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Improvement of Productivity through Manipulating Fabrication Layout in Sewing Department of a Footwear Industry

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Abstract

Productivity of an industry can be defined as the amount of work that can be accomplished per unit time using the available resources. Assembly line balancing is a procedure within an assembly line to a workstation in order to meet the maximum production rate and to achieve a minimum amount of idle time & resource. Assembly line balancing along with the associated operations analysis assists in designing or re-arranging an assembly system, which is the key step in increasing the overall performance of an assembly line. The current thesis addresses the productivity improvement of a single assembly line by making use of operations analysis in the framework of Lean production. A methodology is proposed that helps to increase the productivity of any production process.

Key Words: Productivity, Assembly Line, Lean Production, Bottleneck.

1.1 Introduction:

Productivity of a manufacturing system can be defined as the amount of work that can be accomplished per unit time using the available resources. Assembly lines are one of the most widely used production systems. A manufacturing tool, first made popular by Henry Ford in his manufacturing of automobiles. The principle of an assembly line is that each worker is assigned one very specific task which he or she simply repeats, and then the process moves to the next worker who does his or her task, until the task is completed and the product is made. It is a way to mass produce goods quickly and efficiently. All workers do not have to be human; robotic workers can make up an assembly line as well. Pritchard (1995) defines assembly line productivity as how well a production system uses its resources to achieve production goals at optimal costs. The conventional productivity metrics, namely throughput and utilization rate gives a substantial measure of the performance of an assembly line.

Flexibility and agility are the key factors in developing efficient and competitive production systems. For products involving light manufacturing and assembly, this level of flexibility can be easily achieved through the use of manual assembly systems. Manual assembly lines are most common and conventional and still provide an attractive and sufficient means production for products that require fewer production steps and simple assembly processes. Global competition is forcing firms to lower production costs and at the same time improve quality with lower production lead times. [1]

1.2 Objectives

The objectives of this project are:

- To improve the productivity of the sewing department.
- To reduce production lead times.
- Recognize the location of bottleneck.

Literature Review:

2.1 Lean Production

Lean manufacturing or lean production, often simply "lean", is a systematic method for the elimination of waste within a manufacturing system. Lean also takes into account waste created through overburden and waste created through unevenness in work loads. Working from the perspective of the client who consumes a product or service, "value" is any action or process that a customer would be willing to pay for.

Essentially, lean is centered on *making obvious what adds value by reducing everything else*. Lean manufacturing is a management philosophy derived mostly from the Toyota Production system (TPS) (hence the term Toyotism is also prevalent) and identified as "lean" only in the 1990s.[2][3] TPS is renowned for its focus on reduction of the original Toyota *seven wastes* to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this success.[4]

The espoused goals of lean manufacturing systems differ between various authors. While some maintain an internal focus, e.g. to increase profit for the organization,[5] others claim that improvements should be done for the sake of the customer.[6]

Some commonly mentioned goals are:

- Improve quality: To stay competitive in today's marketplace, a company must understand its customers' wants and needs and design processes to meet their expectations and requirements.

- Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service. See Types of waste, above.
- Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.
- Reduce total costs: To minimize cost, a company must produce only to customer demand. Overproduction increases a company's inventory costs because of storage needs.

The strategic elements of lean can be quite complex, and comprise multiple elements. Four different notions of lean have been identified:[7]

1. Lean as a fixed state or goal (being lean)
2. Lean as a continuous change process (becoming lean)
3. Lean as a set of tools or methods (doing lean/toolbox lean)
4. Lean as a philosophy (lean thinking)

