing research in production design layout problems often fall into two major categories, such as algorithmic and procedural ones. Algorithmic approaches usually simplify both design constraints and objectives in order to reach a surrogate objective function whose solution can then are obtained (Yang, T., Peters, B.A., 1997; Cardarelli, G., Pelagagge, P. J., 1995). These approaches usually only involve quantitative input data (Geiger, C.D., et al., 1997). Their design solutions are easier to evaluate by comparing their objective function values. Procedural approaches can incorporate both, qualitative and quantitative; objectives in the design process (Padillo, J.M., et al., 1997; Muther, R., 1973). For these approaches, the design process is divided into several steps that are then solved sequentially.

The success of a procedural approach implementation is dependent on the generation of quality design alternatives that are often from the output of an experienced designer. Thus, the input from area experts during the design process is considered to be a must towards an effective workshop layout design. It is often the last step for a procedural approach to evaluate the design alternatives. The choice of the final design is often difficult when multiple objectives are considered.

A workshop layout design problem exposes the strong properties of a multiple objective decision problem. For this instance, an algorithmic approach may not be adequate in providing a quality solution. Alternatively, the use of a sound procedural approach with the aid of a proven tool as design evaluation function would be available approach for a workshop layout design problem. It is suggested to use a SLP procedural approach for production process design improvement, because it features both the simplicity of the design process and the objectivity of the multiple-criteria evaluation process as opposed to existing algorithmic approaches, which are ineffective in solving qualitative objective problems, and regular procedural approaches that lack a structural multiple criteria evaluation approach.

The objectives of the current research are:

- To assess the strength and weakness of the existing layout of sewing line of the studied organization.
- To improve the existing layout applying SLP technique.
- To implement the optimal layout in place of existing line.

2. Research Methodology

The research methodology adopted for this study is done by the case study and by some questionnaires. The case study was done in an apparel factory. This study gives an idea about the existing scenarios of garments industry in Bangladesh. This study deals with improved productivity by SLP method. The overall steps involved in the research are shown in Fig. 1.

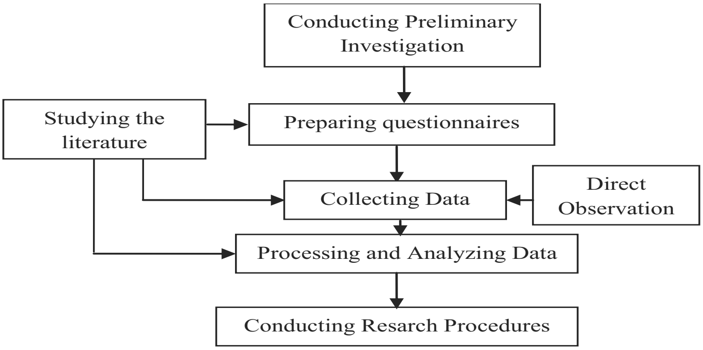


Fig.1. Overall steps of the research

2.1. Steps of SLP

Analyzing of a layout using SLP should pass through five steps. These steps are described below.

2.1.1 Step 1: Establish and Chart the Relationships

- Identify each activity and list all the activities on the Relationship Chart.
- Determine closeness rating for each activity to all other activities (A–Absolutely necessary, E–Especially Important, I–Important, O–Ordinary Closeness, U–Unimportant, X–Undesirable) using the Relationship Chart [11].
- To use the relationship Chart, we must follow the grid. Example: If you are comparing activity 1 with activity 3, you must follow the diamond from activity 1 until you get to where activity 3 intersects activity 1.

2.1.2. Step 2: Establish the Minimum Space Requirements

- Use the names of the Activities you have used in Step 1 and list them on the Activities Area & Features Sheet.
- Identify the space requirement for each activity and record them on the sheet under "Area".
- Identify any other physical restrictions and record on to sheet under using (A, E, I, O, U, X) under "Physical Features Required."
- Identify any specific shape or configuration needed for each activity and list them under "Requirements for Shape or Configuration of Area (Space)".
- Identify any other comments at the bottom of the sheet.

