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An Optimal Layout Design in an Apparel Industry by Appropriate Line Balancing: A Case Study

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Abstract- The layout design problem is a strategic issue and has a significant impact on the efficiency of a manufacturing system. Much of the existing layout design literature that uses a surrogate function for flow distance or for simplified objectives may be entrapped into local optimum; and subsequently lead to a poor layout design. The present study explores the use of appropriate line balancing to facilitate a good layout design. Construction of a quality garment requires a great deal of know-how, a lot of coordination and schedule management. Clothing manufacturing consists of a variety of product categories, materials and styling. Dealing with constantly changing styles and consumer demands is so difficult. Furthermore, to adapt automation for the clothing system is also so hard because, beside the complex structure also it is labour intensive. Overall, the important criteria in garment production is whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall. To achieve this approach, work-time study, assembly line balancing and simulation can be applied to apparel production line to find alternative solutions to increase the efficiency of the sewing line. In this paper we showed how a good layout can be designed and productivity can be increased by appropriate assembly line balancing.

Keywords: line balancing, layout, time study.

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Strictly as per the compliance and regulations of:

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Abstract- The layout design problem is a strategic issue and has a significant impact on the efficiency of a manufacturing system. Much of the existing layout design literature that uses a surrogate function for flow distance or for simplified objectives may be entrapped into local optimum; and subsequently lead to a poor layout design. The present study explores the use of appropriate line balancing to facilitate a good layout design. Construction of a quality garment requires a great deal of know-how, a lot of coordination and schedule management. Clothing manufacturing consists of a variety of product categories, materials and styling. Dealing with constantly changing styles and consumer demands is so difficult. Furthermore, to adapt automation for the clothing system is also so hard because, beside the complex structure also it is labour intensive. Overall, the important criteria in garment production is whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall. To achieve this approach, work-time study, assembly line balancing and simulation can be applied to apparel production line to find alternative solutions to increase the efficiency of the sewing line. In this paper we showed how a good layout can be designed and productivity can be increased by appropriate assembly line balancing.

Keywords: line balancing, layout, time study.

I. Introduction

Layout design often has a significant impact on the performance of a manufacturing or service industry system and is usually a multiple-objective problem. Garment industries are experiencing a very competitive era like many others, thus striving hard to find methods to reduce manufacturing costs, improve quality etc. In garment production, until garment components are gathered into a finished garment, they are assembled through a sub-assembly process. The production process includes a set of workstations, at each of which a specific task is carried out in a restricted sequence, with hundreds of employees and thousands of bundles of sub-assemblies producing different styles simultaneously (Chan et al, 1998). The joining together of components, known as the sewing process which is the most labour intensive part of garment manufacturing, makes the structure complex as the some works has a priority before being assembled (Cooklin,1991). Furthermore, since sewing process is labour intensive; apart from material costs, the cost structure of the sewing process is also important. Therefore, this process is of critical importance and needs to be planned more carefully (Tyler, 1991). As a consequence, good line balancing with small stocks in the sewing line has to be drawn up to increase the efficiency and quality of production (Cooklin, 1991; Tyler, 1991; Chuter, 1988). An assembly line is defined as a set of distinct tasks which is assigned to a set of workstations linked together by a transport mechanism under detailed assembling sequences specifying how the assembling process flows from one station to another (Tyler, 1991). In assembly line balancing, allocation of jobs to machines is based on the objective of minimizing the workflow among the operators, reducing the throughput time as well as the work in progress and thus increasing the productivity. Sharing a job of work between several people is called division of labour. Division of labour should be balanced equally by ensuring the time spent at each station approximately the same. Each individual step in the assembly of product has to be analysed carefully, and allocated to stations in a balanced way over the available workstations. Each operator then carries out operations properly and the work flow is synchronized. In a detailed work flow, synchronized line includes short distances between stations, low volume of work in process, precise of planning of production times, and predictable production quantity (Eberle et al, 2004).

Overall, the important criteria in garment production is whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall.

