Assembly line balancing in textile industry

Prabhuling Umarani[1], Keshav Valase[2]

[1]Department of Mechanical Engineering, Walchand institute of technology, Solapur

[2]Department of Mechanical Engineering, Walchand institute of technology, Solapur

Abstract

Line balancing means balancing the production line, or any assembly line. The main objective of line balancing is to distribute the task over the each work station so that idle time of labor of machine can be minimized. Line balancing aims at grouping the resources or labor in an efficient and best pattern in order to obtain an optimum or proper balance of the resources and flows of the production or assembly processes. Assembly Line Balancing (ALB) is the term commonly used to refer to the decision process of assigning tasks to workstations in a sequence way to production system. The task of elemental operations required to build raw material in to finished product. The emergence of fast changes in fashion has given rise to the need to shorten production cycle times in the garment industry. As effective usage of resources has a significant effect on the productivity and efficiency of production operations, garment manufacturers are urged to utilize their resources effectively in order to meet dynamic customer demand. This paper focuses specifically on line balancing and layout modification. The aim of assembly line balance in sewing lines is to assign tasks to the workstations, so that the machines of the workstation can perform the assigned tasks with a balanced loading.

Keywords: Assembly Line Balancing, Pro Balance, Lean Production, Productivity

I. Introduction

Line Balancing means balancing the production line, or any assembly line. The main objective of line balancing is to distribute the task over the each work station so that idle time of labour of machine can be minimized. Line balancing aims at grouping the resources or labour in an efficient and best pattern in order to obtain an optimum or proper balance of the resources and flows of the production or assembly processes. Assembly Line Balancing (ALB) is the term commonly used to refer to the decision process of assigning tasks to workstations in a sequence way to production system. The task of elemental operations required to build raw material in to finished product.

A product, according to A survey [1] is “any item that is designed, manufactured and delivered with the intention of making a profit for the producer by enhancing the quality of life of the customer. Most products are made up of various parts, where a part can be described as a single unit of a product that are brought together with others to form the finished product. Assembly, therefore, can be explained asthe operation of bringing parts together, either manually by operators or automatically by robots, to form a finished product. Fixing of more complex parts that have more than one component before being assembled to the work-piece as a single unit is called a sub-assembly. A work-piece is an unfinished product whose assembly is in progress.

Garment manufacturing is a traditional industry with global competition. India ranks among the top target countries for any company sourcing textiles and apparel. The production process of garments is separated into four main phases: designing/clothing pattern generation, fabric cutting, sewing, and ironing/packing. The most critical phase is the sewing phase, as it generally involves a great number of operations. The sewing line consists of a set of workstations in which a specific task is processed in a predefined sequence. In general, one to several task are grouped into one workstation. Tasks are assigned to operators depending on the constraints of different labor skill levels. Finally, several workstations in sequence are formed as a sewing line.

Industrial Engineers are concerned with the balance of the lines by assigning the tasks to workstations as equally as possible. Unequal workload among workstations of a sewing line will lead to the increase of both WIP and waiting time, indicating the increase of both production cycle time and cost.

In practice, managers use their experience to assign tasks to workstations based on the task sequence, labor skill levels and the standard time required to complete each task. As a result, the line balance performance cannot be guaranteed from one manager to another with different assignment preference and/or work experience. Therefore this paper focuses to increase the production rates, reduce lead-times, and improve efficiency specifically line balancing efficiency through the implementation of basic lean tools such as 5S, standardized work, line balancing, and quality at the source. The aim of assembly line balancing in sewing lines is to assign tasks to the workstations, so that the machines of the workstation can perform the assigned tasks with a balanced loading with different labor skill levels.

Lean manufacturing is a systematic approach to identify and eliminate wastes (non-value added activities) through continuous improvement by conveying the product at the pull of the customer in pursuit of production. Lean production refers to approaches initially developed by Toyota that focuses on the elimination of waste in all forms. Many other companies that have adopted lean principles have emerged as world-class leaders in various industries.

