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Bottleneck problem reduction of a garment manufacturing industry in Bangladesh by using line balancing technique

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Abstract
In type's production management techniques, operations management is one of the most powerful techniques for production floor management decision making. The application of the techniques is conducive to solve many complex problems associated with assembly controlling, scheduling which otherwise are more difficult to solve. Assembly Line Balancing (ALB) technique is one of the most efficient method of operations management for solving workload related problems and increasing line efficiency. A case study has been carried out at Envoy Textile Limited in Savar about workload allocation and bottleneck related problem. The experimental result shows significant improvement in productivity and line efficiency as compared to the existing system.

Keywords: line balancing, line efficiency, labor productivity, bottleneck

Introduction

Over the past 150 years, garment structures have changed from the manual fitting and assembly of individual hand sewn garments to mechanized, automated and sometimes robotized for batch production [1]. Recently, to fulfill customer's demands through the production of excellence garments product at lowest possible cost are the major focuses in RMG industry [2]. Appropriate planning or controlling system can contribute to achieve better performance in this area. The production process of garments industry can be grouped into three main stages cutting, sewing and finishing [3]. The sewing stage is the most important and crucial stage among them. Sewing stages involves a lot of operations having a different cycle time to perform. In the traditional sewing line of garments, all of the workers are not equally expert to do all the process [4-7]. As a result, the problematic zones arise in the production line, which is usually known as the bottleneck workstation or operation. Bottleneck is an operation having longer cycle time and where process goes slow in the sewing assembly line [8, 9]. This process that have bottleneck problem, is the main reason for reducing the efficiency of the production line [16]. Line balancing is one kind of technique for balancing the production line. At present, traditional production system has to be replaced with assembly lines for greater product variability and shorter cycle time [10]. The aim of this study is to solve the bottleneck problem of sewing line in a garment manufacturing company. The layout of the line was modified using the line balancing and time study technique.

Methodology

Materials and Method

In order to balance an assembly line in sewing floor a line was chosen and necessary data was accrued from the line as shown in Figure-1. Here researchers found that in basic T-shirt sewing line 12 types of different operations have been done. In some process of existing sewing assembly line, huge bottleneck appeared. This bottleneck operation is reducing the efficiency of that process. For improving the efficiency, researchers minimized the bottleneck operation from sewing or production line using line balancing method [11].

Fig 1: Sewing line of T-shirt production

ALB Technique

ALB (Assembly Line Balancing) is a widely used manufacturing process in which exchangeable portions are added in a consecutive manner to make an ended product. At first, Henry Ford and his engineers have used assembly line concept. According to *Adeppa (2015)* [17] ALB with various objectives is classified into three types:

ALB-I: Minimizes the number of workstations, for a given cycle time.

ALB-II: Minimizes the cycle time, for a given number of workstations.

ALB-III: Maximizes the workload smoothness, for a given number of workstations.

Determination of Assembly lines

According to Morshed & Palash (2014) assembly lines are divided into three types. They are Single model assembly line, mixed model assembly line and Multi model assembly lines [18]. In this study researchers have performed their study in single model assembly line shown in figure-2(a).

Single model assembly line: Single model assembly line is a type of assembly line in which assemblers work on the same product just like T-shirt sewing line

Mixed model assembly line: In mixed-model production, assemblers work on the distinct models of a product on the same assembly line without changeovers and then sequencing those models in a way that smooth's the demand for upstream components.

Multi model assembly lines: In Multi-product production process where multiple or single components are run through a processing line which delivers multiple end items or finished products, including waste or by-products.

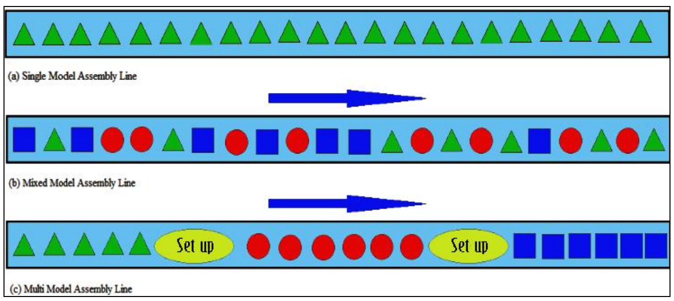

Fig 2: Different types of assembly lines

Determination of Cycle time through Time study

Time study is most popular and used method for line balancing technique and to solve bottleneck problems. During this study researchers have faced major problem of time study which is the Hawthorne Effect. They found that employees change their behavior when they know that their being measured [19].

