International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

A REVIEW OF RECENT DEVELOPMENTS IN ASSEMBLY LINE BALANCING GARMENT MANUFACTURING

M.Karthika,

Assistant prof and Head, Department of Costume Design and Fashion, Erode Arts and Science College, Erode

ABSTRACT

This study is designed to assess and improve apparel sewing section efficiency and productivity throughout line balancing. Apparel industry is one of the oldest and among the most global industry, being primarily concerned with the design and production of cloth and their supply. The central process in apparel manufacturing is the joining together of components which is known as the sewing process , which is the most labour intensive type of manufacturing process .Proper utilization of resources in garment sewing section is more critical to enhance the performance of the apparel industry by reducing production cost and minimizing wastage. For effective utilization of resources in the sewing section, good line balancing is important to increase productivity and production efficiency. This research was a design to analyse and improve the assembling line in the case of Telaje garment manufacturing and sales plc. The study was first conduct observations in the production floor and start work with the selection of sewing line in the garment production process. Among the nine lines of the factory select one on the production floor and one garment ordered product known as five pocket men's jeans trousers are selected. For this study, both qualitative and quantitative research approaches were employed. Both primary and secondary data sources are used to detail the collected relevant data to understand the current efficiency scenario of the factory. The main challenges to minimizing line efficiency and productivity with the expected performance measurement are improper utilization of resources and improper implementation of line balancing in sewing section, therefore this thesis work shows that the bottleneck process and consequence solution will be searched, and finally significantly improving the productivity by 418 unit products/ day and, hence the efficiency will increase from 28.83% to 50.04% of the line.

Key words; Assembly line, Line balancing, Bottleneck, Productivity

1. .INTRODUCTION

As a supply chain of textile industry, garment industry is one of the major industries of the world [11]. The production process of garments is separated into four main phases: designing/ clothing pattern generation, fabric spreading and cutting, sewing and ironing, and packing. The joining together of garment components, known as the sewing process which is the most labour intensive part of garment manufacturing. Furthermore, since the sewing process is labour intensive; apart from material costs, the cost structure of the sewing process is also important [6, 12]. Therefore, this process is of critical importance and needs to be planned more carefully As a consequence, good line balancing with small stocks in the sewing line has to be drawn up to increase the efficiency and quality of production. 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 subassemblies producing different styles simultaneously. An assembly line is defined as a set of distinct tasks which is assigned to a set of workstations linked together by a transport mechanism under detailed assembling sequences specifying how the assembling process flows from one station to another [19] .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 increasing the productivity. Sharing a job of work between several people is called division of labour. Division of labour should be balanced equally by ensuring the time spent at each station is approximately the same. Each individual step in the assembly of the product has to be analysed carefully and allocated to stations in a balanced way over the available workstations. Each operator then carries out the operations properly and the work flow is synchronized [15, 21]. Manufacturing a product in an assembly line requires partitioning the total amount of work into a set of elementary operations called tasks. Tasks are assigned to operators depending on the constrains of different labour skill levels. Assembly lines have been widely used in various production systems to produce high volume standardized products. An assembly line includes a series of stations arranged along a material handling system. The components are processed depending on a set of tasks for a given cycle time. Tasks are assigned to an ordered sequence of stations according to a given precedence relationship among them. The problem of assigning tasks to stations to optimize a specific objective, such as minimizing the number of stations for a given cycle time, minimizing the cycle time for a given number of stations, or maximizing the efficiency of an assembly lines, subject to the precedence relationships among tasks, is called the assembly line balancing (ALB) problem. Multi-manned assembly line balancing problems (MALBP) are a new type of generalized assembly line balancing problems in which there is the possibility of assigning more than one operator to each work station according to the product features[12,14]]. These types of balancing problems typically occur in industries with high volumes of products. In this type of assembly line, in each workstation, instead of one worker, several workers simultaneously perform different operations on the same individual product. The main goal of using this kind of multimanned workstations is to minimize the number of workstations in the line while the total effectiveness of the line (in terms of the number of workers) remains optimal. In this work, the asses' assembly line balancing of the sewing sections to enhance the productivity and efficiency of the company

