PRODUCTIVITY IMPROVEMENT OF ASSEMBLY LINE BY LINE BALANCING TECHNIQUE

ABSTRACT

The study is concerned with the Assembly line balancing of a Sheet set, a product of a textile company that consists ofone fitted sheet, one flat sheet, and two pillows. The study aims to improve the assembly line balancing from stitching to packing Sheet Set. The problem is regarding the number of non-value-adding activities that have been found which bring unbalanced lines such as waiting time, unnecessary movement, and derangement of machines. These non-value-adding activities need to be identified and improved to reduce the labor cost and optimize the line. To overcome this problem the author used the Line Balancing Technique. Line balancing is the mechanisms of cellular manufacturing that involve key techniques of Work-study, and lean manufacturing. Line balancing is also an effective tool for allocating tasks over the workstation so the idle time for men and machines can be reduced so that there is no delay occurring during production, and nothing is overburdened. Successfully applied Line Balancing Technique from Stitching to Checking and then Checking to Packing, increasing productivity and efficiency by reducing the resources and by increasing the production capacity. Removal of non-value-added activities, Reduction in idle time, and Elimination of Bottlenecks help us to Balance the Line. Elimination of Downtime and Ensuring the Availability of Accessories must be taken into consideration while balancing the Line.

Keywords: Line balancing, time and motion study, work-study, process flow chart, assembly line.

1. Introduction

Henry Ford introduced the manufacturing assembly line in the early 1900s as a highly efficient and productive method for manufacturing a specific product. The basic assembly line consists of linearly arranged workstations connected by material handling devices[1]. The assembly line balancing (ALB) process involves assigning tasks to workstations in a manner that ensures all workstations have approximately equal work. Priority relations should not be violated during task assignments, and numerous heuristics have been reported for ALB. This process is commonly used for mass production[2]. The installation of an assembly line is a long-term, capital-intensive decision that requires careful design and balance to ensure efficiency. The system must be re-balanced periodically or after changes in the production process or program. Balancing decisions should be carefully chosen considering the strategic goals of the enterprise, as the long-term impact of these decisions is significant[3].

The assembly line is a popular method in manufacturing industries like electronics, textiles, and furniture, but it often leads to bottlenecks due to difficulties in balancing, resulting in wastes like waiting time, work in process (WIP), and overproduction. A lean line balancing could support smooth WIP flow with minimal buffers[4].

Lean manufacturing, also known as Toyota Production System (TPS), is a set of principles, tools, and techniques adopted by industrial organizations to enhance production efficiency and customer value while eliminating waste[5]. Line balancing, a mechanism of cellular manufacturing, involves work-study and lean manufacturing techniques. Time study and stopwatch time study are used to calculate work progression and time spent on specific processes. Lean manufacturing is increasingly adopted in the textile sector to improve product quality and reduce non-value-added activities[6].

Lean manufacturing is the name under which the Toyota production system (TPS) became widely known and later adopted by many companies worldwide. Lean, also denoted as lean Management, Manufacturing (LM), and Lean Principle (LP), is a set of principles, tools and techniques that many industrial organizations and companies' option to implement, in order to enhance the efficiency of production and overall customer value while at the same time eliminating waste[7].

Line balancing is the mechanisms of cellular manufacturing that involve key techniques of Work-study, and lean manufacturing. The thought of line balancing is that everything and every person are working together in one platform where everybody is concerned with the same quantity of work, but the path may be different, the difference had flattened, no worker is overloaded, no item is waiting, and work has done in a well manner in a perceived way.

Time study directed for calculating work in progression. Previously creation this time study respectively operation was smashed into certain number of elements, which are not large or too short in time, then selected average cooperative operator(s) the stopwatch time study is used to examine a specific process by skilled workers in a determination to find the maximum effective customs in terms of time. Furthermore, this technique measures the time essential for a work process to be accomplished through the finest customs. The time was measured using a stopwatch because it is easier and earlier in data recording. Besides, this category of stopwatches is appropriate for this research because it can progress exact data. This permits the element times to be entered straight on the time study sheet without the requirement for subtractions. Detect operators acting a task record time taken for respective element, over some cycles.

Textile company is the cloth manufacturing company where different process being carried out and change the raw material (cotton) by applying different processes like spinning, weaving, dying, printing, and stitching to form a finish product. These 3 processes are the complete formation of the finish product (cloth) but some of the small and medium textile company just do some of the process like spinning, and weaving, although the textile sector is very much complex and focus on quality improvement and waste reduction therefore the lean manufacturing being adopting widely in textile sector.