II. Definition of Layout Problems

A facility layout is an arrangement of everything needed for production of goods or delivery of services. A facility is an entity that facilitates the performance of any job. It may be a machine tool, a work centre, a

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manufacturing cell, a machine shop, a department, a warehouse, etc. (Heragu, 1997). The layout design generally depends on the products variety and the production volumes. Four types of organization are referred to in existing articles, namely fixed product layout, process layout, product layout and cellular layout (Dilworth, 1996). These key organizations are sometimes discussed differently according to the authors. In Fixed product layout, the products generally circulate within the production facilities (machines, workers, etc.); in this particular type of layout, the product does not move, it is the different resources that are moved to perform the operations on the product. This type of layout is commonly found in industries that manufacture large size products, such as ships or aircrafts. Process layout groups facilities with similar functions together (resources of the same type). In this paper, we focused on process layout and tried to show the optimistic way of process layout.

III. Methodology

In the production of garment, at first garment model is designed. Then, according to model requirements, a sort of fabrics are cut as well as classified due to their sewing sequences.

Then, cut fabrics are sewn and assembled in order to form garment. After the sewing and pressing process, garment is controlled for eliminating sewing faults, and finally it is sent to package and expedition.

In this paper, to analyze the structure of garment assembly processes, a T-shirt sewing line was considered. The first step performed in this study was to understand T-shirts sewing processes' components and sewing line problems. The objective was to have a clear idea on how a T-shirts production-sewing process line flows and then, how the line can be balanced as well as the performance of production line can be increased.

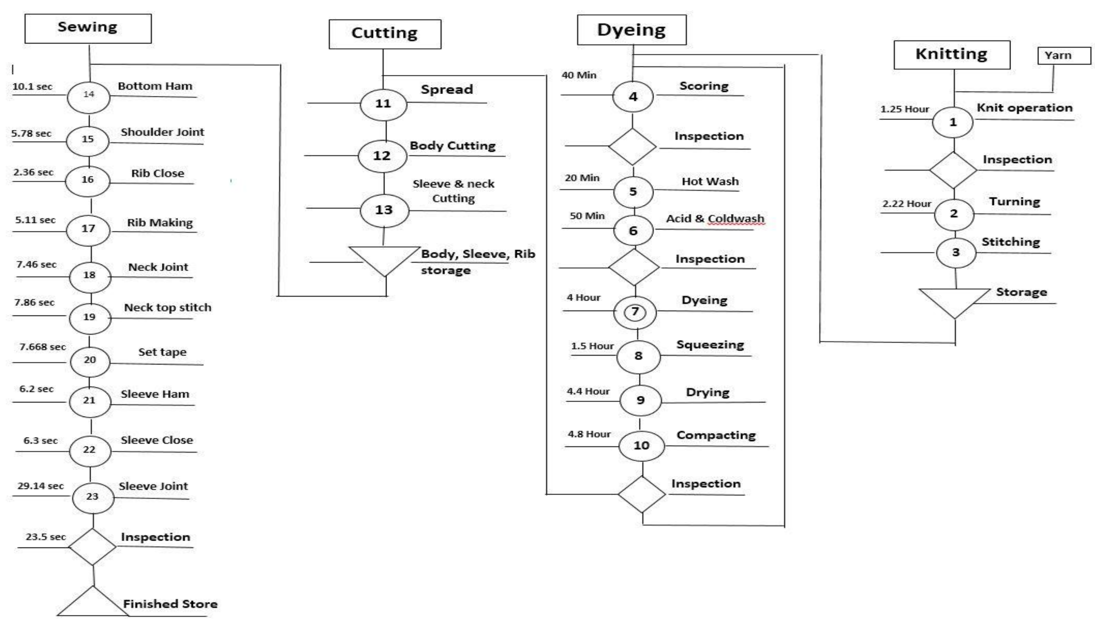


Fig. 1 : Processes required to produce T-shirt

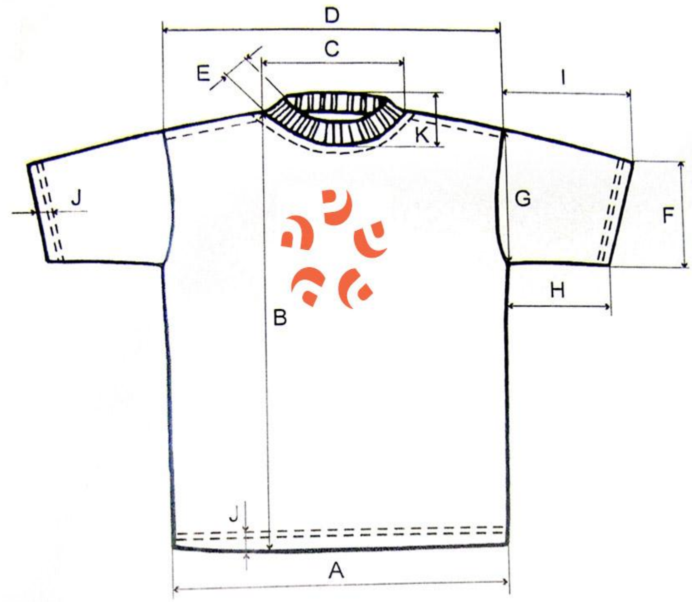
In this industry four processes are capable. The successive processes are knitting, Dyeing, Cutting and Sewing. Fig-1 showing the complete process maintained in this industry. Here total line balancing and optimized layout is obtained in sewing process.