2. MATERIALS AND METHODOLOGY

2.1 METHODS:

This research was designed to analyse and enhance the assembling lines in the case of Telaje garment Manufacturing and sales Plc. The study was first conducted through observation starting from the production floor. Selection of sewing lines and ordered products are made. Then the experimental work is performed and then analysed. Based on the results obtained, the way for improving asseTelaje garment production will be proposed. Both qualitative and quantitative approach methods were used. Collected data were analysed using descriptive statistics for analysis. The obtained results were presented using numerical value and the graph

2.2 Data collection

The data were collected from Telaje Garment Manufacturing and Sales plc. in the garment sewing section .Both primary and secondary data sources were used to collect relevant data. Primary data was collected from direct observation from the production floors and interviews with the line supervisors and other responsible persons. The data mainly focused on one type of product within the assembling line knows as five pocket men Jeans Trousers. Secondary data were collected through reviewing related literature, different books and journals and different legal documents. For the effectiveness of this study, some garment sewing section line balancing calculations including work study, time study, and SMV were used.

2.3 Data analysis

For this study, among nine lines of the factory, one line on the production floor, and one garment ordered product which is known as five pocket men's jeans trousers are selected. For the selected product, perform an operation breakdown based on their style and operational sequences before doing line balance. Working out a performance breakdown to compare the current factory method and the possible standard methods. Examine work measurement to establish the time for a qualified worker to carry out a specified job at a defined level of performance, and collecting and recording the time studies to systematic recording and critical examination of existing & proposed ways of doing work. Further Calculation was made for SMV & Efficiency to know the time required to complete one piece of garment by a qualified (standard) operator at standard condition. Finally, for smooth production flow, improved efficiency and productivity, appropriate and a balance line will be proposed with modified layout based on.

3. RESULTS AND DISCUSSION

For this thesis work the researcher interpret and analysis three main data, first analysis current company used data as it is, this data was directly collected from the company .secondly analysis current factory performance study by the researcher who record observing time to analysis correctly for method study and time study to the current garment assembly line in sewing section, thirdly critically analysis assembly line balance of the factory and implemented finding solutions on the assembly line balancing of Telaje garment and sales plc., Based on the two data reduce drawback of the existing scenario and implementation proposed solutions to enhance productivity and efficiency.

Table 1: line balancing data of the factory

Assigned	description of operation type of machine	M/c type	No. opr	Cycle time						Ratin g(%)	SAM
				1	2	3	4	5	Avg		
A01	O/L Fly Box and Left Fly	3Th o/l	1	32	31	33	30	32	31.6	80	0.53
B	Front										
B01	Attach Side Pkt facing to Pkt Lining	DNLS	1	14	15	13	14	14	14	85	0.25
B02	hem coin pkt	DNLS		12	12	13	12	12	12.2	90	0.23
B03	press coin pkt edge	Iron	1	17	16	17	16	17	16.6	85	0.29
B04	attach coin pkt	DNLS		23	22	21	23	24	22.6	80	0.38
B06	Sew Side Pocket Bag To Front	DNLS	2	38	37	39	36	36	37.2	80	0.63
B07	top s/t side pkt bag	SNLS	1	29	28	27	25	26	27	80	0.46
B08	Run Stich Side Pkt Bag	DNLS	1	19	20	19	21	22	20.2	85	0.36
B09	Tack Side Pkt	SNLS	1	29	29	27	28	26	27.8	80	0.47
B10	Sew Left Front Fly & Edge S/T	SNLS	2	55	54	57	53	55	54.8	75	0.87
B11	J-Stitch	SNLS	1	26	24	24	24	25	24.6	85	0.44
B12	Attach Zipper Right Fly & Fly Box	DNLS	2	53	52	51	51	51	51.6	75	0.82
B13	Front Rise Attach	SNLS	1	43	44	43	42	42	42.8	75	0.68
B14	Top Stich Front Rise	SNLS	1	26	27	25	24	23	25	85	0.45
C	Back										
C01	hem back pkt mouth	DNLS	2	21	23	23	19	26	22.4	80	0.38
C02	sew decoration stitch		1	74	72	73	72	71	72.4	70	1.07
C03	Mark Back Pkt Position	W/Table	1	18	16	15	19	17	17	85	0.31
C04	Attach Bk pkt to back trouser	SNLS	5	125	122	127	119	121	106.4	70	1.58
C05	Attach back yoke & trouser	5TH OL	1	32	30	29	31	30	30.4	85	0.55
C06	top s/t back yoke & trouser	FOA	1	35	34	36	32	35	34.4	80	0.57
C07	Sew Back Rise	5TH OL	1	18	19	21	23	19	20	80	0.33
C08	Top Stich Back Rise	FOA	1	29	27	23	28	27	26.8	80	0.45