2.2 Line balancing

The manufacturing assembly line was first introduced by Henry Ford in the early 1900's. It was designed to be an efficient, highly productive way of manufacturing a particular product. The basic assembly line consists of a set of workstations arranged in a linear fashion, with each station connected by a material handling device. The basic movement of material through an assembly line begins with a part being fed into the first station at a predetermined feed rate. A station is considered any point on the assembly line in which a task is performed on the part. These tasks can be performed by machinery, robots, and/or human operators. Once the part enters a station, a task is then performed on the part, and the part is fed to the next operation. The time it takes to complete a task at each operation is known as the process time (Sury1971). The cycle time of an assembly line is predetermined by a desired production rate. This production rate is set so that the desired amount of end product is produced within a certain time period (Baybars1986). In order for the assembly line to maintain a certain production rate, the sum of the processing times at each station must not exceed the stations' cycle time (Fonseca et al , 2005). If the sum of the processing times within a station is less than the cycle time, idle time is said to be present at that station (Erel et al,1998). One of the main issues concerning the development of an assembly line is how to arrange the tasks to be performed. This arrangement may be somewhat subjective, but has to be dictated by implied rules set forth by the production sequence (Kao, 1976). For the manufacturing of any item, there are some sequences of tasks that must be followed. The assembly line balancing problem (ALBP) originated with the invention of the assembly line. Helgeson et al (Helgeson et al, 1961) were the first to propose the ALBP, and Salveson (Salveson1955) was the first to publish the problem in its mathematical form. However, during the first forty years of the assembly line's existence, only trial-and-error methods were used to balance the lines (Erel et al,, 1998). Since then, there have been numerous methods developed to solve the different forms of the ALBP. Salveson (Salveson 1955) provided the first mathematical attempt by solving the problem as a linear program. Gutjahr and Nemhauser (Gutjahr & Nemhauser 1964) showed that the ALBP problem falls into the class of NP-hard combinatorial optimization problems. This means that an optimal solution is not guaranteed for problems of significant size. [8]

2.3 Bottlenecks in Production System

According to Boyson, Fliedner & Scholl (2007), a production line processes a raw material and it is converted into a finished product after a set of value added activities. There are different types of production system and they are classified based on the types of product processed, processing time between stations, constraints adopted etc. There is a need for process improvement in any industry to remain competitive in the market. One of the problems faced by any production industry is disruption of work flow by various failures. These failures in any machine in upstream or downstream to starve or block the products flowing through the system.

The flow of products in any system is disrupted due to various failures such as machine failure, operator failure, power failure & material failure. If these failure occur repetitively, then the machine causing these failures are bottlenecks. The failure in any machine would disrupt the whole system. So, one of the important process improvement technique is to mitigate the bottlenecks. There is a 30 to 40% reduction in the system efficiency due to bottleneck machines (Chiang, Kuo, & Meerkov, 2001). Bottleneck identification is the first step to mitigate the bottlenecks.

There are many researches for identifying bottleneck machines as follows. Lawrence and Buss, (1994) proposed the longest queue length method where the machine with the longest queue of products becomes a bottleneck. Kuo, Lim and Meerkov (1996) proposed that the machine which has the lowest production rate becomes a bottleneck as it reduces the flow of products in the whole system. Chiang, Kuo and Meerkov (1998) proposed that the machine with the lowest blocking and starving time becomes a bottleneck. Similarly, the machine with highest utilization becomes a bottleneck machine. (Law and Kelton, 2000). Roser, Nakano, and Tanaka (2002) proposed that the machine with the longest active duration as a bottleneck machine. All the previous research considered multi product production system because of the complexity of the problem.

Tamilselvan, Krishnann, and Cheraghi (2010) developed new matrics for identifying bottlenecks based on inactive duration method. The metrics developed are bottleneck time ratio, bottleneck ratio, bottleneck shifting frequency, and bottleneck serving ratio. Since they considered single product production systems, there is a need for developing new matrices based on multi-product systems to identify the bottleneck machines. Since all these methods and metrics were used in single product production systems, their validity for complex production systems were tested using sample case studies.

Once the bottlenecks are identified, methods have to be developed for mitigating it. Previously, Chiadamrong, and Limpasontipong (2003) proposed that allocating buffer to bottleneck machine would solve blocking or starving there by mitigating bottleneck machines. Tamilselvan, Krishnan, and Cheraghi (2010) used additional capacity and buffers to mitigate bottlenecks. So, methods are needed to allocate buffer and machines for mitigating bottlenecks in multi-product production system.[9]

2.4 PFD allowance

PFD allowance stands for Personal needs, fatigue, and unavoidable delays allowance. It is the adjustment done to the normal time to obtain the standard time for the purpose to recover the lost time due to personal needs, fatigue, and unavoidable delays.[16] By providing a small increase to the normal time in each cycle, the worker can still be able to cover lost time and complete the work assigned to him. Generally PFD allowance are taken 15% of the overall time measured.