The steps of sewing process are following:

a) Bottom ham
b) Shoulder joint
c) Rib close
d) Rib making
e) Neck joint
f) Neck top stitch
g) Set tape
h) Sleeve ham
i) Sleeve close & joint
j) Inspection

After making gray fabrics bar, this bar or roll is sent to cutting section. Here fabrics are cut with predetermined dimension. This cut input is sent to sewing line. This input is then distributed to bottom ham, Rib cutting and sleeve ham machine. Sewing work is started with three machine same time. Then remaining work is done according to the flow chart given bellow. Finished t-shirt is collected from process 9(sleeve close) for checking those and sent to rework if needed. After final checking, output is sent to packaging.

Measurement of T-shirt cutting used in Gildan Fabrics-



	A	B	C	D	E	F	G	H	I	J	K [cm]
S/158	46	63	17	44	3	16	20	12	17	2,5	8
M	54	73	19	52	3	19	25	17	22	2,5	9
L	56	75	19	54	3	20	26	18	23	2,5	9
XL	58	78	20	56	3	21	27	19	24	2,5	10
XXL	60	80	20	58	3	22	28	20	25	2,5	10
XXXL	68	84	22	65	3	24	30	21	26	2,5	11

Fig. 2 : Dimension for T-shirt

To obtain optimized layout a comparison is shown here between the conventional process and improved layout, here three scenarios are shown.

a) Scenario 1 (existing layout)

All the data shown here are collected from Gildan fabrics; the conventional process which is used in the industry is shown below:

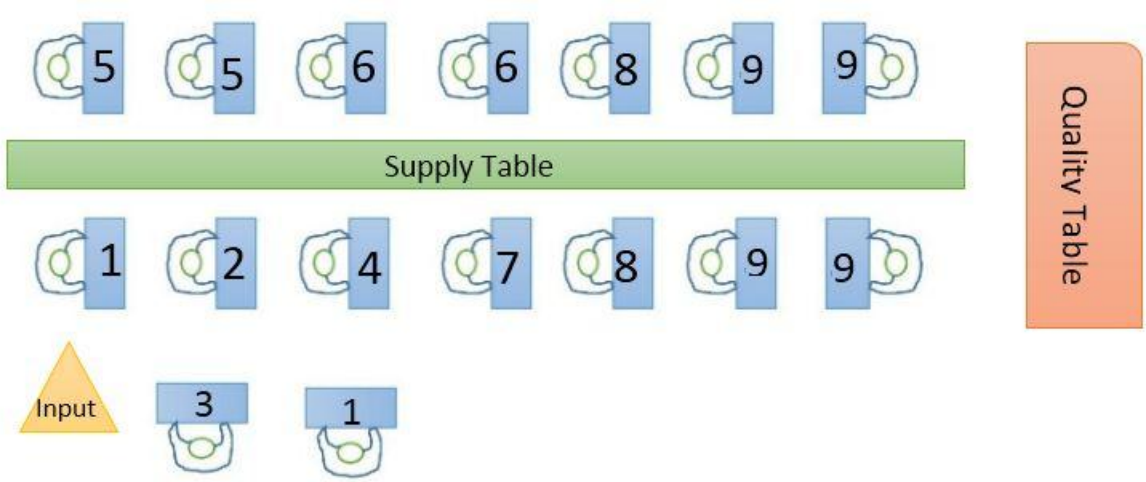


Fig. 3 : Existing layout of sewing (for T- Shirt)