D	Assembly										
D01	Sew Inseam	5th ol	1	142	137	144	134	140	139.4	70	2.06
D02	Top Stitch Side Seam	FOA	1	121	128	144	144	144	136.2	70	2.02
D03	Sew Side Seam	5TH OL	1	51	49	49	52	51	50.4	75	0.8
D04	Topstitch waist side	SNLS	1	40	38	34	36	35	36.6	80	0.62
D05	Make Belt Loop	BLM/fdr	1	18	18	19	18	17	18	90	0.34
D06	Mark Belt Loop Position		1	29	26	29	30	26	28	85	0.48
D07	Tack Belt Loop On Waist Body	SNLS	1	51	51	51	53	51	51.4	80	0.86
D08	Waist Band Attach To Body	SNLS	4	215	178	225	218	224	212	75	3.36
D09	Topstitch waist band corner	SNLS	4	427	447	440	448	416	435.6	70	6.45
D10	Bottom Hemming	SNLS	1	147	144	140	155	145	146.2	75	2.32
D11	Make Tack On Fly, Side Pkt	BT	1	39	41	39	40	48	41.4	80	0.7
D12	Quality Inspection			42	42	43	41	40	41.6	80	0.7
D12	Trimming			32	34	33	30	33	32.4	85	0.58
sum				2122	2087	2146	2141	2121	2123.4	**80**	**33.39**

The above data was collected by the researcher using stop watch method for five cycle time during the production process, in some causes this cycle time extended up to fifteen if the recorded data have high range. From the table, the researchers only wrought recording observing time and calculated SAM value, such as operation breakdown of five pockets, mean jeans, trousers, machine types, and target output taken as it is. The data was collected from each operator during performing each task, the data was recorded in seconds by stop watch method, this data is known as observing time, so that to assembly five pockets mean jeans trousers 2123.4 seconds observing time is required and 33.39 standard minute. From this we understand SAM values of the table 1 approached to the standard SAM value of five pockets mean jeans trousers .According to (Sharmin Akter, Kazi Rezwan Hossain, 2017)

Efficiency= {(per hour production X total SMV)/ (man required X working minute)} X 100%

Where the numbers of operators are 44 and garment SAM is 33.39

Efficiency= {(per hour production X total SMV)/ (man required X working minute)} X 100%

$$= \frac{184*33.39*8*100}{44*480}$$

$$= 29.1\%$$

According to (Noor Ahmed Raaz, 2015)

To calculate the operator efficiency, the following formula should be followed by any industrial engineer. Examples to calculate a single operation such as O/L Fly Box and Left Fly

$$\text{Operator efficiency (\%)} = \frac{\text{Total minute produced by an operator} \times 100}{\text{Total minute attended}}$$