2.1.3. Step 3: Diagram the activity Relationship

- Use circled numbers as a representation of an activity. Draw out all the activities. Connect the nodes with lines to show the relationship between activities.
- Four lines connecting nodes represents the most desired closeness down to one line. A zigzag line represents the most undesirable closeness.
- Draw in all the activities with "A" rated relationships with four lines.
- If needed, redraw the "A" rated relationships for the best arrangement.
- Draw in all the "E" rated activities with three lines.
- Rearrange the drawing if needed.
- Draw in all the "I" rated activities with two lines.
- Rearrange the drawing if needed.
- Draw in the "O" rated activities with one line.
- Rearrange the drawing if needed.
- Draw in the "X" rated activities with zigzags [1].

2.1.4. Step 4: Propose Some Alternative Layout Arrangements

- Choose some scale for your layout.
- Use the space requirements from Step 3 to mark of the area need for each activity.
- If this project requires new construction, make any adjustments needed so that there are reasonably straight exterior walls and interior walls.
- Show all features needed such as columns, walls, access doors.
- If there is an existing building, add any permanent features such as utility service points, restrooms, load-bearing wallet.
- Check the layout for best orientation with any surrounding features such as streets, rail access, utility lines etc.
- Come up with different layouts.

2.1.5. Step 5: Evaluate Alternative Arrangements

- Develop some factors involved in relation with the operations.
- Give weight to each factor according to the importance given to them by the management of studied organization.
- Evaluate the alternatives established at step 4, considering the selected factors and their weight.
- Choose the best alternative from the evaluation.
- Install the selected layout.
- Compare with existing layout.

3. Results and Analysis

3.1. Status of existing sewing line

A sewing line was studied and short sleeve T-shirt was manufactured on that line. The overall description of that line is given below-

- Line number: 18, Total equipment: 26
- Total manpower: Operator = 26, Helper = 10, Final Quality checker = 02, In total = 38
- Average Production rate: 98 pieces/hour
- Working hour in a day: 10 hours

The line contains 26 workstations. Other relevant information about the line is given in Table 1.

Table 1. Relevant information about the studied line

Sl. No.	Description of the Operation	Operator	Helper	SMV	SAM Allowance (20%)
1.	Bone Contrast Attach	1		0.23	0.28
2.	Bone Pocket Mark		1	0.24	0.29
3.	Front Part Mark		1	0.24	0.29
4.	Bone Pocket tack with body	1	1	0.39	0.47
5.	Bone Pocket Cut		1	0.24	0.29
6.	Bone Pocket Close	2		0.55	0.66
7.	Bone Pocket Servicing	1		0.3	0.36
8.	Bone Pocket Top Stitch	2		0.6	0.72
9.	Back + Front Part Match		1	0.24	0.29
10.	Shoulder Joint	1	1	0.35	0.42
11.	Nk Rib Make	1		0.3	0.36
12.	V-Neck Servicing	1	1	0.35	0.42
13.	V-Make Tack	1		0.3	0.36
14.	V-Tack with Body	1		0.38	0.46
15.	Nk Rib Join	1		0.32	0.38
16.	Back Neck Piping	1		0.22	0.26
17.	Back Neck Piping Ts	2	1	0.43	0.52
18.	Slv Contrast Part Attach	1		0.4	0.48
19.	Sleeve Hemming	1		0.36	0.43
20.	Sleeve & Body Match		1	0.24	0.29
21.	Sleeve Join	2		0.63	0.76
22.	Side Seam	2	1	0.77	0.92
23.	Care Label Attach	1		0.23	0.28
24.	Sleeve Opening + Press Tack	2		0.46	0.55
25.	Body Hemming	1		0.4	0.48
26.	Checking		2	0.3	0.36
Total		**26**	**12**	**$\sum$=9.47**	**$\sum$=11.38**

In Table 1, SMV means Standard Minute Value. It is the time required for a qualified worker working at standard performance to accomplish a given task. SAM is developed by providing 20% allowance to SMV. This allowance is machine and worker allowance.

From the above information following calculations were done.

