ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1, April 2012

THE IMPACTS OF ALB IN APPAREL SUPPLY CHAIN

[1]Shibbir Ahmad, [1]Mst.Nasima Bagum, [1]C.A.Anam.Rashed, [1]Al-Amin.B.Khalil, and [1]M. Iqbal

[1]Department. of Industrial and Production Engineering
Shah Jalal University of Science and Technology,
Sylhet, BANGLADESH.

ABSTRACT

An assembly line is a manufacturing process consisting of various tasks in which interchangeable parts are added to a product in a sequential manner at a station to produce a finished product. This paper presents and applies mathematical formulae of line balancing, to determine product flow status across supply chain of apparel industries. Precedence diagram portrayed actual situation of sewing line and model developed defining workstation in balancing mode to make the supply chain smooth. Outcome showed that ALB greatly effect on overall supply chain. While unbalanced sewing line, delivery date cannot be met, resulting in, leads to air shipment. Finally, in order to saving air shipment and make the delivery on time, this paper demonstrated how the ALB and better efficiency can be used as planning and control path for managing apparel supply chain.

Keywords: *Assembly line balancing (ALB), Apparel supply chain, profitability*

INTRODUCTION

Over the past 170 years, apparel structure has changed from the custom fitting and assembly of individual hand-sewn garments to the mechanized, automated and sometimes robotized mass production and distribution of ready-to-wear products in the world market. Apparel manufacturing comprises a variety of product categories, materials and styling, and such complexities of manipulating flexible materials and dealing with constantly changing styles limits the degree of automation for the production system. Therefore, Glock et al (1995) and Caputa et al (2005) has explained when it is compared to many other productions, apparel manufacturing remains labor intensive. That is why line balancing in sewing line is very important in order to maximize efficiency of garments manufacturing industry.

Klin .G (1991) summarized that when apparel manufacturing is analyzed, the central process in the manufacturing is the joining together of components which is the most labor intensive part of this type of manufacturing, known as the sewing process. Furthermore, Tyler ,(1991) outlined that when the cost structure is analyzed, apart from material costs, the cost structure of the sewing process is of critical importance because of the labor intensity. Therefore, Huter (1988) has described that good balancing and small stocks of work in progress during sewing are the basic concepts to increase the efficiency of production.

An assembly line is described as a set of distinct tasks that is assigned to a set of workstations connected by a transport mechanism in detailed assembling sequences (Baybars, 1986). In garment sewing, the components are assembled through a sub-assembly process in order to form the finished product. Therefore the production process includes a set of workstations, at each of which a specific task is carried out in a restricted sequence, with hundreds of employees and thousands of bundles of sub-assemblies producing different styles simultaneously (Chan et al, 1998).

Leena and Luna International, Oyama, Japan.
Copyright © 2012

In assembly line balancing, the allocation of jobs to machines is based on the objective of minimizing the workflow among the operators, reducing the throughput time as well as the work in progress and thus increases productivity. Up to now, researchers have developed different algorithms to estimate the performance of scheduling (Raja Kumar et al, 2005 and Bracken bury, 1992).

Generally apparel manufacturers are focused on whether assembly work will be finished on time for delivery, finding ways to have more efficiency, how machines and employees are being utilized and how labor intensity can be minimized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall (Hui et al,1999).

Therefore, in order to focus on this kind of labor-intensive structure, a sweatshirt sewing line was chosen for this study. The production line is analyzed by considering the innovative use of industrial engineering concepts, time study, assembly line balancing and simulation (Kursun et al,2006). Firstly, real data taken from the factory floor using time studies and precedence constraints are taken into consideration to model the allocation of operations to the operators for simulation with the objective of minimizing the workflow among the operators. Afterwards with the help of the simulation model of the sewing line, the bottlenecks are determined. Finally, possible scenarios are tried in order to increase the efficiency of the line and to suggest investment strategies to manufacturers.

Today's business climate for clothing manufacturers requires low inventory and quick response systems that turn out a wide variety of products to meet customer demand. It is especially in the apparel industry that managers are trying to develop their current systems or looking for new production techniques in order to keep pace with the rapid changes in the fashion industry. There is no doubt that the sewing department is the most important department in the whole firm. Because there are lots of different operations which are done manually, the sewing department has to be under constant control. Consequently, all line balancing processes which determine the speed of an assembly line are done in this department. But it is a big mistake not to consider the relationship of the sewing department with other departments. In the apparel industry, it is essential to form a new production line for each order, and also the number of workers is changed according to the complexity of the order, the number of operations, throughput etc.