The sewing process starts with bottom hamming which is shown by 1; then it is passed for shoulder joint, as bottom hamming is a long process, so extra worker is for process 1. Rib closing is done before shoulder joint in this process. Then the total rib is processed by folding and stitching. When rib is ready, it is with the main part of the fabrics and is known as neck joint which is shown by process 5 in the figure. Neck top stitch is done by process 6 and then a tape is attached in it .At last sleeve is processed. It includes sleeve hamming, closing and jointing and are shown by process 7, 8, 9. In this scenario four workers are occupied for sleeve closing and jointing. Three workers were applied for help. Total 23 workers were used. Doing all these steps a finished product is found and it is passed to quality table for checking. It is very important to inspect the finish product carefully. A huge amount of time is spent for this process. Here, three workers were applied for inspecting the finished product. The calculated time for each process is shown in the diagram. These were done by time study. By the sum of the time for each process, total time was calculated and it is shown by SAM. Total worker required was calculated. With the help of these data, efficiency of the layout was measured. The target output was predetermined.

The output of this layout & time study is shown below:

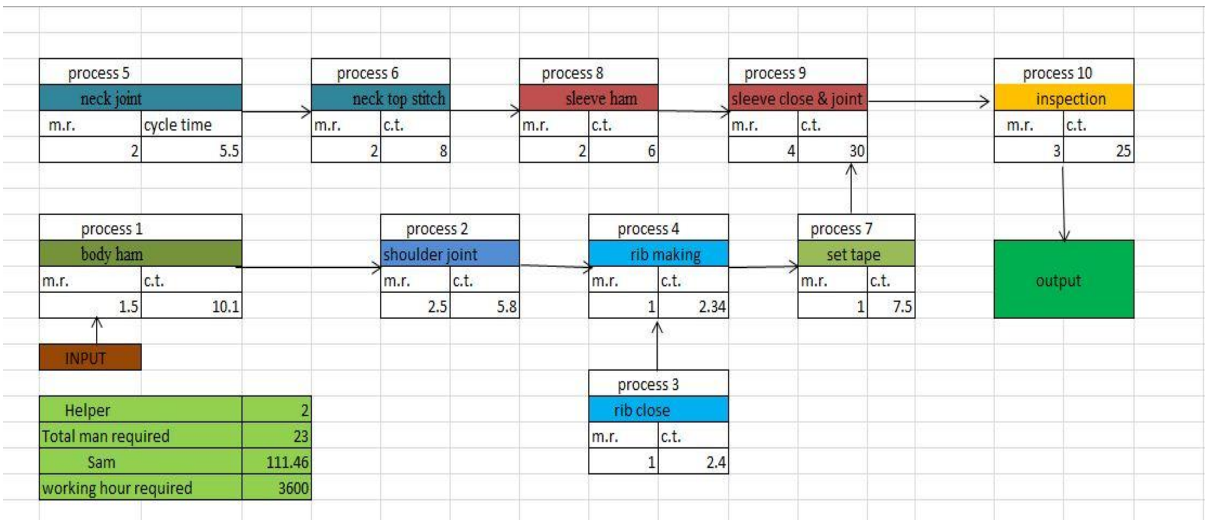


Fig. 4 : Time study for scenario 1

Table 1 : Data for existing layout

Process no.	Name of process	Man required	Cycle time
01	Bottom ham	1.5	10.1
02	Shoulder joint	1.5	5.8
03	Rib close	1	2.4
04	Rib making	1	2.34
05	Neck joint	2	5.5
06	Neck top stitch	2	8
07	Set tape	1	7.5
08	Sleeve ham	2	6
09	Sleeve close & joint	4	30
10	Inspection	3	25
		Helper =2	5
TOTAL		23	111.46

Efficiency can be measured as:

Efficiency = (Product target* SAM)/ (W.H.* M.R.)

Here, W.H. = working hour

M.R. = Man required

Target output was 370;

Now, efficiency= (370*111.46)/ (3600*23)

= 46.2%

b) Scenario 2(an alternative layout)

The whole process can be done in another sequence which is shown below. It is more efficient than the previous one or conventional one. Productivity is increased as well as the time is also optimized. In this case the following layout was done and it is look like closed loop system. In this process two supply tables were arranged and material was flowing in a loop. Here 22 workers were applied. No big change was made but efficiency was increased. It shows that only applying an appropriate layout efficiency of a process can be increased in a considerable level.

