An Application of Industrial Engineering Tools to Enhance Productivity at a Knit Composite Industry

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ABSTRACT

Process improvement is of great concern to any manufacturing company. Due to the ever-growing competition in the market, companies must be proactive if they want to sustain and grow in the long run. But this is an intricate task which requires detailed research and adequate resources, resulting in a high initial investment which many companies are reluctant to do so. Nevertheless, companies always strive for optimization when it comes to production. This paper shows the application of industrial engineering tools in a knit composite industry. After analyzing the overall production flow some areas were identified for the implications of industrial engineering tools. A modification of cutting floor layout was done using Load-Distance (L-D) score calculation and a modified layout was proposed. This modification reduced the L-D score to 48 from 52 along with reduced worker movement which is more convenient and less time-consuming. In the sewing section, line balancing was used to reduce the Standard Minute Value (SMV) by 0.42 minute as well as increasing the efficiency of the sewing line by 1.89%. Sewing defects were identified and Pareto analysis was implemented to figure out the major defects that consisted the 80% of the total defects. Material handling is an important process in many industries because it not only contributes greatly to the profit margin but also allows industries to maintain a competitive edge in the market. Some improvement ideas were suggested which could be really useful for improving the material handling system.

Keywords: Process improvement, L-D score, SMV, Line Balancing, Pareto Analysis, Material Handling.

1. Introduction

Process improvement is a key feature which most companies thrive to obtain. It is a systematic approach followed by a specific methodology. But with process variety and the company's need, different approaches are considered. These approaches aim to identify process issues, come up with a solution to fix them, and continuously analyzing the success or failure of these solutions. There are various process improvement techniques such as L-D score calculation, line balancing, Pareto analysis, etc.

Load-distance score calculation is a mathematical model which is used for location planning. Its primary objective is to select a location and minimize the total frequency of movement into and out of the facility. To calculate this for any location the multiplication of distance and loads flowing to and from the facility are summed together. The layout with the lowest L-D score gets preferred by the company.

Line balancing is a method to create a production line more flexible and efficient as well as removing unnecessary irregularities. It is linked up with labor assignments. Assigning labor on a production line based on an individual's skills and capabilities to get the most output is the main target of this method. Balancing the equipment and possible failure of any parts are also considered while applying line balancing.

Pareto analysis is a decision-making statistical technique which is used to select a limited number of tasks that have a significant amount of impact on a process. It is based on the 80/20 rule which Implies that 80% of problems are caused by only 20% causes. This methodology is widely used on Total Quality Management (TQM) and six sigma. The Pareto analysis helps to identify and prioritize the causes and guides the team for corrective action to fix the problems.

Material handling is a process of moving goods and materials from one place to another within a facility or warehouse. Material handling is comprised of processing, storing as well as controlling goods. Every manufacturing process is related somehow to material handling. So, a proper material handling system would increase efficiency. Most of the manufacturing companies are focusing on their resources to create an effective material handling approach.

2. Literature Review

Lean is one of the buzzword Industrial Engineering (IE) tools which removes waste and non-value-added activities from the manufacturing process flow [1]. To improve operational effectiveness, identifying and examining the critical operational activities are very crucial [2]. According to Toho Yang and Chih-Ching Hung, layout design can create a consequential impact on the overall performance of a service or manufacturing industry [3]. While designing or optimizing a layout, qualitative, and personnel factors should be given more priority than quantitative and computer-based models [4]. Standard Minute Value or simply SMV is the standard or mean operational cycle time. This tool is used widely in the fashion and apparel industries nowadays. Efficient line balancing could help to reduce processing time and operational costs as well as increase revenue [5]. Balancing the production line can reduce SMV and gives the company opportunities to meet increased demand in the future [6]. A study shows that management's focus on solving simple problems has evolved to solve more generalized problems with different additional characteristics [7].

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The Pareto analysis involves statistical tools to identify a few numbers of factors that result in a huge amount of overall impact [8]. These factors are termed as "Vital Few". Many manufacturers agreed to a term that, material handling could be one half of the total cost of manufacturing. A great deal of resources from both employee & equipment is needed for this activity [9]. The proper material handling system is crucial when it comes to production. By using the labor and equipment effectively, the flexibility of an operation is enhanced as well as increase productivity [10].

