Artificial Neural Network for Assembly Line Balancing

Pius Ucheagwu
Department of Production Engineering, University of Benin, Benin
E-mail:ucheagwupius@gmail.com

Johnmary Ugochukwu Okeke
Department of Civil Engineering, University of Benin, Benin
E-mail:okekejohnmary@gmail.com

Christian I. Okonta
Department of Civil Engineering, University of Benin, Benin
E-mail:okonta.christian@yahoo.com

Efosa Osamuyimwen
Department of Physics, University of Benin, Benin
E-mail:pasionpatrick@yahoo.com

Abstract
This study examines an assembly line balancing using artificial neural network. An organization that balances the unique workloads must respect the limits and restrictions that hinder the assembly. To optimize the very specific operations, balancing an assembly line may require different methods, including: genetic algorithm, heuristic approach, simulation techniques, the ant colony optimization (ACO), etc., but in this study, artificial neural networks was applied to solving problems of assembly line balancing. This study also explores the characteristics of the assembly line and the classification of the assembly balancing problems, suggesting as an artificial neural network solve.

Keywords: Assembly, Line balancing, Artificial Neural Network.

1. Introduction
A production system can be defined as a set of integrated devices (including production equipment and tools, handling devices, the work positioning systems and computer systems) and human resources, the function of which is to perform one or more treatments and/or operations, raw materials, by mounting a part or assembly of parts (Groover, 2008). In this system, it requires full-time or recurring to keep the system running human resources. A production system includes seven systems are; taxonomy, individual stations cells, group technology, flexible manufacturing system, manual assembly lines, automatic assembly lines and transfer lines. In this study, the discussion will focus on a mounting system.

The balance of the assembly lines is becoming one of the most important elements of a system of industrial production must be closely monitored. The balance of the assembly line has a considerable influence on the success of the target production. Since then, many industries and researchers of the course are trying to find the best methods or techniques to keep the balance of the assembly line and also to make it more efficient. In addition, this problem is known as the problem of balancing assembly lines. As the research was done, some techniques and methods have been used to solve optimization problems. They are based on mathematical models, such as the use of linear and then on artificial neutral network programming.

2. Features of Assembly Lines
A working element and a workstation forming part of the group. Therefore, it is better to know a work item and a workstation before knowing all about the assembly lines. A work item is productive work of the smallest unit that adds the values in the product, such as locking (thinning / reducer) a screw, welding, and the insertion of a gear. A workstation is also called a collection of a series of work items that are executed there. A product passes along the line and visit each workstation in sequence. An assembly line contains a series of sequential work stations, generally

connected by a continuous handling system. It is designed to assemble the components of a product and to perform operations relating to the production of the finished product. It also contains other components, namely workers (manual and robotic) system, a material handling (transport), buffers spaces, unloading and storage, a drawing (linear, U-shaped, and others).

Referring to Tasan & Tunali (2008), a group consisting of a sequence of operations, each with a processing time and operation of a series of priority relationships, it is widely adopted in manufacturing floors (according with previous literature (Becker and Scholl, 2006), a series of workstations has the same meaning with a sequence of activities in this context). The reports contain the priority order in which tasks must be performed.
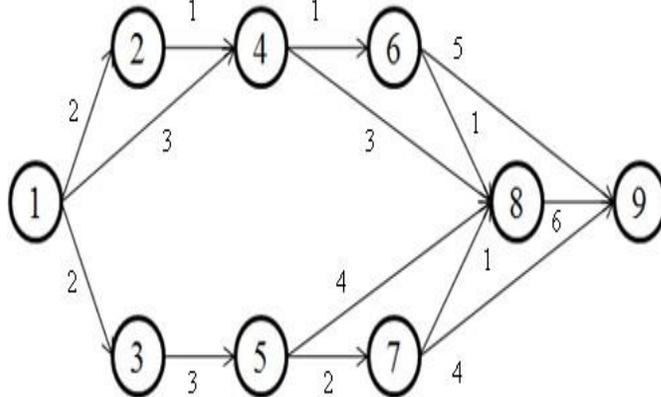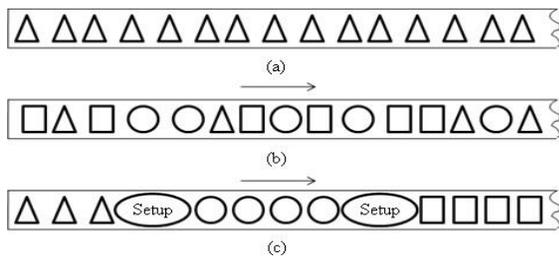

Figure 1: Graph of precedence

Figure 2 is an illustration showing the characteristics of the lines as a function of the quantity and variety of products.