To meet the cost-reduction need of the era of mass production, the problem of assembly line balancing was addressed in (Bryton, B., 1954). Recently past, balancing of assembly line has again assumed importance under global strategy for standardization and cost reduction, and translation of core competence into competitive advantage (Keegan, W.J., 1995).

Assembly line balancing problems have been investigated by researchers well over 4 decades. The problem was first introduced as an integer programming problem. Glock et al (1995) and Klin .G (1991) had proposed well-known heuristic methods to group operations into stations. The linear programming model was introduced by Caputa et al (2005) . The dynamic programming formulation for assembly line balancing problems was proposed and solved by Tyler ,(1991) Huter (1988) Proposed the formulation in zero-one integer programming and solved the problem using Fibonacci search.

An improvement on branch-and-bound method to solve the assembly line balancing can be found in (Baybars ,1986). Raja Kumar et al, (2005) applied a backtracking technique to the network precedence diagram.

Several researchers investigated the problems of assembly line design. Bowman, (1960)and Held,(1963) provided good general overview on the topic. Keegan, W.J., (1995) Focused on designing assembly line for modular products. While much work has been done in solving the assembly line balancing problem effectively, the techniques are difficult to apply in practice. For example, the number of workers available must be taken into account in the assembly line balancing. Chan et al,(1998) and Bryton, B., (1954), addressed the issues of assigning more than one worker to the station. Kursun et al,(2006) considered the problem of assigning tasks to a fixed number of stations using assembly line mapping techniques. Bracken bury et al,(1992) and Jackson, (1956) also tried to determine the minimum number of workers for the assembly line.

MATHEMATICAL FORMULA OF ALB

Time study

Time study is the combination of eight steps (Heozer and Render, 2001) of activities which are used for developing the **standard time** of a projected task. Eight steps of activities are discussed below:

Step 1: Define the task- In this step; a job should be selected for time study according to the requirements.
Step 2: Divide the task into precise elements (parts of a task that often take no more than a few seconds)
Step 3: Decide how many to measure the task -numbers of job cycles or samples needed.
Step 4: Time and record elemental times and rating of performance-Recording the time can be done by a stopwatch, either on the spot or by analyzing a videotape of the job by Chase et al,(1999). When observation time will be taken for an operation, simultaneously normal performance rating should be recorded for the related worker (Khanna, 1992).

*** Performance timing**
Performance rating is the assessment of the workers rate of working relative to the observer's concept of the rate corresponding to the standard pace (Anonymous, 2010).
Performance rating = Normal rating / Standard rating
*** Standard rating**
The standard level is the average rate at which qualified workers will naturally work at a job, when using the correct method and the employees are motivated to apply themselves to their work (Khanna, 1992). For standard rating following three conditions must be ensured (Anonymous, 2010) .

a. qualified workers
b. correct method
c. motivated workers

*** Normal rating**
It is the average rate at which a qualified worker will naturally work even he has no specific motivation to apply himself to his work (Khanna, 1992).
Rating factors:

- The figure 100 represents standard performance.
- If the operator is apparently with less effective speed, than the assignment factor is less than 100.
- If, on the other hand, the effective rate of working is above standard, the operator gets a factor above hundred.
- Performance rating will follow the subsequent relation :

Observed time * performance rating= constant

Step 5: Compute the average observed time
In this step, average observed cycle time should be measured form the collected observed time data of step 4.

Copyright © 2012

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

Average observed time = Sum of the times recorded to perform each element /Number of observations

Step 6: Determine the performance rating then compute the normal time for each element

Normal time should be measured by using the following equation:

Normal time = (observed cycle time)*(performance rating)

Step 7: At the normal times for each element to develop a total normal time for the task

Required allowance should be added with normal time to make it standard and usable for the employee. Allowance is the amount of time added to the normal time for personal needs, unavoidable delays, and fatigue. Allowances include time for labor fatigue and personal needs, equipments breakdown, rest periods, information delays, and so on. Mainly the following allowance should be considered for standard time:

- ✓ Work allowance
- ✓ Workshop allowance
- ✓ Fatigue & physical allowance
- ✓ Others allowance
- ✓

Step 8: Compute the standard time

Finally, the standard time should be measured by the following equation Chase et al,(1999) :

Standard time = Total normal time / (1-Allowance factor)

In many garment assembly plants, standard push production systems with dozens of workers are being reorganized into straight assembly lines. In sewing departments the Standard time (*St*) for each operation is calculated by the sum of the base time (*Bt*), the fatigue allowances (*Fa*) and the idle time (*It*). The base time consists of the stopwatch time (*Sw*) and the performance rating (*Pr*). It is calculated as follows;

$$St = Bt + Fa + It = Sw \times Pr + Fa + It \qquad (1)$$

The line balancing problem of sewing departments is solved by using *St, and* it's assumed that all of the same operations are processed equally. However, in reality, all operations are completed at different times because of their stochastic structure, and the stochastically of operations makes it almost impossible to follow a fixed time pattern. Therefore, managers are up against unexpected queues and decreasing levels of performance during the sewing process. New calculation methodology which reflects reality better is needed in order to estimate more realistic production quantities and performance.

