PRODUCTIVITY IMPROVEMENT OF LEATHER PRODUCTS INDUSTRY IN BANGLADESH USING LEAN TOOLS: A CASE STUDY

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ABSTRACT. There is great potential for the leather industry in Bangladesh to become one of the country's major foreign exchange earners, experts say. After readymade garments (RMG), productivity improvement can help to enrich profit of a leather products industry by minimizing excess work and developing a new method for particular operation. Nowadays, productivity improvement is a popular topic for any kinds of industry. Therefore, improving productivity is one of the main concerns of leather products industries. Lean manufacturing tools are most important tools that can help to increase productivity in leather products industry. In Bangladesh, few industries use these lean tools which can be proved as a real beneficial one. Hence, this study addresses the implementation of lean principles in a leather goods manufacturing industry in order to evaluate present process cycle efficiency (PCE), lead time and productivity prior to developing an improved strategy to bring the improved PCE, productivity and to reduce the lead time. By applying lean tools in the industry at the production line for bi-fold wallet, productivity has been improved by 85.42%. At the beginning state, the PCE was found 38.19% and after the implementation of lean tools, it would be 77.51% and lead time would also be reduced by 46.68% evaluated by takt time, bottleneck analysis, cause-effect analysis and Pareto analysis. The production flow was optimized by minimizing several non-value-added (NVD) activities such as bottlenecking, machine breakdown, queue time, waiting time, material handling time, etc.

KEY WORDS: productivity, lean tools, PCE, lead time, Pareto chart, wallet production line

ÎMBUNĂTĂȚIREA PRODUCTIVITĂȚII INDUSTRIEI PRODUSELOR DIN PIELE DIN BANGLADESH UTILIZÂND INSTRUMENTE SUPLE: UN STUDIU DE CAZ

REZUMAT. Industria de pielărie din Bangladesh are un mare potențial de a deveni unul dintre sectoarele cele mai profitabile din țară, conform experților. După îmbrăcămintea de masă, îmbunătățirea productivității poate contribui la creșterea profitului industriei produselor din piele prin reducerea la minimum a excesului de muncă și prin dezvoltarea unei noi metode pentru o anumită operațiune. În prezent, îmbunătățirea productivității este un subiect popular pentru orice tip de industrie. Prin urmare, îmbunătățirea productivității este una dintre principalele preocupări ale industriei produselor din piele. Instrumentele suple de producție sunt cele mai importante instrumente care pot contribui la creșterea productivității industriei produselor din piele. În Bangladesh, puține industrii folosesc aceste instrumente suple, care pot fi de real folos. Prin urmare, acest studiu abordează implementarea unor principiilor suple în industria de fabricare a articolelor din piele pentru a evalua eficiența ciclului de proces (PCE), timpul de producție și productivitatea înainte de a dezvolta o strategie pentru a îmbunătăți PCE și productivitatea și pentru a reduce timpul de producție. Prin aplicarea instrumentelor suple în industrie în linia de producție a portofelului cu îndoitură, productivitatea a fost îmbunătățită cu 85,42%. La început, PCE a fost de 38,19%, iar după implementarea instrumentelor suple, ajunge la 77,51%, iar timpul de execuție se reduce cu 46,68%, evaluat în funcție de timp, analiza blocajelor, analiza cauză-efect și analiza Pareto. Fluxul de producție a fost optimizat prin reducerea la minimum a câtorva activități care nu adaugă valoare (NVD), cum ar fi blocajele, defectarea mașinilor, timpul de așteptare, timpul de manipulare a materialelor etc.

CUVINTE CHEIE: productivitate, instrumente suple, PCE, timp de execuție, diagramă Pareto, linie de producție a portofelelor

AMÉLIORATION DE LA PRODUCTIVITÉ DE L'INDUSTRIE DES PRODUITS EN CUIR AU BANGLADESH À L'AIDE D'OUTILS DE GESTION ALLÉGÉE: UNE ÉTUDE DE CAS

