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PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING ON STITCHING LINE IN A FOOTWEAR INDUSTRY

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Abstract

The Indian Footwear Industry has shown substantial growth in the global production network. Many Indian consumers now spend as much on footwear as on apparel and change their shoes for different occasions, helping expand footwear range from formals, casuals and home wear to weddings, monsoons, club-wear, sportswear, adventure, beachwear and lounge wear. They have also helped the footwear industry almost double in the past five years. The Indian footwear industry is labour intensive industry. Small & mid size Companies are not able to match the market requirement as well as market competition as a result, under pressure, engage more & more of human force. Ironically, effective layout & if proper line balancing of Stitching & Assembly lines is done, less human force is required to generate the existing level of output or even higher output.

Keywords Line Balancing, Throughput, footwear industry

INTRODUCTION

India produces nearly 3000mn pairs of footwear annually out of which 10% are exports. The country accounts for nearly 15% of the total footwear output of the world which is over Rs 20,000mn pairs. The global footwear market which is growing at a CAGR of about 5 %, is currently estimated at about Rs 10.2tn is likely to reach Rs 12.34tn by 2015. The industry is highly unorganized with 70% of the market with unorganized sector and remaining 30% organized. As per the ASSOCHAM report, Indian footwear industry is likely to reach about Rs 387bn by 2015 from the current level of about Rs. 220bn growing at a CAGR of 15%.

The domestic footwear market is driven by growing fashion consciousness together with increased disposable income among India's urban middle class, which contributes about 45 per cent of overall footwear market, making India the second largest global producer of footwear across varied segments after China. To continue cost leadership and stay globally competitive, the company has to improve productivity of its manufacturing processes. This can be done through work measurement studies & Line Balancing (LB). To work effectively, with no work pile-ups between stations, the line must be *balanced*, simply we can say that work must get through each workstation in roughly the same amount of time.

Common Approaches to Line Balancing:

1. Estimating the number of operators for a given number of stations.
2. Work element sharing: grouping activities per work elements into stations or jobs performed by a single person (some time multiple people work in concert at a single station or machine). A line can sometimes be balanced with less cost by rearranging the sub-work elements (e.g. activities composing a work element) i.e by giving activities from the busiest element to elements with *idle* time.

In a perfectly balanced line -

1. *All* operations at *all* station would take *identical* time.
2. Efficiency would be 100 % , however, this rarely happens!!, 100 % efficiency is rarely achievable,

A more reasonable goal is 95 % efficiency. However, even that may not be achievable depending on the nature of the operations.

Line balance = Total Work Content / (No. of Stations X Max CT)

Total Work Content = Sum of all Cts

All stations should have CT which is at least 80% of Required Rate CT

LITERATURE SURVEY

An assembly line consists of work-stations k = 1,...., m usually arranged along a conveyor belt or a similar material handling equipment. The jobs are consecutively launched down the line and are moved from station to station. At each station, certain operations are repeatedly performed regarding the cycle time. In general, the line balancing problem consists of optimally balancing the assembly work among all stations with respect to some objective. For this purpose, the total amount of work necessary to assemble a product is split up into a set V = {1,...., n} of elementary operations named tasks. Performing a task j takes a task time t j and requires certain equipment of machines and/or skills of workers. The total workload necessary for assembling a work piece is measured by the sum of task time Σt.

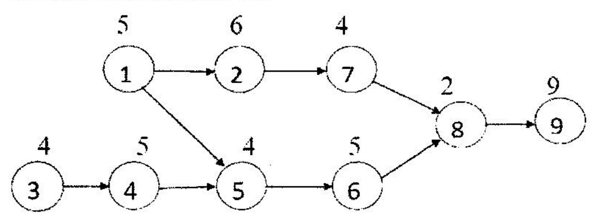

Figure-A: Precedence Diagram (Kriengkorakot and Pianthong,2007)

These elements can be summarized by a precedence diagram. It contains a node for each task, node weights for the task times, arcs the direct and paths for the indirect precedence constraints. Figure A shows a precedence diagram with n = 9 tasks having task times between 2 to 9 in time unit. A feasible line balance, i.e. an assignment of tasks to stations has to ensure that no precedence relationship is violated. The set Sk of tasks assigned to a station k constitutes its station load or work content, the cumulated task time t (Sk) = ΣjSk j t is called station time. When a fixed cycle time c is given (paced line), a line balance is feasible only if the station time of neither station exceeds c. In case of t (Sk) < c , the station k has an idle time of c – t(Sk) time unit in each cycle. For example in Figure 1, a feasible line balance with cycle time c =11 and number of station, m = 5 stations is given by stations loads; S1 ={1,3}, S2 ={2,4}, S3 = {5,6}, S4 = {7,8} , S5 = {9} A usual objective consists in maximizing the line utilization which is measured by the line efficiency E as the productive fraction of the line's total operating time and directly depends on the cycle time c and the number of stations m. In the most simple case, the line efficiency is defined as follows: E = Σt /(m*c).