There are two types of interruption: (1) the interruption related to work (2) the in % eruption not related to work. For example, machine breakdown, rest break to overcome fatigue and receiving instruction from the manager are the interruption related to work, but personal needs, lunch break and personal calls are the interruption not related to work. However, the two types of interruption are essential for the worker because it seems to be impossible to work continually during a regular shift.

2.3.1 Personal needs

The personal needs allowance is the time that is associated with workers' daily personal needs which include restroom, phone call, water fountain and similar interruption of a personal nature. However, it is categorized as 5%, but it is also conditional to work environment in term of uncomfortably and temperature for example.[16]

2.3.2 Fatigue

The fatigue allowance is intended to cover the time that the worker should be given to overcome fatigue due to work related stress and conditions. There are three factors that cause fatigue :(1) physical factor like standing and use of force (2) mental and cognitive factor like mental strain and eye strain (3) environmental and work factor like poor lighting, noise and heat.[16]

2.3.3 Unavoidable Delays

Unavoidable delays are categorized under unavoidable interruption that occurs at random times during the day in work place. They usually refer to work- related events like cleaning up at the end of the shift and machine breakdowns or malfunction. Unavoidable delays occur because of many random events in work stations.[16]

Methodology

ASSEMBLY LINE PRODUCTIVITY IMPROVEMENT METHODOLOGY

The common methodology as listed below in Table 01 is followed to improve the operational performance of the production system.

As-Is Study	• Product selection • Current process Study • Time Study

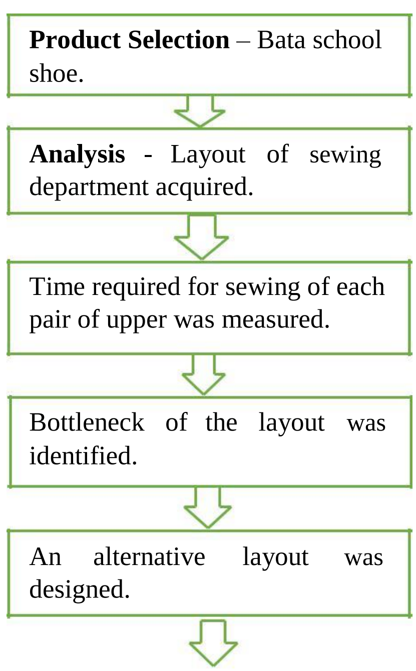
Analysis and To-Be System	• Operations Analysis • Assembly line Balancing
System Evaluation	• Performance Evaluation

Table 01: Productivity Improvement Methodology

3.3 Operations analysis

The operation analysis is a method used to identify and analyze the productive and non-productive activities described above by deployment of Lean elements and is concerned with developing techniques to improve productivity and reduce unit costs. The practice of examining business methods for efficiency. Operations analysts work to ensure that a company's management operates in the most effective methods possible. Analysts regularly maintain their own small businesses and work with larger companies on a contract basis to review and overhaul operations that may cause poor performance. Operations analysts are responsible for gathering information to locate and isolate problematic operations, interviewing existing personnel for insight on the procedures used, analyzing data from a variety of sources, recommending potential solutions or opportunities for improvement, and following up with companies after implementation to ensure the end result is satisfactory.[12]

3.4 Sequence of data collection & analysis



System Evaluation- Productivity was calculated with new alternative layout.

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Result – Productivity Increased with the new alternative layout.