3. Methodology

This study aims to identify potential improvement areas to enhance the productivity of a knit composite industry. GMS Composite Knitting Industry Ltd. was selected for our two months-long industrial training program.

During this time different processes, production lines, departments, material handling systems were studied to find possible improvement opportunities. After discussing with corresponding management and operator of different levels some areas were found out to implement industrial engineering tools. These are:

1. Modification of Cutting Floor Layout with L-D Score calculation
2. Line Balancing of Sewing Section
3. Pareto Analysis on Sewing Defects
4. Improvement of Material Handling System.

3.1 Modification of Cutting Floor Layout with L-D Score calculation

Process layout is a plan which represents how the workstations and machineries will be allocated along the line of production. The load Distance score or LD score is the sum of the product of the flow matrix and distance matrix of different workstations. The following table 1 represents the movements of workers during 1 hour among different workstations of the cutting floor:

Table 1 Flow Matrix of Cutting Section.

	Workstations	A	B	C	D	E	F	G	H
A	Inventory	-	12	-	-	-	-	-	-
B	Cutting	-	-	8	-	-	-	-	-
C	Numbering	-	-	-	8	-	-	-	-
D	Bundling	-	-	-	-	8	-	-	-
E	Quality	-	-	-	-	-	-	3	-
F	Replace Table	1	-	-	-	2	-	-	-
G	Input Area	-	-	-	-	-	-	-	3
H	Sewing Section	-	-	-	-	-	-	-	-

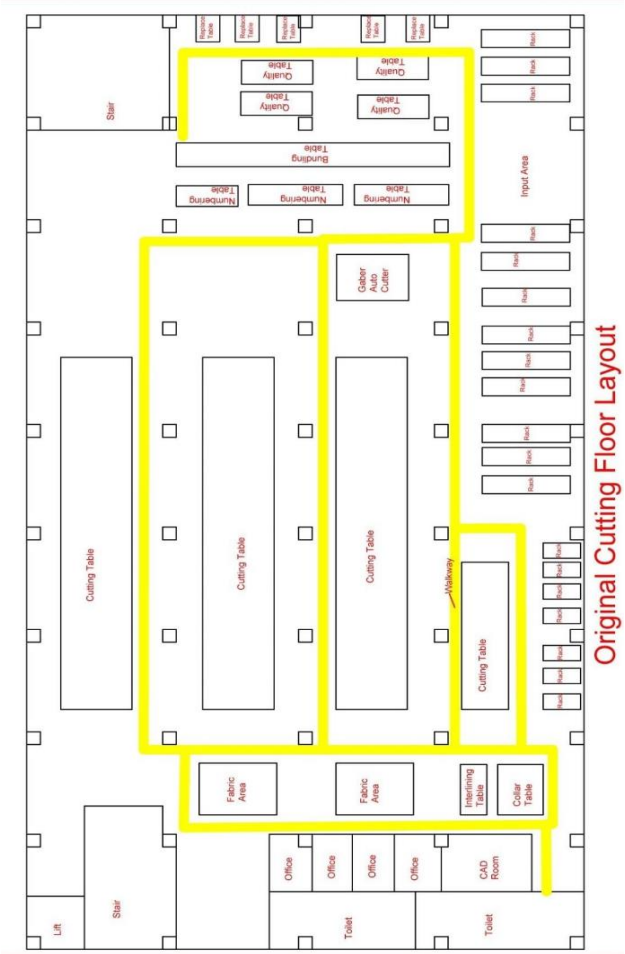

Fig.1 Existing Layout of Cutting Floor.

	F	
H	**E**	**G**
	D	
	C	
	B	**A**

Fig.2 Existing Distance Matrix.

In the existing layout, after competing tasks in Input Area (G) section materials are transported to the Sewing Area (H) section. But in between G & H sections, there are three sections Bundling (D), Quality (E) & Replace Table (F). To reduce these unnecessary movements of transporting from G & H, sections D, E, F are shifted rightwards, and Section G is shifted leftwards so that materials can be transported with lesser movements.