Classification - Assembly Line Balancing Problem (ALBP)

In this section, characteristics of balancing problems considered in the literature are provided and some classification schemes (Ghosh and Gagnon, 1989; Becker and Scholl,2006; Scholl and Becker, 2006) Ghosh and Gagnon (1989) classified the ALBP into four categories are given; as shown in Figure B

- Single Model Deterministic (SMD)
- Single Model Stochastic (SMS)
- Multi/Mixed Model Stochastic (MMS)
- Multi/Mixed Model Deterministic (MMD)

The SMD version of the ALB problem assumes dedicated, single model assembly lines where the task times are known deterministically and an efficiency criterion is to be optimized. This is the original and simplest form of the assembly line balancing problem (SALB). Introducing other restrictions or factors (e.g. parallel stations, etc) into the model and the problem becomes the General Assembly Line Balancing Problem (GALB)

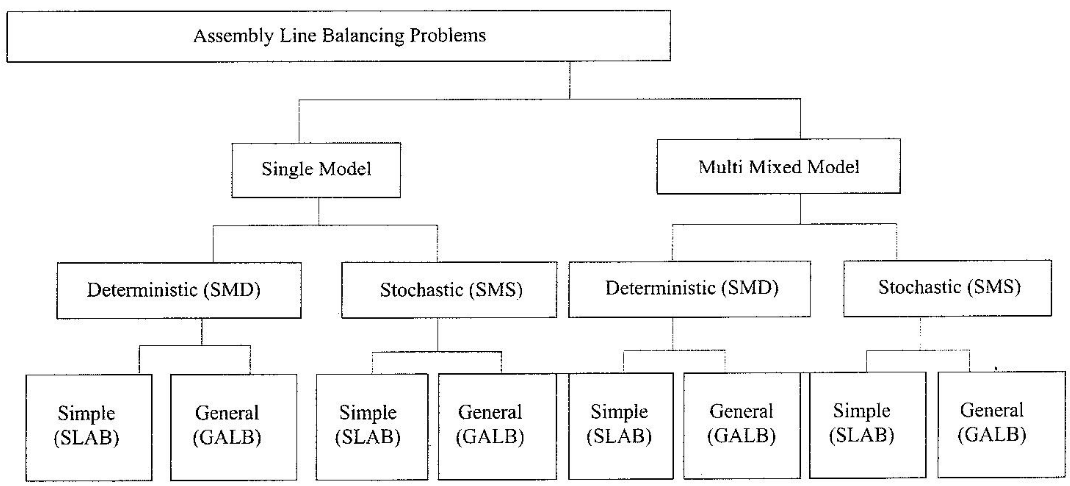

Figure B. Classification of assembly line balancing literature (Ghosh and Gagnon 1989)

The SMS problem category introduces the concept of task-time variability. This is more realistic for manual assembly lines, where workers' operation times are seldom constant.

With the introduction of stochastic task times many other issues become relevant, such as station times exceeding the cycle time (and perhaps the production of defective or unfinished parts), pacing effects on workers' operation times, station lengths, the size and location of inventory buffers, launch rates and allocation of line imbalances. The MMD problem formulation assumes deterministic task times, but introduces the concept of an assembly line producing multiple products. Multi-model lines assemble two or more products separately in batches. In mixed-model lines single units of different models can be introduced in any order or mix to the line. Multi-mixed model lines introduce various issues that are not present in the single model case. Model selection, model sequencing and launching rate(s) and model lot sizes become more critical issues here than in the single model case.

The MMS problem perspective differs from its MMD counterpart in that stochastic times are allowed. However, these issues become more complex for the MMS problem because factors such as learning effects, worker skill level, job-design and worker task time variability become more difficult to analyze because the line is frequently rebalanced for each model assembled.