Where, Total minutes produced=Total pieces made X SAM of the operation

Thus that Total minute produced=184 *1.0145

=186.668

Total minutes attended=Total hours worked in the machine X 60

= 8hr X 60

= 480 min

$$\text{Operator Efficiency\%} = \frac{\text{Total minute produced by an operator} * 100}{\text{Total minute attended by operator}}$$

$$= \frac{186.668 * 100}{480}$$

$$= 38.89\%$$

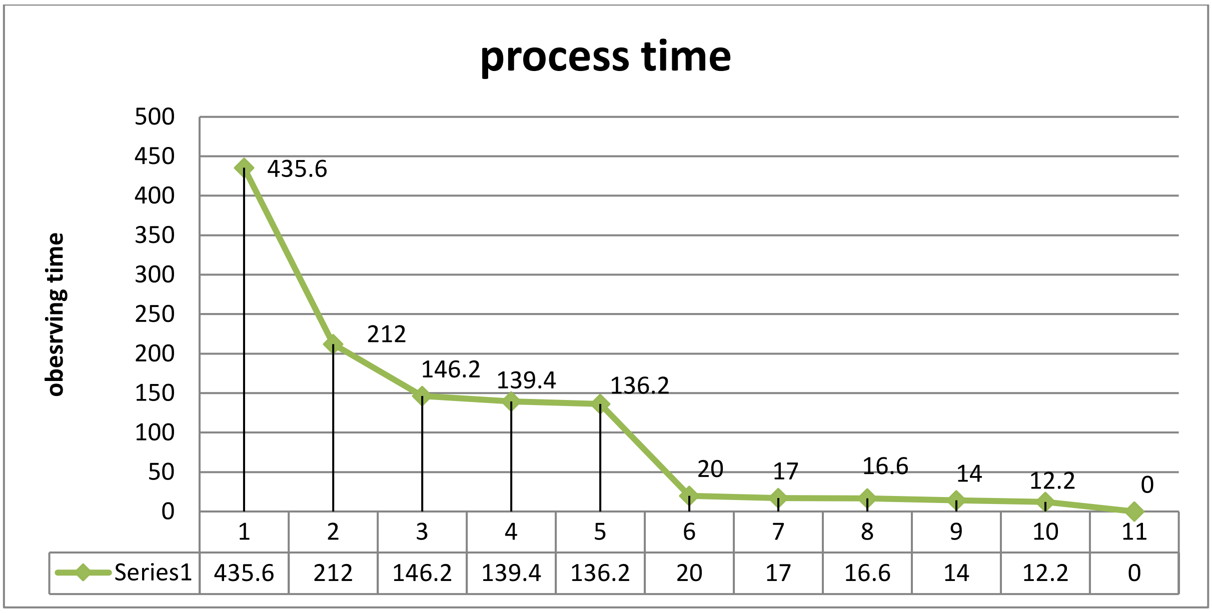

Figure 1:-process time

The researcher observes and records the individual operator cycle time to perform each task to be assigned .The graphs indicates the maximum and minimum observing time of 10 operators. First five observing times indicate high time taken operation and the second five operations are low operation time taken