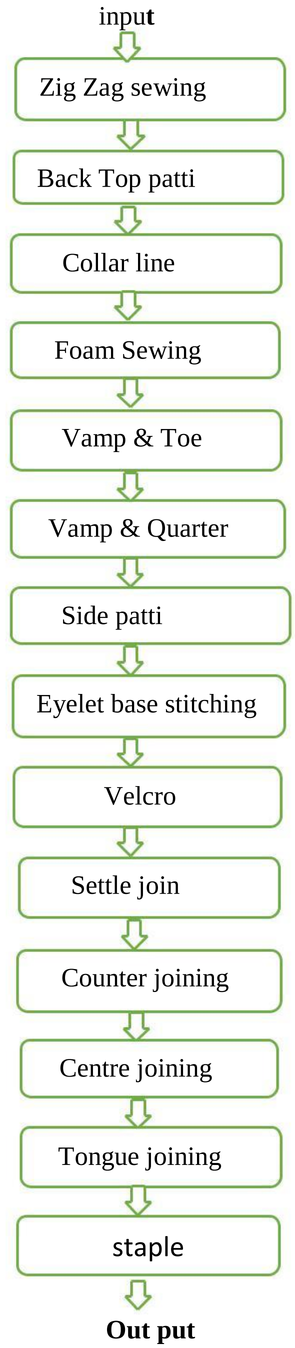
Table 02: Sequence of data collection & analysis

The sewing department consists of a number of machines. There are 14 machines

They are:

1. Zig Zag sewing
2. Back Top patti
3. Collar line
4. Foam Sewing
5. Vamp & Toe
6. Vamp & Quarter
7. Side patti
8. Eyelet base stitching
9. Velcro
10. Settle join
11. Counter joining
12. Centre joining
13. Tongue joining
14. Staple

The flow chart of machines are given below:



Layout 1: Manual single assembly line [13]

Data collection

4.1 Standard time

The standard time is the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method. It includes appropriate allowances to allow the person to recover from fatigue and, where necessary, an additional allowance to cover contingent elements which may occur but have not been observed.

The standard time is calculated by multiplying the normal time by 1 plus the PFD allowance. [15]

$$T_{std} = T_n * (1+A_{pfd})$$

- T_{std} = Standard time.
- T_n = Normal time.
- A_{pfd} = PFD allowance.

Table 1 shows the time required by each operator of different operations to sewing a pair of upper. At first time required for sewing a piece of upper is observed. Then standard time is calculated for each piece. For superior accuracy, the standard time is calculated for two piece of upper. Then those two standard times are averaged. From the average, the final time required to sewing a pair of upper is calculated. This method of calculation was followed for all the 14 machines.

Operation	**Observed normal time for 1st Piece (sec)**	**Standard time for 1st piece (sec)** [= * (1+)]	**Observed normal time for 2nd Piece (sec)**	**Standard time for 2nd piece (sec)** [= * (1+)]	**Average time (sec)**	**Per pair Time (sec)**
Zig Zag sewing	3.67	**5.698**	3.62	**5.585**	5.64	11.28
Back top Patti	5.25	**9.384**	5.02	**8.8**	9.092	18.184
Collar line	4.4	**7.30**	4.37	**7.234**	7.267	14.534
Foam sewing	5.45	**9.90**	5.20	**9.256**	9.5825	19.165
Vamp & toe	4.5	**7.5**	4.55	**7.655**	7.5775	15.155
Vamp & quarter	4.67	**7.94**	4.56	**7.67**	7.80	15.6
Side Patti	9.44	**22.80**	9.5	**23.03**	22.91	45.83
Eyelet base stitching	7.23	**15.07**	7.4	**15.61**	15.34	30.68
Velcro	5.4	**9.774**	5.3	**9.51**	9.642	19.284
Settle join	5.42	**9.82**	5.32	**9.56**	9.69	19.38
Counter joining	5.38	**9.72**	5.27	**9.43**	9.575	19.15
Centre joining	3.92	**6.22**	3.97	**6.33**	6.275	12.55
Tongue joining	5.65	**10.43**	5.67	**10.47**	10.45	20.9
Staple	6.30	**12.25**	6.27	**12.16**	6.285	12.57

Table 3: Time required to sewing a pair of upper

Table 2 shows hourly production of upper by each operator. Calculation was made giving time allowances to each operator. Time allowances mean allow the person to recover from fatigue and, where necessary, an additional allowance to cover contingent elements which may occur but have not been observed. In sewing department, the rate of production of upper per hour is 80-85. Table 2 shows that it is reasonable as the operator of side patti machine produces 78 upper per hour which is the lowest in this single manual assembly line.