Scholl and Becker (2006) have classified the main characteristics of assembly line balancing problems considered in their several constraints and different objectives as shown in Figure:C. It has illustrated the classification of assembly line balancing problems.

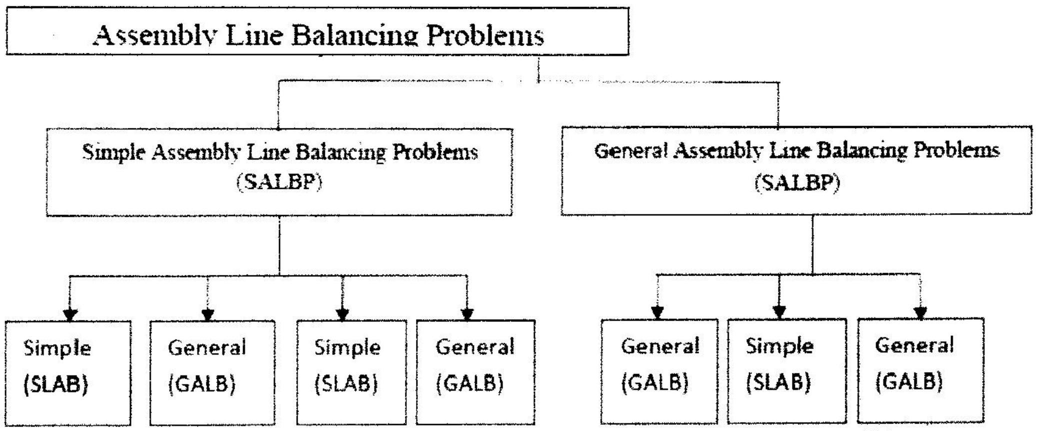

Figure C: Classification of assembly line balancing problems (Scholl and Becker (2006)

CASE STUDY – At leading footwear industry of India

The Company under study is one of the leading footwear industries in India and have various labour intensive manufacturing units spread across northern part of India. Company commenced its journey with the manufacture of slippers. It has now grown into a large-scale enterprise catering to the basic needs of the quintessential Indian citizen. Company is in the business of manufacturing large variety of footwear, sports shoe, sandal, slippers, kids' shoes etc., for all the segments.

In the case under study, the need is to improve productivity and reduce cost for various manufacturing process components, by increasing production rate and by utilization of optimum manpower. Being a labour intensive unit, production efficiency is mostly dependent on labour turnout on daily basis. Besides labour turnout, availability of skilled labour also plays an important role in achieving the production targets. Keeping this view in focus, the study is conducted. The major observations with Opportunities / Objectives are -

- ✓ Reduced Line Efficiency: Faster station is limited by slowest station. Thus, decreasing the rate of productivity. (TOC)
- ✓ Un-Balanced Workload: The workers need to wait the products to come. (LB)
- ✓ Accumulation of WIP : Huge amount of WIP (work in process) (Single Piece Flow)
- ✓ In-effective Line Lay out : Over 100 feet of line resulting in much traveling of product. (Layout)
- ✓ Push type Flow of pieces : Different parts of the products are moving in unorganized way as a result all workstations are full of pieces which results in difficulty to work. (Single Piece Flow)
- ✓ Improper Housekeeping : Housekeeping is a difficult task to maintain as the process involves different types of fabrics, leather, threads etc and heavy cutting. (5S)
- ✓ High Non Value Added activities : line becomes regular practice which consumes much of time. (VA)
- ✓ To and fro Movement of Pieces prevents single piece flow. (Muda)