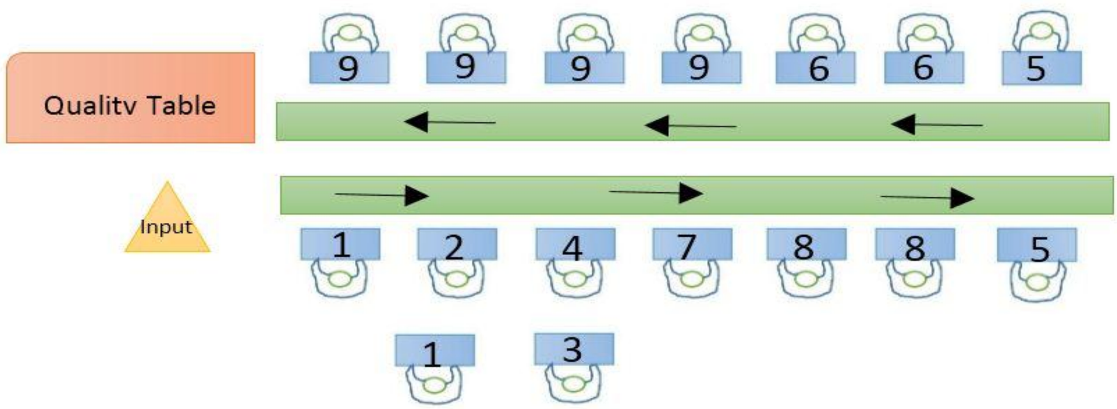


Fig. 5 : An alternative layout

The difference between this two is that, in second scenario there is no crossing in the process. Material is flowing in a U shaped path. By time study it is seen that, it is more optimized than 9 the previous one. Here, after bottom ham, shoulder joint & rib making, neck was made before sleeve and sleeve work was done at last as it was the most time consuming. By using this layout, productivity was increased which is shown later.