- ✓ Labor Productivity of that line
  = (Total number of output per day)/(Number of worker worked)
  = (98×10)/38 = 25.79 pieces/worker/day

- ✓ Machine Productivity of that line
  = (Total number of output per day)/(Number of machine used)
  = (98×10)/26 = 37.69 pieces/machine/day
- ✓ Line Efficiency
  = (Total number of output per day ×SAM)/(Total manpower in that line × Total working minute per day) (Shumon, M.R.H., et. al., 2010)
  = (98×10×11.38)/(38×60) ×100% = 48.91 %

The layout of the existing line is shown in Fig. 2.

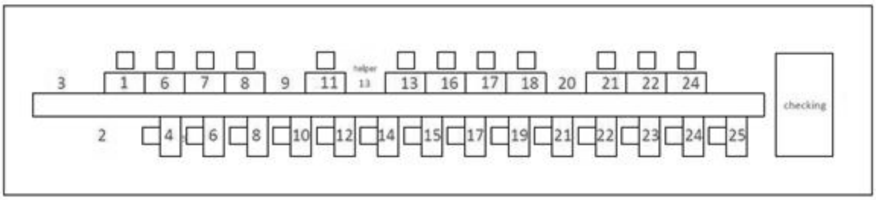


Fig. 2 Existing layout of the studied line

3.2. Analysis

While analyzing the existing line some strength were found like below-

- The sequence of operation was perfect.
- The line needed at least 26 workstations.
- The line was balanced.

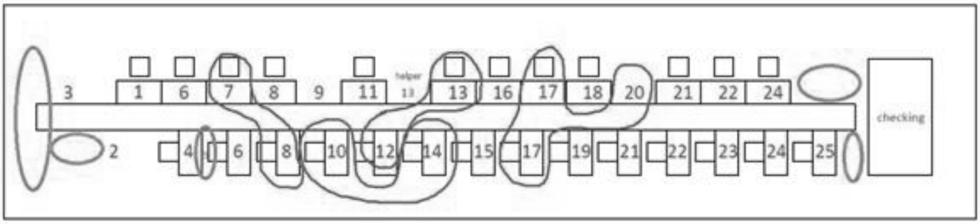


Fig. 3. Problems of Existing line (blue zone represents wasted space, red zone represents wrong placement of sequential works, green zone-congested place)

- The line had some unnecessary places and those places were excess. Some of those places are indicated in Fig. 3. The wasted space of existing line is 58.25 ft^2.
- Four problems of sequential placement of operations were observed as shown in Fig. 3.
- Some places were too congested and it is also represented in Fig. 3.

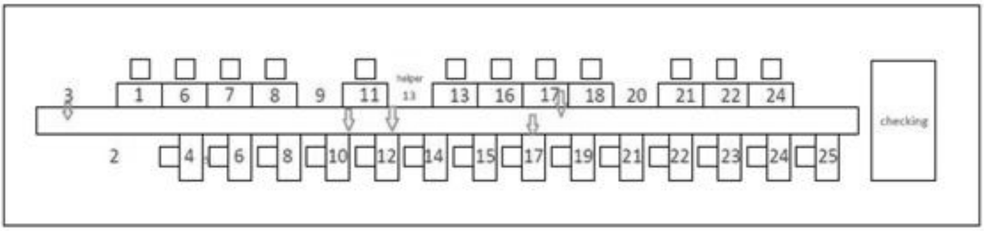


Fig. 4. Work-in-process in existing line

- Some works in process were observed and is shown at Fig. 4.

To resolve the problems of existing line the SLP steps were implemented. The space available for the studied line is of (72 ft×10ft) i.e.720 sq. feet area. Arrangement & required spaces are calculated. Dimension of workstations, working areas are observed and the total required area for 26 workstations are shown in Table 2.