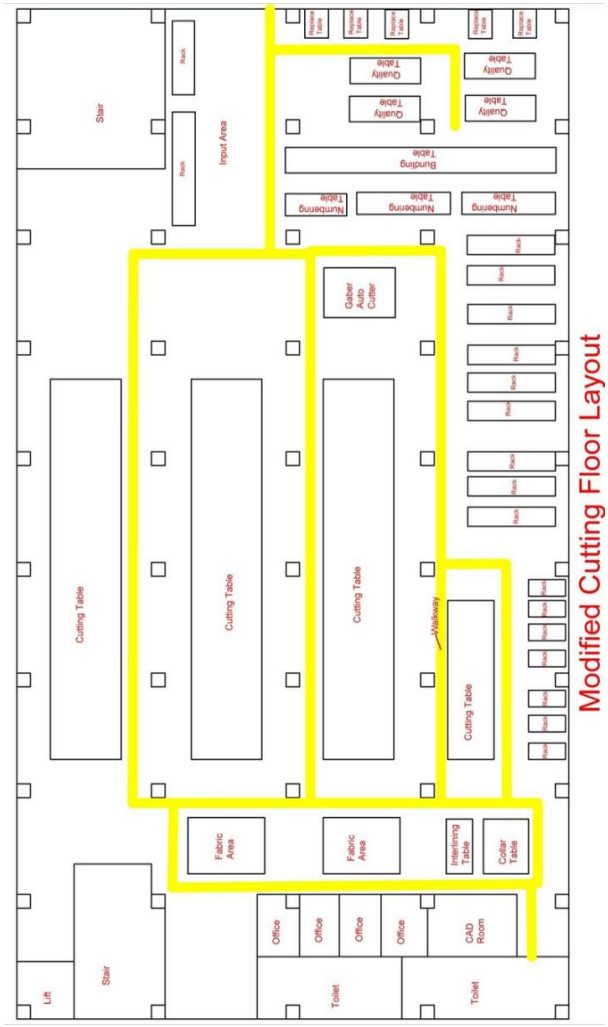

Fig.3 Modified Layout of Cutting Floor.

		F
H	**G**	**E**
		D
	C	
	B	**A**

Fig.4 Modified Distance Matrix.

3.2 Line Balancing of Sewing Section

In a sewing section production lines are adjusted according to different types and styles of products. Here, the production line for a basic t-shirt was analyzed and bottlenecks were identified. Some modifications were done to remove them.

Table 2 Existing Production Line.

Activity	**Time (Sec.)**	**SMV**	**Idle Time**		**Predecessor**
Shoulder Join	13	.21	0	A	-
Neck Rib Make	12	.2	1	B	A
Neck Join	13	.21	0	C	B
Size Label Attach	11	.18	2	D	C
Back Tape Piping	12	.2	0	E	D
Back Tape Close	18	.3	0	F	E
Sleeve Join	28	.46	0	G	F
Care Label Make	11	.18	17	H	G
Side Seam	40	.66	0	I	H
Sleeve Hem	13	.21	27	J	I
Bottom Hem	12	.2	1	K	J
Logo Attach	18	.3	0	L	K
Total Time	**201**	**3.31**	**48**		

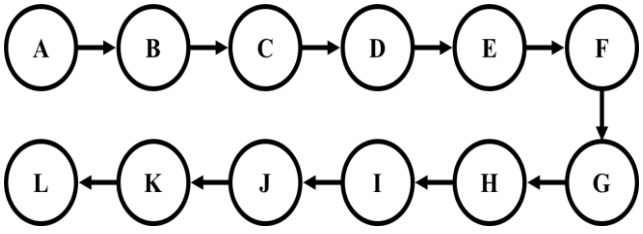

Fig.5 Existing Precedence Diagram.

In the current production line Side Seam(I) operation takes 40 seconds to complete and Sleeve Hem(J) takes 13 seconds to complete. So, the operator performing Sleeve Hem has to wait 27 seconds. This idle time can be minimized if three operators are placed instead of one. If three operators perform Side Seam operation, then the next in line Sleeve Hem operator will receive

inputs after every (40/3) 13.33 or 14 seconds. So, the idle time will reduce by 26 seconds.

Table 3 Proposed Production Line.