LINE LAYOUT BEFORE LINE BALANCING

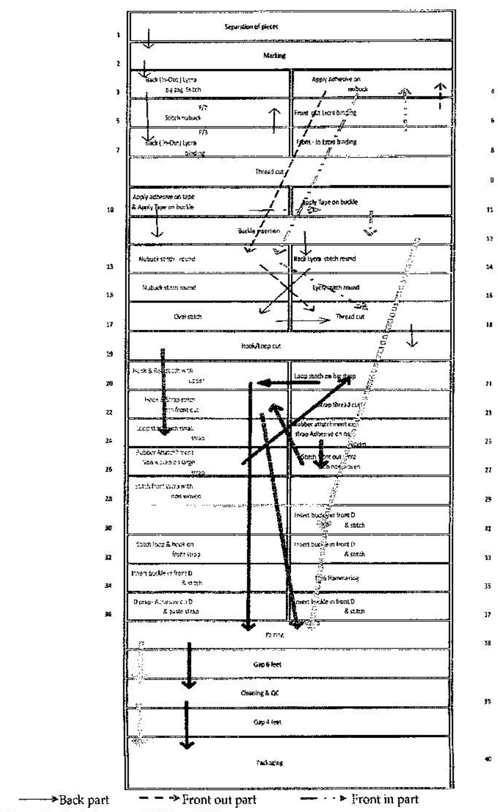

Figure D – As-Is Layout with Material Flow

Facts & Figures about existing stitching Line

The Length of Stitching Line is 102 ft.
Width of Stitching Line - 8 ft,
Total Manpower Deployed on the Line is 52.
Accumulation of huge amount of WIP .

Summary of All operations in ABC Sandal Manufacturing- Before Line Balancing

S.No	SA / AS	O	T	I	D	S	Dist	CT	WIP	M/P
SA01	Back Part Sub Assembly	14	15	1	16	1	407	135.9	1010	17
SA02	Neubuck Sub Assembly	5	6	0	6	1	127	--	810	4
SA03	Buckle Sub Assembly	5	5	0	6	1	189	13.9	810	3
SA04	X Mark Sub Assembly	4	5	0	5	1	217	14.4	2250	2
SA05	Velcro & Non-Woven Cutting	3	6	0	3	0	360	17.4	150	1
SA06	Belt Sub Assembly	6	7	0	7	1	351	23.0	1800	5
SA07	Buckle Tape Cutting	1	2	0	1	0	120	3.0	50	1
SA11	Front-Out Part Sub Assembly	10	13	1	12	1	459	51.6	930	5
SA12	Neubuck Sub Assembly	4	5	0	5	1	131	--	790	2
SA13	Velcro & Non-Woven Cutting	3	6	0	3	0	360	16.6	150	0
SA14	Belt Sub Assembly	6	7	0	7	1	351	25.4	1800	5
SA21	Front-In Part Sub Assembly	11	13	0	12	1	193	93.2	990	2
SA22	Neubuck Sub Assembly	4	5	0	5	1	123	4.5	790	2
SA23	Buckle Sub Assembly	4	4	0	5	1	115	5.1	790	2
SA24	Buckle Tape Cutting	1	2	0	1	0	120	3.0	50	1
	Total	81	101	2	94	11	3623	407.1	13170	52

Figure E - Summary of All operations in ABC Sandal Manufacturing- Before Line Balancing

(Note: Dist - Distance in Ft, Wip in Pairs, CT- Cycle Time in Secs, M/P – Manpower, O- Operation, T- Transportation, I- Inspection, D- Delay, S- Storage)

Methodology Used in the Process of Line Balancing
First the product (**Sandal**) is identified.
Different components of the product are identified.
Different processes used in making the Product on Stitching line:

Various Parts (Components)	Various Processes
1. Back in 2. Back out 3. Front in 4. Front out	1. Marking 2. Simple Stitching 3. Zig-zag Stitching 4. Binding 5. Pasting 6. Buckle fitting 7. Velcro fitting

PROCESS SEQUENCE

Sequence of the Process on Stitching Line from start to end is written down pointing out the back movement of pieces & Bottleneck processes in the stitching process. Back movement of pieces is removed or replaced by the support station.

Estimation Cycle Time for each Process

- Each process is video-graphed from start to end.
- Process is than divided in to *small elements* and the time of each element is recorded (15 cycles).
- Sum of average of each element gives *Total Observed Time.*
- Each process is than rated and on the basis of rating *Normal time* is calculated.
- Allowances are given and *Standard time* is calculated.
- The above procedure is followed for all the workstations on Stitching line to get the cycle time for each and every process.

LINE BALANCING

Balancing of Line is essential to make the operational flow of sequences smoother as compared to the previous layout.

Considering working distance, type of machines and efficiency. Workers who have extra time after completing their works, have been given additional work to maintain the index time.