- Control Line: mounting systems can distinguish regarding the control of movement of workers between stations. The exact type of the control line, with serious consequences on the intake structure of the staircase is divided into lines with and without rhythm.
- The variability of working time: in reality, the working time is, in principle, non-deterministic (Tempelmeier, 2003).
- Design Line: an assembly line is traditionally arranged in series; with individual stations located along a conveyor belt (right). However, the current design of the line is not necessarily determined before the decision to balance. The actual arrangement of the conveyor usually does not affect the allocation decision and therefore can be ignored
- Assembly work in parallel: mass production makes heavy use to increase the efficiency of the work by dividing the total work between different production units.
- Process equipment and alternatives: to perform an assigned task, the station must be equipped with productive resources such as operators, resources such as operators, machines and tools that provide the necessary skills and / or technological capabilities. In addition, the necessary equipment should be available.
- Attributes restrictions: In ALB, assigning tasks to the stations are always bound by the priority relations. In the model formulations, the corresponding priority chart can have a general structure or be limited to a particular type of chart, such as linear (Kimms, 2000), diverging or converging graphics. In all cases, priority must be acyclic graph (done) to find the sequences of more achievable tasks (Ahmadi & Wurgaft ,1994) machines and tools which provide the necessary and / or technological skills capacity) request should be.
- Allocation available restrictions: in ALB, assigning tasks to the stations are always limited by the model of

formulations priority relationships, the corresponding graph priority can have a general structure or limited to one.

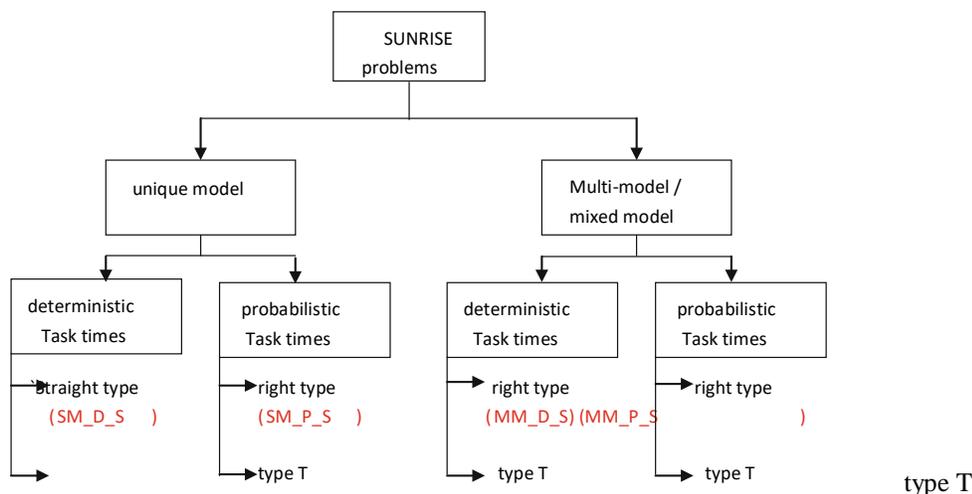## 3. Classification of Assembly Line Balancing Problems

Balancing problems of the assembly line (ALB) can be classified according to the number of models produced in the chain, the nature of the times of the task (deterministic or probabilistic) and the nature of the flow (linear or T-type). . In the same assembly line, one or more models can be assembled products. If only one model is mounted on the line, the production system is defined as a model of a single assembly system; otherwise, this is called a multi-mounting system model. Task processing times may be deterministic or probabilistic. If the activities are performed using all the tools and accessories for highly qualified sophisticated tasks, the task processing time can be accurate to the deterministic quantity, because variability in processing time may be less in a situation of this kind.

This is due to the nature of facilitation tools and operators that provide the necessary skills. But usually, in the assembled operations, processing times may vary, which can be characterized by a probability distribution. The configuration of the work station of the assembly line can be linear or U-shaped (Baybar, 2016). In U-shaped design, an operator can manage multiple workstations. In the assembled operations, processing times may vary, which can be characterized by a probability distribution. The configuration of the work station of the assembly line can be linear or U-shaped (Baybar, 2016).