RÉSUMÉ. L'industrie du cuir au Bangladesh a un grand potentiel pour devenir l'un des secteurs les plus rentables du pays, selon les experts. Après les vêtements de masse, l'amélioration de la productivité peut contribuer à la croissance des bénéfices de l'industrie des produits en cuir en minimisant l'excès de travail et par l'élaboration d'une nouvelle méthode pour une opération. À l'heure actuelle, l'amélioration de la productivité est un sujet populaire pour tous les secteurs. L'amélioration de la productivité est donc l'une des principales préoccupations de l'industrie des produits en cuir. Les outils de gestion allégée sont les outils les plus importants qui peuvent aider à accroître la productivité de l'industrie des produits en cuir. Au Bangladesh, peu d'industries utilisent ces outils qui peuvent s'avérer utiles. Par conséquent, cette étude porte sur la mise en œuvre des principes de la gestion allégée dans la fabrication des produits en cuir pour évaluer l'efficacité du cycle de processus existant (PCE), le temps de la production et la productivité avant d'élaborer une stratégie pour améliorer le PCE et la productivité et pour réduire le temps de production. En appliquant les outils de gestion allégée à la ligne de production de portefeuilles, la productivité a été améliorée de 85,42%. Au début, le PCE était 38,19%, et après la mise en œuvre des outils de gestion allégée, il atteint 77,51% et le temps d'exécution est réduit de 46,68%, évalué par temps de prise, analyse des goulots d'étranglement, l'analyse cause-effet et l'analyse de Pareto. Le flux de production a été optimisé en minimisant les multiples activités et les temps sans valeur ajoutée tels que les goulots d'étranglement, les pannes de machines, les temps d'attente, les temps de traitement des matériaux, etc.

MOTS CLÉS : productivité, outils de gestion allégée, PCE, temps d'exécution, diagramme de Pareto, ligne de production de portefeuille

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INTRODUCTION

Manufacturing is a vital sector in society, irrespective of being a high or low-income economy [1]. The leather sector is playing a vital role in our national economy, earning us huge amounts of export earnings. Most leather goods and footwear manufactured here are export-oriented. According to the Export Promotion Bureau (EPB), leather exports totaled USD 116.73 million in the last fiscal year 2016-2017; the amount was USD 92.50 million the previous year [2]. In the world, it is one of the leading manufacturing industries based on raw material, geographical condition, and workforce and is highly favorable for the growth of leather products industry. The demand for processed leather products is rapidly increasing in the busy world and consequently, it seems a rapid expansion of leather products industry in Bangladesh as well as in other countries. It needs several production steps to produce the finished goods from raw materials. Today higher productivity achievement is a very important factor for the production field. With the higher productivity, other various factors must be taken into consideration in manufacturing industries such as global competition, lead time and customer need in terms of quality and quantity [3, 4]. Continuous improvement with or without capital infusion necessitates competitive manufacturing [5]. Lean manufacturing is based on the Toyota Production System developed by Toyota which focuses on eliminating waste, reducing inventory, improving throughput, and encouraging employees to bring attention to problems and suggest improvements to fix those [6]. Lean manufacturing has been increasingly applied by leading manufacturing companies throughout the world. A core concept of lean manufacturing is pulling production in which the flow on the factory floor is driven by demand from downstream pulling production upstream. Some of the changes required by lean manufacturing can be disruptive if not implemented correctly and some aspects of it are not appropriate for all companies [7, 8]. A lean manufacturing facility is capable of producing the product in only the sum of its value-added work content time [9]. The main scope of lean manufacturing is to eliminate waste and reduce the cycle time to increase the profit and competitiveness by increasing the production and decreasing the cost of product [10]. On the other hand, applications of lean manufacturing in the continuous process sector have been far fewer [11-13]. To sustain the positive growth, it is necessary to ensure the proper utilization of resources. Financial growth of any industry largely depends on minimizing excess work and productivity improvement. This study was masterful with some specific objectives which were to identify, quantify and to reduce the NVD activities and time towards the exalted PCE and therefore to reduce the lead time.

METHODOLOGY

The primary data was collected from personal observations of researchers of bi-fold wallet production lines at different production stages from a leading export-oriented leather products industry in Bangladesh. The secondary data was taken through the internet, books, journals, related studies and other sources of information. The methodology of carrying out this project work is divided into the following steps. In each of the steps, lean tools have been used which have been discussed in each section further [14].

Process mapping ⟶ Takt time calculating ⟶ Lead time counting ⟶ Bottleneck Analysis ⟶ Cause-effect analysis ⟶ Introducing time reducing technique ⟶ Results

Process Mapping

A process map is a planning and management tool that visually describes the flow of work [15]. Process maps show a series of events that produce an end result. It shows who and what is involved in a process and can be used in any business or organization and can reveal areas where a process should be improved [16]. There are many research articles that have discussed about the process mapping techniques used in various small and medium scale manufacturing industries [17]. The present & proposed process mapping of bi-fold wallet production line are shown in the following Figures 1 & 2.