II. Literature Review

Lean production is a conceptual frame work popularized in many western industrial companies since the early 1990's. Initially, the publication of the book "The Machine that Changed the World" [2] started diffusion of some lean manufacturing practices developed by the most competitive auto manufactures in the world. Competitiveness [3-4]. Lean manufacturing is most frequently associated with elimination of seven wastes [5]. The purpose of implementing it is to increase productivity, reduce lead time and cost, and improve quality [6].

Quality is a major focus in lean manufacturing, because poor quality management should result in huge waste and scraps. Right quality management at right time will help to control the manufacturing process [7]. Though many literatures on lean implementation are comprehensively available, very few have addressed the garment industry. [8]The pressure placed on firms in the garment industry from international competition has been enormous. The increase in competition has led to an increased focus on customer satisfaction as a survival of the company in the long run".

The garment industry has opportunities to improve, but requires some changes. Under the highly competitive environment, the garment industry has numerous opportunities for improvement using lean principles [9]. Lean practices can fulfil the customer demands with high quality and services at right time. Now, many countries have started to practice lean tools in the garment industry and observed tremendous improvement [10]. Balancing assembly lines becomes one of the most important parts for an industrial manufacturing system that should be supervised carefully. The success of achieving the goal of production is influenced significantly by balancing assembly lines. Since then, many industries and for sure researchers, attempt to find the best methods or techniques to keep the assembly line balanced and then, to make it more efficient. Furthermore, this problem is known as an assembly lines balancing problem [11].

An assembly line consists of workstations that produce a product as it moves successively from one workstation to the next along the line, which this line could be straight, u-line or parallel until completed. To balance an assembly line, some methods have been originally introduced to increase productivity and efficiency. These objectives are achieved by reducing the amount of required manufacturing time to produce a finished product, by reduction in number of workstations or both of them [12].

The Largest Candidate, Kilbridge and Wester (column) and Ranked Positional Weights (RPW) are different heuristic methods commonly utilized to arrange and distribute the description element time along the workstations in the system. Each of those methods could be results in a different type of workstations layout [13]. This study involved applying the first heuristic algorithms to study the Dantee process planning gaining a reduced production time. In this paper, largest Candidate Rule (LCR), balancing method is selected for Dantee Assembly Line balancing.

Lean and agile manufacturing is a very vast field and Line Balancing in industries is also very important. Many times in conferences this is main topic of discussion and many students and scholars also publish their work on this topic. Amen (2000) [15] presented work on an exact method for cost-oriented assembly line balancing. Characterization of the cost oriented assembly line balancing problem had been shown by without loading the stations maximally the cost oriented optimum. According to him criterion two stations rule had to be used. An exact backtracking method was introduced for generating optimal solutions in which the enumeration process was limited by modified and new bounding rules. Results of an experimental investigation showed that the new method finds optimal solutions for small and medium-sized problem instances in acceptable time. A survey on heuristic methods for cost-oriented assembly line balancing was presented by Amen (2000) [16].

In this work main focus was on cost-oriented assembly line balancing. This problem mainly occurs in the final assembly of auto-motives, consumer durables or personal computers, where production is still very labor-intensive, and where the wage rates depend on the requirements and qualifications to fulfill the work. In this work a short problem description was presented along with classification of existent and new heuristic methods for solving this problem. A new priority rule called best change of idle cost was proposed. This priority rule differs from the existent priority rules because it was the only one which considers that production cost were the result of both, production time and cost rates. A work on new heuristic method for mixed model assembly line balancing problem was published by Jin and Wu (2002) [17].