Standard allowed minute (SAM) are calculated by using following eq.:

$$SAM = (Average\ observed\ time\ X\ Rating\ \%)\ Allowance\% \qquad [1]$$

Bottleneck Analysis

A bottleneck is a point of blockage in a process or assembly lines that occurs when workloads arrive too quickly for the assembly process to handle. In this study researchers found few bottleneck points that they have solved by using line balancing technique [12-15].

Line Efficiency and Labor Productivity determination

Labor efficiency and Labor Productivity was calculated by using following eq.

$$Line\ Efficiency = \frac{Output\ Per\ Day\ X\ SMV}{No\ of\ worker\ X\ Working\ Time(Min)} \qquad [2]$$

$$Labor\ Productivity = \frac{Total\ Number\ of\ Output\ per\ day\ per\ line}{Number\ of\ workers\ worked} \qquad [3]$$

Results

Dimensions of basic T-Shirt

Sewing line is an industrial arrangement of machines, equipment's and workers for continuous flow of work pieces in mass production operation just like t-shirt production floor. During this study researchers have found different dimension of t-shirt shown in Figure-3 [20]

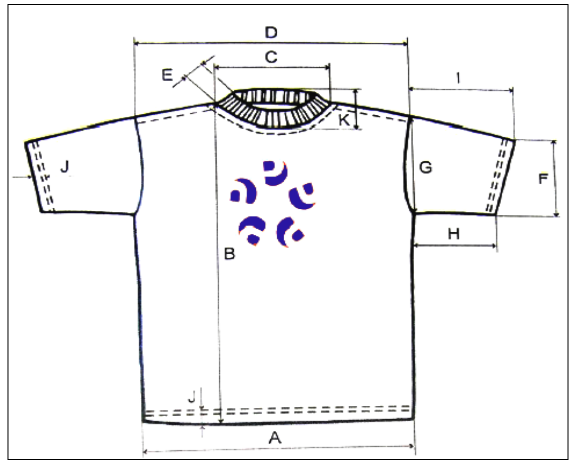

Fig 3: Dimensions of basic T-shirt

Researchers found that Envoy Textile Ltd. produces five different sizes of T-shirts (S, M, L, XL, and XXL) and their measurements are shown in Table-1.

Table 1: Dimensions of basic T-Shirt

Sizes (cm)	A	B	C	D	E	F	G	H	I	J	K
S	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	56	78	20	56	3	21	27	19	24	2.5	10
XXL	60	80	20	58	3	22	28	20	25	2.5	10

Analysis of existing sewing layout

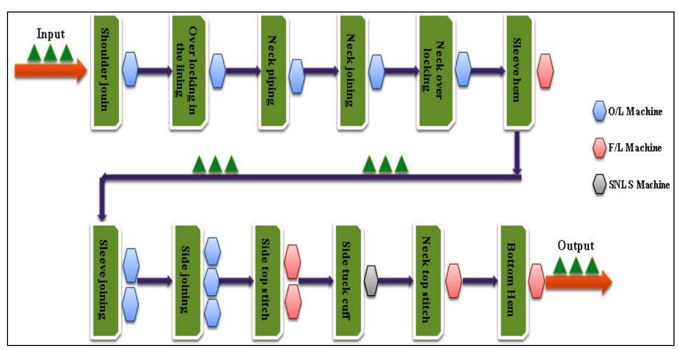

Fig 4: Existing layout of a T-Shirt sewing line

Researchers have found that three types of machines were used in existing sewing layout as shown in Figure-4. Process wise capacity of each workstation has been shown in Table-2.

Table 2: Operational bulletin of T-Shirt before rearrangement

SN	Process name	M/C type	No. of m/c	Performed SMV	Allocated SMV	Output/Hr(pcs)
1	Shoulder joining	O/L	1	0.23	0.18	258
2	Over locking of lining	O/L	1	0.22	0.18	279
3	Neck piping	O/L	1	0.22	0.18	279
4	Neck Joining	O/L	1	0.27	0.23	223
5	Neck over locking	O/L	1	0.23	0.20	258
6	Sleeve hem	F/L	1	0.23	0.20	258
7	Sleeve joining	O/L	2	0.47	0.36	258
8	Side joining	O/L	3	0.61	0.54	294
9	Side top stitch	F/L	2	0.47	0.39	258
10	Side tuck cuff	SNLS	1	0.47	0.43	129
11	Neck top stitch	F/L	1	0.27	0.22	223
12	Bottom hem	F/L	1	0.27	0.20	223

