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ASSEMBLY LINE BALANCING in a CLOTHING COMPANY

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Abstract: *Assembly lines take the attention of researchers and companies because of its great effect on efficiency. Efficiency in assembly lines has an important role on cost and quality which are the basic fundamentals of competition. Assembly lines contain a number of workstations and tasks (jobs) are processed in these stations and are moved from station to station. The tasks are assigned to each station regarding a cycle time. The cycle time is the maximum available time for the production of a job at any workstation. The assingning of jobs to workstations is based on the objective of minimizing the workflow among the workstations, reducing the throughput time as well as the work in progress and thus increasing productivity. If the jobs are not allocated in balance, this will cause idle workstations and waste of workforce besides the loss of overall efficiency. In this study, an assebly line balancing problem was examined for a five pocket denim trousers in a clothing company. Firstly, priority associations and standard durations of operations of denim trousers were determined. Then, assembly line balancing study was carried out by using ranked positional weights assembly line balancing method developed by Helgeson and Birnie to increase the production in a clothing company manufacturing five pocket denim trousers.*

Key words: *Assembly line, Denim, Ranked Positional Weights Method, Clothing, Efficiency*

1. INTRODUCTION

In some of the manufacturing enterprises, the manufacturing process is performed on one or more lines. By the addition of various raw materials and semi-products from the beginning of the production lines, the product is obtained at the end of the production line. As the sequences and the balance of operations in the line will affect the efficiency, the designing of the production lines is very important for the companies.

Since there is a large number of operations in the production line and large quantities of production are made, even small improvements that can be made on the production line, will provide high productivity increase. In this study, a line balancing study was carried out for a denim trousers production line in a garment factory. With this study, it was aimed to resolve not only the wrong settlement patterns and lost times in the production line but also were tried to increase labor productivity.

2. ASSEMBLY LINE BALANCING

The assembly line is a production model defined as the transfer of materials along a line through labor or automatically. Operations on the part of the assembly line are carried out at work stations arranged along the line [1]. Workers at work stations do their own one or more operations to ensure that semi-finished products entering the production line exit as products at the end of the line. One of the most important problems in assembly line management is to group the tasks of consecutive workstations. The allocation of jobs to workstations is based on the objective of minimizing the workflow among the workstations, reducing the throughput time as well as the work in progress and thus increasing productivity [2]

2.1 Basic Concepts Used in Assembly Line Balancing

Station: A unit where one or more operations on the assembly line are made by the employee. One or more people can work in a workstation depending on the need for operation [4, 5].

Cycle time (C): The cycle time is the maximum available time for the production of a job at any workstation [3]

Cycle time= (Production time per day)/(Output per day)

Total operation time: Sum of task times of all work items on the line.

Station time: It is the total time required for completing the tasks in the station. In order to avoid delay between stations, station time cannot be smaller than the longest transaction time in the station and greater than the cycle time.

Minimum Number of Stations Required: The minimum number of workstations required for a product to run on a specified cycle time.

Number of station = (Total operation times)/ (Cycle time)

Precedence Matrix: This matrix provides the expression of the relationships between tasks. For transactions that have a direct or indirect priority relationship between each other, "1" is placed in the intersection cell of the line of prior task and the column of the following tasks "0" is placed in the other cells.

Line efficiency (E): It is the ratio of total operation time to cycle time and the actual number of stations.

LE %= (Total operation time)/(Actual no of stations X Cycle time)*100

Balance Delay: A measure used to indicate the imbalance of work or the distribution of employees to workstations. In other words, it shows the idle time ratio on the line.

BD=((Actual no of stations X Cycle time- Total operation time))/(Actual no of stations X Cycle time)*100

Theoretical efficiency (TE): Efficiency when the line is established with minimum number of stations without exceeding the specified cycle time.

3. MATERIAL METHOD

Assembly line of five pocket denim trousers (Fig 1) was examined in this study. Operation list, precedence relatons were determined for the model. After that, the base operation times of processes were measured in seconds by the help of a chronometer. A 10% allowance was added to these base operation times in order to get standard times. Ranked Positional Weighted Method provides fairly quick and acceptable solutions compared to other methods, and the solutions obtained together give approximate values. Therefore, this method was selected to be used in this problem. The steps of Ranked Positional Weight Method are as below [6];

Step1. Find the positional weights of each task. The positional weight of an operation is calculated by summing the operation times of other operations which follows that operation in series

Step 2. Rank the tasks based on their positional weights. The task with the highest positional weight is ranked first

Step 3. Proceed to assign tasks to the workstations, where tasks with the highest positional weight and rank are assigned first

Step 4. If additional time remains at any workstation after assignment of an operation, assign the next succeeding ranked operation to the workstation, as long as the operation does not violate the precedence relationships and the station times do not exceed the cycle time

Step 5. Repeat steps 3 and 4 until all elements are assigned to the workstations

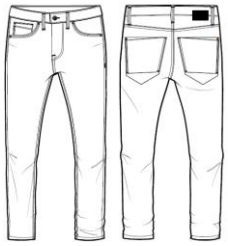

Fig 1: *Five pocket denim trousers*

4. RESULTS

The determined precedence matrix (Fig 2) and the flow chart (Fig 3) is given below.