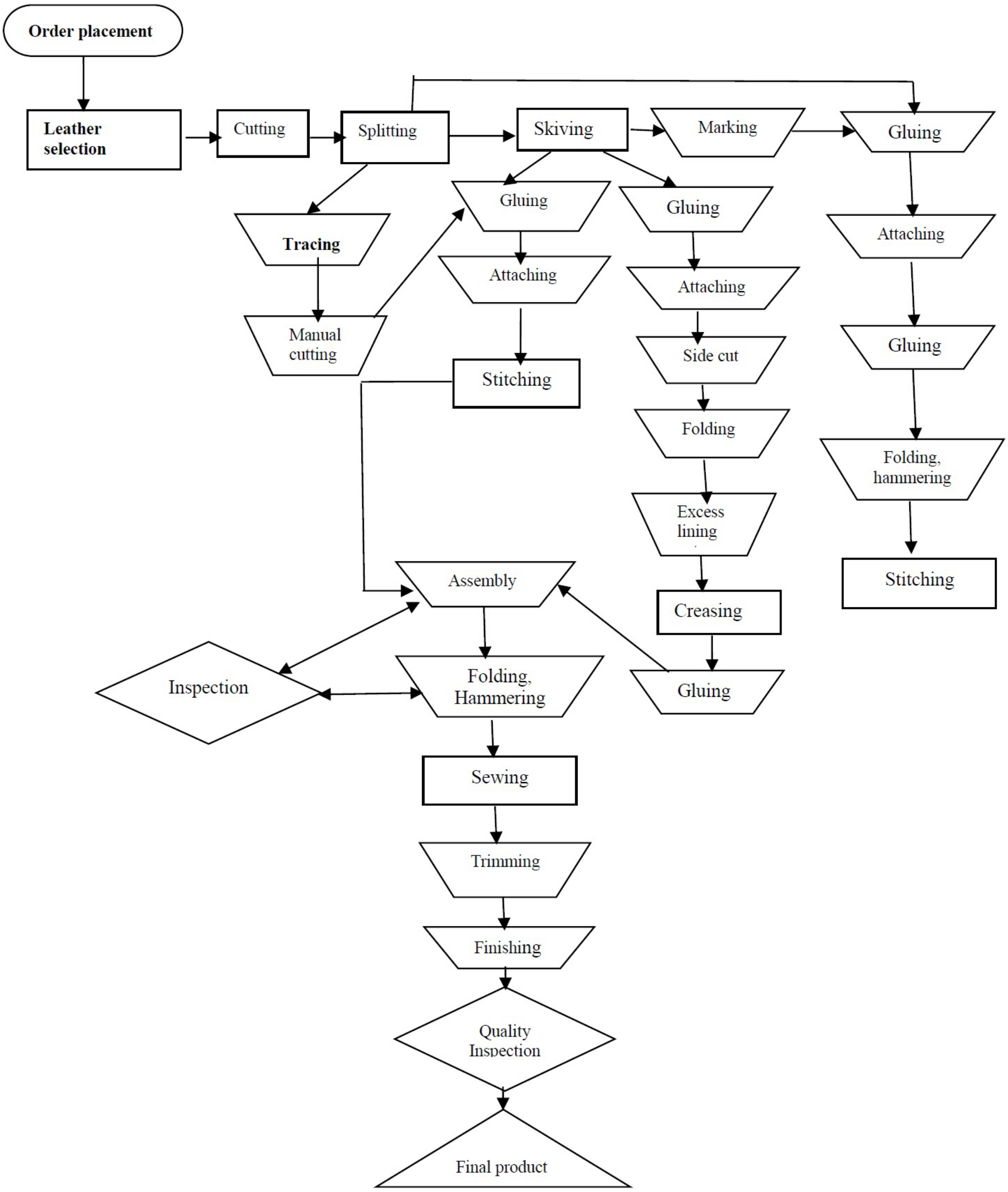

Figure 1. Present process mapping of bi-fold wallet production line

Proposed Process Mapping

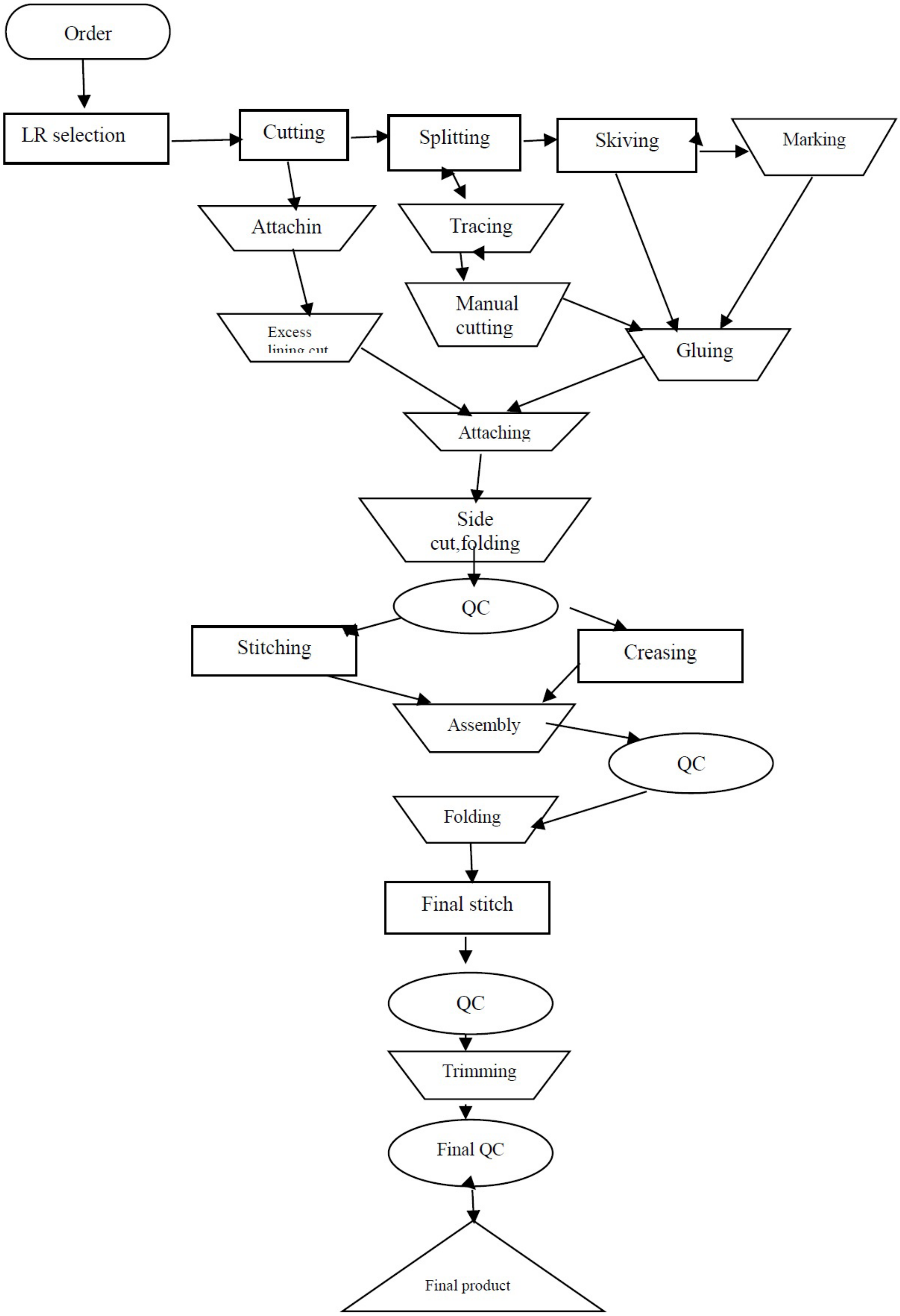

Figure 2. Proposed process mapping of bi-fold wallet production line

Takt Time Analysis

Takt-time is the unit of time in which a product must be produced (supply rate) in order to match the rate at which that product is needed (demand rate) [18]. It is calculated by dividing the total available time per day by the daily customer demand:

Takt time = Available work time/ Customer's demand

Available production time = (7 hours 45 minutes) ×8

= 465 × 8 minutes

= 3720 minutes

Customer's demand is 50 pcs of Double wallet.