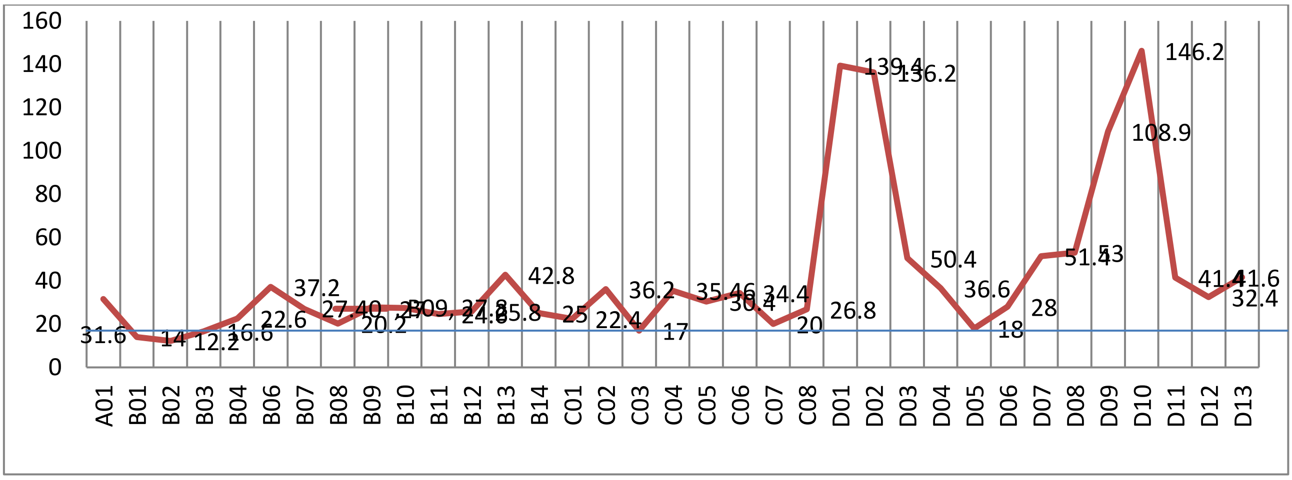

Figure 2:- Pitch time graph

Pitch Time = Garment SAM/No. of operations.

Pitch time is used for line setting and calculating the production targets for the line.

A graphical presentation of individual operation's time and pitch time on the same chart is called pitch diagram. In this chart on X-axis operation the assigned name and on Y-axis the time value is depicted. First, conduct a capacity study for all operators and determine how many pieces the operators are making at each operation. Where more than one operator is doing the same operation, sum up their capacity for that particular operation. Based on this information, the calculated existing scenario of pitch time is mandatory for assembly line balancing.

$$\text{Basic pitch time} = \frac{\text{Net process time}}{\text{Total number of operators}}$$

$$= \frac{2123.4}{44}$$

$$= 48.259$$

$$\text{Control limits Upper limit} = \frac{\text{pitch time} * 100}{\text{Target organization efficiency}}$$

Lower limit= 2*pitch time upper limit

: - Where pitch time referee value for synchronization of the division of labour, it provides the average time allotted to each worker