A goal chasing method was presented which is a popular algorithm in JIT system for the mixed model assembly line balancing problem. In this work, definition of good parts and good remaining sequence were provided and analyze their relationship with the optimal solutions objective function value. A new heuristic algorithm was also developing called variance algorithm' the numerical experiments showed that the new algorithm can yield better solution with little more computation overhead. Fleszar and Hindi (2003) [18] presented a work on enumerative heuristic and reduction methods for the assembly line balancing problem. They presented a new heuristic algorithm and new reduction techniques for the type 1 assembly line balancing problem. The new heuristic was based on the Hoffmann heuristic and builds solutions from both sides of the precedence network to choose the best. The reduction techniques aimed at augmenting precedence, conjoining tasks and increasing operation times. A test was carried out on a well-known benchmark set of problem instances; testify to the efficacy of the combined algorithm, in terms of both solution quality and optimality verification, as well as to its computational efficiency. A work on assembly line balancing in a mixed model sequencing environment with synchronous transfers was presented by Karabati and Sayin (2003) [19].

An assembly line balancing problem was considered in a mixed-model line which was operated under a cyclic sequencing approach. Study of the problem was done in an assembly line environment with synchronous transfer of parts between the stations. They formulated the assembly line balancing problem with the objective of minimizing total cycle time by incorporating the cyclic sequencing information. They showed that the solution of a mathematical model that combines multiple models into a single one by adding up operation times constitutes a lower bound for this formulation. An alternative formulation was proposed that suggested minimizing the maximum sub cycle time.

Problem Statement

It was observed that the floor condition was in a haphazard situation. There were lots of in process inventories between the workstations hence its output was quite less than the sewing. No precise work distribution was followed by the workers. Materials used to travel large distance from input receiving to cartooning. The line supervisors were not strict enough to control the quality right at the first time. So lots of reworks were there and the total completion time was delayed and the proportion of non–value added time was increased. So, a smooth, streamlined and continuous flow is really necessary to avoid all such unexpected occurrence.

Objectives

The main goal of this study is to ascertain how lean manufacturing (LM) practices affect layout facility designing and line balancing. A severe case study was conducted specifically in the garments sewing section. At the very beginning a detailed work measurement of their existing Sewing process and layout study was conducted. The paper addresses to solve the assembly line balancing with different labour skill levels to reduce in-process inventory and workload smoothing in the workstations of sewing.

III. CASE STUDY

Sewing assembly line is selected. Table 1 shows the operations and time taken for the entire garment to produce. The line consists of 16 work stations.

Table.1 Sewing Operations

Task Description	Task Time (Min)
Main label tack	0.51
Shoulder attach	0.51
Shoulder placket attach	0.84
Shoulder placket tack	0.84
Neck binding	0.50
Shoulder placket tack	0.65
Sleeve gathering	1.05
Sleeve hemming	0.69
Sleeve hemming	0.69
Sleeve attach	1.62
Sleeve attach	1.62
Side seam close with wash care label	1.35
Side seam close	0.60
Side seam close both sides	1.59
Bottom hemming	0.81
Sleeve tack & Neck tack	1.20

From the hourly production report, it was calculated that, for 10 hours production, the maximum production was 300pcs/day. So, the hourly sewing output would be 30pcs. A schematic scenario of present sewing section layout is given in the Figure 1. The number of manpower working in the current layout is 18.