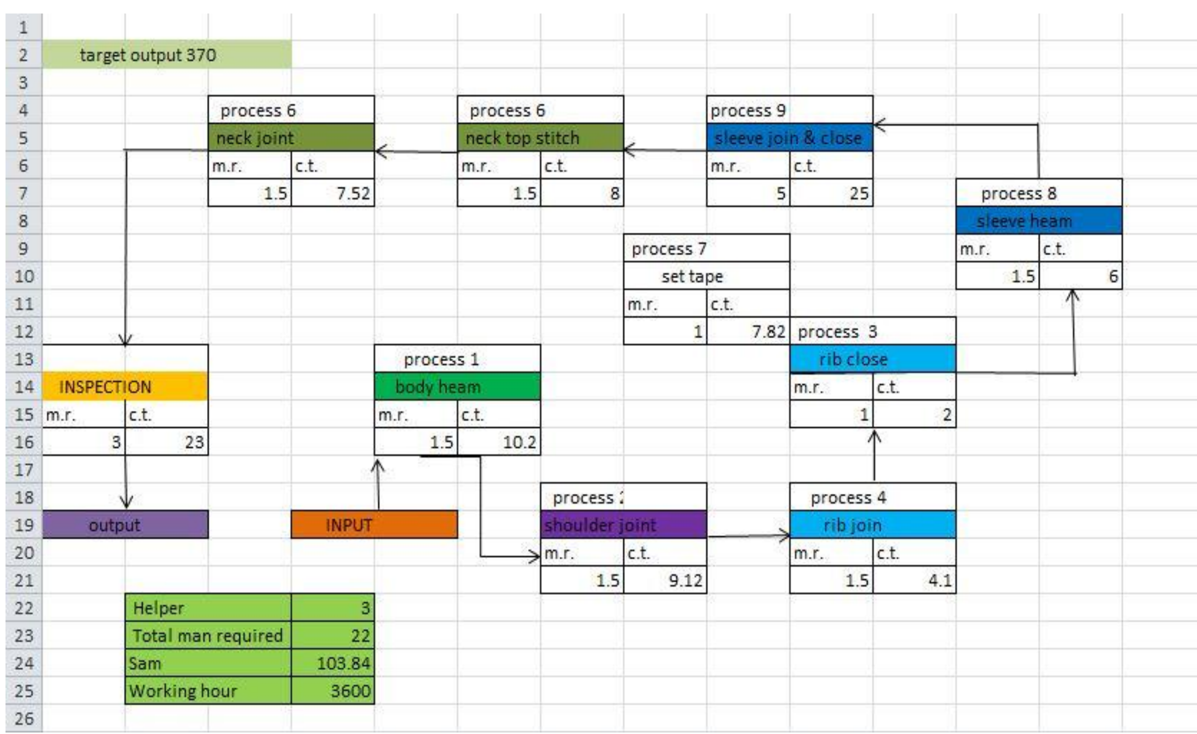


Fig. 6 : Time study for sceranio 2

Table 2 : Data for alternative layout

Process no.	Name of process	Man required	Cycle time
01	Bottom ham	1.5	10.2
02	Shoulder joint	1.5	6.12
03	Rib close	1	2
04	Rib making	1.5	4.1
05	Neck joint	1.5	5.5
06	Neck top stitch	1.5	8
07	Set tape	1	7.82
08	Sleeve ham	1.5	6
09	Sleeve close & joint	5	25
10	Inspection	3	23
		Helper = 3	5
TOTAL		22	103.84

In this case, the efficiency = (370*103.84)/ (3600*22)

= 48.5%

c) Scenario 3 (proposed layout)

By comparing the above layout, a combined layout was designed and it was seen that efficiency was further increased. This time the following layout was made.

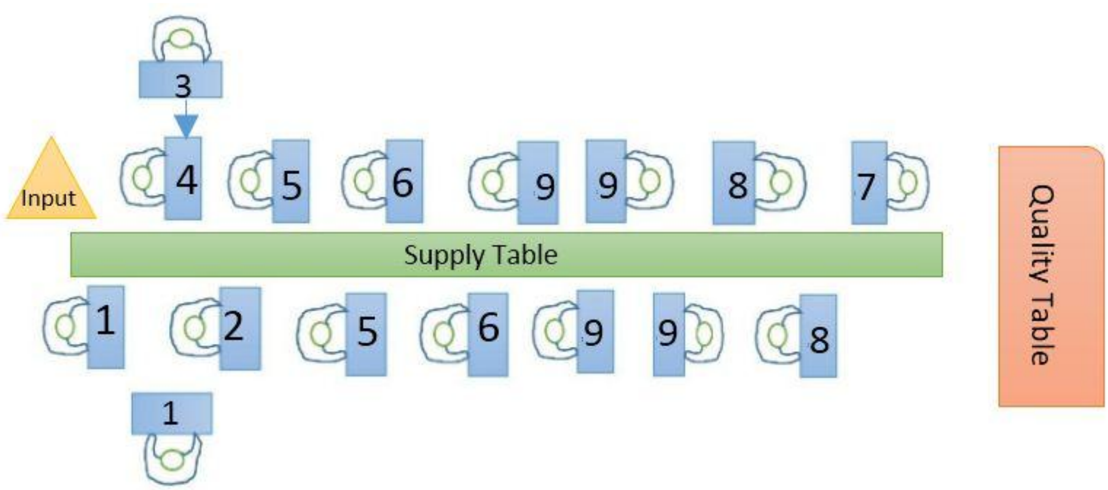


Fig. 7 : Optimal alternative layout

In this layout, an extra worker was added for process one. Worker doing same job were placed closer. The worker doing process three, was helping in process one. A supply table is used as a temporary storage. Here layout is done by the sequence of 1, 2,4,5,6,9,8,7. Bottom hamming was done first, then shoulder joint, rib making, neck making and at last sleeve joint. As the worker doing same process were arranged side by side, then materials were need not to pass a long distance like the previous one and time is also saved.