Assembly Line balancing

Assembly lines are flow oriented production systems which are still typical in the industrial production of high quantity standardized commodities and even gain importance in low volume production of customized products. Among the decision problems which arise in managing such systems, assembly line balancing problems are important tasks in medium-term production planning. An assembly line consists of (work) stations**;** k=1,........................,m (2)

The garments raw materials are consecutively launched down the line and are moved from station to station. At each work station, certain operations are repeatedly performed regarding the cycle time (maximum or average time available for each work cycle). The decision problem of optimally partitioning (balancing) the assembly work among the stations with respect to some objective is known as the assembly line balancing problem (ALBP).

Manufacturing a product on an assembly line requires partitioning the total amount of work into a set of elementary operations named **tasks** V = {1,...,n}. Performing a task j takes a **task time** tj and requires certain equipment of machines and/or skills of workers. Due to technological and organizational conditions **precedence constraints** between the tasks have to be observed. These elements can be summarized and visualized by a **precedence graph**. It contains a node for each task, node weights for the task times and arcs for the precedence constraints.

Figure 1 shows a precedence graph with n=13 tasks having task times between 30 and 36 (time units). The precedence constraints for, e.g., task 2 express that its processing requires the tasks depends on tasks 1(direct **predecessors**) and from 3 to next others tasks depended on each other.

Any type of ALBP consists in finding a feasible **line balance**, i.e., an assignment of each task to a station such that the precedence constraints and further restrictions are fulfilled. The set Sk of tasks assigned to a station k (=1,...,m) constitutes its **station load**, the cumulated task time t(Sk) = Σj∈Sk tj is called **station time**.

Steps in Assembly line Balancing

According to Chase and Jacobs the steps in balancing an assembly line are straight forward. They are:

- Specify the relationship among tasks using precedence diagram. The diagram consists of circles and arrows. Circles represent individual tasks; arrows indicate the order of task performance.

- Determine the required **cycle time(C)** using the formula

$$C = \frac{\text{Production time per day}}{\text{Required output per day}}$$

$$= 60 \text{ sec x } 600 \text{ min} / 1000 = 36 \text{ sec}$$

- Determine the theoretical minimum **number of workstations (N)** required satisfying the cycle time constraint using the formula.

$$N = \frac{\text{Sum of task times}}{\text{Cycle time}}$$

$$= 312/36 \text{ sec} = 8.6 = 9 \text{ (rounded up)}$$

- Find out Daily Output derived using formula

Daily Output = No. of worker* No. of Working hours (in min) * Efficiency / SMV
= (13*600*0.96)/ (6.24)
= 1200 pcs

- Evaluate the efficiency of the balanced derived using formula

Efficiency **=** Some of task time /(Actual number of workstation X cycle time)

= 312 /(9*36)
= 96%

If the efficiency is unsatisfactory, rebalance using a different decision rule.

Leena and Luna International, Oyama, Japan.
Copyright © 2012

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

INDUSTRIAL PRACTICES

Precedence diagram with model development

Task	Task time(seconds)	Task name	Task that must precede
1	18	Back Rise	None
2	21	Label join at back part	1
3	18	Front rise	None
4	15	Match Back & Front part	2,3
5	35	Side seam	4
6	35	Inseam	5
7	22	Back Pocket make	None
8	16	Mark for pocket attach	6
9	20	Pocket attach	7,8
10	14	Belt make & marking	None
11	35	Belt join	9,10
12	32	Leg Hem	11
13	31	Thread Cut	12

Table-1: Task Breakdown As well As completion time

Assignment rule
Prioritize tasks in order of the largest number of following tasks**.**

Task	No. Of following Task
1	ix
2,3	viii
4	vii
5	vi
6	v
7,8	iv
9,10	iii
11	ii
12	i
13	0

