American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-5, pp-22-28
www.ajer.org
Research Paper Open Access

Appraisal of Cocacola Production Line Using Line Balancing

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***ABSTRACT**: The appraisal of the coca cola production line was carried out using line balancing method. The original daily production capacity of the line was 1000 bottles of 35cl bottles of coca cola. This study used longest operation time heuristics to analyze the production line. It takes 14479 seconds to produce one crate of 35cl bottles of coca cola. Against the original 1000 bottles daily production capacity, the plant has a maximum daily output of 557bottles. The labour utilization efficiency is 43% and the daily idle time is 122.5 hours. Also, it consists of 9 workstations, 9 workers and 20 work elements. As a result of line balancing, although the amount of product produced per day remains the same, labour utilization efficiency increased from 43.3% to 97.4% and daily idle time reduced from 112.5 hours to 2.5 hours. The number of workstation reduced from 9 to 4 workstations and the number of workers reduced from 12 workers to 11 workers. Consequently, the same amount of product is produced at reduced cost.*

Date of Submission: 25-04-2019 Date of acceptance: 05-05-2019

I. INTRODUCTION

Nigerian Bottling Company Plc, Oweri Plant, Nigeria has been in existence for decades. Appraisal of its production line is a right step in the right direction. This will go in a long way to help the company forge ahead in competitive market of our day.

Nowadays, companies around the world are producing high quality products to sell them at the lowest price possible. This is not because they do not want to earn more money through the sales of products. It is because they are facing the necessity of increasing their participation in the market because competitors also are selling products with high quality at the lowest price possible (Milas, 1990).

There are several techniques to continuously improve quality and reduce operation costs. One of these techniques is called line balancing. The line balancing problem consists of assigning approximately the same amount of work to each workstation (worker) in an assembly (or production) line. Line balancing involves selecting the appropriate combination of tasks to be performed at each workstation so that the work is performed in a feasible sequence and approximately equal amount of time are required at each of the workstations (Heizer and Barry, 1988).

Assembly line exists when we assemble or handle any device or product in a planned, sequential manner with two or more operators performing tasks of repetitive work at established workstations (Milas, 1990). When the products have many operations and the demand is high the process of balancing the line becomes more and more difficult. There are two types of optimization problems for the line balancing problem (Ajenblit, 1998). In type I problem, the cycle –time (Maximum amount of time units that can be spent at each workstation) is fixed and the objective is to minimize the requirement number of the workstations. The type II attempts to minimize the maximum cycle-time given a fixed number of workstations. This study adopted the type I problem.

Optimum balancing of production line usually leads to increase in production of the company. Productivity is defined as measure of effectiveness, a ratio between output and input. The input or work content means the amount of work "contained" in a given product or process measure in man-hours or machine –hours. Output, input and work content are measurable by work study.

Work study can be defined as a term used to embrace the technique of method study and work measurements which are employed to ensure the best possible use of human and materials resources in carrying out specific activities (ILO, 1979). Method study is concerned with the reduction of work content of the operation, while work measurement is concerned with the investigation and reduction of ineffective time and the subsequent establishment of time standard for the operation on the basis of the work content as established by the method study.

In this study, work measurement is used to determine the balance delay of the assembly lines which shows the degree of idle times and finally the balancing of the lines to minimize idle time.

II. OBJECTIVES

The overall objective of the study is to appraise the productivity of coca-cola production line of Nigerian Bottling Company Plc, Oweri Plant. The specific objectives are:

i. To minimize the number of work stations
ii. To minimize balance loss
iii. To distribute balance loss evenly between stations.

Research Methodology

On the production line, the existing number of workstations, cycle time and idle time were identified and observed. A new number of workstations were calculated after which the production line was balanced to minimize idle time and labour and to ensure maximum profit.

Data were collected from the production line. The collected data includes:

i. Rating factor
ii. Observed time
iii. Work elements (tasks)
iv. Number of workstations
v. Number of workers per stations

Ten cycles were observed in the industry and the result was tabulated.

Work Elements On The Production Line

The work elements that make up the production line are as follows:

1 Carrying pallets from the store by the forklift to the production line
2 Depalletizing by depalletizer.
3 Moving one crate to uncaser.
4 Uncasing by uncaser.
5 The empty crate moves to the packing table.
6 Moving the bottle to pre-inspection point.
7 Pre-inspection by inspector.
8 The bottles moves to he washing machine.
9 Washing of the bottle.
10 The bottles move to empty inspection light.
11 Empty inspection by the inspector.
12 The bottle moves to the filler and crowner.
13 Filling of the bottle with the beverage and crowning.
14 The bottle moves to full inspection light.
15 Full inspecton by inspector.
16 The bottle moves to the packing table.
17 Packing at the packing table.
18 A crate moves to the palletizer.
19 Palletizing by the palletizer.
20 Carrying a pallet to the store by forklift.