Takt Time Formula = 3720/50 = 74.4 minutes/wallet

In this research, after receiving order, the production process started and the final product (Double wallet) was delivered to the customer. The factory had 8 days to deliver 50 pcs of wallet, of which 1 day was off-day. The factory has a 9-hour workday for its workers and staffs, of which 1 hour is allocated lunch break, 15 minutes is wasted in the startup process in the morning.

Data Analysis

Information related to assembly line [19-21] such as production time, inventory storages, inspections, rework loops, number of workers and operational hours per day were collected and documented in Tables 1 & 2.

Table 1: Existing cycle time analysis of bi-fold wallet production line

No	Operation name	Average cycle time (sec)	No. of workers	Waiting time in seconds	Total waiting time	Process gap time (sec)	No. of pcs of work	Total time (sec)
1	Cutting leather, lining, net	6	4				1800	10800
2	Splitting leather	4	1				750	2823
3	Skiving	12	1			86400	250	3000
3	Marking outer top	50	1				50	2500
4	Foam attaching on lining	56	2				50	2800
5	Excess lining cutting	20	1	16	800		50	1000
6	Gluing outer top	25	1	25	1250		50	1250
7	Lining with foam attaching on outer top	9	1	19	950		50	450
8	Adhesive applying on top side	10	1	18	900		50	500
9	Folding, hammering	45	1				50	2250
10	Stitching	10	1			293	50	500
11	Gluing center piece	20	1			293	100	2000
12	Center piece attaching on lining	18	1	2	200		100	1800
13	Stitching	10	1	40	4000		100	1000
14	Gluing on step pocket	10	1			293	360	3600
15	Lining attaching	6	1	4	1440		360	2160
16	Top side folding, hammering	40	2				360	7200
17	Gluing on stamp pocket	12	1	16	2400		150	1800
18	Lining attaching	6	1	22	3300		150	900
19	Side cut for folding	5	1	23	3450		150	750
20	Folding, hammering excess lining cutting	45	1				150	6750
21	Inspection	10	1	35	5250		150	1500

No	Operation name	Average cycle time (sec)	No. of workers	Waiting time in seconds	Total waiting time	Process gap time (sec)	No. of pcs of work	Total time (sec)
22	Creasing	20	1			3750	150	3000
23	Window pocket tracing	18	1				50	900
24	Manual cutting	88	1				50	4400
25	Gluing on window pocket	15	1	73	3650		50	750
26	Net attaching on window pocket	10	1	78	3900		50	500
27	Side cut for folding	5	1	85	4250		50	250
28	Top side folding, hammering	23	1	67	3350		50	1150
29	Inspection	18	1	72	3600		50	900
30	Creasing	20	1			350	50	1000
31	Gluing on both sides of step pocket	5	1				360	1800
32	Assembling 3 step pockets	25	1				120	3000
33	Stamp pocket placing	12	1	17	850		120	1440
34	Excess lining cutting	20	1	11	550		50	1000
35	Stitching	10	1			4050	50	500
36	Assembling 2 step pockets	15	1				50	750
37	Window pocket placing	20	1				50	1000
38	Excess lining cutting	22	1				50	1100
39	Stitching	5	1			2850	50	250
40	1 step pocket, 1 cut pocket attaching	40	2			405	100	4000
41	Joining window and 1 cut pocket by stitching	10	1	17	850		50	500
42	Assembling asther-1	50	1			285	50	2500
43	Assembling asther-2	50	1			300	50	2500
44	Joining by stitching	10	1			2350	50	500
45	Attaching Asther on outer top	55	1				50	2750
46	Gluing three sides of outer	20	1	35	1750		50	1000
47	Folding, hammering	62	1				50	3100
48	Final stitching	12	1	50	2500		50	600
49	Trimming, thread cutting	25	1	37	1850		50	1250
50	Final checking	50	1	12	600		50	2500
51	Packaging	30	1	32	1600		50	1500
	Total	1244			53240	101619		102373

Present Process Cycle Efficiency

Process Cycle Efficiency (PCE) is measured as the percentage of ration of VD time and lead time, where lead time is the summation of value-added time (VD) and non-value-added time (NVD) [22]. PCE is a measure of the relative efficiency in a process - it represents the percentage of value-add time (changing form, fit, function) of a product down the critical path.