In the drawing, U-shaped, an operator can manage multiple workstations. in the assembled operations, processing times may vary, which can be characterized by a probability distribution. The configuration of the work station of the assembly line can be linear or U-shaped (Baybar, 2016). In U-shaped design, an operator can manage multiple workstations. In this document, the classification hierarchy based on these parameters ALB problem illustrated in Figure 3. The resulting categories based on the above parameters are listed below:

- Single-deterministic straight type model (SM_D_S) problem
- model single-deterministic type U (SM_D_U) problem
- Single-model probabilistic law (SM_P_S) problem
- Single probabilistic model U (SM_P_U) problem
- Multi-deterministic straight type model (MM_D_S) problem
- multi-deterministic model of type T (MM_D_U) problem
- Multi-probabilistic straight type model (MM_P_S) problem
- Multi-probabilistic model T (MM_P_U) problem

As mentioned above, the assembly line balancing problems basic classifications are simple Balance assembly line (SALB) -1 problem and simple balancing assembly line (SALB) -2 problem. Some authors considered both classifications, i.e. simple assembly line balancing (SALB) -1 problem and simple assembly line Balance (SALB) -2 problem. So new categories are formed in each of the eight categories indicated in Fig.1Balance simple nesting assembly line (SALB) -1, the simple balanced line assembly (SALB) -2, simple assembly and Balance Line (SALB) -1 and the balance of simple assembly line (SALB) - 2. For example , 1 means SM_D_S-category SM_D_S for simple assembly line balancing (SALB) -1-SM_D_S problem 2/2

(SM_D_U) (SM_P_U) (MM_D_U) (MM_P_U)

Figure 3 Classification of ALB problems

SM_D_S category of simple assembly line balancing (SALB) -2 problem. The resulting extended categories are presented below:

is SM_D_S-1,   SM_D_S-2,   and   SM_D_S-1   and-2
   SM_D_S

is SM_D_U-1,   SM_D_U-2,   and   SM_D_U-1   and-2
   SM_D_U

is SM_P_S-1, SM_P_S-2, and SM_P_S-1 and-2 SM_P_S

is SM_P_U-1,   SM_P_U-2,   and   SM_P_U-1   and-2
   SM_P_U

is MM_D_S-1,   MM_D_S-2,   and   MM_D_S-1   and-2
   MM_D_S

is MM_D_U-1, MM_D_U-2, and MM_D_U-1 and

   MM_D_U-2

is MM_P_S-1,   MM_P_S-2,   and   MM_P_S-1   and-2
   MM_P_S

is MM_P_U-1,   MM_P_U-2,   and   MM_P_U-1   and-2
   MM_P_U

4. Application of Artificial Neural Networks in Solving Problems of Assembly Line Balancing

An artificial neural network is a system that aims to make it similar to the human brain (Pitts & McCullough, 1947) intelligent tasks. A neural network memorizes their knowledge through learning within the connection strength between neurons called synaptic weights. These networks proved capable of solving approximate function including the time series forecasting approach and modeling of the physical condition, data processing, including filtering, sorting, and the non-linear controller. The most common model is to Perceptron neural network-layer (MLP). other MLP neural network models can be trained and using a learning algorithm, such as back propagation (error), steeper decline, errors less square, genetic algorithms, evolutionary computation, maximizing the expectations and methods. Non parametric using one of these algorithms,

Karp (2012) examined the problem of simple balancing assembly (SALB) -1, in which the objective is to maximize the efficiency of equilibrium for a given cycle time. They have developed an approach Petri nets this problem, researching activated transitions (or assignable tasks) in Petri model network of relationships among the priority tasks, and then the task that minimizes downtime is assigned to the solution. Petri net is a mathematical tool and graphic modeling and analysis of discrete event systems. Future work could aim to compare this algorithm with a branched and bound algorithm. In addition, this algorithm can be tested for SALB (simple assembly line balance) - 2 problem.

Karp (2012) examined the easy assembly line problem (SALB) -2, in order to minimize the variations in workload between workstations for a given number of work stations. The author has developed a network of Petri

heuristics to solve this problem. Heuristics determines the available activities and assigns them to the current working station through Accessibility analysis, one of the main characteristics of Neural network and move the pieces. To improve the solution, a binary search procedure is performed between the first and the last viable solution not feasible solution. They developed three versions of the heuristic processes by integrating the upstream, downstream and bi-directional. This card can be used as a seed generation algorithm on a simulated annealing algorithm. Also, this algorithm can be combined with Metaheuristics taboos such as research, genetic algorithm, etc. sends hybrid algorithms. In addition, a new lens can be added, such as the fluidity of the workload.