Operation	Production per hour
Zig zag sewing	**320**
Back top Patti	198
Collar line	247
Foam sewing	188
Vamp & toe	238
Vamp & quarter	232
Side Patti	**78**
Eyelet base stitching	117
Velcro	187
Settle join	186
Counter joining	188
Centre joining	287
Tongue joining	172
Staple	148

Table 4: Production per hour of different sewing operations.

Results & Discussion

5.1 Results & Discussion:

The aim of the thesis is try to improve the productivity of a single assembly line. So for this the bottleneck of the assembly line is analyzed. Table 1 shows that side patti operation requires the most time as both side of the upper needs to be sewed. For this reason, the hourly production of the side patti operator is lowest & it is 78 according to table 2. Without completing all the sewing, the upper is not transferred to the next workstation. That is why in a flow line, the lowest production rate per hour by an operator is the final production per hour of upper in the sewing department. So if the side patti production can be increased, the overall production of upper per hour can also be increased. An alternative assembly line is showed below where an additional side patti machine is attached. The operator from zig zag sewing machine does the additional side patti upper sewing after full filling considerable amount of zig zag upper sewing.

For zig zag sewing,

Total time required for production of 320 pairs = (320*11.28)=3609.6sec

Total time required for production of 220 pairs = (220*11.28)=2481.6sec

Time saved=(3609.6-2481.6)=1128sec

For Side Patti,

Total time required for production of 78 pairs = (78*45.83) = 3574.74 sec

After adding saved time (from zig zag sewing) to side Patti production, the increase in side Patti production per pair = (1128/45.83) = 24.61 ≈ 22 (for safety measure)

So,Finally, the production of side Patti = (78+22) pair/hour

= 100 pair/hour

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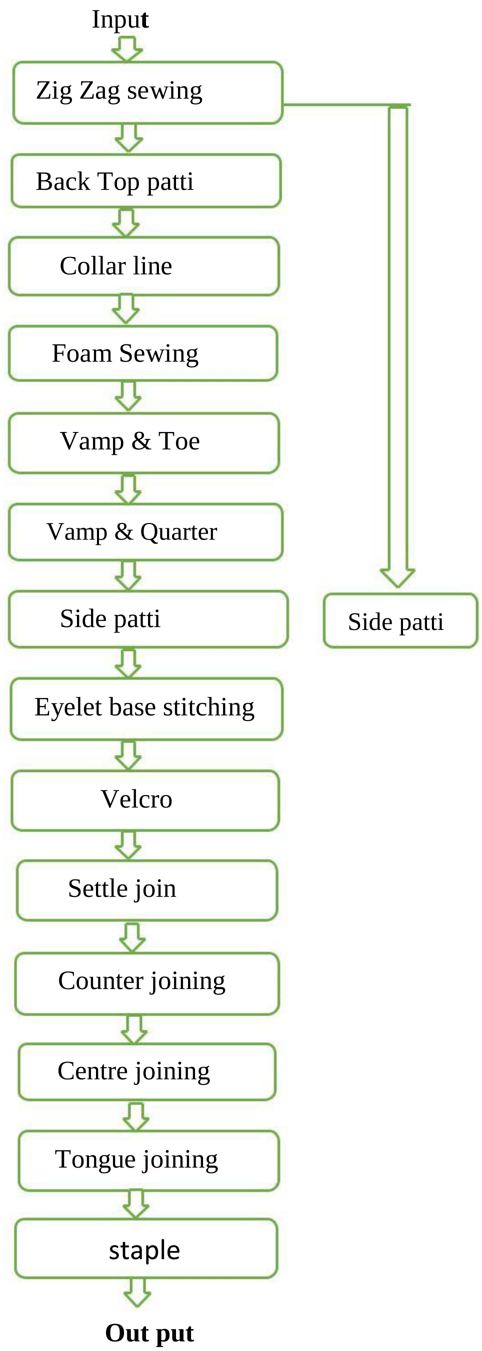