Table 2 - Minimum area required for the studied line

Operation Description	Number of Equipment	Each Equipment Length (Feet)	Each Equipment Width (Feet)	Working Length	Working Width	Total Length for each equipment	Total Width for each equipment (Feet)	Area Required for each eq.(Feet^2)	Total area for Operation (Feet^2)
Bone Contrast Attach	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Bone Pocket Mark	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Front Part Mark	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Bone Pocket tack with body	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Bone Pocket Cut	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Bone Pocket Close	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
Bone Pocket Servicing	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Bone Pocket Top Stitch	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
Back + Front Part Match	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Shoulder Joint	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Nk Rib Make	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
V-Neck servicing	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
V-Make Tack	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
V-Tack with Body	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Nk Rib Join	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Back Neck Piping	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Back Neck Piping Ts	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
Slv Contrast Part Attach	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Sleeve Hemming	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Sleeve & Body Match	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Sleeve Join	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
Side Seam	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
Care Label Attach	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Sleeve opening + Press Tack	2	3.5	1.8	3.5	2	3.5	3.8	13.3	26.6
Body Hemming	1	3.5	1.8	3.5	2	3.5	3.8	13.3	13.3
Checking	1	7	4	7	2	7	6	42	42
Minimum total area required for that line is :									**467.6**sq. feet

Activity relationship diagram is drawn to understand the relations among the operations within the line. It is drawn from the relationship found at step 1.

The lines between the activities illustrated as four lines for 'A' related activities, three lines for 'E' related activities, two lines for 'I' related activities, one lines for 'O' related activities and zigzag lines for 'X' related activities.

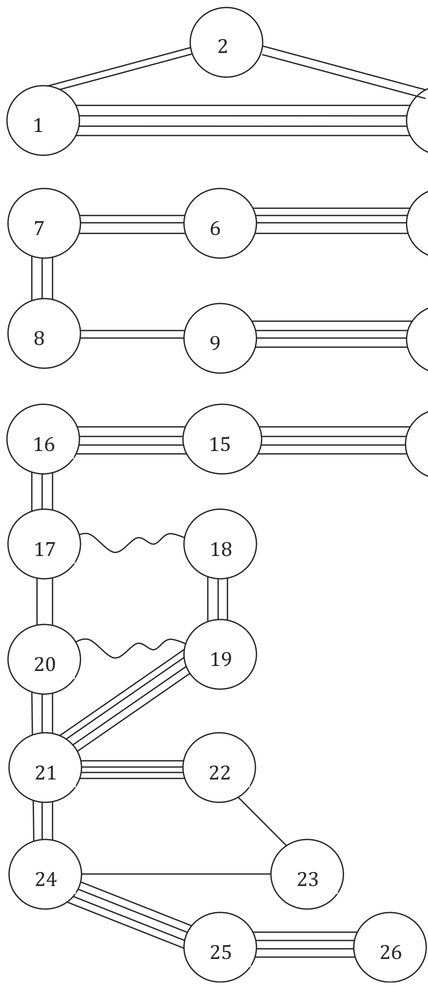
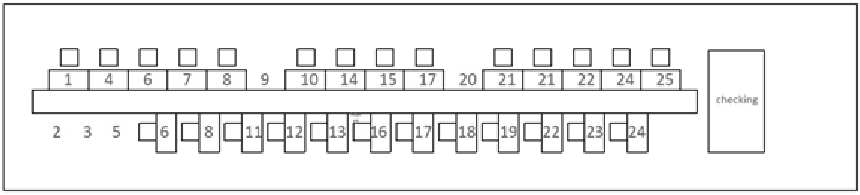
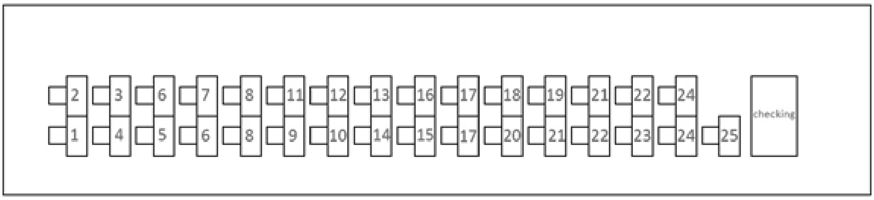