GUIDELINES FOR BALANCING

- Arrange all the process in operational sequence.
- Mention their cycle time (CT) & manpower deployed in front of them.
- Suggested output rate at which the line needs to be balanced is 90 Pairs Per Hour.
- This gives us the Index Time (Required Cycle Time) of 20 Sec / Odd (40 Sec / Pair)
- (60 Min in One Hr X 60 Sec in One Min/90 Pairs = 40 Sec / Pair)
- This means that all the processes in the sequence should have
- Cycle Time Below or equal to 20 Sec
- The Pulse rate of our Line is 20 Sec.
- Identify the processes that are Below 15 Sec and Above 32 Sec.
- For the processes, where CT is above 32 sec, a duplicate station should be added
- Processes with CT Below 15 Sec should be combined in a way that the Total CT after combining the processes should be less than or equal to 22 Sec.

GUIDELINES FOR BALANCING

- Line balance = (Total Work Content / No. of Stations X Max CT)
- Total Work Content = Sum of all Cts
- All stations should have CT which is at least 80% of Required Rate CT
- For Example, this means, for sandal line, Min CT should be 16 Sec.
- Line should be balanced only for Main Line Activities. For Sub Assemblies, the work content should be balanced to support main line.
- For Example, Velcro Cutting, Strap Stitching etc are off line sub assemblies, which should be done by the team of operators and the output should match the 20 Sec CT of main line.

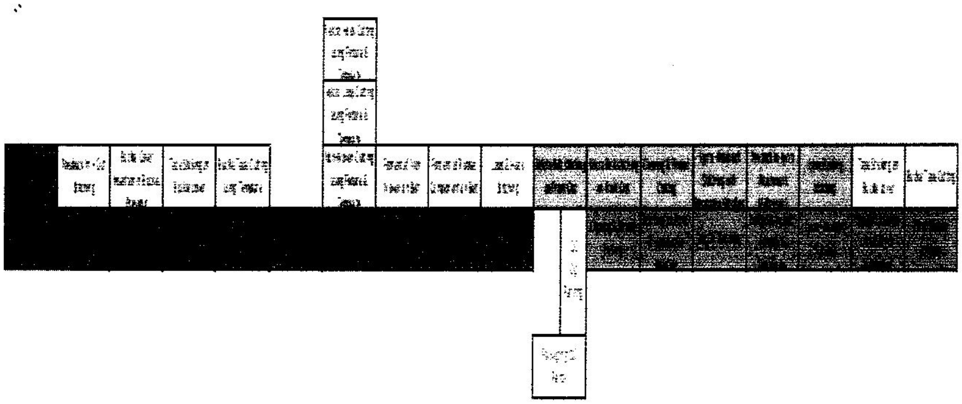

Figure F – Proposed Layout of the Line (Implemented)

Comparison of tangible benefits before and after Line Balancing

S No	Parameters	Target	Current	Previous	% Change
1	Hourly Production (pairs)	90	80	60	33 %
2	Manpower	34	34	52	- 32 %
3	Productivity (Man -Hr)	2.65	2.35	1.52	57 %
4	Machine Required	16	16	22	-27 %
5	WIP (Pairs)	25	30	10	- 97 %
6	Rework on line (Pairs/Day)	< 4	< 25	100	-75 %
7	Daily Production (8 Hrs)	720	640	840	00 %
8	Line Length (feet)	60	72	102	-29 %
9	Line Area	480	576	816	-29 %

Figure G – Comparison Table after implementation of Balance Line

Other Benefits as Reported by shop floor management

S.No.	Parameter	Current	Previous
1	*House Keeping*	Good	Poor
2	*Supply to Assembly*	Matching and Production in One go, along with marking required for assembly.	Mismatching, Marking for assembly done on Assembly line
3	*Impact on Production during Break Down.*	Total Attention on Line, Maintenance done on top proirity, Spare Machine used if Maintenance time is more	Maintenance done as per availability
4	*Material Movement on Line*	Single Pair	20-30 Pairs
5	*Supervision*	Very Good	Normal
6	*Supervisor's Effort*	Reduced	High
8	*Material Handling*	Less, Easy, & smooth	More, Difficult, done by operator resulting in less production
9	*Traceability of Defects*	Easier	Difficult

Figure H – Intangible Benefits of Improved Line

CONCLUSION

Significant improvements are possible through the implementation of various line balancing techniques. I the case study discussed above, the Stitching line has major (upto 50%) improvement chances for Sandal manufacturing, while it is 30% in case of Shoes. The output rates are nearly doubled. The manpower deployment has been considered after keeping the present problems faced by the company due to uncertain turnout of operators. Line balancing along with suitable changes (as per the product requirement) in layout shows drastic improvement in production output and helps a lot in assessing the manpower deployment.

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