	Task	Operasyon Name	Standard Time	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	Position Weight
P	1	Stitch zipper to fly	15		1																				+										+	+	+	+	+	+	+	+	+	+	+	246
P	2	Right fly overlock	3																						2										+	+	+	+	+	+	+	+	+	+	+	234
P	3	Left fly overlock	3																		3	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	363
P	4	Coin pocket seam	6					4	+	+	+	+	+	+	+						+	+	+	+	+										+	+	+	+	+	+	+	+	+	+	+	418,8
P	5	Insert coin pocket	18						5	+	+				+						+	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	418,2
P	6	Coin pocket bartack seam	4,8							6	+	+			+						+	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	415,2
P	7	Front pocket facing coverstitch	19,2								7	+			+						+	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	410,4
P	8	Front pocket bag overlock	15									8			+						+	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	391,2
P	9	Front pocket bag blind stitch	18												9						+	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	394,5
P	10	Back pocket seam	11,4											10							+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	448,2
P	11	Join back pocket	25,8												11						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	462,6
P	12	Trimming preparation and attaching seam	13,2																		12	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	376,2
P	13	Stitch waistband in series	9															13	+																				+	+	+	+	+	+	+	155,4
P	14	Waistband interlining	8,4															14																					+	+	+	+	+	+	+	146,4
P	15	Waistband wrapping	2,4																																				15	+	+	+	+	+	+	140,4
P	16	Sewing loops in series	4,2																	16																								+	+	+	68,4
P	17	Belt loop forming	4,2																																							17	+	+	+	64,2
F	18	Stitching left fly to front and edge seam	16,8																			18	+	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	363
F	19	Front fly edge stitch	9,6																				19	+	+	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	346,2
F	20	Fly topstitch	12																					20	+	+	+	+							+	+	+	+	+	+	+	+	+	+	+	336,6
F	21	Attach binding to front pocket	18																						21	+	+	+							+	+	+	+	+	+	+	+	+	+	+	324,6
F	22	Join front pieces	22,8																							22	+	+							+	+	+	+	+	+	+	+	+	+	+	306,6
F	23	Seam front pieces with two needle	22,2																								23	+							+	+	+	+	+	+	+	+	+	+	+	283,8
F	24	Pocket bag fastening	27																									24							+	+	+	+	+	+	+	+	+	+	+	253,2
F	25	Front piece overlock	18																										25						+	+	+	+	+	+	+	+	+	+	+	234,6
F	26	Bartack	8,4																																26	+	+	+	+	+	+	+	+	+	+	216,6
B	27	Back and yock joint	15																											27	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	282
B	28	Center back seaming	16,8																												28	+	+	+	+	+	+	+	+	+	+	+	+	+	+	267
B	29	Back piece side overlock	15,6																													29	+	+	+	+	+	+	+	+	+	+	+	+	+	250,2
B	30	Join back pocket	14,4																														30	+	+	+	+	+	+	+	+	+	+	+	+	234,6
B	31	Back pocket manuel bartack stitch	12																															31	+	+	+	+	+	+	+	+	+	+	+	220,2
A	32	Close inside leg 5 thread overlock	16,8																																32	+	+	+	+	+	+	+	+	+	+	208,2
A	33	Inside legs seaming	12																																	33	+	+	+	+	+	+	+	+	+	191,4
A	34	Close outside legs	24																																		34	+	+	+	+	+	+	+	+	179,4
A	35	Side edge stitch	17,4																																			35	+	+	+	+	+	+	+	155,4
A	36	Join waistband	18																																				36	+	+	+	+	+	+	138
A	37	Close waistband	18																																					37	+	+	+	+	+	120
A	38	Side seam ironing	18																																						38	+	+	+	+	102
A	39	Hemming	24																																							39	+	+	+	84
A	40	Automatic loop stitching	18																																								40	+	+	60
A	41	Side bartack	13,2																																									41	+	42
A	42	Final check	24																																										42	28,8
A	43	Open buttonhole	4,8																																											4,8
			617,4																																												