Value added time = 102373 seconds = 28.44 hrs

Non-value-added time = Set-up time + Total waiting time + Total process gap time

= (10800+53240+101619) seconds = 165659 seconds = 46.02 hrs

Lead time = Value added time + Non-value-added time

= (102373+165659) seconds = 268032 seconds = 74.45 hrs

No. of worker = 14

Productivity = 0.048

PCE = (Customer Value Added Time ÷ Process Lead Time) ×100%

= (102373 ÷ 268032) ×100% = 38.19%

Bottleneck Analysis

The bottleneck of a production system is recognized as the machine that has the strongest impact on the overall system performance [23]. By definition, a bottleneck is a phenomenon where the competency of a complete system or line is restricted or limited by a single or limited number of components or resources and analysis of such event is called bottleneck analysis. Hence, bottleneck analysis is nothing but identifying which part/machine of the manufacturing process/line limits the overall output and focuses on improvement the performance of that part/machine of the process/line [24]. Bottleneck analysis is usually done along with the Time Study Method. From the process map and cycle time analysis table, we can calculate the time required in each path.

Path-1: Splitting-Skiving-Making-Gluing-Attaching-Gluing-Folding-Stitching = 297 seconds

Path-2: Splitting-Gluing-Attaching-Stitching =106 seconds

Path-3: Splitting-Skiving-Gluing-Attaching-Side Cut-Folding-Excess lining cut-Creasing =270 seconds

Path-4: Splitting-Skiving-Gluing-Attaching-Side Cut-Folding-Excess lining cut-Creasing =270 seconds

Path-5: Splitting-Tracing-Manual Cutting-Gluing-Attaching-Side Cut-Folding-Creasing =576 seconds

Path-6: Creasing-Gluing-Assembly-Folding-Final Stitch-Trimming-Finishing-Inspection-Final product= 736 seconds

Here, Path-6 takes the longest period of time to complete one cycle. So, the Bottleneck is Path-6.

Cause-Effect Analysis

As the Ishikawa diagram is prior to any data analysis, every possible cause is taken into consideration. It is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes [25]. Although it was originally developed as a quality control tool, it can be used just as well in other ways [26]. For instance, it can be used to discover the root cause of a problem, uncover bottlenecks in your processes, identify where and why a process is not working etc. Since we found that lead time is 88.8 minutes/wallet, whereas, takt time is 93 minutes/wallet; this is a serious problem that may cause huge delay in delivery. Therefore, we used Fishbone Diagram to find out possible cause behind this which is shown in the following Figure 3.