The work elements (or tasks) are represented by numbers 1 to 20 and the precedence diagram is shown in figure 1

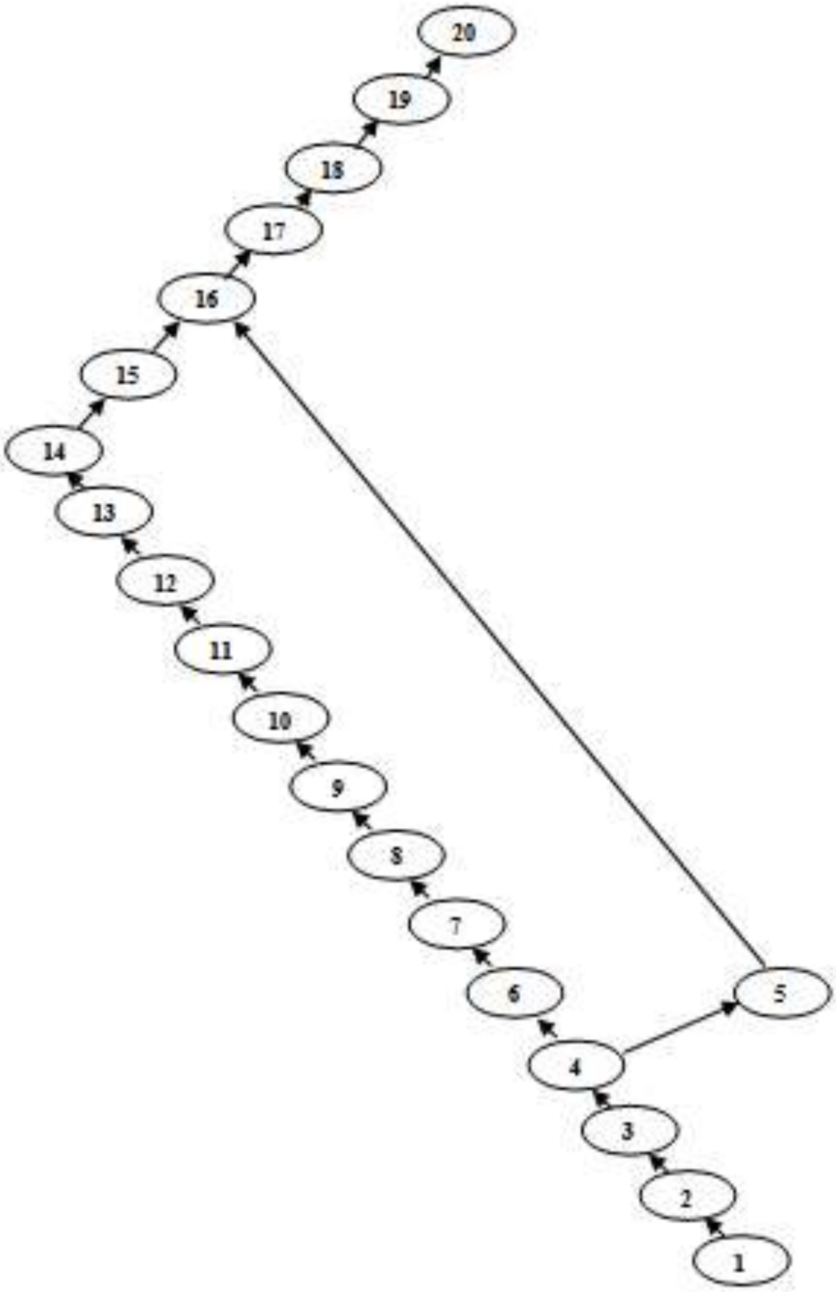

Fig. 1: Precedence Diagram of Coca Cola Production Line

III. DATA ANALYSIS AND RESULT

The research was conducted on 35cl bottle of Coca Cola. One pallet contains 48 crates, which contains 24 bottles each. Therefore, the total number of bottles in one pallet is 1152 bottles.