Fig 2: *Precedence matrix of five pocket denim trousers*

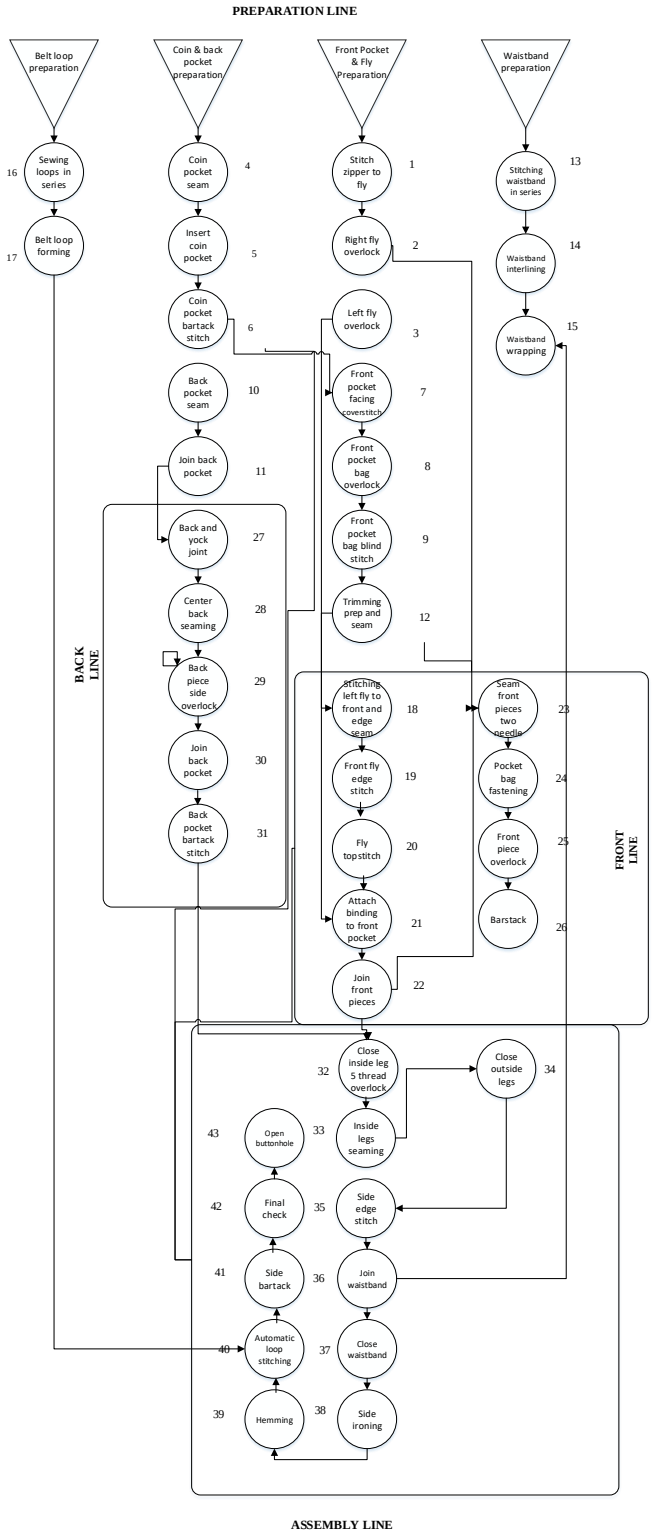

Fig 3: *Flow chart of five pocket denim trousers*

In figure 2, the precedence relations and positional weights of the operations are seen. Before assigning the operetaions to workstations cycle time should be calculated.

C = T / N = (545 minute* 60 seconds.) / 1500 (pieces/day) = 21,8 seconds

C = 22 seconds.

Minimum number of required workstations is as below;

n_{min} = Max (n_{min}; $n_{probable}$)

n_{min}= [Σ t_i / C]$^+$ = [617 /22]$^+$ = 28,04

$n_{probable}$ = t_i> (C/2 = 22/2 = 11) Probable tasks = 31 (1, 5, 7, 8, 9, 10, 11, 12, 18, 20, 21,22 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42)