Table 3

Benchmark Target per hour	250 pcs
Total manpower (Operator+Helper)	18 persons
Working time	480 min
SMV	3.94 min
Practical Output per hour	129 pcs
Line Efficiency	47%
Labor Productivity	57 pcs

Process wise capacity of each operation has been shown in Table-2 where Standard Allowed Minutes (SAM) has been calculated by taking average cycle time for each process and considering allowances. Table-2 shows the target per hour for the line calculating total 18 manpower worked on that line for 480 minutes with a SAM value of 3.94 min. Researchers standardized the Bench mark target of 250 pieces of garment at 92% efficiency. Observation before balancing the line has been reflected as labor productivity is 57 pcs, line efficiency is 47%.

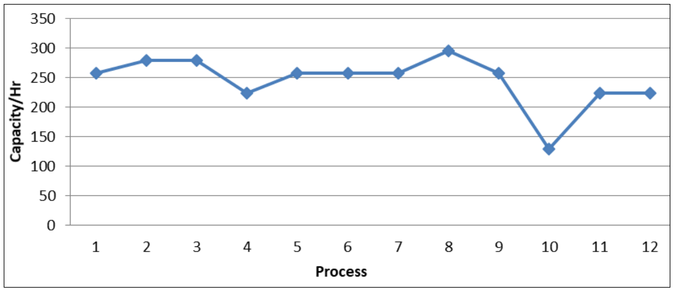

Fig 5: Process wise capacity variations (Before rearrangement

Figure-5 shows the variation of each process from the bench mark target as the upper output is 294 pcs/hr where the lower output is only 129 pieces per hour compare to the benchmark 250 pcs. This figure shows where the imbalance the line and bottleneck occur.

Proposed sewing layout

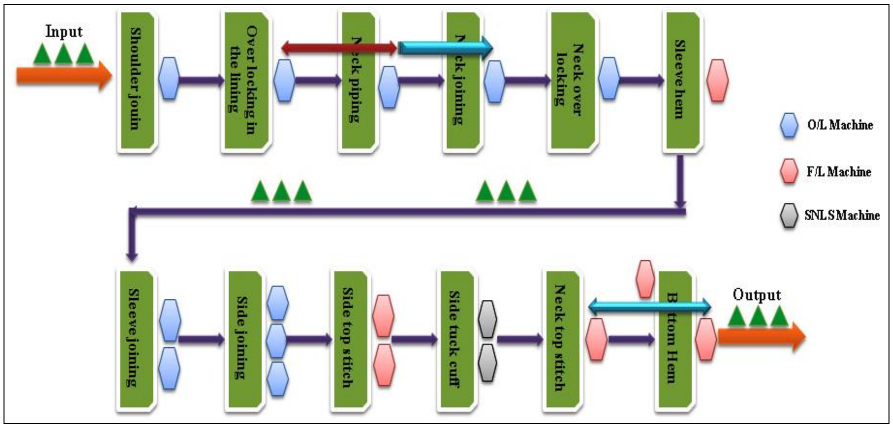

Fig 6: Proposed Sewing Layout

In this study researchers have identified some variations in process capacity from the benchmark target. The lower capacity from the benchmark target is the bottleneck point in process as production flow would stuck on the bottleneck point shown in Figure-6. In such condition researchers have rearranged existing plant layout and added two more sewing machines (SNLS & F/L) to meet benchmark target. Operators of over locking in the lining and neck piping process have helped the operator of neck joining to eliminate bottleneck and improve line efficiency shown in Table-4.