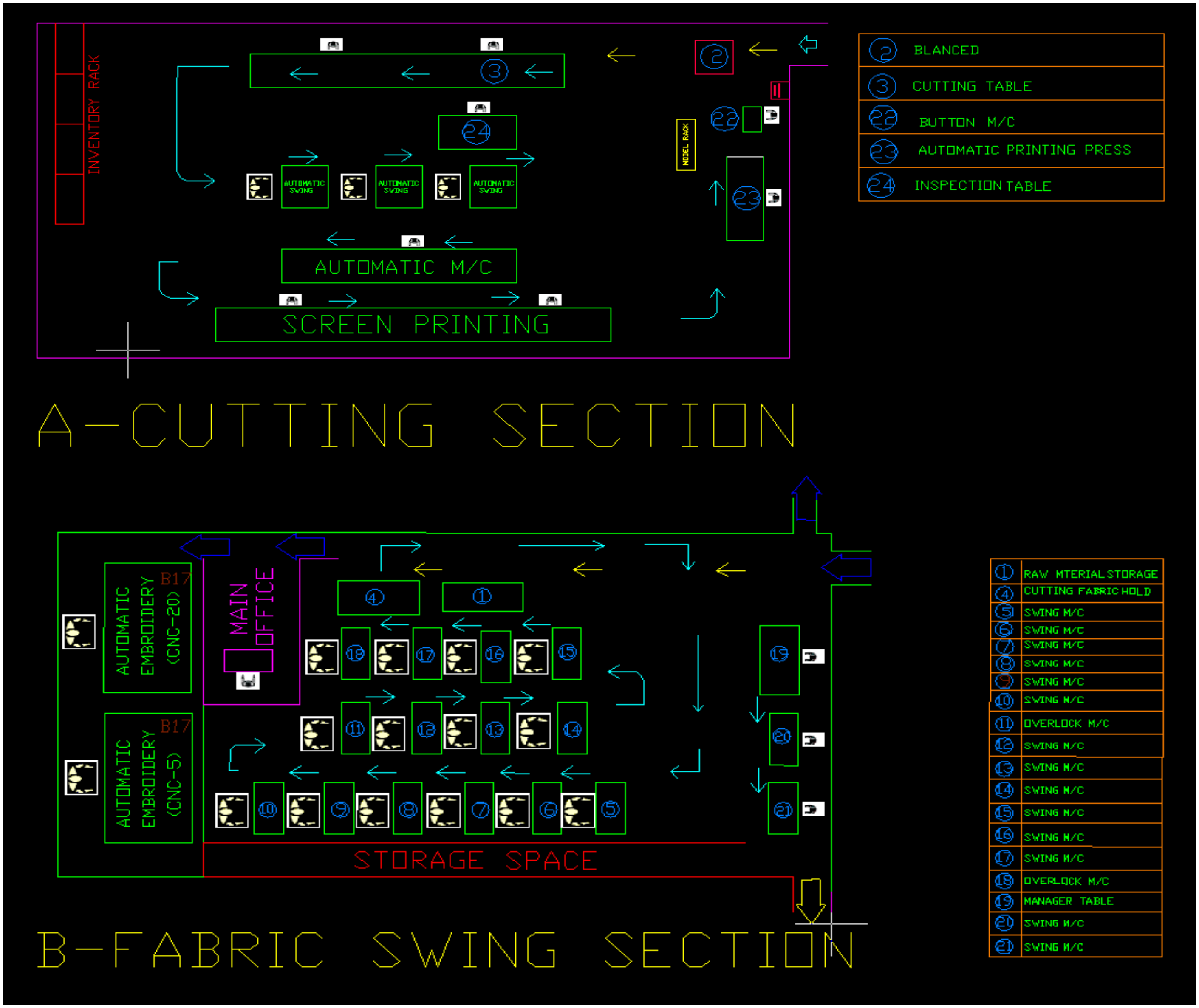


Fig.4 show current scenario layout

Drawbacks in the current scenario:-

- Processes are not broken down properly.
- Inefficient use of manpower which is not uniformly distributed.
- High level of in-process inventory.
- Haphazard layout results huge amount of cross and back flows of garments.
- Low level of productivity than it should be with the existing level of resources.
- Cutting fabric (raw material) transfer from section “A” to “B” required more time.

Assembly Line Balancing

Assembly is a manufacturing process in which interchangeable parts are added in a sequential manner using certain material flow and design layouts. The line assembly is the efficient utilization of facilities with minimum material handling as well as easy production control. Since different workstations have different working capacity it is then important to apportionment the sequential work activities into workstations in order to achieve a high utilization of labour, equipment, and time. The Assembly Line Balancing in sewing line assigns a given set of tasks to an ordered set of work stations and ensures that the precedence constraints are satisfied while the given performance measure is optimized. The line balancing process is performed first by calculating certain parameters such as the Customer Takt Time, Line balancing efficiency etc.