The concept of lean manufacturing now widely used in textile companies, because of the demand in the production and quality of product therefore textile sector now greatly using lean manufacturing tools to eliminate the non-value added activities from the production process and make the worth of the product different tools used in textile company whereasline balancing greatly used in assembly purpose mostly in stitching line 5s greatly used because to improve the management between the low and middle management and the flow of process remain undisturbed.

1.1. Problem Statement

After visiting and analyzing the Assembly lines it is observed that there are a few problems that need to be identified and could be improved. Firstly, there are the unnecessary workers at the lines and their positions are scattered and complicated. Secondly, the cycle time of the batch is not constant and sometimes becomes higher than the total lead time, when this occurs it might be hard for the line to achieve the daily target furthermore the task time of similar activities is not the same this causes an increase a in cycle time of the batch. The next problem is regarding the number of nonvalue-addingactivities that have been found which bring unbalanced lines. Thesenonvalue-adding activities need to be identified and improved to reduce labor costs andoptimize the line.

1.2. **Aim of study**; To enhance the efficiency of the assembly line.

1.3. **Objectives of study**; To streamline the assembly line process by minimizing excess manpower and machinery, thereby enhancing the efficiency of the sheet set assembly line. Additionally, to suggest or advocate for an optimized layout design following thorough line balancing.

1.4. Scope Of the Study

The study concentrates on understanding the theory and concept of Assembly linebalancing. The data collected from the industry was analyzed using a time and motionstudy of Line Balancing. The study shall be concerned with line balancing effectiveness byeliminating unnecessary Activities from the Assembly line and providing sequentialwork activities in the Assembly line with minimum idle time. The main target is toexplore the companies suitable for this project, learn and collect necessary data fromthe existing system, and propose the optimum system based on parameters, forexample, cycle time, line efficiency, and balance delay. The project is concerned withthe Assembly line balancing of the Sheet set a product of Textile Company in Pakistan that consists of one fitted sheet, one flat sheet, and two pillows.

2. Literature

Line balancing assembly involves allocating tasks and activities among operators in a balanced manner to minimize waiting time and ensure equal intensity. This process can increase productivity, reduce costs, and improve product quality in the manufacturing industry by balancing the time it takes to complete different tasks[8]. Assembly line planning involves optimizing process time and productivity through logical and physical operations. Line balancing categorizes work equally for all workstations to minimize resources and maintain productivity. Designing and balancing an assembly line for industrial products is crucial as it eliminates trial and error activities and costs associated with large-scale production[9]. Bottlenecks in the sewing assembly line cause longer cycle times and slow processes, reducing production line efficiency. Line balancing is a technique for balancing production lines. Traditional production systems need to be replaced with assembly lines for greater product variability and shorter cycle times[10].

Line balancing operates under two constraints: precedence requirement, represented by a precedence diagram, and cycle time restriction. The precedence diagram shows the sequence of tasks, with work elements represented by nodes. Cycle time is the maximum time a product can spend at each workstation, ensuring that tasks are completed before any other tasks[11].

Lean also denoted as lean Management, Manufacturing (LM),and Lean Principle (LP), it is a set of principles, tools and techniques that many industrial organizations and companies option to implement, in order to enhance the efficiency of production and overall customer value while at the same time Eliminating waste[12].

Time and motion studies are a systematic and critical approach to analyzing the efficiency and economic efficiency of tasks. They involve breaking down complex jobs into simple steps, observing the sequence of movements to detect wasteful motion, and measuring the time taken for each correct movement. This information is used to calculate production and delivery times, prices, and incentive schemes. Time and motion studies were first proposed by Frederick Winslow Taylor and developed by Frank Gilbreth and Dr. Lillian Gilbreth[13].

The main objectives of time study include determining the standard time for various operations, estimating product costs, predicting work durations, determining the number of machines an operator can run, determining the optimal number of men and machines, providing information for planning and scheduling, balancing work of all workers in a group, and comparing work efficiency of different workers/operators. Techniques for time study include time study using stopwatches, predetermined motion time systems (PMTS), work sampling, and analytical estimating[13].