Table 4: Operational bulletin of T-Shirt after rearrangement

SN	Process name	M/C type	No. of m/c	Performed SMV	Allocated SMV	Output/Hr
1	Shoulder joining	O/L	1	0.23	0.18	258
2	Over locking of lining	O/L	1	0.22	0.18	279
3	Neck piping	O/L	1	0.22	0.18	279
4	Neck Joining	O/L	1	0.27	0.23	235
5	Neck over locking	O/L	1	0.23	0.20	258
6	Sleeve hem	F/L	1	0.23	0.20	258
7	Sleeve joining	O/L	2	0.47	0.36	258
8	Side joining	O/L	3	0.61	0.54	294
9	Side top stitch	F/L	2	0.47	0.39	258
10	Side tuck cuff	SNLS	2	0.47	0.43	258
11	Neck top stitch	F/L	1.5	0.27	0.22	335
12	Bottom hem	F/L	1.5	0.27	0.20	335

Table 5

Benchmark Target per hour	250 pcs
Total manpower (Operator+Helper)	20 persons
Working time	480 min
SMV	3.94 min
Practical Output per hour	235 pcs
Line Efficiency	77%
Labor Productivity	94 pcs

Researchers have proposed to add two more sewing machines and sharing the workloads with process-II & III to reduce bottleneck from process-IV. Observation after balancing and sharing the workloads the labor productivity is 94 pieces, line efficiency is 77%.

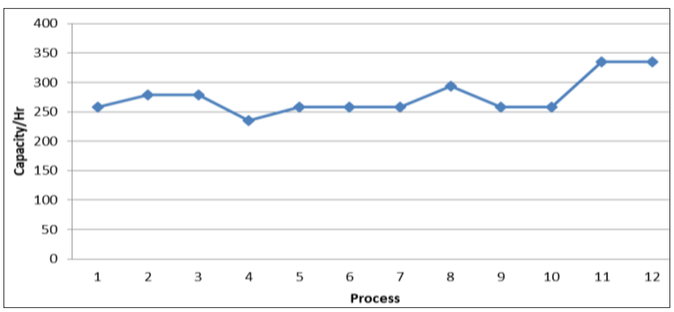

Fig 7: Process wise capacity variations (After rearrangement)

Figure-7 illustrates variation in each process capacity/hour compare to benchmark target improves after workload reallocation and line balancing. Proposed layout illustrates that the target capacity for each operation are above or very close to the benchmark capacity/hour. So, the bottleneck problem has been minimized by using line balancing method.

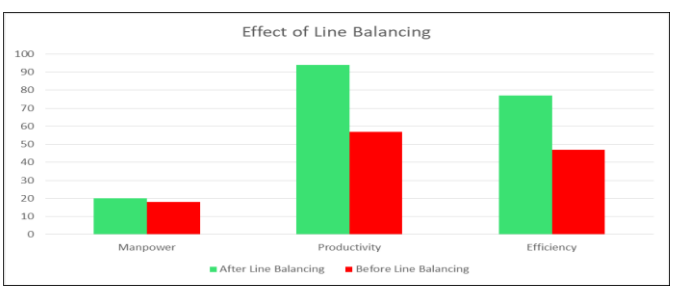

Fig 8: Significant Improvements

Functional labor flexibility analysis

In this study researchers have proposed a new sewing layout, where the number of workers and helpers were changed 18 Persons to 20 persons as shown in Figure-8. If the labor cost is 8000tk/month then total labor cost would increase 144000tk to 160000tk per month with improved output 129pcs/hr to 235pcs/hr. So that total output 22048pcs/month increased with the cost of labor 16000tk/month.

Discussion

From this study it is easily seen that, efficiency of sewing line has increased by exact positioning of machines. In the first scenario, overall 18 workers were applied but efficiency was 47% and productivity was 57 pcs/hr, Side tuck cuff was the most time-consuming process and also the capacity of Neck Joining process is relatively low. In the second scenario, an optimal layout was proposed. It was mainly focused on the Side tuck cuff and Neck Joining process as these two were the most time consuming of the whole process. In proposed layout the workloads were well balanced and two more machines added to reduce the bottleneck problem. Then finally overall 20 workers were applied but efficiency was 77% and productivity was 94 pcs/hr.

Conclusion

Result should have been more accurate if researchers would have analysis two or more existing sewing layout and balancing the process which is related to same machines with similar operations. In this study, two different layouts were shown for a common process and the efficiency for each different process was measured. Researchers have actually tried to show that how an optimal layout can increase efficiency by reallocating the workload and line balancing technique. It has also shown how the same process with the relatively same manpower can be more efficient by an appropriate layout.

Limitations and Recommendations

This study can be enhanced by a cost analysis for each scenario. Researchers suggest that if the simulation technique could be used then the proposed layout would be more validated. Multi-skilled workers can improve the efficiency of the production processes and proper training of the operator is necessary to achieve improvements on productivity and efficiency.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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