Layout 02: Alternative Manual Single Assembly Line [14]

Operation	Production per hour
Zig zag sewing	**220**
Back top patti	198
Collar line	247
Foam sewing	188
Vamp & toe	238
Vamp & quarter	232
Side patti	**100**
Eyelet base stitching	117
Velcro	187
Settle join	186
Counter joining	188
Centre joining	287
Tongue joining	172
Staple	48

Table 5: Production per hour with alternative layout

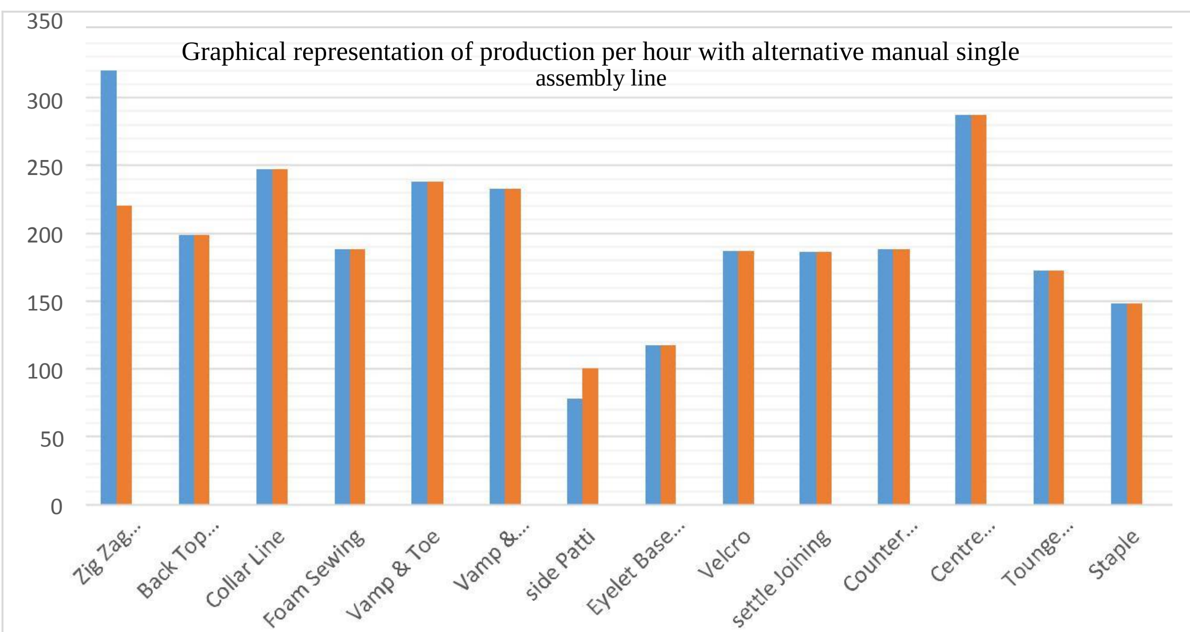

Figure 01: Graphical representation of production per hour with alternative manual single assembly line

Conclusion

6.1 Conclusion: Industrially Bangladesh is emerging as an important sector with expanding production base, in view of natural advantage having raw-material combined with of available of abundant work force. So it is industrially beneficial to all the industries if the production rate is increased by a slightest of margin. Here an alternative layout is suggested for the increment of production in a manual single assembly line. Though industries are converting to multilayer assembly line due to tough competition & rapid industrialization, Single assembly line is still used in many medium to small industries. Specially many small industries in Leather goods & footwear sector still heavily rely on manual single assembly line. A small change in the assembly line can increase the production by a great margin which is briefed & showed in the whole thesis. An increase in production leads to the increase of earnings as well as benefits of an industry so thus to the government. So the government as well as the authority should give proper concentration to the increment of productivity & should earnestly take effective initiative for the improvement of this sector as soon as possible

6.2 Limitations

- The Thesis is based on single manual assembly line.
- There was not any cycle time chart available.

7. Refference

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