Activity	Time (Sec.)	SMV	Idle Time		Predecessor
Shoulder Join	13	.21	0	A	-
Neck Rib Make	12	.2	1	B	A
Neck Join	13	.21	0	C	B
Size Label Attach	11	.18	2	D	C
Back Tape Piping	12	.2	0	E	D
Back Tape Close	18	.3	0	F	E
Sleeve Join	28	.46	0	G	F
Care Label Make	11	.18	17	H	G
Side Seam	14	.24	0	I1, I2, I3	H
Sleeve Hem	13	.21	1	J	I1, I2, I3
Bottom Hem	12	.2	1	K	J
Logo Attach	18	.3	0	L	K
Total Time	175	2.89	22		

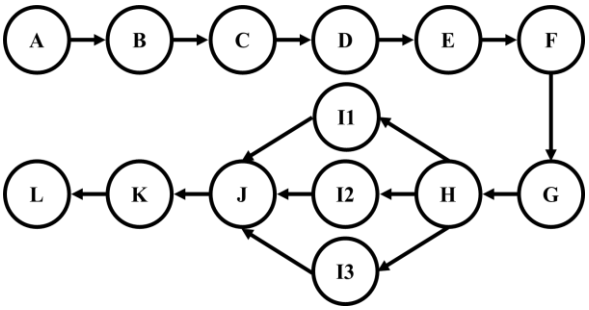

Fig.6 Modified Precedence Diagram.

3.3 Pareto Analysis of Sewing Defects

Different types of sewing defects hamper the final quality of apparel. These defects were found out with their exact frequency for three weeks. The Pareto analysis was done based on these data and the topmost defects were identified so that necessary steps can be taken to deal with these defects first.

Table 4 Sewing Defects for September

Types of Defects	1st Week	2nd Week	3rd Week	Total	%
Uncut Threads	5600	5640	6700	17940	55.91
Dirty Mark	970	742	1100	2812	8.76
Others	676	832	898	2406	7.50
Oil Mark	550	578	720	1848	5.76
Broken Stitch	340	338	396	1074	3.35
Skipped Stitch	284	302	342	928	2.89
Hole/ Fabric Reject	166	241	285	692	2.16
Shearing/ Gathering	169	234	248	651	2.03
Uneven Seam	129	184	207	520	1.62
Up Down	144	147	220	511	1.59
Puckering	120	129	145	394	1.23
Pleated	118	130	132	380	1.18
Open Seam	81	114	183	378	1.18
Raw edge	64	149	146	359	1.12
Twisted	107	102	128	337	1.05
Label Wrong Placement	73	104	151	328	1.02

Size Mistake	0	129	149	278	.87
Shading	47	0	135	182	.57
Knot/ Slub	68	0	0	68	.21
Button/ Button Hole	0	0	0	0	0
Cut/ Needle Damage	0	0	0	0	0
Foreign Yarn	0	0	0	0	0
Wavy	0	0	0	0	0
Measuring Problem	0	0	0	0	0
Placket/ Box	0	0	0	0	0
Slanted	0	0	0	0	0
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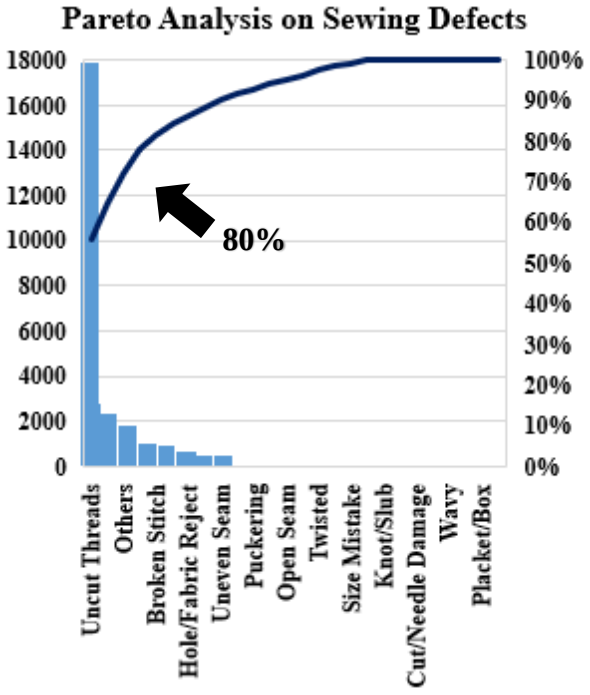

Fig.7 Pareto Analysis of Sewing Defects.