Waste can be identified in seven forms: defaults, overproduction, waiting, conveyance, processing, inventory, and motion. Each form has its own causes and solutions and eliminating them can lead to multiple benefits[14]. Defaults involve unnecessary work at the end of the production process, which adds cost and resources that could be allocated to value-bringing operations. Overproduction results in inventory pileup, which requires additional space for storage and handling, deprives work hours, and hinders problem resolution. Waiting is time wasted during processes like setup changeovers, equipment breakdowns, or material delivery delays. Conveyance refers to excess transportation of materials and people due to poor planning and layout. Processing refers to over processing when operations are not required to meet customer demands due to poorly defined quality standards or poor control. Inventory is vital for smooth operation but can absorb material, spatial, and human resources when in excess. Motion is linked to workers' behavior, promoting futile movement and heavy machinery lifting, taking up time and effort, and rendering workerscounterproductive[15].

Textile companies are responsible for manufacturing cloth by applying various processes like spinning, weaving, dying, printing, and stitching to transform raw materials like cotton into a finished product. While some companies focus on spinning and weaving, the textile sector is complex and focuses on quality improvement and waste reduction. Lean manufacturing is increasingly being adopted in the textile sector to eliminate non-value-added activities and improve product value. Tools like line balancing are used in assembly, particularly in stitching, to improve management between low and middle management and maintain the flow of the process. This approach is crucial for the success of textile companies in the complex and demanding industry.