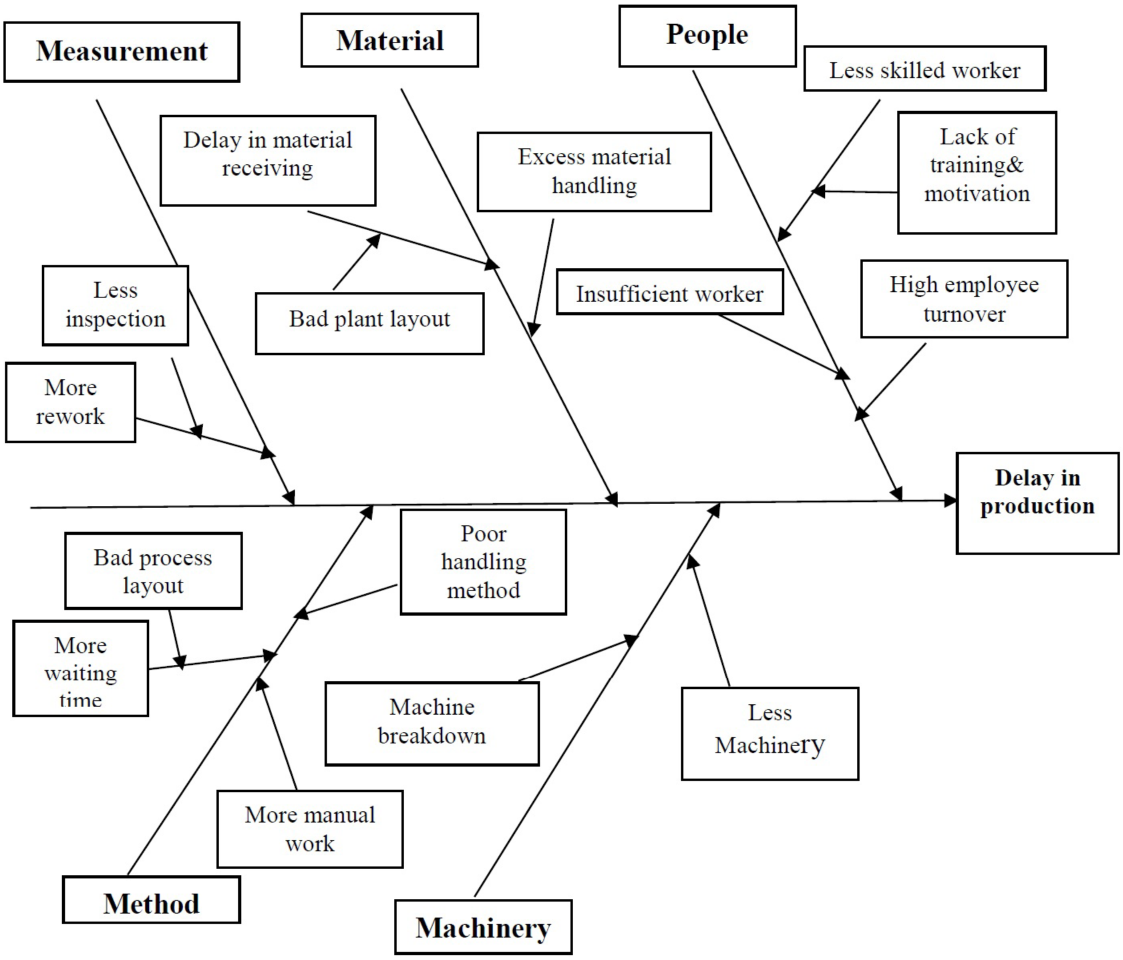

Figure 3. Cause-effect analysis of bi-fold wallet production line

Pareto Analysis

It is a statistical technique in decision making that is used for selection of a limited number of tasks that produce significant overall effect. It uses the Pareto principle – the idea that by doing 20% of work, 80% of the advantage of doing the entire job can be generated [27]. The Pareto Principle also known as the “80/20 Rule” which is the idea that 20% of causes generate 80% of results [28-30]. In this study, by using this tool it was tried to find out the 20% of causes that is generating 80% NVD activities. This tool focuses on the most damaging causes on a project.

In this essence, the application of the Pareto chart consisting of causes for downtime or NVD activities along the X axis while the Y axis represents the cumulative percentage of downtime. Most of the NVD activities were documented on sewing, pre-lasting, post-lasting and finishing steps where these were frequently observed due to different causes. The highest frequency of NVD activities that derived the down time were found for mainly needle & threads breakage while the lowest frequency was varied shown in the following Figure 4.