3.4 Improvement of Material Handling System

Material handling is an important process in many industries because it not only contributes greatly to the profit margin but also allows industries to maintain a competitive edge. There could be various improvement suggestions regarding the material handling system. Some of them are:

1. Utilization of Space: Building new facilities is expensive and time killing. The trend is to do more with existing space. To utilize every inch of space vertical carousels and vertical lift modules can be used.
2. Utilizing Manpower: To improve productivity and efficiency utilizing manpower is a must. If multiple workers crisscross the facility to pick parts, productivity could increase.
3. Utilization of Movement: A huge time loss occurs when workers spend walking and searching places for parts. A dynamic picking system could a solution for this.
4. Revenue Generating Activities: The reclaimed floor space from the previous action could be put to better use by additional manufacturing or adding quality control.
5. Use of Technology: Inventory management software such as Fastpic5 could be used to manage the space directing the operator where to put the part for maximum storage utilization.
6. Ergonomic Concern: The safety of workers needs to be ensured by the organization. So, working on the 'Goods to person' principle, parts are delivered to an operator at an ergonomic height to reduce worker's compensation issues and keep workers safe.

4. Result & Discussion

4.1 Modification of Cutting Floor Layout with L-D Score calculation: For the modified layout, the L-D score decreases from 52 to 48. This results in less worker movement thus time could be saved. The goal of this experiment was to reduce worker movement & increase their efficiency by saving time. Our proposed layout can achieve this goal.

Table 5 Load-Distance (L-D) Score Calculation.

		Current Layout		Proposed Layout	
Depts.	No. of trips (L)	Distance from distance matrix (D)	L-D Score	Distance from distance matrix (D)	L-D Score
A→B	12	1	12	1	12
B→C	8	1	8	1	8
C→D	8	1	8	1	8
D→E	8	1	8	1	8
E→G	3	1	3	1	3
A→F	1	5	5	4	4
E→F	2	1	2	1	2
G→H	3	2	6	1	3
Total			52		48

4.2 Line Balancing of Sewing Section

	Existing Production Line	Proposed Production Line
Balance Delay = (Idle Time/Total Time) × 100%	(48 / 201) × 100% = **23.89%**	(22 / 201) × 100% = **22%**
Efficiency = 100% - Balance Delay	(100 -23.89) % = **76.11%**	(100-22) % = **78%**

The modified production line decreases the existing balance delay by 1.89%. This results in increased efficiency & a much better production process than before.

4.3 Pareto Analysis of Sewing Defects

The Pareto analysis was done to identify major defects that are responsible for quality concerning issues. From the analysis, it was revealed that Uncut Threads, Broken Stitches, Oil Marks, Dirty Marks are the major defects that are responsible for 80% of the total number of defects. Necessary steps should be taken to reduce these defects to lessen the defect rate in the sewing section.

4.4 Improvement of Material Handling System

By implementing the improvement ideas given material handling system, numerous opportunities will be available. For example, by using vertical lift modules up to 85% of floor space can be saved. If goods are delivered directly to the workers, more orders can be processed in less time. Reduced worker movement will save time and increase productivity. The use of automation will lessen a great number of difficulties regarding material handling.

5. Conclusion

As we have entered a new era, our manufacturing process is going towards more versatility and complexity. So now, optimization of the process flow is needed more than ever to get the best output within limited resources. Identifying non-value-added activities in a process and waste minimization has become a great concern in today's world. Proper positioning of workstations through l-d score calculation will reduce movement and save time. The proper implication of line balancing can improve process efficiency and increase productivity. The Pareto analysis will help to find out the core reasons for defects. Possible countermeasures to eliminate these defects will help to improve profitability.

Improvement suggestions for material handling will alleviate space-related problems. But when it comes to a larger facility, creating an effective and efficient material handling system is not an easy task. With fast-forwarding changes in the manufacturing process, it is difficult to accomplish a long-term plan but there is always room for improvement.

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