3. Methodology

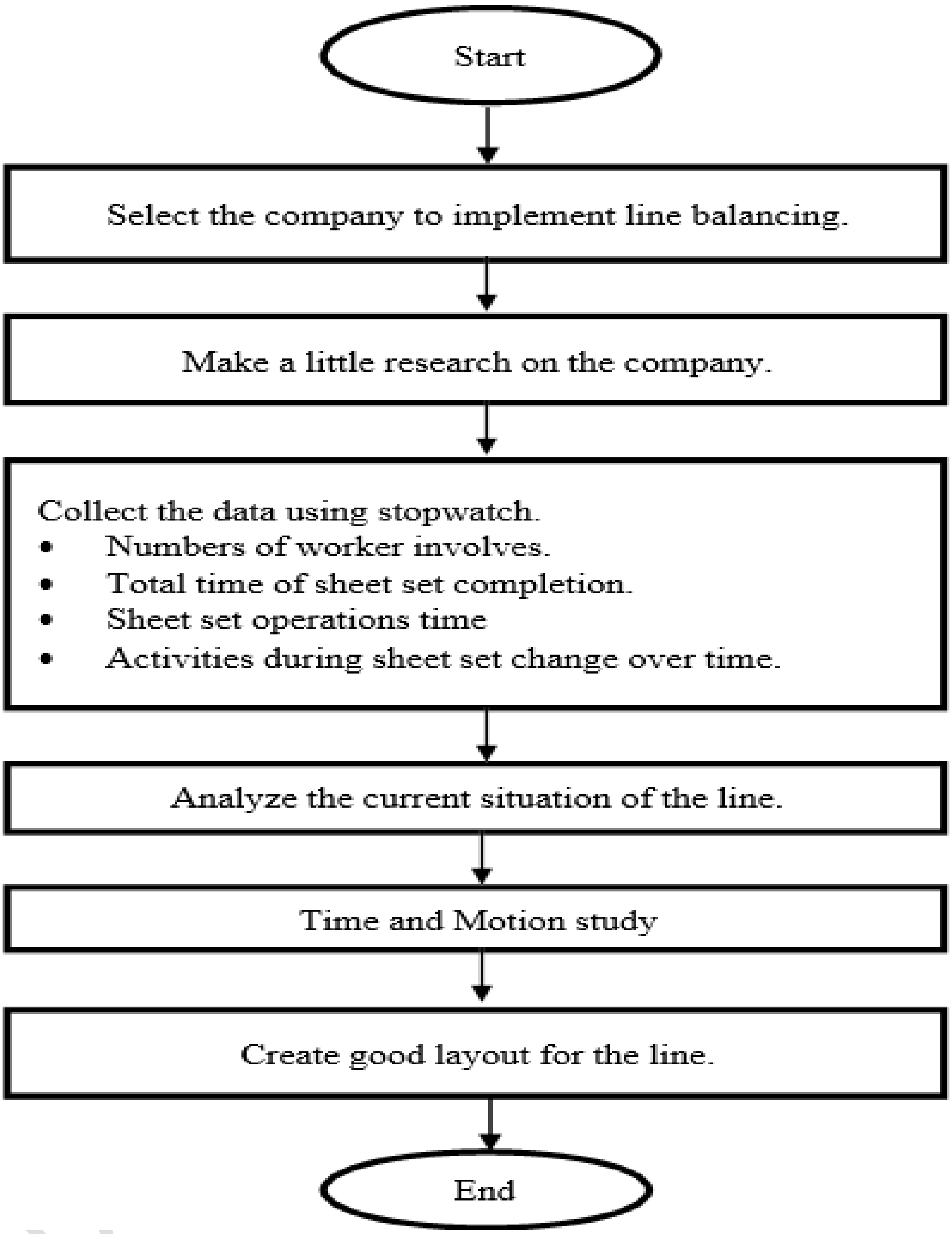

Figure 1: Flow Chart of Methodology

The above flow chart shows the methodology steps that we have followed in this study first of all have identified the company, as the interest area was in textile sector so this study conducted in thetextile mill limited Karachi Pakistan and observe the whole process of company that how the production take place and how product flow through different processes as this study was focused in the stitching department of company and did time and motion study of whole assembly process from stitching to packing by stopwatch and analyze the current situation of the line that how much time the whole process is taken to complete the product assembly so author takes the before reading and which assure that line is unbalance by calculation of SAM, capacity and man, machine requirement then change some scenarios of whole assemble line like(remove the dumping of the material through which WIP reduced Start Select the company to implement line balancing Make a little research on the company Collect the data using stopwatch; Numbers of worker involves, total time of sheet set completion , sheet set operations time , activities during sheet set change over time. Analyze the current situation of the line Time and Motion study to create a good layout for the line endand reduce the bottleneck again take the final reading of the whole assembly line and find the improvement then accordingly authorcreates or recommendsa better layout for stitching line.

Line balancing involves analyzing the current situation of a line and providing the best solution for it. Methods study focuses on decreasing work satisfaction in a job or operation, while the work dimension is concerned with unsuccessful time related to the process and following the formation of time values for the operation. Tools for observing procedures judgmentally are provided, covering activities achieved, complex operators, equipment and tools used, and materials treated or moved.

Time motion study calculates work in progression by breaking down operations into smaller, less time-consuming elements and selecting an average cooperative operator(s). A Stopwatch time study is used to examine a specific process by skilled workers to find the maximum effective customs in terms of time. This technique is easier and earlier in data recording, allowing element times to be entered directly on the time study sheet without the need for subtractions.

The time study of fitted sheet sets is used for three articles of sheet set. The stopwatch method calculates the cycle time of each operation of each article, calculates the SAM, and calculates the capacity and machine requirement of the line.

The goal of this study is to decrease processing time through falling unsuccessful times and form the basis for new work orders. Operator views are measured based on allowances and difficulties faced in real situations, making the procedure friendlier and suitable for workers.

4. DATA COLLECTION AND ANALYSIS

Theanalysisofthisassembly lineresultsinasetofstandardizedproductioninstitching, checking, and packaging operations. The next step was to organize thesetasks/activitiesoptimallytoachievetherequiredtargets.Theimportantdecisionproblemthatariseswhenconstructingorre-configuringanassemblylineislinebalancing. Line balancing consists of distributing the total workload uniformlyamong all the workers present along the stitching, checking, and packing. The overallperformanceof thesystem was greatlyaffected bythis distribution of work.

A line balancing problemwas associated withthe design ofa processflow line,which, generally consists of several processes that were joined together by sometype of material handling system, for example,the transport of finished products to thewarehouse, after ten to fifteen minutes a worker bringsa packet of packing box and otheraccessories materials before the start of new batch, etc. For a given product, the entireassembly line processes are broken down into several work elements or tasks. Eachtask is performed by workers assigned to the line. The product assembly line wascompletedbysequentialcompletion ofall the tasks.

Every product goes through the same sequence of assembly line tasks in the sameorder. However, the operations for the completion of the article may be changed due to thechangeofcustomer.

4.1. CurrentSituation of the Company

The study aims to control the fluctuating SAM (Structured Average Movement) by ensuring timely provision of product accessories and maintaining worker efficiency. Workers are often unaware of potential product loss due to delivery delays, leading to defective products. The first reading revealed widespread product dumping, resulting in Work in Progress (WIP) due to the unavailability of packing materials or management's failure to order from the warehouse. The stitching and checking line forwarded the product to the packing line after completing their task, causing dumping. This shift in working efficiency will result in a change in the SAM (Structured Average Movement) of packing line workers, as they lose their working spirit, affecting their overall efficiency. The study suggests that the timely provision of product accessories and maintaining worker efficiency can help maintain a consistent SAM throughout the operation.