Pitch time =48.259

Target organization efficiency=55%

$$\text{Upper limit} = \frac{48.259*100}{55}$$

$$= 87.74 \text{seconds}$$

Lower limit= 2*pitch time upper limit

=2*48.259-87.74

=8.778 seconds

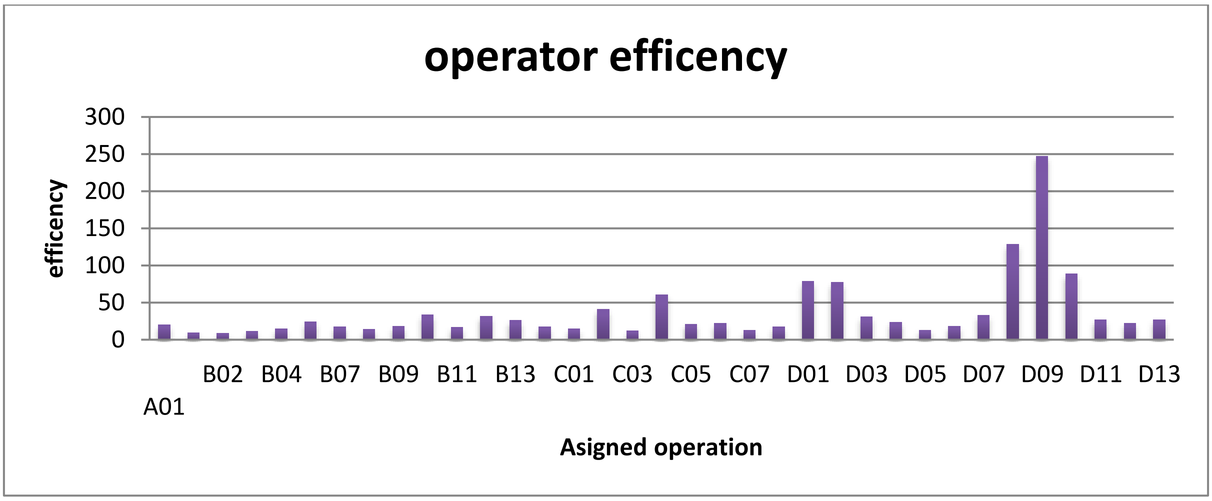

Figure 3:- operator efficiency

Table 2:-Proposed operational breakdown and SAM values

Sl. no.	Operations	M/C Type	Manpower	average basic time	SMV
Front					
1.	coin pocket hemming	DNLS	1	14	0.23
2.	coin pocket attach jet piece (right)	DNLS	1	29	0.47
3.	pocket bag attach with jet piece	DNLS	1	38	0.62
4.	o/l pocket bag	3T O/L	1	21	0.35
5.	top stitch pocket bag	SNLS	1	23	0.37
6.	o/l zipper fly	3T O/L	1	14	0.23
7.	o/l front panels @ crotch	3T O/L	1	15	0.25
8.	zipper attach @ left fly	DNLS	1	31	1.0
9.	left fly attach front panel (inseam & top stitch)	SNLS	2	50	0.8
10	J-stitch left fly	SNLS	1	19	0.32
11	front pocket mouth hemming	DNLS	1	16	0.41
12	pocket bag stitch to front panel side & top (wt. w/c label)	SNLS	2	37	0.6
13	right fly attach with zipper & crotch join	SNLS	2	47	0.76
Back					
14	pocket hemming	DNLS	1	28	0.46
15	pocket o/l	ST O/L	1	13	0.22
16	pocket creasing	ADPC	1	16	0.27
17	pocket attaching	SNLS	5	105	1.77
18	second stitch back pocket	SNLS	1	17	0.28
19	back yoke attach	ST O/L	1	120	1.94
20	back rise join	ST O/L	1	32	0.53
21	size label attach	SNLS	1	23	0.38
Assembly					
22	main label attach waist band, & w/b joining in chain	SNLS	6	186	3.1
23	Sew inseam	FOA	2	39	0.65
24	side seam join (attach front & back panels)	5T O/L	2	33	0.8
25	top stitch side seam	ST O/L	2	51	0.85
26	Prepare waists band	SNLS	1	48	0.81
27	waist band stitch	SNLS	3	189	3.15
28	waist band corners finish	SNLS	4	244	4.07
29	loop preparation	BLM/fdr	1	97	1.27
30	loop attach	SNLS	1	45	0.75
31	bottom hemming	BHM	1	123	2.05
32	Trimming		1	35.7	0.59
33	Quality Inspection		1	40.1	0.68
	Total		54	1838.8	31.03

The above table and data somehow it is different from the existing data in operational breakdown and sequence. Those data work on based on preceding diagram and standard operational sequence of five pocket jeans men trouser.

Observed Data are recorded by the researcher by using of stop watch methods and same calculated method from the above.

According to (Brian Harrington 2017) to find out numbers of work stations required:

Takt time = Available working Time/ Customer Demand

Availability working minutes per day =480 minutes and customer demand =418

=480minutes/418units

=1.148 minutes/unit product

=69 second

Each station should at least have a 69 second design cycle time to meet required demand. So that to know numbers of work station as follows

Number of Stations = Total task Cycle Time / Takt Time

Therefore total cycle time =1838.8 Sec and Takt time =69 seconds

Number of Stations =1838.8 /69 =27 workstation

Production estimation

Estimation Daily production = Total man minutes available in a day/SAM * Average Line efficiency

So that, total number of operators=50, total minutes available =480 minutes/day, SAM =31.03 and according to (KARUNA SINGH 2016) line efficiency is 50% for calculated estimation production

Total available man-minutes =Total no. of operators X Working hours in a day X 60

=50*480 minutes=24000mintus

So Estimation Daily production = Total man minutes available in a day/SAM * Average Line efficiency

Estimation Daily production=24000*50/31.03*100

1296000

3103

=387pices/day

Where 31.03 SAM value from table 2

Line Efficiency% = (Line output X garment SAM X 100)/ (Number of operators X minute worked in day)

= 387*31.03*100

50*480

1200861

24000

50.04%

As comparing the existing scenario and proposed data based on rate, basic time, SAM value target and total capacity are analysis as follows. In existing scenario it gives 90% of rating but based upon operator experience, Fluid motions, coordination and wasted actions this data is more exaggerated so that proposed rating is 80% within the line. Average basic time for the existing scenario are not properly recording and the proposed average basic time is 1838.8 second by reducing un necessary movements of operator and batter working methods. Due to incorrect recording of basic time, tabulated and calculation problem and assign of allowance the existing scenario of SAM value is 23.33 but to properly calculated based on the data assign by the factory is 33.39 but the proposed line data SAM value are 31.03 finally based on the above data proposed line target output per day is 387 and per hour 48 and line efficiency are 50.04%