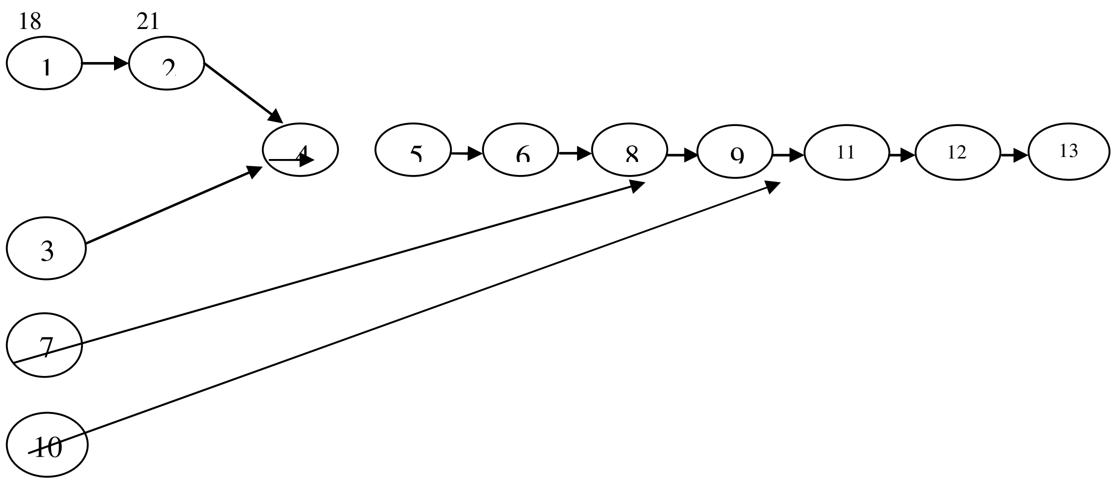

Figure 1: Precedence Diagram

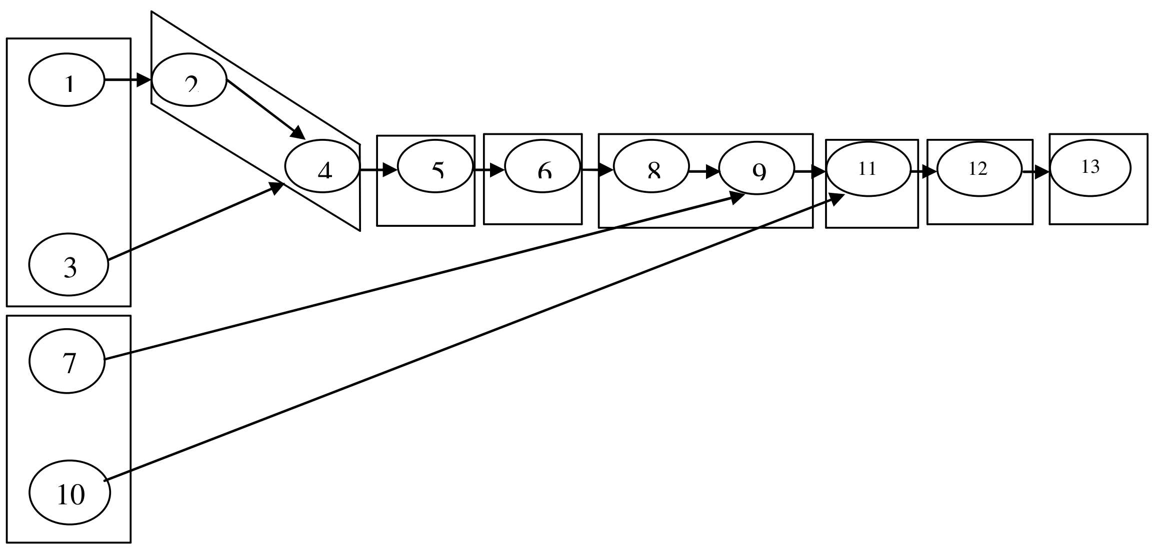

Figure 2: Precedence Diagram (defining work station)