n_{min} = Max (28; 31) = 31 minimum number of workstations

STATION NUMBER	TASK NUMBER	TASK NAME	POSITIONAL WEIGHT	TASK TIME	CUMULATIVE TASK TIME	LEISURE TIME
PREPARATION						
1	10	Back pocket seam	448,2	11,4	11,4,	10,6
2	11	Join back pocket	462,6	25,8	25,8	-3,8
3	4	Coin pocket seam	418,8	6	6	16
	5	Insert coin pocket	418,2	18	24	-2
4	6	Coin pocket bartack seam	415,2	4,8	4,8	17,2
	7	Front pocket facing coverstitch	410,4	19,2	24	4,8
5-6	8	Front pocket bag overlock	391,2	15	15	29
	9	Front pocket bag blind stitch	394,5	18	33	-4
7-8	12	Trimming preparation and attaching seam	376,2	13,2	13,2	30,8
	1	Stitch zipper to fly	246	15	28,2	15,8
	2	Right fly overlock	234	3	31,2	12,8
	3	Left fly overlock	363	3	34,2	9,8
	13	Stitch waistband in series	155,4	9	43,2	0,8
9	14	Waistband interlining	146,4	8,4	8,4	13,6
	15	Waistband wrapping	140,4	2,4	10,8	11,2
	16	Sewing loops in series	68,4	4,2	15	7
	17	Belt loop forming	64,2	4,2	19,2	2,8
FRONT PREPARATION						
10	18	Stitching left fly to front and edge seam	363	16,8	16,8	5,2
11	19	Front fly edge stitch	346,2	9,6	9,6	12,4
	20	Fly topstitch	336,6	12	21,6	0,4
12	21	Attach binding to front pocket	324,6	18	18	4
13	22	Join front pieces	306,6	22,8	22,8	-0,8
14	23	Seam front pieces with two needle	283,8	22,2	22,2	-0,2
15-16	24	Pocket bag fastening	253,2	27	27	17
	25	Front piece overlock	234,6	18	45	-1
17	26	Bartack	216,6	8,4	8,4	13,6
BACK PREPARATION						
18-19-20-21	27	Back and yock joint	282	15	15	73
	28	Center back seaming	267	16,8	31,8	56,2
	29	Back piece side overlock	250,2	15,6	47,4	40,6
	30	Join back pocket	234,6	14,4	61,8	26,2
	31	Back pocket bartack stitch	220,2	12	73,8	14,2
ASSEMBLY LINE						
22	32	Close inside leg 5 thread overlock	208,2	16,8	16,8	5,2
23	33	Inside legs seaming	191,4	12	12	10
24	34	Close outside legs	179,4	24	24	-2
25	35	Side edge stitch	155,4	17,4	17,4	4,6
26	36	Join waistband	138	18	18	4
27	37	Close waistband	120	18	18	4
28	38	Side seam ironing	102	18	18	4
29	39	Hemming	84	24	24	-2
30	40	Automatic loop stitching	60	18	18	4
31	41	Side bartack	42	13,2	13,2	8,8
32	42	Final check	28,8	24	24	-2
33	43	Open buttonhole	4,8	4,8	4,8	17,2

Fig 4: *Balancing of five pocket denim trousers assembly line*

The assignments of operations to workstations were done according to positional weights by following the steps of used method. The results are seen in figure 4. After assignment of operarations to the workstations, balance delay, theoretical efficiency and line efficiency were calculated as below and the efficiency results are in given in Table 1.

BD(%) = (33*22 – 617,4) / (33*22) = %14
TE (%) = [617,4/ (28,06*22)] *100 = %100
LE (%) = [617,4/ (33*22)] *100 = %85

Table 1: *Efficiency results of five pocket denim trousers assembly line*

	Number of tasks	**Cycle time C (seconds)**	**Minimum Number of workstations**	**Assigned number of workstations**	**Theoretical Line Efficiency TE (%)**	**Line Efficiency LE (%)**	**Balance Delay BD (%)**
Assembly line	43	22	31	33	%100	%85	%14

5. CONCLUSION

Assembly line balancing is an extremely important issue for using resources efficiently and reducing the costs in the garment industry. In this study, the production flow of a five pocket denim trousers was examined. According to the defined production flow, operation times of each operation were obtained by holding time with a chronometer. Then the positional weights of the operations were calculated and the tasks were assigned to the workstations regarding these positional weights. Thus, an efficient production line system was tried to be established. Theoretical efficiency is calculated according to the theoretical minimum number of workstations and it is preferable to obtain the closest results to this value. The obtained line efficiency is 85% and the balance loss is about 14%. Due to the small number of work items, the high priority relationships, and the large variety of machines, assigment of tasks to the workstations has less flexibility. Therefore, high balance loss can sometimes be normal. In general, it is not desired to get the line efficiency is to be under 80% [7]. The results of our model is over the general expectation.

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