Table 3: Highly Bottleneck Operation in the Existing Scenarios and balanced proposed line

Assigned no	description of operation	M/c type	Existing M/C and Opr.	Existing Line Output	Existing Balance Efficiency	Proposed M/C and Opr.	Proposed Line Output	Proposed Balance efficiency
D01	Sew Inseam	5th ol	1	184	29.1%	2	387pices/day	50.04%
D02	Top Stitch Side Seam	FOA	1	184	29.1%	2	387pices/day	50.04%
D08	Waist Band Attach To Main Body	SNLS	2	184	29.1%	6	387pices/day	50.04%
D09	Topstitch waist band corner	SNLS	2	184	29.1%	6	387pices/day	50.04%

Bottleneck processes are a Delay in transmission that slow down the production rate. This can be overcome by balancing the line. From the above pitch diagram and line capacity graph we understand that workers having lower capacity level are doing their jobs at operation such as Sew Inseam, Top Stitch Side Seam, Waist Band Attach To Main Body and Topstitch waist band corner are take more time that cross upper control

Limit (UCL) and it is approximately 87.74seconds. They require more processing time for which cannot pass required amount of product to the next operator or next operation. These positions are creating bottlenecks. On the other side

Not any operators were doing the jobs more promptly than the requirement. So this indicates the line was imbalance. work load is excess that was distributed among the higher capacity possessing workers considering the layout. Thus the bottlenecks were solved and maximum capacity was utilized and most importantly productivity was improved. Finally minimize thus bottleneck process and increasing line productivity and total line efficiency enhancing up to 50.04%.

Proposed line Operational procedure for selected style

3.3. Production Cost for five pocket trousers

In the daily production report, many companies include the actual garment production costs of the style. In this study, the production cost represents the sewing room cost and is taken to identify the cost of each situation. Therefore, all direct and indirect costs that are connected to garment sewing and managing sewing lines are considered in the calculated garment production cost. Based on telaje garment manufacturing and seals PLC production manager handles eight lines, monthly salary is 8500:00 birr considered as cost incurred per line per day by dividing the number of lines .To calculate machine deprecation average price of machine 16000ETB it gave 10 years deprecation for one day =16000birr/10year*12month*26 day =4.1birr, where 26 are working days in a month.

The rent of the house was 60,000birr/month. Rent of per day = 60000birr/26day=2307.69birr. For one line divided by the number of lines which is 288.46birr.

Expense per month 12,000 birr; For one day =12000birr/26day = 461.538birr;for one line 461.538/8 = 57.69birr .Actual garment production cost of five pocket trousers is sum of the cost incurred for direct and indirect cost

Table 4: production cost of trouser excising line scenario 1and 2

No	Employee designation	Daily salary	Number of employees	Total daily salary in ETB
1	Manager	461.53	1	461.53
	Designer	326.92	2	653.92
2	Production manager	326.92	1	326.92
2	Line supervisor	276.92	1	276.92
3	Maintenance	84.65	2	169.3
4	quality control	84.65	1	84.65
5	Recorder	69.23	1	69.23
6	Bundle transporter	69.23	2	138.46
7	Operators	69.23	44	3046.12
8	Helper	69.23	4	276.92
9	Expense	57.69birr		57.69
10	Depreciation	4.1birr	44machine	184.4
10	Rent	288.69birr	.33	288.46
Total				6034.52Birr per day
	Existing line daily production cost per picess	pcs daily output184	Daily production cost = Total cost/day 6034.52 daily output/pcs 184 32.796Birr/pcs	6034.52
	Proposed line	Daily product=220.375pcs	Daily production cost = Total cost/day 6470.5 daily output/pcs 387 =16.72Birr/pcs	6470.5