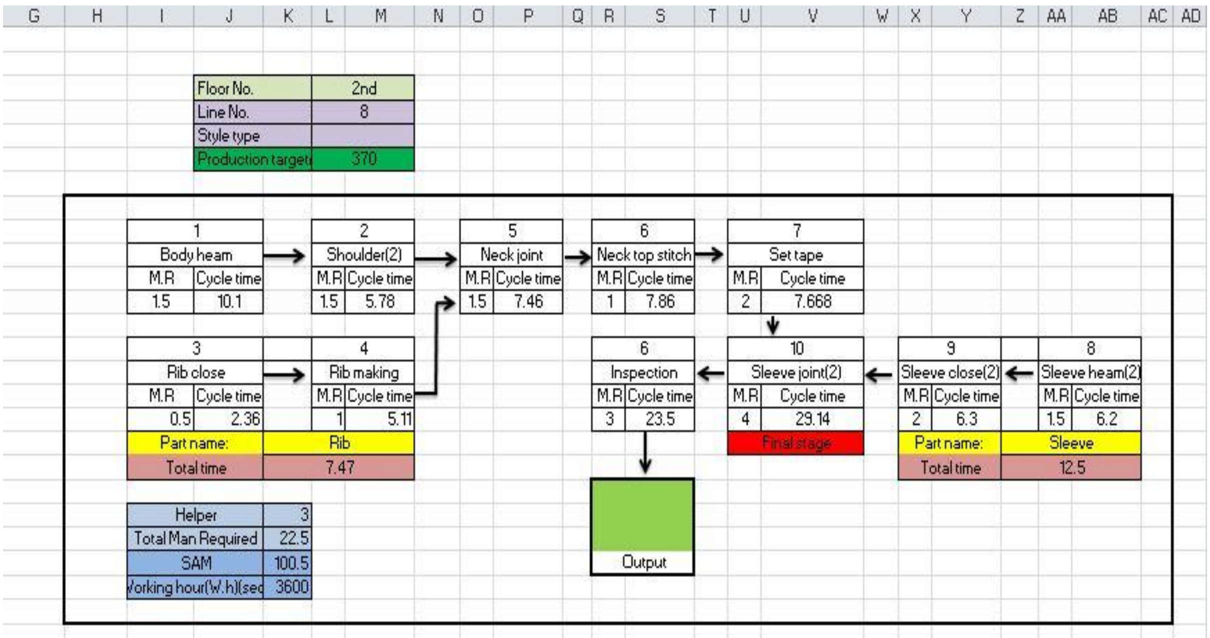


Fig. 8 : Time study of optimum layout

Table 3 : Data table for optimum layout

Process no.	Name of process	Man required	Cycle time
01	Bottom ham	1.5	10.1
02	Shoulder joint	1.5	5.7
03	Rib close	0.5	2.36
04	Rib making	1	4.1
05	Neck joint	1.5	7.4
06	Neck top stitch	1	7.81
07	Set tape	2	7.6
08	Sleeve ham	2	6.2
09	Sleeve close & joint	5	22
10	Inspection	3	23.5
		Helper =3	5
TOTAL		22	100.5

For this proposed layout efficiency becomes, (370*100.5)/ (3600*22)

= 50.9% 12

Table 4 : Output of the line

SN	Process Name	M/C Quantity	M/C Capacity per Hou	Worker	Actual Rate
1	Botom Ham	2	1416	2	1172
2	Shoulder Joint	2	2098	2	1778
3	Rib Close	1	1666	1	1287
4	Rib making	1	829	1	634
5	Neck Joint	2	1984	2	1723
6	Back neck top stitch	2	1000	2	737
7	sleeve Ham	1	1791	1	1345
8	sleeve close	2	7546	2	6243
9	sleeve Joint	4	1056	4	528
		Total = 17			

Floor No	4
Line No	23
Pd Target	370

Supporting Worker	
mark	=1
finish	=1
sort	=2
line man	=1
Total	=5

Total MR = 22
SAM =100.47 sec
Efficiency= 51%

IV. Analysis

From these scenarios it can be easily seen that, efficiency is increasing by exact positioning of machines. In the first scenario, overall 23 workers were applied but efficiency was 46%, sleeve closing & joint was the most time consuming process and 6 workers were applied for that.

In scenario 1 every machine is sequentially arranged. Here machine arranging is the main objective. An extra machine line is added to supply supporting jobs. First input storage is also added in this line. Here extra time is consumed to deliver the product after finishing from one machine to other. The total time required to process a finished product was measured by time study. It was seen that most time is consumed on sleeve processing and in inspection.

In scenario 2, another optimal layout was shown for the same process. Here machine arrangement was different from the previous one and a closed loop system was followed. By time study it was seen that the time needed for the process was reduced, man requirement was also reduced. By the calculated time study, efficiency was measured and it was seen that the efficiency was improved.

In scenario 3, our proposed layout was shown. It was based on first two scenarios and mainly focused on the sleeve processing and inspection as these two were the most time consuming of the whole process. It was tried to arrange a layout so that the time required for those scenarios can be reduced. By the proposed layout and its time study it was seen that the time required for the process was reduced but the man required was same as scenario 2 and finally from calculation improved efficiency was found.