This study made a standard by the negotiation with the stitching, checking, and packingline supervisor. To start the assembly line, work the packing line supervisorconfirms theavailability of all the packing accessories first and then orders to stitching line supervisor to start their work result to avoid dumping of product and run the whole assemblylineundisturbed,thisstudyalsominimizesthemachines,manpowerofstitching, checking, and packing line respectively. The target was achieved concerningthe capacity of a whole assembly line. The data is shown in the below table.

Table 1 showsthe before data of sheetsetstitching operationsmachinerequirementofsheetsetflat,fitted,andpillowforthesheetsetflatmachinerequirement that calculated for the operation 10 cm hem (1 side) and 1 cm hem (3sides) plus 1 label attach is 5 and 10 respectively. A total of 15 machines were required insheetset flat stitchingline.

For sheet set fitted machines requirement that we calculate for the operation 4 cornersstitch (4 sides) and elastic attach (4 sides) is 6 and 11 respectively. A total of 17 machineswererequired in sheet setfitted stitchingline. Forthesheetsetpillowthemachinerequirementthat calculates fortheoperation10 cm hem (2sides), safety(2 sides)plus1 label attach,and tacking (1 side) is 5, 5, and 1 respectively total in stitching line of sheet set pillow was 11machines.

Table1: Machine requirements for sheet set stitching operations before data analysis.

MACHINE REQUIREMENT

Sheet Set (Flat)						
Stitching Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
10 cm hem (1sides)	SNL	450	3500	0.5	4.58	*5*
1cm hem (3 sides) + 1lbl	SNL	450	3500	1	9.15	10
TOTAL				1.50	13.73	15
Sheet Set (Fitted)						
Stitching Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
4 corners stitch (4sides)	SNL	450	3500	0.6	5.49	6
Elastic Attach (4 sides)	SNL	450	3500	1.2	10.98	11
TOTAL				1.80	16	17
Sheet set (Pillow)						
Stitching Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
10cm hem (2 sides)	SNL	450	7000	0.25	4.58	5
Safety (2 sides) + 1lbl	SF	450	7000	0.26	4.76	5
Tacking (1 side)	SNL	450	7000	0.05	0.92	1
TOTAL				0.56	10.25	11.00

Table 2 sheet set data of stitching operations shows the result in before and afterformat. Here the authorhas minimized the number of machines as the target of the line was reachedconcerning line capacity in a sheet set flat, the study has reduced the machines from 15 to10 machines. In the sheet set fitted we have reduced the machine from 17 to 16 and in a sheetsetpillowthemachineremains the samebecausetherequiredtargetwasachievedonthese 11 machines accordingto thelinecapacity.

Table 2: After analyzing data from sheet set stitching operations: Machine requirements.

MACHINE REQUIREMENT
Sheet Set (Flat)

	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
Stitching Operations	M/C Type	Working Minutes	Daily Target	SAM		
10 cm hem (1 side)	SNL	450	3500	0.41	3.73	4
1cm hem (3 sides) + 1lbl	SNL	450	3500	0.62	5.65	6
TOTAL				1.03	9.39	10
Sheet Set (Fitted)						
	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
Stitching Operations	M/C Type	Working Minutes	Daily Target	SAM		
4 corners stitch (4 sides}	SNL	450	3500	0.44	4.01	5
Elastic Attach (4 sides)	SNL	450	3500	1.14	10.46	11
TOTAL				1.58	14	16
Sheet Set (Pillow)						
	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
Stitching Operations	M/C Type	Working Minutes	Daily Target	SAM		
10 cm hem (2 sides)	SNL	450	7000	0.22	4.08	5
Safety (2 sides) + 1lbl	SF	450	7000	0.23	4.14	5
Tacking (1 side)	SNL	450	7000	0.05	0.92	1
TOTAL				0.50	9.13	11.00

Table 3 sheet set data of stitching operations shows the result of capacity in beforeand after format. Here calculated the capacity with the help of SAM and the number ofmachines and conclude that the given target has been achieved. In the sheet set flat before datashows that the target in 1cm hem (3sides) +1 label attach not achieved and no of machinewas 8, but in after the target has achieved in all of two operations of sheet set flat.Similarly, the sheet set fitted before data shows that in elastic attach (4 sides)) operationthe given target wasn't achieved but after data, it was achieved, and the total number of machines was reduced from 18 to 16. In the last sheet set pillow before data shows that in the starting oftwo operations the given target wasn't achieved but after data, all three operationsachievedthegiven target.