Customer Takt Time

Customer Takt time is defined as the ratio between the planned operating time per to the customer demand.
Customer Takt Time = available working time/ daily demand

= 90 seconds/piece

Line Balancing Efficiency

Line balancing Efficiency = (Total Station Line Time ÷ Cycle time x no. of workstations) X 100%

Line balancing Efficiency (As-is) = 59.9%

Largest Candidate Rule Algorithm (LCR)

Known as the main aim of the Line Balance is to distribute the total workload on the assembly line as evenly as possible, despite the reality in which it is impossible to obtain a perfect line balance among the workers. It is then the role of line balance efficiency which is related to the differences in minimum rational work element time and the precedence constraints between the elements. The Largest Candidate Rule (LCR) accounts for work elements to be arranged in a descending order (with reference to the station time and work elements) to each station value which is not exceeding the allowable preceded. Table 2 depicts the precedence relationship and immediate predecessor between these tasks.

Table 2. Task Precedence Relations and Immediate Predecessors

Task Description	Task Time (Min)	Immediate Predecessor(s)
Main label tack	0.51	-
Shoulder attach	0.51	1
Shoulder placket attach	0.84	2
Shoulder placket tack	0.84	3
Neck binding	0.50	4
Shoulder placket tack	0.65	5
Sleeve gathering	1.05	-
Sleeve hemming	0.69	7
Sleeve attach	1.62	8,6
Sleeve attach	1.62	9
Side seam close with wash care label	1.35	10
Side seam close	0.60	10
Side seam close both sides	1.59	12,11
Bottom hemming	0.81	13
Sleeve tack & Neck tack	1.20	13

A task can be done by machines of different types and also by operators of different labor types. The processing time of any task is a variable determined by the skill level and efficiency of the operator. The work is divided in such a way that each operator gets equal work load. The conceptual framework proposed and briefly summarized in the preceding section serves the purpose of demonstrating how the proposed framework would work.

Table 3 depicts the work elements arranged according to stations. Then figure 3 shows the Operator line balancing chart after the line balancing process and the operator cycle times have been increased by providing the workers with extra operations and the idle times of the workers was reduced and to improve the productivity. Thus the operation in the line assembly which was handled by 18 workers is now reduced by 40 % to 12 workers.