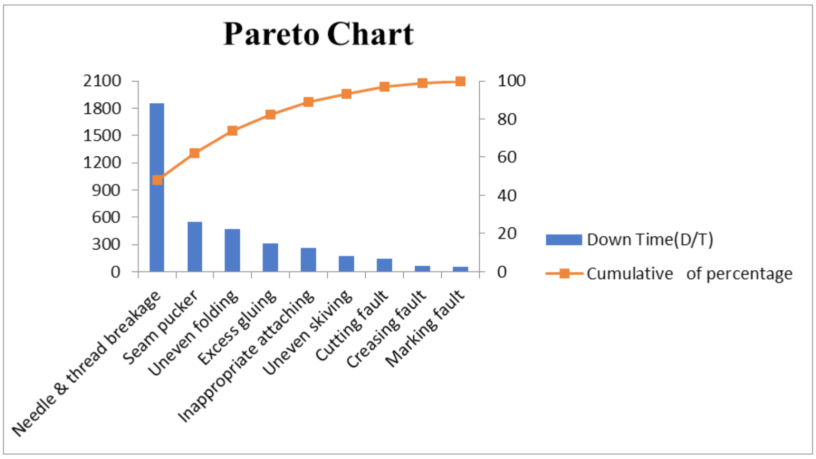

Figure 4. Pareto chart of bi-fold wallet production line

Table 2: Cycle time analysis for proposed way of bi-fold wallet production line

No	Operation name	Average cycle time (sec)	No. of workers	Waiting time (sec)	Total waiting time	Process gap time (sec)	No. of pcs of work	Total time (sec)
1	Cutting leather, lining, net	6	4				1800	10800
2	Splitting leather	4	1				750	2823
3	Skiving	12	1				250	3000
4	Marking outer top	50	2				50	2500
5	Foam attaching on lining	56	2				50	2800
6	Excess lining cutting	20	1	16	800		50	1000
7	Gluing on outer top	25	1				50	1250
8	Lining & foam attaching on outer top & gluing on top side	19	1	6	300		50	950
9	Folding, hammering	45	1				50	2250
10	Stitching	10	1			237	50	500
11	Gluing center piece	20	1			237	100	2000
12	Center piece attaching on lining	18	1	2	200		100	1800
13	Stitching	10	1	10	1000		100	1000
14	Gluing on step pocket	10	1			237	360	3600
15	Lining attaching	6	1	4	1440		360	2160
16	Top side folding, hammering	40	1				360	14400
17	Gluing on stamp pocket	12	1			237	150	1800
18	Lining attaching & side cut	11	1				150	1650
19	Folding, hammering excess lining cutting	45	1				150	6750
20	Inspection	10	1	19.36	2905		150	1500
21	Creasing	20	1				150	3000
22	Window pocket tracing	18	1				50	900
23	Manual cutting	88	2				50	4400
24	Gluing on window pocket, net attaching & side cut	30	1	14	700		50	1500

No	Operation name	Average cycle time (sec)	No. of workers	Waiting time (sec)	Total waiting time	Process gap time (sec)	No. of pcs of work	Total time (sec)
25	Top side folding, hammering & inspection	41	1	3	150		50	2050
26	Creasing	20	1	24	1200		50	1000
27	Gluing on both sides of step pocket & assembling 3 step pockets	40	1				120	4800
28	Stamp pocket placing & excess lining cutting	33	1	7	840		120	3960
29	Stitching	10	1	30	3600		120	1200
30	Assembling 2 step pockets	15	1				50	750
31	Window pocket placing	20	1				50	1000
32	Excess lining cutting	22	1				50	1100
33	Stitching	10	1	12	600		50	500
34	1 step pocket, 1 cut pocket attaching	40	2				100	4000
35	Joining window and 1 cut pocket by stitching	10	1	17	850		50	500
36	Assembling asther-1	50	1				50	2500
37	Assembling asther-2	50	1				50	2500
38	Joining by stitching	10	1	40	2000		50	500
39	Attaching asther on outer top	55	2				50	1375
40	Gluing three sides of outer	20	1	15	750		50	1000
41	Folding, hammering	62	1				50	3100
42	Final stitching, thread cutting	45	1	17	850		50	600
43	Final checking	50	1	12	600		50	2500
44	Packaging	30	1	32	1600		50	1500
		Total =1218			Total =20385	Total =948		Total =110768

Process Cycle Efficiency after using Lean Tools:

Value added time = 110768 seconds= 30.8 hrs

Non-value-added time = Set-up time + Total waiting time + Total process gap time

= (10800+20385+948) seconds= 32133 seconds=8.93 hrs

So, Lead time = Value added time + Non-value-added time

= (110768+32133) seconds = 142901 seconds=39.69 hrs

No. of workers = 14

Productivity = 0.089

Productivity improvement = (0.089-.048)/0.048 ×100%=85.4%

PCE = (Customer Value Added Time ÷ Process Lead Time) ×100%

= (110768 ÷ 142901) ×100%= 77.51 %

Existing Productivity:

Value added time = 102373 seconds or, 28.43 hrs

Non-value-added time = 165659 seconds or 46.02 hrs

Lead time = 268032 seconds or 74.45 hrs

Productivity = 0.048

Process cycle efficiency =38.19%

Productivity after using Lean Tools:

Value added time = 110768 seconds or 30.77 hrs

Non-value-added time = 32133 seconds or 8.92 hrs

Lead time = 142901 seconds or 39.69 hrs

Productivity = .089

Process cycle efficiency = 77.51%

Results:

Productivity improvement = (.089-.048)/.048 ×100%= 85.42%

Lead time reduction = (74.45-39.69)/74.45×100% =46.69%

Value added time increased = (30.77-28.43)/28.43×100%= 8.23%

Non- value-added time reduction = (46.02-8.93)/46.02×100% = 80.59%

PCE improvement = (77.51-38.19) %= 39.35%

CONCLUSION

The leather products industry is one of the key export-earning sectors in Bangladesh. Productivity improvement is a crucial matter in this industry. The profit earning of this industry totally rely on productivity improvement. The implementation of the lean concept in the leather products industry is primarily focused in order to reduce lead time and improve PCE. This model paves the way to ease implementation of lean concepts in leather products industry not only in Bangladesh but around the globe.

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