Table 3: Dataof sheetsetstitchingoperationsCapacity**.**

Before	**After**

CAPACITY					
***Sheet* Set (Flat)**					
Stitching Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SA M	
10 cm hem (1sides)	SNL	450	8	0.5	6120 3060
1cm hem (3 sides) +1lbl	SNL	450	8	1	
TOTAL		450	16	1.50	4080
Sheet Set (Fitted)					
Stitching Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c m/c	SA M	
4 corners stitch (4sides)	SNL	450	9	0.6	5738
ElasticAttach (4sides)	SNL	450	9	1.2	2869
TOTAL		450	18	1.80	3825
Sheet set (Pillow)					
Stitching Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c m/c	SA M	
10 cm hem (2 sides)	SNL	450	2	0.25	3060
Safety (2 sides)	SF	450	4	0.26	5885
Tacking (1side)	SNL	450	2	0.05	15300

CAPACITY					
***Sheet* Set (Flat)**					
Stitching Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SAM	
l0cm hem (sides)	SNL	450	4	0.41	3750
1cm hem (3sides) + 1lbl	SNL	450	6	0.62	3714
TOTAL		450	10	1.03	3728
Sheet Set (Fitted)					
Stitching Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SAM	
4 corners stitch (4 sides)	SNL	450	5	0.44	4347
Elastic Attach (4 sides)	SNL	450	II	1.14	3691
TOTAL		450	16	1.58	3873
Sheet set (Pillow)					
Stitching Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SAM	
10cm hem (2 sides)	SNL	450	5	0.22	8693
Safety (2 sides)	SF	450	5	0.23	8315
Tacking (1 side)	SNL	450	1	0.05	7650

TOTAL	450	8	0.56	5464	TOTAL	450	11	0.5	8415

Table 4: ManpowerRequirement for sheet set checking operations before data analysis.

MANPOWER REQUIREMENT						
Sheet Set (Flat)						
Checking Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping+ Stacking	Manual	450	3500	0.8	7.32	8
Bundle Making	Manual	450	3500	0	0.00	0
TOTAL				0.80	7.32	8.00
Sheet Set (Fitted)						
Checking Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping +Stacking	Manual	450	3500	0.8	7.32	8
Bundle Making	Manua l	450	3500	0	0.00	0
TOTAL				0.80	7	8.00
Sheet Set (Pillow)						
Checking Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping+ Stacking	Manual	450	7000	0.1	1.83	2
Turning	Manua l	450	7000	0.03	0.55	1
TOTAL				0.13	2	3

Table 5: AfterdataofsheetsetcheckingoperationsManpowerRequirement

MANPOWER REQUIREMENT						
Sheet Set (Flat)						
Checking Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping + Stacking	Manual	450	3500	0.48	4.39	5
Bundle Making	Manual	450	3500	0	0.00	0
TOTAL				0.48	4.39	5.00
Sheet Set (Fitted)						
Checking Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping+ Stacking	Manual	450	3500	0.47	4.27	5
Bundle Making	Manual	450	3500	0	0.00	0
TOTAL				0.47	4	5.00
Sheet Set (Pillow)						
Checking Operations	Efficiency		85%		M/C Requirement @ 85%	M/C Requirement @ 85%
	M/C Type	Working Minutes	Daily Target	SAM		
Cropping + Stacking	Manual	450	7000	0.10	1.83	2
Turning	Manual	450	7000	0.03	0.51	1
TOTAL				0.13	2	3

The above tables 4 shows the data set of checking before the line balancing andTable 5 setsthe data of checking operations to show the result. Here minimizes the amount of manpower as the target of the line was achievedconcerning linecapacityin sheet set flatreduced themanpower from 8 to 5. Similarly, the sheet set fitted reduced the manpower from 8 to 5, and in the sheet setpillow,themachineremained the samebecausetherequiredtargetwasachievedonthe 3pairs ofmanpower accordingto thelinecapacity.

Table 6: Data of sheet set stitching operations Capacity.