Line balancing Efficiency (To-be) = 85.5%

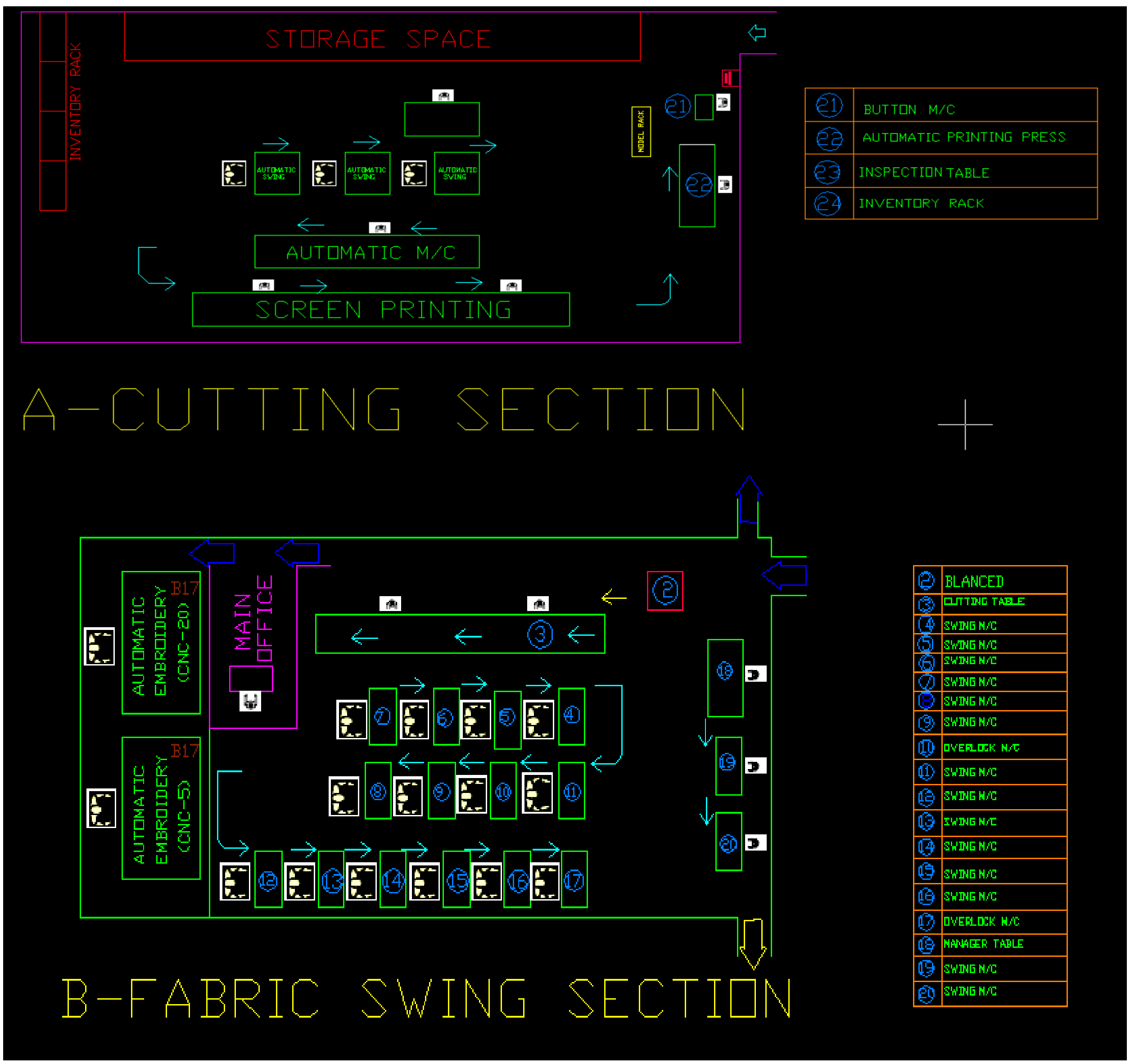
Table.3 Work elements assigned to stations

Station	Task Assigned	Task Description	Task Time (Min)
1	7	Sleeve gathering	0.51
	1	Main label tack	0.51
2	8	Sleeve hemming	0.84
3	2	Shoulder attach	0.84
4	3	Shoulder placket attach	0.50
	4	Shoulder placket tack	0.65
5	5	Neck binding	1.05
	6	Shoulder placket tack	0.69

6	9	Sleeve attach (Right)	0.69
	10	Sleeve attach(Left)	1.62
7	12	Side seam close with wash care label	1.62
8	11	Side seam close	1.35
9	13	Bottom hemming	0.60
10	14	Sleeve tack	1.59
11	15	Neck tack	0.81

The manufacturing line is redesigned to form a lean line with an optimum layout which results primarily in the productivity improvement. The area of the current layout was determined and the rearrangement of the machines in the layout so that there is a decrease in the area. The machines are kept in single straight line according to the operation sequence.

The final garment from last operation is fully checked and corrected immediately for any defects. Two workers iron the garments and pass to packing section were two workers in front of them who inspects the ironing, attach tags at required places and performs polying and cartooning. The layouts of the current and the proposed lean line are shown in the figure 4.



Features of Our Lean System

- Production time of the garment has been reduced by 1.28 minutes; this has been achieved by combining operations with other operations.
- Operators and machines have been reduced to 8 & 12 from 18. The numbers of operators are less than the number of operations (machines); one operator has to perform at least two operations. This will help to increase operator skill.
- Secondly, batch processing is converted into single piece movement by the implication of new layout.
- The rework level has been decreased over existing trends. The main reason for rework reduction is due to reduction in WIP and balanced work cells. Due to low inventory, mistakes are clearly visible and if any defect is found in the garment, it will be cleared inline, and the piece comes out as a final product.
- Stations were labelled with a description of the process as well as pictures that detail each step. Garments in feeding rack were sorted size wise, & the feeding was done size wise.