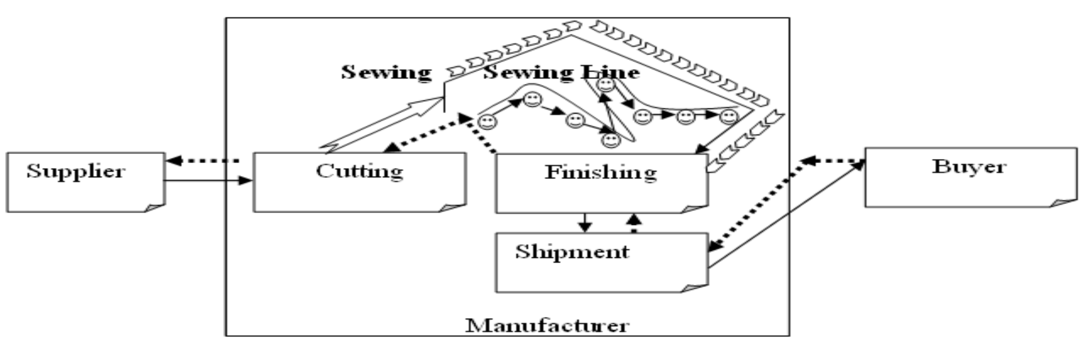

Figure 3: Apparel Supply Chain Structure

Ff

Copyright © 2012

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

Date	Cutting		Sewing		Finishing		Buyer ship date
7-Dec	1000		1000	900	900	100	
8-Dec	1000	2000	1000	1900	1900	1100	
9-dec	1000	3000	1000	2900	2900	2100	
10-dec	1000	4000	1000	3900	3900	3100	
11-dec	1000	5000	1000	4950	4950	4100	
12-dec	1000	6000	1000	5950	5950	5100	
13-dec	1000	7000	1000	6950	6950	6100	
14-dec	1000	8000	1000	7950	7950	7100	
15-dec	1000	9000	1000	9000	9000	8100	
16-dec	1000	10000	1000	10000	10000	9100	
17-dec	1000	11000	1000	11000	11000	10100	
18-Dec	1000	12000	1000	12000	12000	11100	
19-dec	1000	13000	1000	13000	13000	12100	
20-dec	1000	14000	1000	14000	14000	13100	
21-dec	1000	15000	1000	15000	15000	14100	
22-dec	1000	16000	1000	16000	16000	15100	
23-dec	1000	17000	1000	17000	17000	16100	
24-dec	1000	18000	1000	18000	18000	17100	
25-dec	1000	19000	1000	19000	19000	18100	
26-dec	1000	20000	1000	20000	20000	19100	
27-dec	1000	21000	1000	21000	21000	20100	
28-Dec	1000	22000	1000	22000	22000	21100	
29-dec	1000	23000	1000	23000	23000	22100	
							3th Jan

Table-3: Entire Supply Chain status while line balanced

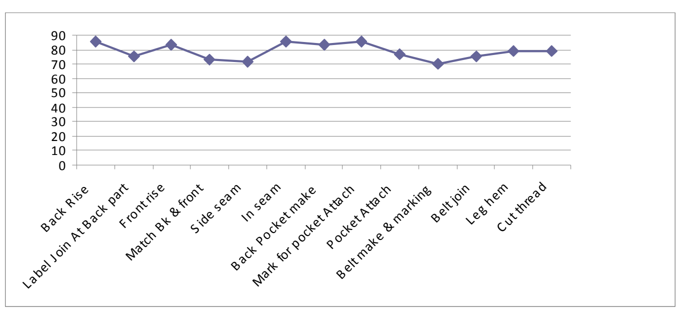

Figure 7: Existing Capacity Graph of sewing line before balancing

	Task	Task Time (Seconds)	Remaining unassigned time; Idle time (Seconds)	Feasible Remaining tasks	Task With most followers	Task with longest operation time
Station-1	1	18	18	3	1,3	-
	3	18	0	None		
Station 2	2	21	21	4	-	-
	4	15	0	None		
Station 3	5	35	35 1	None	-	5
Station 4	6	35	35 1	None	-	6
Station 5	7	22	22	10	7	-
	10	14	0	None		
Station 6	8	16	16	9	-	-
	9	20	0	None		
Station 7	11	35	35 1	None	-	11
Station 8	12	32	32 4	None	-	-
Station 9	13	31	31 5	None	-	-

Table-2: Balance Made (According to Largest-Number-of-Following-Tasks Rule)

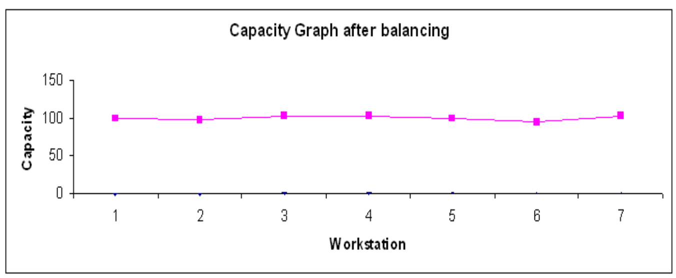

Figure 8: Improved Capacity Graph of sewing line after balancing

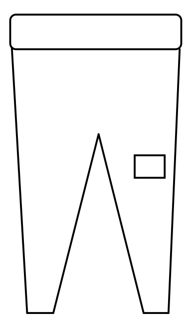

Figure 6: Sample style with its description

Copyright © 2012

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

DATA VALIDATION

Validation is necessary to show that the proposed model has an acceptable level of confidence in the performances processing assumed. Validation is also associated with whether the proposed model is indeed an accurate representation of the real system. There are several ways to validate the model. Model validation was accomplished through hypothesis tests using a throughput with a 95% confidence interval as follows (Hines, 1989) ;

The hypotheses are:

H0: μ**SL** = μ**GSD**

H1: μ**SL** $\neq$ μ**GSD**

The test is if ***t*calculated** < ***t*table**, we would accept the null hypothesis H0, where, m*F* is the basic pitch time BPT from the field; m*A,* is the mean production time for each process from the GSD model. 2 *p S* is the pooled mean variance.

nF and *nA is* the number of field samples and runs of the model, respectively.

