BUS 314: PRODUCTION MANAGEMENT & CONTROL I

Line balancing

Introduction

Firms sometimes experience imbalance in capacity and resources utilization. Quite often, a particular work station may have more than enough work to cope with, while others are idle. The problem is complicated by the relationships among tasks imposed by product design and process technologies. This is called the precedence relationship, which specifies the order in which tasks must be performed in the assembly process.

Learning Outcomes

When you have studied this topic, you should be able to:

- Define line balancing
- Explain the steps in balancing an assembly line
- States the terms in line balancing
- Describe the Solution Techniques in Line Balancing
- Explain how to Compute Line Balancing Problem

Line Balancing defined

Line balancing is defined as a technique which seeks to distribute tasks to each work station in a way that will optimize some appropriate measures of line operation. The line-balancing problem is one of assigning all tasks to a series of workstations so that each workstation has no more than can be done in the workstation cycle time, and so that the unassigned (idle) time across all workstations is minimized.

The steps in balancing an assembly line

The steps are:

i. Specify the sequential relationships among tasks using a precedence diagram.

ii. Determine the required cycle time C, using the formula

C = Production time per day ÷ Required output per day (in units)

iii. Determine the theoretical minimum number of workstations (N*t*) required to satisfy the cycle time constraint using the formula:

N*t* =Sum of task times (T) ÷ Cycle time (C)

iv. Select a primary rule by which tasks are to be assigned to workstations, and a secondary rule to break ties.

v. Assign tasks, one at a time, to the first workstation until the sum of the task times is equal to the workstation cycle time, or no other tasks are feasible because of time or sequence restrictions. Repeat the process for workstation 2, workstation 3, and so on until all tasks are assigned.

vi Evaluate the efficiency of the balance derived otherwise called balance delay,

ViiIf efficiency is unsatisfactory, rebalance using different decision rule.

Terms in Line Balancing

- **Tasks**

These are the smallest groupings of work that can be assigned to workstation. It can also be referred to as the smallest units into which the total job content can be divided.

- Assembly line: is referred to as progressive assembly linked by some material handling device.
- **Precedence relationship**

  This specifies the order in which a task must be performed in the assembly process

- **Work Stations**

The minimum allowable number of work stations is a function of two variables; the cycle time (C) and the total work content of the job. If the cycle time is fixed at a value of C, then the number of stations (N) must be equal to or greater than the integer value of the ratio of T/C, or a if N equals the minimum number of stations, then

N = T/C

- **Cycle Time**

A cycle time is the maximum time allowable for a task or group of tasks to be completed at each work station. Usually the total time taken by each work station on the line must be equal to or less than the cycle time ($Sj \leq C$). This means that no station over-loading is allowed.

If we are to have N minimum work stations and the total elemental time for the entire job is T Minutes, then the cycle time (C) can be derived as:

$$C = \frac{T}{N}$$

- **Balance Delay**

This measures the degree of inefficiency in the system, it reflects the proportion of idle time over the the total available work time. The closer the value of balance delay to zero, the more the balance in the line.

Balance delay (BD) = $(NC - \sum^{t}i) \div NC$

$$BD = \frac{NC - \sum^{t}i}{NC} \times 100$$

The idle time = $NC - \sum^{t}i$

Line Balancing Solution Techniques

The solution technique can be classified into two categories: the exact or optimization method and the heuristic method. The optimization method is a mathematical approach, whose solutions are usually optimal. The heuristic method is usually a simulation and intuitive solution approach whose solutions may be feasible but not necessarily optimal. The difference between the two approaches is that one method guarantees optimal solutions and is objective while the other is subjective and does not guarantee optimal solutions.

Exact Method of Solution

The Exact method is concerned with applying mathematical formulations to provide answers to the line balancing problem (Banjoko 2009). Salveson (1955) applied a linear programming approach to obtain solutions to a line balancing problem. In, E. H. Bowman (1960) also devised a linear programming solution to a line balancing problem. In 1963, Held and his co-researchers offered a dynamic programming formulation of the assembly line balancing problems that provided solution for another set of line balancing problems.

Heuristic Solution Method

Heuristic Method for solving line balancing problems has been developed by many authors in the field of production. Wester and Kilbridge (1962) made systematic use of the tasks precedence relationship inachieving near optimum allocation of tasks to work stations. Helgeson and Bimie (1961) also developed the Ranked Positional Weight Techniques for solving line balancing problems, which require weights to be assigned to tasks and at the same time used as a source for allocating optimum tasks to work stations such that idleness would have been reduced.