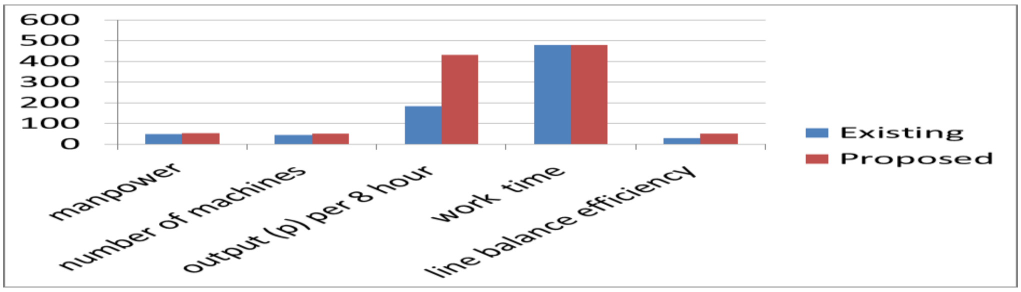

Figure 4: performance measurement

From the above graph we understand some performance measurement with regarding to line balancing focused on manpower ,machine ,output per 8 hour,working time per day and line balancing efficency of selected line.in the case of out put per day the proposed line has shows postive performance from 184 output per day for the exsisting to 387pices/day out put per day and also line efficency increase from 29.1% to 50.04% .inorder to minimize bottleneeck area of the line increasing manpower by 6 operator and machine from 44 to 50 machine from the exesting senario.

4. CONCLUSION

The objective of this thesis was to improve the productivity of the manual single model assembly line. Line balancing concept was applied to a case study problem and four different assembly solutions were developed and compared, namely, (I) Increasing the level of resources in the bottleneck process, (II) avoiding non-value added activities by changing work method and layout, (III) merging operations having similar machines and (IV) combination of scenario II and III. Based on the analysis of each key performance indicator (KPIs), after measuring the results, the fourth scenario was suggested for implementation. This thesis work analysis the current situation relate to assembly line and developed the proposed line to improve the key performance parameters such as line efficiency, productivity, and production cost by reducing and eliminating the problem of existing scenario of the line based on this proposed scenario was improving the efficiency from 29.1% to 50.04%,productiveity from 184 pieces/day to 387 pieces/day and production cost was minimize from 32.796 cost per pieces(ET birr) to16.72 cost per pieces(ET birr).Therefore this thesis work improved assembly line in all aspects especially productivity and efficiency of the company.

REFERENCES:

1. M Sandra Helena Da Silva De Santis, Franco Giuseppe Dedini, Joao Paulo Pereira Marcicano, Regina Aparecida Sanches, Maria Silvia Barros De Hel, et al. (2016) Project Metodology Applyed to Smart Fabrics. Journal of Textile and Fashion 2: 7-17.

2. Andra Helena Da Silva De Santis, Franco Giuseppe Dedini, Joao Paulo Pereira Marcicano, Regina Aparecida Sanches, Maria Silvia Barros De Held, et al. (2017) Strategy of textile design: Use of design methodology tools in the creative process. Strategic Design Research Journal 10(1): 57-66.

3. Cross N (2006) Forty years of design research. Design Research Quarterly 1: 3-5.

4. Chai K H, Zhang J, Tan K C (2005) A TRIZ-based method for new service design. Journal of Service Research 8(1): 48-66.

5. Ertas A, Jones J C (1996) The engineering design process. New York, Wiley, USA.

6. Horrocks AR, Anand SC (2000) Handbook of Technical textiles, Boca Raton, The textile Institute CRC press, USA, pp. 358-381.

7. Kalkan, Adnan, Özlem £etinkaya Bozkurt, Mutlu Arman (2014) The impacts of intellectual capital, innovation and organizational strategy on firm performance.” Procedia-Social and Behavioral Sciences 150: 700707.

8. Chawla KK, Aragao FEA, Montero RRC, Fernandez FG, Moraes MM (1980) Advances in Composite Materials. In: Bunsell AR, Bathais C, Martrenchar A, Menkes D, VereHery G (Eds,). ICCM, paris 1: 414.