V. Comparative Efficiency of the Layout

It is conspicuous from table 5 and figure 9 that the efficiency increased in the proposed layout with the decreasing in cycle time and man power. Cycle time in scenario 1 isestimated as 111.4 with a manpower requirement of 23. In the alternative layout it reduces the cycle time to 103.84 with manpower 22. At last the proposed layout shows 50.9% efficiency with efficiency increase at 10.173 % from the existing layout.

Table 5 : Efficiency for different scenarios

Name	Cycle time	Man required	Efficiency
Scenario1(Existing layout)	111.46	23	46.2%
Scenario2(Alternative layout)	103.84	22	48.5%
Scenario3(Proposed layout)	100.5	22	50.9%

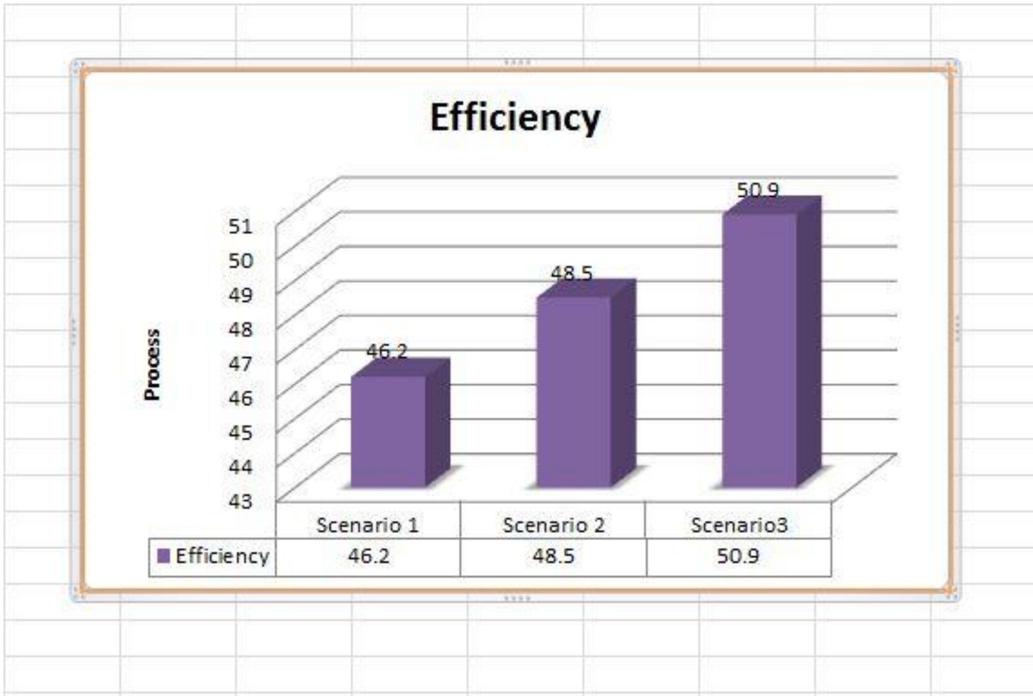


Fig. 9 : Comparative efficiency of layout

VI. Discussion

In this article, different layouts were shown for a common process and the efficiency for each of the process was measured. We actually tried to show that how an optimized layout can increase efficiency and reduce the nonproductive time. It was also shown how the same process with the same manpower can be more efficient by an appropriate layout. In this chapter, the structure of garment assembly line was analysed by simulation. A T-shirt sewing line was considered for simulation model. Firstly, the work flow of the line as well as the chronological sequence of assembly operations needed to transform raw materials into finished T-shirts were described in detail. Then, a detailed work and time studies were performed along the line. To set-up the model, all fitted data and allocation of operations to the operators with machines considering precedence constraints were transferred to simulation model. Due to model statistics, possible scenarios were formed by various what-if analyses in order to balance line as well as increase its efficiency. These scenarios can provide investment decision alternatives to company administrators. Moreover, in order to present more comprehensive decision alternatives, study can be enhanced by a cost analysis of the possible scenarios. To conclude, this chapter has demonstrated the use of simulation technique to solve assembly line balancing problem in a garment production. From this analysis, it appears that articles related to layout design continue to be regularly published in major research journals and that facility layout remains an open research issue.

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