Newer techniques include the use of artificial intelligence methods to balance the assembly lines. Miltenburg (2012) uses the artificial neural network (ANN) to measure line voltage disturbances. The results showed that the calculation time is almost instantaneous. This shows that ANN can be a very useful technique to balance the assembly lines. The artificial neural network is a computer composed of a number of elements of simple, highly interconnected on the basis of manufacturing process information to their dynamic state and its response to external stimuli (Rubinovitz & Levitin, 2015). The artificial neural network (ANN) is a recent development established before the advent of the computer, with the first artificial neuron produced by Neurophysiologists and logic (Warren and Walter, 1943). ANA.

5. Assembly Line Balancing Problem

The decision to split the problem in an optimal way the editing (Final) (tasks) between stations compared to some objective is known as the problem of assembly line balancing (ALBP)

"Try to get the best compromise between labor needs, structures and resources to meet a certain volume of production.

Common Formulation:

"- series of assignments, precedence graph of tasks and the cycle time to resolve the number of stations

"- the cycle time limits

Along - a strategic problem in the long term the environment in the design of the assembly line
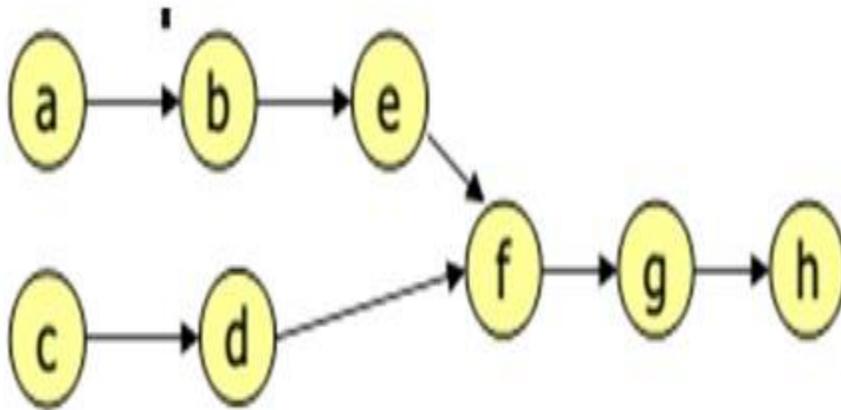

Table 1: Precedence graph for an assembly process

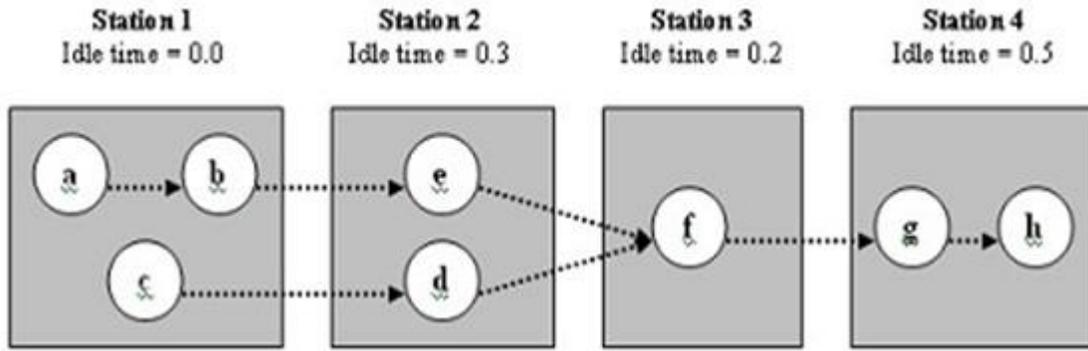| Task	Description	Task Time (Minutes)
A	Position controller lowering houses	0.2
B	Position bimetal coil	0.2
C	Attach power cord from heating unit	0.8
D	Position controller upper housing	0.6
E	Attach male plug to line cord	0.3
F	Attach fuse to line cord	1.0
G	Affix logo	0.4
H	Seal controller housing	0.3
	Total time	3.8

Figure 4: Assignment of tasks for a cycle time of 1.2 minutes
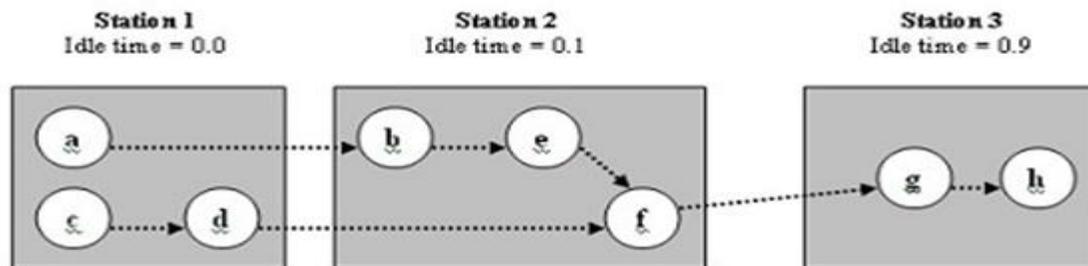
Figure 5: Assignment of tasks for a cycle time of 1.6 minutes