Computation of Line Balancing Problem

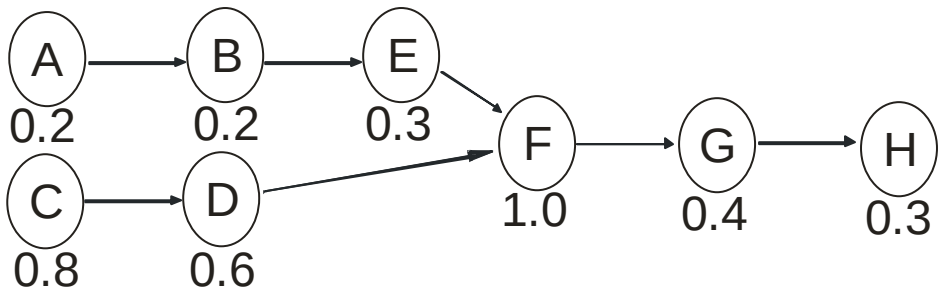
Let us consider this problem as shown in the table below. The management of an organisation wants to balance the line with the hope of minimizing idle time. The output required is 400 units and operation is carried out in an 8 hour work.

Task	**Task Time (minutes)**	**Predecessor**
A	0.2	-
B	0.2	A
C	0.8	-
D	0.6	C
E	0.3	B
F	1.0	D, E
G	0.4	F
H	0.3	G

You are required to:

i. Draw the network diagram
ii. Calculate the cycle time
iii. Calculate the number of work station
iv. Calculate the idle time
v. Assign tasks to work stations

(b) (i)



Drawing the table requires a systematic drawing and consideration for the precedent relationship for each activity, for instance, task A and task C mark the beginning of the project or job, task B takes its precedence from Task A, D from C, E from B, while F from E&D. G takes its precedence from F, so also H from G.

(ii) Cycle time = $\frac{Production\ time}{Desired\ ouput} = \frac{8hrs \times 60mins}{400} = \frac{480}{400} = 1.2mins$

Computing the cycle time requires that the daily working hour per production be divided against the desired output for the day.

(iii) Number of Work stations = $\frac{\sum t}{c} = \frac{3.8}{1.2} = 3.167 \cong 4\ work\ stations$

The total task time for the job is summed up and further divided against the computed cycle time.

(iv) Idle time = NC - £t = (4 x 1.2) – 3.8 = 4.8 – 3.8 = 1.0mins

The idle time is computed by subtracting the product of the number of work stations from the total task time.

(v)

Work station	Cycle time (mins)	Available tasks	Assigned tasks	Assigned task time
1	1.2	A,B,C,D,E,F,G,H	A,B,C	1.2
2	1.2	D,E,F,G	D,E	0.9
3	1.2	F,G,H	F	1.0
4	1.2	G,H	G,H	0.7

Balancing the line requires that the various task times for each task is assigned to individual work stations such that the total task time in each workstation is not greater than the computed cycle time. However, the precedence relationship for individual tasks is considered. For example, work station 1 has task A,B and C assigned to it after considering their precedence relationship.

Summary of line balancing

The study section considers the step attributable to line balancing and described tasks as the work unit to be performed and assigned to work station. The techniques for solving line balancing problem were classified into exact method and Hereustic solution method. Emphasis was placed on how to compute a line balancing problem ranging from how to draw the Network, the computation of the Cycle Time, Work Station and Balance Delay.

Self-Assessment Questions

Instruction: Choose the best option to each question (or statement) from the alternatives lettered a – d.

1. ------ is the order to which tasks must be performs in the assembly process (a) job scheduling (b) job sequencing (c) precedence relationship (d) event
2. All of these are steps in balancing an assembly line except (a) specify sequential relationship among tasks (b) determine theoretical minimum number of work station (c) select primary rule by which tasks are to be assigned (d) define the problem in each work station
3. The smallest groupings of work that can be assigned to work station is _____ (a) project (b) work (c) tasks (d) balance delay
4. Cycle time and work content of the job are two variables for determining _____ (a) balance delay (b) work station (c) cycle time (d) assembly line
5. The minimum requirement for the balance in the line is ____ (a) balance delay farther zero (b) balance delay greater than zero (c) balance delay equal efficiency ratio (d) balance delay closer zero
6. The heuristic solution technique for balancing the line often time term (a) objective (b) optimal (c) subjective (d) deterministic
7. ---------- Applied a linear programming technique to obtain solution to line balancing problem (a) Salveson (b) Webster & Kilbridge (c) Held 1963 (d) Helgeson and Birnie
8. _____ offered a dynamic programming formulation of the assembly line balancing problem (a) Salveson (b) Webster & Kilbridge (c) Held 1963 (d) Helgeson and Birnie
9. _____ developed the ranked positioned weight technique for solving the line balancing problem (a) Salveson (b) Webster & Kilbridge (c) Held 1963 (d) Helgeson and Birnie

10. The cycle time required for a daily working hr is given as 1.2 mins, while the daily working hour is 8hrs. What is the desired output? (a) 100 units (b) 200 units (c) 300 units (d) 400 units