Fig. 5 Activity relationship diagram

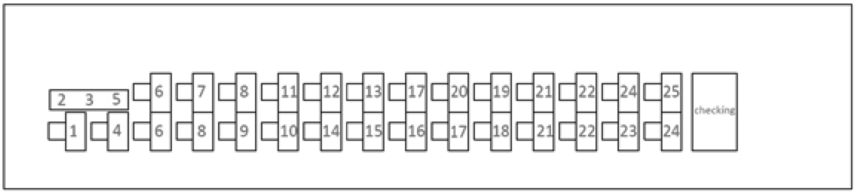
According to the routes, activities relational diagrams and area, previously obtained and mentioned above, there have been proposed different alternatives of layout. Three of such proposed alternative solutions are shown in Fig. 6.



(i)



(ii)



(iii)

Fig. 6 Proposed layout (i), (ii) and (iii)

For proposed layout – (i),

- Space required 67×9.3 i.e. 623.1 sq. feet.
- Space wasted 4.5×3.5 i.e. 15.75 sq. feet.
- Sequencing/bottleneck problem in one place.
- One congested operation.

For proposed layout – (ii),

- Space required 67.8×7 i.e. 474.6 sq. feet.
- Space wasted 3.8×3.5 i.e.13.3 sq. ft.
- No sequencing / bottle-neck problem.

For proposed layout – (iii),

- Space required 64×7 i.e. 448 sq. feet.
- No wasted space.
- Sequencing/bottle-neck problem in three places.

The weight of each factor took value from 1 to 8 and has been assigned accordingly to the importance given to them by the management of the factory, in correspondence to the agreement levels and the point awarded on scale of ‘0’ to ‘3’ for the agreement levels of poor, regular, good and excellent respectively.

Table 3 shows the evaluation data for the existing layout and the three alternatives, considering the selected factors and their weights.

Table 3. Evaluation of four alternatives

Factors	Points / Alternatives			
	Existing	Proposal (i)	Proposal (ii)	Proposal (iii)
Materials flow easiness (7.5)	1	2	3	1
Optimum use of the space (7.5)	1	1	3	3
Safety (5.5)	2	2	2	2
Facility of control and supervision (3)	2	2	2	2
Facility of installations maintenance (1.5)	2	2	2	2
Flexibility of the factory plan (1.5)	0	0	2	2
Proximity of places with workers or machine shared (5.5)	2	2	2	2
Working conditions (4)	1	1	1	1
Total Result	**50**	**57.5**	**83**	**66.5**

From the obtained evaluation data, there can be seen that the alternative with the best score is the proposed layout-(ii). Proposed layout (ii) should be used in case of existing layout as it decreased work in process material, resulting in increased production.

Comparing the two layouts, we found that, by installing the new layout, we were able to reduce 4 extra helpers and increase 8 pieces/hour productions in that line.

Solving sequential problem

Remarking the backward flow for providing a balance of material.

Again, the partial productivity and efficiency of that line become-

- ✓ Labor Productivity of that line

= (Total number of output per day)/(Number of worker worked)
= $(106\times10)/34 = 31.18$ pieces/worker/day

✓ Machine Productivity of that line
= (Total number of output per day)/(Number of machine used)
= $(106\times10)/26 = 40.77$ pieces/machine/day

✓ Line Efficiency
= [(Total number of output per day ×SAM)/(Total manpower in that line × Total working minute per day)] (Shumon, M.R.H., et.al., 2010)
= $(106\times10\times11.38)/(34\times60)\times100\% = 59.13\ \%$

From the obtained result it is clear that by installing the new layout design,

- Labor Productivity is improved by 20.9%
- Machine Productivity is improved by 8.17% and
- Efficiency of that line improved by 20.91%

The comparison of material flow length covered by any single product when it is in manufacturing, between the two layouts, it is found that, in the existing layout, a single product had to pass maximum 69 feet length while manufacturing, where, at the new layout, it has to pass maximum 59 feet length. So, the handling cost per unit product reduced by about 14%. The longest route covered by the product at the existing and new line is illustrated at Fig. 7. The route is shown by arrow (↑) sign and distance between two operations (in feet) is denoted by black numeric numbers beside the route arrows.