The data collected was tabulated as shown in table 4.1. The table shows the study summary sheet for the producton line. It takes 680368 seconds to produce one pallet. This means, a crate, which contains 24 bottles, is produced in 14479 seconds. Task 10 is the bottleneck operation and its task time of 3717 seconds is the cycle time. The following symbols are used in table 4.1:

E -Element

F-Frequency of occurrence per cycle

FA-Fatigue allowance

PNA-Personal need allowance

B.T-Basic time

S.T-Standard time
F.A=4 percent of basic time
PNA=6 percent of basic time
S.T=B.T + FA + PNA
All times are in seconds.

Table 1: Study Summary Sheet for the Production Line

Task or Element	Frequency	Basic Time (Sec.)	ALLOWANCE (Sec.) Fatigues (4%)	Personal Need (6%)	Standard Time per Pallet (Sec.)	Standard Time per Crate (Sec.)
1.	1/1	181	7.24	10.86	199	4
2.	1/1	292	11.68	17.52	321	7
3.	1/1	1469	58.76	88.14	1616	34
4.	1/1	130	5.20	7.80	143	3
5.	1/1	6438	257.52	386.28	7082	148
6.	1/1	37324	1492.96	2239.44	39564	824
7.	1/1	8058	322.32	483.48	8864	185
8.	1/1	27279	1091.16	1636.74	30007	625
9.	1/1	63080	2523.20	3784.80	69388	1446
10.	1/1	162203	6488.12	9732.18	178423	3717
11.	1/1	69011	276.44	414.66	7602	158
12.	1/1	70965	2838.60	4257.90	78062	1626
13.	1/1	11520	460.80	6901.20	12672	264
14.	1/1	62210	2488.40	3732.60	68431	1426
15.	1/1	5760	230.40	345.60	6336	132
16.	1/1	148263	5930.52	8895.78	163089	3398
17.	1/1	5400	216.00	324.00	5940	124
18.	1/1	1729	69.16	103.74	19002	40
19.	1/1	561	22.44	33.66	617	12
20.	1/1	100	4.00	6.00	110	2
TOTAL					**680368**	**14479**

Task number 10 has a task time of 3717 seconds given us a production rate of 23.2 crates which is calculated as shown below.

$$\text{Maximum daily output} = \frac{\text{Available time per day (seconds)}}{\text{Cycle time required per crate}}$$

$$= \frac{86400}{3717}$$

$$= 23.2 \text{ crates}$$

The production line is operational for 24 hours daily. From the above calculation, the maximum daily output is 23 crates, 5 bottles (i.e. 577 bottles).

The results of observed data are listed in table 2 showing the distribution of the tasks among the workstations. The table also indicates the number of workers per workstations.

Table 2: Assignment of Task to Workstations in the Production Line

Work Station	Number of Workers	Task or Work Element	Task Times (Sec.)	Time per Station (Sec.)	Idle Time per Station (Sec.)
1	2	1 2 3	199 7 34	206	3511
2	1	4	37	37	3680
3	1	6 7	824 185	1009	2708
4	1	8 9	625 1446	2071	1646
5	1	10	3717	3717	0
6	1	11 12 13	158 1626 264	2048	1669
7	1	14 15	1426 132	1558	2159
8	2	16 17 5	3398 124 148	3670	47

9	1	18 18 20	40 13 110	163	3554
TOTAL	**11**		**14479**		**18974**

Labour utilization effectiveness is calculated as shown in Table 3.

Table 3: Labour Utilization Effectiveness for the Production Line

	Stations										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	Total Time per cycle (Sec.)	Utilization of Employee (Efficiency)
Productive time (Task time) expended each cycle	206	37	1009	2017	3717	2048	1558	3670	163	14479	$\frac{14479 \times 100}{33453}$ =43.3%
Available employee time (Cycle time)	3717	3717	3717	3717	3717	3717	3717	3717	3717	33453	-
Idle time each cycle	3511	3680	2608	1646	0	1669	2159	47	3554	18974	$\frac{18974 \times 100}{33453}$ =56.7%

From Table 3, labour utilization effectiveness is 43.3% and the idle time is 56.7% of the available time per cycle. The idle time per day is calculated as follows:

$$\text{Idle time per day} = \frac{(\text{Idle Time/Cycle})(\text{Available Time /day} \div \text{Cycle Time})}{\text{One hour in seconds}}$$

$$= \frac{(18974)\ (86400 \div 3717)}{60 \times 60}$$

$$= \frac{18974 \times 23.24}{3600}$$

$$= \frac{440955.76}{3600}$$

$$= 122.5 \text{ hours}$$

Although there are many heuristic rules in balancing assembly line, longest operation time is used to balance the production line. Originally, the production line has 9 workstations. In an attempt to balance the line, the new number of workstations is calculated as follows:

$$\text{Number of workstations} = \frac{\{\text{Total work comment}\}\ \{\text{Desire number of unit per day}\}}{\text{Total productive time available per day}}$$

$$= \frac{\{\text{Total time per cycle}\}\ \{\text{Desire number of unit per day}\}}{\text{Total productive time available per day}}$$

$$= \frac{14479 \times 23.2}{86400}$$

$$= \frac{335912.8}{86400}$$

$$= 3.89$$

$$= 4 \text{ Stations}$$

To balance the production line, the task or element would be assigned to at least 4 work stations following the precedence relationship of the elements.
The performance time assigned to each station cannot exceed 3717 seconds cycle time. The result is shown in table 4.

Table 4: New task workstation assignment in Coca Cola Production Line

Work station	Number of workers	Task or element	Task time (Sec.)	Time per station (Sec.)	Idle time per station (Sec.)
	4	1	199		
		2	7		
		3	34		
		4	3		
		5	148		
		6	824		
		7	185		
		8	625		
1		9	1446	3471	246
2	1	10	3717	3717	0
		11	158		
		12	1626		
		13	264		
3	2	14	1426	3606	111
		15	132		
		16	3398		
		17	124		
		18	40		
		19	13		
4	3	20	110	3685	32
TOTAL	**10**		**14479**		**389**

To minimize idle time, the line should now have 4 workstations and 10 workers instead of the former 9 workstations and 11 workers. The new labour utilization effectiveness is calculated in Table 5. According to Table 5, the new labour utilization effectiveness is 97.4% while the idle time per cycle is 2.6% of the available time per cycle. The idle time is calculated as follows:

$$\text{New idle time} = \frac{(\text{idle time/cycle})\ (\text{available time/day} \div \text{cycle time})}{\text{One hour}}$$

$$= \frac{(389)\quad(86400 \div 3717)}{60 \times 60}$$

$$= \frac{389 \times 23.24}{3600}$$

$$= \frac{9040.36}{3600}$$

$$= 2.5 \text{ hours}$$

Table 5: New labour utilization effectiveness for the production line

	Station				Total time per cycle (Sec.)	Utilization of employee (efficiency)
	1	2	3	4		
Productive time (task time) expended each cycle	3471	3717	3606	3606	14479	$\frac{14479 \times 100}{14868}$ = 97.4%
Available employee time (cycle time)	3717	3717	3717	3717	14868	
Idle time each cycle	245	0	111	32	389	$\frac{389 \times 100}{14868}$ = 2.6%

The new idle time per day is 2.5 hours compare to the former 122.5 hours.

In summary, to maximize idle time, the production line should have 4 workstations and 10 workers instead of the current 9 workstation and 11 workers. It was discovered that the worker responsible for task 4 could also take care of task 5. This led to the reduction of workers from 11 to 10 workers. As a result of this, the labour utilization increased from 43.3% to 97.4% and the idle time reduced from 56.7% to 2.6%. Consequently, daily labour hour idle reduced from 122.5 hours to 2.5 hours

IV. CONCLUSION

The industry used for this study did not make any existing precedence diagrams or definite information on cycle time available. The cycle time used and the precedence diagram were based on the result of this study.

It took 14479 seconds for Nigeria Bottling Company Plc, Owerri plant to produce one crate of 35cl bottles of Coca Cola. The maximum daily output of the company is 557 bottles (i.e. 23 crates and 5 bottlos) and the production line runs 24 hours daily.

Also, the production line is made up of 9 workstations and 12 workers including one supervisor. Before optimum line balancing, the line was not efficient. The labour utilization was 43.3% and the daily idle time was 122.5 hours. As a result of optimum line balancing, labour utilization efficiency increased from 43.3% to 97.4% and daily idle time reduced from 122.5 hours to 2.5 hours. Although, the output remain the same but the number of workstation was reduced from 9 to 4 workstation and the number of workers reduced from 12 to 11 workers including a supervisor. Although the daily maximum production of the company has decreased from 1000 bottles to 557 bottles but the production cost has also been reduced.

RECOMMENDATION

On Coca Cola production line, it was discovered that there is a bottleneck at task 10 and also the washing machine in task 9 is slow. In this case, the company should crate three or more pathways linking washed bottled to empty inspection light and the slow washing machine should be replaced with new and faster one. Consequently, the original daily production capacity of 1000 bottles will be met.

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Oke D. B." Appraisal of Cocacola Production Line Using Line Balancing" American Journal of Engineering Research (AJER), vol.8, no.05, 2019, pp.22-28