The BPT of 13 items of data (*n*1 = 13) collected from the line was m*F* = 6463.78 unit with variance 2 *F S* = 48.72. and that for the GSD was m*A* = 6462.58 with variance 2*AS* = 1.56 which makes ***t*calculated** = 1.19 and from the 't' table (%95 C.I.) ***t*table** = 1.96

Since, ***t*calculated** < ***t*table**

It implies that there is no significant difference between the means, i.e H0: μ**SL** = μ**GSD**

Therefore the model is valid.

RESULTS AND DISCUSSIONS

Line balancing is the crucial factor for apparel supply chain. Maximum time shipment is delayed due to sewing section. This is the point where supply chain is unsuccessful i.e. when shipment fails; it is gone ahead to break total chain's profitability. When time has been lost at the predecessor members of chain, this time lost has to wrap up by sewing section often scenery of the garments industry, consequently total pressure move toward to sewing line.

At that time, 15 days sewing program have to complete within 9 or 10 days. Otherwise shipment will be air or get money off on that lot. For saving air or discount on product apparel manufacturing industry is always prompt. In spite of containing consciousness about air shipment, air shipment has to be done because of sewing line is imbalanced. Considering this matter of uncertainty, owners have been emphasized on line balancing now days. As this misbalancing is vastly impacts on overall supply chain, so balancing sewing line is the prior job for production manager.

Form the figure 4, it has been seen that lead time of garments manufacturer exceeded on account of imbalance sewing line. As a result, predefined lead time crossed the delivery date, and delivery will be one week delay which is not adequate to the buyer. At that circumstances buyer does not concur to make delivery extension. Customer sited their order at least 4 months earlier. Later 4 months, when buyer demands extension from customer, customers are decided not to place order to this buyer next time since customers are waiting for their product. On the other hand, competition of market has been moved up, such kind of incident happened at the apparel manufacturing industry. Buyer demand air shipment from manufacturer's cost in order to keep customers commitments. Resulting in, massive loss for manufacturer. To conquer at this situation, there is only routine to overcome such kinds of risk for savings air shipment through line balancing. For that rationale, not only afforded additional cost for imbalance line by manufacturer but also impede on production for consequent quantity. When one week has been unmitigated for specific quantity, its lead to extend automatically for next quantity. At that occasion, company determined to have overtime duty which is another problem for apparel manufacturing industry. When working length per week has surpassed 60 hours then audit of compliance will be abortive and which leads not to consign order for the company from buyer. In one sense, overtime dig up lost for company, on the other sense overtime guide to get closing the factory. In order to save companies overtime cost, air cost, or discount cost, make sewing line balancing for smooth production, shipment, and supply chain in apparel manufacturing.

In this research, a style has selected for understanding impact of line balancing on apparel manufacturing industry:

Description:

Style: SSS001

Order Qty: 24800 pcs

Total Color: 5 (20,00 pcs/color)

Delivery Time: 47 Days

Fabric: 65 % Polyster ,35%Cotton

Figure 3 symbolize the apparel supply chain structure, at the sewing section product flow has seen non-smoothed because of imbalance sewing line. In this research, this is the main concentration to make the chain lucrative. From the figure 7, it has sighted that due to imbalance, so production does not achieve schedule wise, much probability not to deliver garments on time. As a result, it acquires negative impact on total supply chain. Air shipment leads to get lost for overall supply chain profitability. Figure 9 showed efficiency of sewing line, where existing sewing efficiency is on an average 80% whereas required efficiency is 96%. The difference between existing efficacies vs. required efficacy alarming that objective of chain has fall short, furthermore demonstrated greatly effect on apparel chain. When planned efficacy does not obtain in the sewing line, the objective of the supply chain has distorted.

Figure 11 portrayed the difference between plan targets per hour vs. target lost per hour. It has been identified that sewing section made backlog per hour by 20 pieces. In this way, it has observed two weeks later 2800 pieces production need to do extra to meet the shipment. For that case, manufacturer must have to do OT or night work or holiday work. This is not profitable for whole supply chain as well.