Before						After					
CAPACITY						**CAPACITY**					
Sheet Set (Flat)						**Sheet Set (Flat)**					
Checking Operation	Efficiency		85%		capacity	Checking operation	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SAM			M/C Type	Working Minutes	No of m/c	SAM	
Cropping + stacking	Manual	450	8	0.8	3825	Cropping + stacking	Manual	450	5	0.48	3984.375
Bundle Making	Manual	450	0	0	0	Bundle Making	Manual	450	0	0	0
TOTAL		450	8	0.8	3825	TOTAL		450	5	0.48	3984.375
Sheet Set (Fitted)						**Sheet Set (Fitted)**					
Checking Operation	Efficiency		85%		capacity	Checking Operation	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SAM			M/C Type	Working Minutes	No of m/c	SAM	
Cropping + stacking	Manual	450	8	0.8	3825	Cropping+ Stacking	Manual	450	5	0.47	4069.1489
Bundle Making	Manual	450	0	0	0	Bundle Making	Manual	450	0	0	0
TOTAL		450	8	0.8	3825	TOTAL		450	5	0.47	4069
Sheet Set (Pillow)						**Sheet Set (Pillow)**					
Checking Operation	Efficiency		85%		capacity	Checking Operation	Efficiency				capacity
	M/C Type	Working Minutes	No of m/c	SAM			M/C Type	Working Minutes	No of M/c	SAM	
Cropping + stacking	Manual	450	2	0.1	7650	Cropping+ Stacking	Manual	450	2	0.10	7650.0000
Turning	Manual	450	1	0.03	12750	Turning	Manual	450	1	0.03	12750
TOTAL		450	3	0.13	8826.923	TOTAL		450	3	0.13	8826.923

The above sheet set data of checking operations shows the result of capacity in before and after format. Here in the sheet set flat both format before and after, the target has been achieved but now this time we gave the preference number ofmanpower,sotheresulthasshowninthe abovedatasheet,beforedatathemanpowerwas8hasachievedthetargetbutinafterreadingthegiventargetwasachievedin5manpower.Similarlyinthe sheetsetfittedinbothformatstargetwasachievedbutreducedthemanpowerfrom 8 to 5 andinthe sheetsetpillowthereisa number ofmanpower reductionbecausethetargetcanachieveatleast3manpower.

Table 7: BeforedataofsheetsetPackingoperationsManpowerRequirement

MANPOWER REQUIREMENT						
Sheet Set						
Packing Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
2 inlay card insertion in polybag	Manual	450	3500	0.2	1.83	2
Fitted Folding	Manual	450	3500	0.13	1.19	2
Flat Folding with stiffener	Manual	450	3500	0.25	2.29	3
Pillow Pairing	Manual	450	3500	0.29	2.65	3
Fitted+Pillow Pairing	Manual	450	3500	0.16	1.46	2
Set Pairing(Fitted. flat· Pillow)	Manual	450	3500	0.13	1.19	2
Set insertion in polybag	Manual	450	3500	0.12	1.10	2
Zip closing	Manual	450	3500	0.37	3.39	4
2 Stickers attach	Manual	450	3500	0.44	4.03	5
Insertion in carton	Manual	450	3500	0.12	1.10	2
carton sealing	Manual	450	3500	0.2	1.83	2
TOTAL				2.41	22.05	29.00

The above table shows the Manpower requirement of the sheet set packing operations,beforethe datethe operationswere done manually by the workerseachworkerhada time of 450 minutes in a day and each hada target of 3500 according to theircalculated SAM the Manpower requirement of operation 2 inlay card insertion inpolybag, Fitted Folding, Flat Folding with stiffener, Pillow Pairing, Fitted + Pillow Pairing, Set Pairing (FittedflatPillow), Set insertion in polybag, Zip closing2 Stickers attach, Insertion in carton, carton sealing is 2, 2, 3, 3, 2, 2, 2, 4, 5, 2, and 2respectively.

Table 8 shows the set data of Packing operations shows the result. Here the studyminimized the amount of manpowerfrom 29 to27 asthe target of the linewas achieved concerning linecapacity.