Results & Discussions

Applying the new workstation design will improve the productivity significantly. In this Study the lean manufacturing tools and techniques were studied and used. The problem of batch processing of existing is addressed by using single piece movement of WIP. Thus by converting long assembly line into work cells, the assumed worker multi-skilling seems effective as well as communication between operators is fast and accurate. The other benefits observed are the flexibility of rework reduction and online packing.

As discussed above the Production time of the garment has been reduced from 5.18 to 3.90 minutes. Operators have been reduced to 4 from 18. Assembly line efficiency has been increased from 59.5% to 85.5 %. Productivity per hour has been increased by 25 % through assembly line balancing.

REFERENCES

1. Assembly line balancing: A survey". International Journal of Production Economics, Vol. 68, pp. 1-14.
2. Womack.J. et al (1990), "The machine that changed the World" Rawson associates, newyork, NY.
3. Lowe .J. et al (1997) "High- performance manufacturing evidence from the automotive components industry" Organization Studies, Vol. 18 No. 5, pp. 783-98.
4. Oliver.N. et al (1996), lean production practices international comparisons in the auto component industry" british journal of management, vol.7 special issue, pp. 529-44
5. Shah,R and Ward, P.T., 2007 "defining of developing measure of lean production" Journal of operation management25, pp 785-805.
6. Karlsson, C. and Ahlstrom, p., 1996. "Assessing changes towards lean production", International Journal of Operation & Production management 16, pp. 24-41.
7. Nakamura, M., Sakakibara, S. and Schroeder, R., 1998. "Adoption of Just-In-Time manufacturing methods at US.and Japanese Owned Plants: some empirical evidence", IEEE transactions on engineering management 45, pp. 230-240.
8. Schmidt.M. (2000), "Application of lean principles to an enterprise value stream; a lean analysis of an automotive fuel system development process" International Journal of Production Research, Vol. 15 No. 6, pp. 553-64.
9. Kapuge, A.M. & Smith, M. (2007). Management Practices and Performance Reporting in the Sri Lankan Apparel Sector. Managerial Auditing Journal, 22 (3), 303-318.
10. Mercado, G. (2007). Question Garments- Ask the Lean Manufacturing Experts Applying Lean in the Garment Industry Retrieved January 12, 2008, Thomas Publishing Company.
11. Mazany, P. (1995). A Case Study- Lessons from the Progressive Implementation of Just-in-Time in a Small Knitwear. Manufacturer. International Journal of Operations and Production Management, 15, (5), 271-228.
12. M. Z. Matondang and M. I. Jambak (2010) "Soft Computing in Optimizing Assembly Lines Balancing Journal of Computer Science," 6 (2): 141-162, ISSN 1549-3636 © 2010 Science Publications.

13. N Ismail, G. R. Esmaeilian, M. Hamedi, and S. Sulaiman (2011) "Balancing of parallel assembly lines with mixed-model product," International Conference on Management and Artificial Intelligence IPEDR Vol.6 IACSIT Press, Bali, Indonesia pp (120-124).
14. M.P.Groover, (2008), "Automation, Production Systems, and Computer-Integrated Manufacturing," 3rd Edition, ISBN: 0132070731. USA.
15. Amen (2000)"An exact method for cost oriented assembly line balancing". International Journal of Production Economics, Vol. 64, pp. 187-195.
16. Matthias Amen Int. (2000) "Heuristic methods for cost-oriented assembly line balancing: A survey". International Journal of Production Economics, Vol. 68, pp. 1-14.
17. Mingzhou Jina, S. David Wub (2002) "A new heuristic method for mixed model assembly line balancing problem". Computers & Industrial Engineering, Vol. 44, pp.159–169.
18. Krzysztof Fleszar, Khalil S. Hindi (2003) "An enumerative heuristic and reduction methods for the assembly line balancing Problem" .European Journal of Operational Research Vol. 145pp. 606–620.
19. Selcuk Karabati, Serpil Sayin (2003) "Assembly line balancing in a mixed-model sequencing environment with synchronous transfers". European Journal of Operational Research, Vol. 149, pp.417–429.