Leena and Luna International, Oyama, Japan.
Copyright © 2012

ISSN: 2186-845X ISSN: 2186-8441 Print
Vol. 1. No. 1. April 2012

For example, figure 6 depict the actual garments status. When supply chain does not effort smoothly i.e. when sewing line is misbalanced, balancing sewing line is only the solution for keeping customers commitments, and keeping successful supply chain tracking. Table 3 given actual status of entire chain for a style,

Order quantity = 24800 pcs

Completion status on 29th December = 92 % (sewing)

Completion status for finishing = 89%

So it can be summarized that shipment will be on time, because delivery date was on 3rd January. Supply chain department makes sure about on time shipment on 29th december by witness of 89% completion status. Meanwhile ,supply chain department can be able to take decision for next proceedings of garments shipment. Figure 1 illustrated precedence diagram of sewing line where 13 manpower has allocated for completion of work. It has been viewed that line efficiency was low, due to imbalanced sewing line. In this research, to make the smooth supply chain, tremendous effort has given on line balancing and resulting outcome has been viewed at figure 2. Initially there are 13 workstation exist in sewing line, after balancing line there are only 9 workstation has remained. In order to keep smooth supply chain, this paper visualized, great effort has provided to make all the operator multi skilled in order to do multi task which guide to higher efficacy of sewing line (96 %). After balancing sewing line, it has outlook total four manpower has been reduced; plan target 1000 pieces achieved per day. Table-1 showed task breakdown as well as completion time, Table -2 give balance made based on According to Largest-Number-of-Following-Tasks Rule.

Finally table -3 explained the triumph of line balancing in apparel supply chain. Supply chain department see plan target achieved at every member of the chain in apparel manufacturing industry. Figure 5 given that total supply chain work has been completed within predefined lead time, which was 47 days. For that style, Sea shipment has done where balancing sewing line helped to acquire such achievement. It has summarized that in the apparel industry, When time has been lost in other members of chain, pressure fall on sewing section. For this reason, Assembly line balancing is important to make smooth supply chain in sewing section, and delivering garments to buyer on time.