Moreover, the area required by the proposed new line was reduced by 245 sq. ft. More space is available to set other lines on that floor and obviously, more production lines causes more productivity.

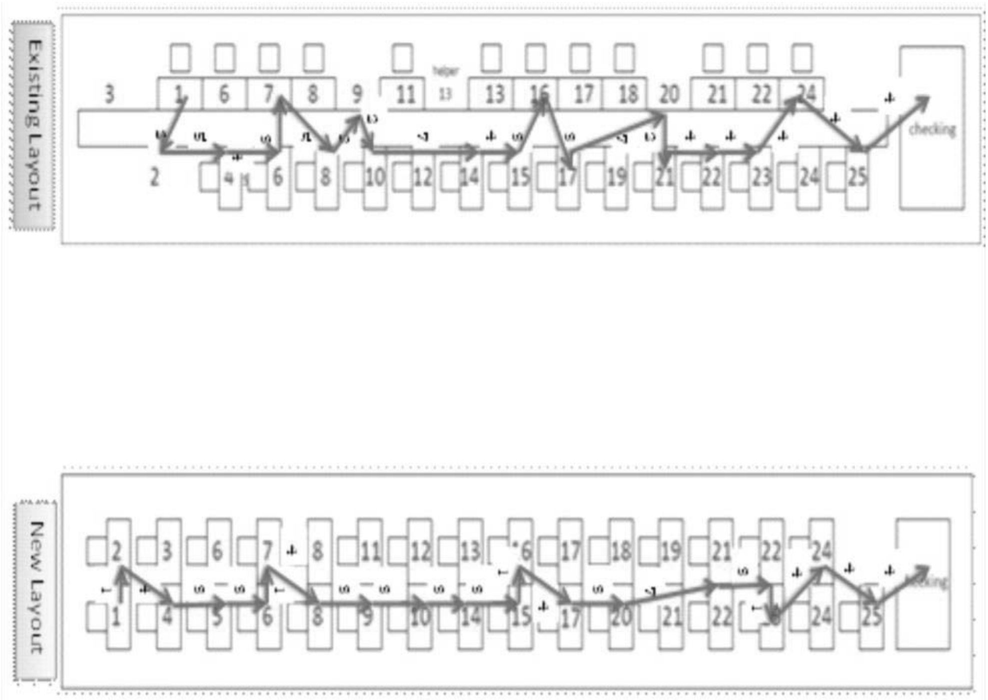


Fig. 7. Longest route of material flow for existing and new layout

By implementation of the proposed new layout (ii) most important objectives of SLP i.e., reduction of the space required for manufacturing and also increase of the productivity was fulfilled. The suggested plan reduced wastage of travel of people and materials, located tools and supplies at work stations, and allowed for workforce expansion as the company grows. If the whole floor layout could be re-designed using SLP, we could achieve the objectives fully.

4. Conclusions

The paper presents an application of the SLP (System Layout Planning) method for establishing, in an efficient manner, the layout of a productive enterprise. A case study is described in the paper, referring to a factory designated for manufacturing knit textile products. The phases of the SLP method application are described in the paper, together with the presentation of one particular product (Short sleeve T-shirt) given as example. The optimal solution of the productive system's layout is selected by analyzing three possible identified alternatives.

The case study of SLP at this company illustrates that small and medium firms can successfully layout and re-layout their facilities with this easy to use technique. The results arrived from SLP does not completely satisfy all but it clearly shows why decisions are made. This study shows that SLP process was as valuable as the final layout.

- Per hour output increased by systematic re-layout design and removing the zigzag and unnecessary flow of operation. It also helps to reduce 4 helpers.
- The layout of line is changed from zigzag shape to I shape. It reduces wastage space, high work-in-process at 3, 10, 12 and 17 workstations.
- For these improvements we are able to increase-
  - Labor productivity 20.9%
  - Machine productivity 8.17% and
  - Efficiency of that line 20.91%

For a different product with different sequence and operation, it is needed to develop five steps SLP again.

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