Table 8: AfterdataofsheetsetPackingoperationsManpowerRequirement

MANPOWER REQUIREMENT						
Sheet Set						
Packing Operations	**Efficiency**		**85%**		**M/C Requirement @ 85%**	**M/C Requirement @ 85%**
	M/C Type	**Working Minutes**	**Daily Target**	**SAM**		
2 inlay card insertion in polybag	Manual	450	3500	0.2	1.83	2
Fitted Folding	Manual	450	3500	0.12	1.10	2
Flat Folding with stiffener	Manual	450	3500	0.19	1.74	2
Pillow Pairing	Manual	450	3500	0.22	2.01	3
Fitted+Pillow Pairing	Manual	450	3500	0.14	1.28	2
Set Pairing (Fitted-Flat-Pillow)	Manual	450	3500	0.13	1.19	2
Set insertion in polybag	Manual	450	3500	0.12	1.10	2
Zip closing	Manual	450	3500	0.33	3.02	4
2 Stickers attach	Manual	450	3500	0.36	3.29	4
Insertion in Carton	Manual	450	3500	0.12	1.10	2
Carton sealing	Manual	450	3500	0.2	1.83	2
TOTAL				**2.13**	**19.49**	**27.00**

Table09 : Dataof sheetset PackingoperationsCapacity

Before						**After**					
CAPACITY						**CAPACITY**					
Sheet Set						**Sheet Set**					
Packing Operations	Efficiency		85%		capacity	Packing Operations	Efficiency		85%		capacity
	M/C Type	Working Minutes	No of m/c	SAM			M/C Type	Working Minutes	No of m/c	SAM	
2 inlay card insertion in polybag	Manual	450	2	0.2	3825	2 inlay card insertions in polybag	Manual	450	2	0.2	3825
Fitted folding	Manual	450	2	0.13	5884.6154	Fitted Folding	Manual	450	2	0.12	6375
Flat Folding with stiffener	Manual	450	3	0.25	4590	Flat Folding with stiffener	Manual	450	2	0.19	4026.3158
Pillow Pairing	Manual	450	3	0.29	3956.8966	Pillow Pairing	Manual	450	3	0.22	5215.9091
Fitted + Pillow Pairing	Manual	450	2	0.16	4781.25	Fitted+Pillow Pairing	Manual	450	2	0.14	5464.2857
Set Pairing (fitted-Flat· Pillow)	Manual	450	2	0.13	5884.6154	Set Pairing (Fitted-Flat· Pillow)	Manual	450	2	0.13	5884.6154
Set insertion in polybag	Manual	450	2	0.12	6375	Set insertion in poly bag	Manual	450	2	0.12	6375
Zip closing	Manual	450	4	0.37	4135.135	Zip dosing	Manual	450	4	0.33	4636.3636
2Stickers attach	Manual	450	5	0.44	4346.5909	2Stickers attach	Manual	450	4	0.36	4250
Insertion in Carton	Manual	450	2	0.12	6375	Insertion in Carton	Manual	450	2	0.12	6375
Carton sealing	Manua l	450	2	0.2	3825	Carton sealing	Manual	450	2	0.2	3825
TOTAL		450	29	2.41	2.6971	TOTAL		450	27	2.13	4848.5915

Operations show the result of capacity in before and after format. Here is thecombinedresult of Flat, Fitted, and pillow. After performing all the operations of stitching and checking to Flat,Fitted, andpillow they combine into a sheet set and assemble in a packing room the above sheetshowsthe whole sheet set capacity.

5. CONCLUSION

The study aimed to enhance the productivity of the assembly line for sheet sets, focusing on operations from stitching to packing. Key points included reducing cycle time, optimizing workers, and increasing production capacity. Machine requirements were reduced for Flat and Fitted Stitching Operations and increased for Pillow Operations. Production capacity was balanced for Flat and Fitted Sheets and Pillow Operations to meet line targets. Manpower requirements were reduced for Flat and Fitted Sheet Checking and Pillow Checking, while increasing capacity for checking for Flat and Fitted Sheets and Pillow. Packing manpower was reduced from 29 to 27 and increased capacity. The balanced line layout was designed for a balanced production line. Overall, the project successfully improved the assembly line's efficiency.

6. RECOMMENDATIONS

The discussion revolves around the importance of timely accessory availability in balancing production lines. The Time Study emphasizes the need for an Integrated Management System (ERP) to streamline operations and reduce Work in Progress (WIP). The company should also provide comprehensive training to supervisors and floor in-charges on the ERP system to minimize unnecessary movement, reduce waiting times, and enhance lead times in the production process. This strategic move aims to reduce unnecessary movement and improve overall efficiency.

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