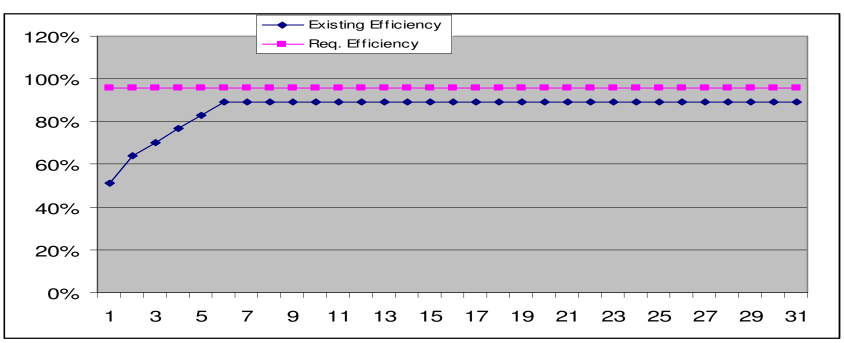

Figure 9: effect of Efficiency on supply Chain

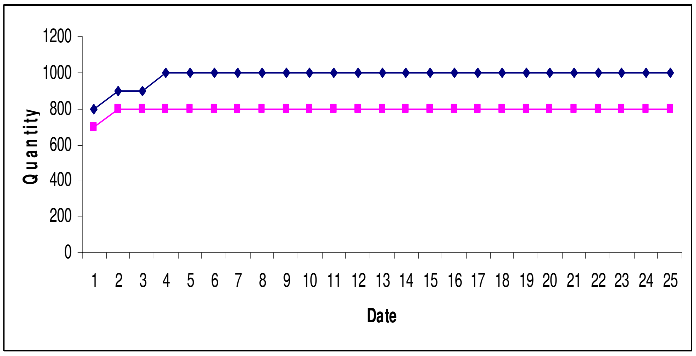

Figure 10: Effect of Plan target vs. Achieve qty on Supply Chain

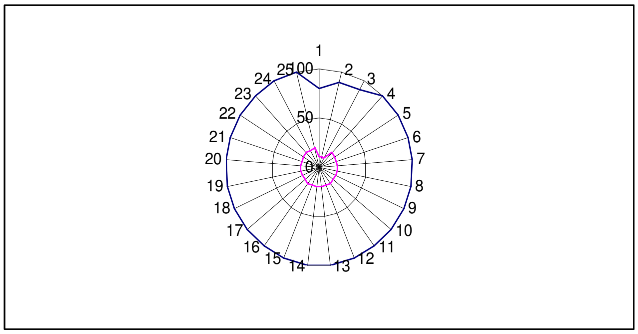

Figure 11: Effect of Plan qty vs. Recover qty on Supply Chain

CONCLUSIONS

Assembly lines are flow-oriented production systems which still are typical in the industrial Production of high-quality standardized commodities and even gain importance in Low-volume production of customized products. In this paper, tried to make sewing line balancing which leads to smooth supply chain in apparel manufacturing industry. Initially poor efficiency & imbalance sewing line barricade the objective of supply chain. After balancing the sewing line, efficiency has been increased to 96% from 80% which is pre-defined efficiency level for keeping smooth product flow through supply chain in apparel manufacturing industry. By giving afford for making multi-skilled operator, trained the operator, it has been able to reduce four manpower from sewing line, as a result, improved efficiency of the line, keep the better profitability for the total supply apparel supply chain. After analyzing the mathematical formula, it has been viewed that theoretically found 1200 pieces capacity of the sewing line whereas our plan target was 1000 pieces per day. Before balancing sewing line, output of production target was 800 pieces per day which fright the supply chain management department that shipment will not be met on time. Achieving target capacity wise and make the supply chain more efficient will be future work in apparel manufacturing industry. Implementing such kind idea, strong support should be provided from top management.

Copyright © 2012

REFERENCES

Anonymous 2, 2010, Work Design and Organizational Performance, website: www.tarleton.edu/.../Powerpoint/Work%20%Design%20and%20Organizational%20Performance.ppt , Date of Retrieval 25 November, 2010.

Bryton, B., (1954), Balancing of a continuous production line. M.Sc. Thesis, North-Western University.

Baybars, I.; A surveyof exact algorithms for the simple assemblyline balancingproblem, Management Science, 32 (8), 909 (1986).

Brackenbury, T.; Knitted ClothingTechnology, Blackwell Scientific, Oxford, 1992, p. 151.

Caputo A. C Palumbo M.; Manufacturingre-insourcingin the textile industry: A case study, Industrial Management & Data Systems, 105 (2), 193-207 (2005).

Chan, K., Hui, P and et. al..; Handlingthe assemblyline balancingproblemin the clothingindustryusinga geneticalgorithm, Int. J. of ClothingScience and Technology, 10, pp. 21-37 (1998).

Chase, R. B.; Nicholas, A. J.; Jacobs,R. F. 1999, Production and Operations Management, Eight Edition, ISBN0-07-463566-2; Tata McGraw-Hill Publishing Co.Ltd, New Delhi.

E.M. Bowman, Assembly-Line Balancing by Linear Programming, Opns. Res. **8** (1960) 385–389.

Glock, R. E. and Kunz, G. I.; Apparel Manufacturing-Sewn Product Analysis, Prentice Hall, New Jersey, 1995, p:4

Huter, A. J.; Introduction toClothingProduction Management, Blackwell Science, Oxford, 1988, pp. 60-63, 57

Hui, C. Ve Ng, S.; A studyof the effect of time variations for assemblyline balancingin the clothingindustry, Int. J. of ClothingScience and Technology, 11, pp. 181-188 (1999).

Heozer and Render,2001, operations Management, work measurement Supplement 10, Published by Prentice Hall Inc., Upper Saddle River, N.J07458.

J.R. Jackson, A Computing Procedure for a Line Balancing Problem, Management Sci. **2** (1956) 261-272

Hines W. W., Mongomery D. C., 'Probability and statistics in engineering and management science'. New York: Wiley,1989.

Klin, G.; Introduction toClothingManufacturing, Blackwell Science, Oxford, 1991, p. 104.

Kursun, S. and Kalaoğlu, F.; AnalyzingThe Bottleneck Problems On Production Line In

ClothingManufacturingBySimulation, in Proc. 37th International Symposiumon novelties in Textiles, Ljubljana, Slovenia, 2006.

Keegan, W.J., (1995), Global marketing management. Prentice Hall of India, 351.

Tyler, D. J.; Materials management in clothingproduction, BSP Professional Books Press, London, 1991.

Khanna,O.P; 1992,industrial engineering and management; Dhanpatri Rai Publications.

M. Held, R.M. Karp and R. Sharaeshian, Assembly Line Balancing-Dynamic Programming with

Precedence Constraints, Opns. Res. **10** (1963) 442-460

Rajakumar, S., Arunachalam, V. ve Selladurai, V.; Simulation of workflow balancingin assemblyshopfloor operations, J. of ManufacturingTechnologyManagement, 16, pp. 265-281 (2005).

Copyright © 2012