Note: minimum cycle time = 1 minutes

Line Efficiency

$$E = \frac{\sum_{i=1}^{j} t_i}{nC}$$

t = task time for i
j = number of tasks
C = cycle time
n = number of stations
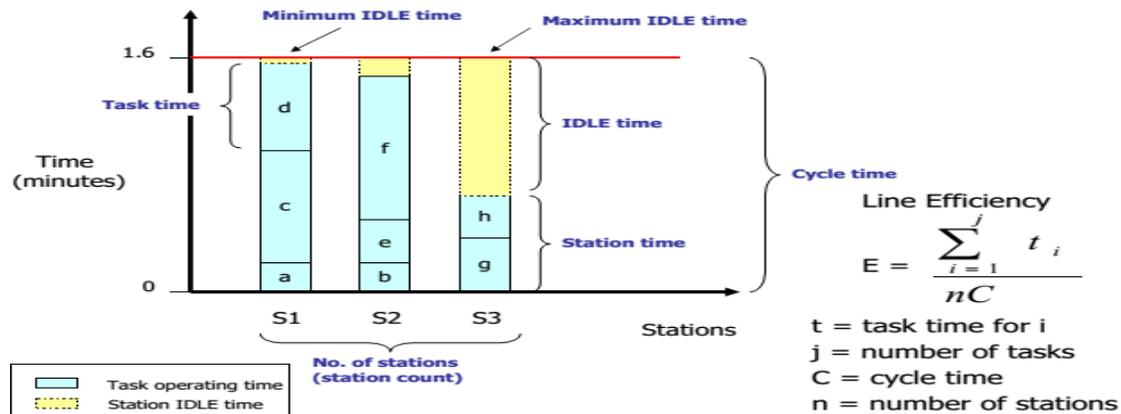
Example of work Items (small electric appliance)

Table 2:

No	Element Description	Tej (minutes)	Must be Precedence by
1	Place frame on work holder and clamp	0.2	--
2	Assemble plug, grommet to power cord	0.4	--
3	Assemble bracket to frame	0.7	1
4	Wire power cord to monitor	0.1	1, 2

5	Wire power cord to switch	0.3	3
6	Assemble mechanism plate to bracket	0.11	3
7	Assemble blade to bracket	0.32	3
8	Assemble motor to bracket	0.6	3, 4
9	Align blade and attach to motor	0.27	6, 7, 8
10	Assemble switch to motor bracket	0.38	5, 8
11	Attach cover, inspect, and test	0.5	9, 10
12	Place in tote plan for parking	0.12	11
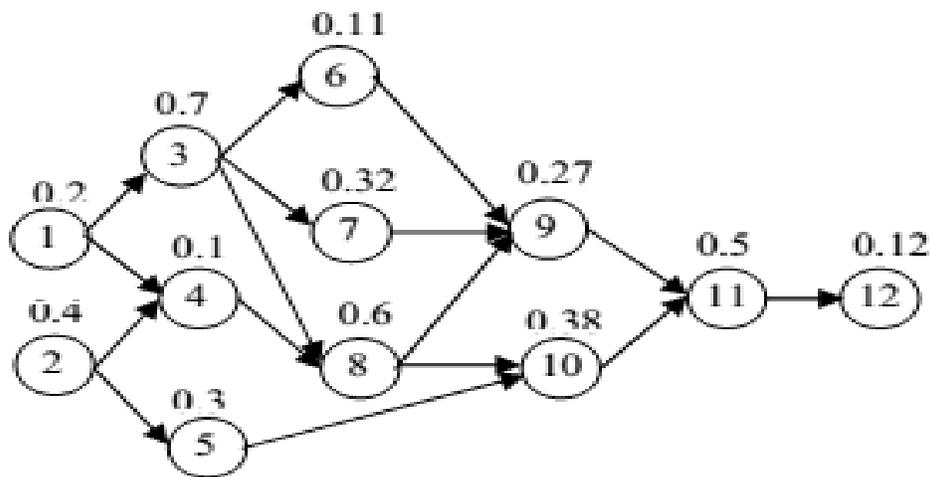
Line Balance Method
* None of the methods guarantees an optimal solution, but it is likely to result in good solutions that the true optimal approach.

Rule-Large Candidate (LCR)

Procedure:
Step 1. List all the elements in order of Te value, the greater is the top of the descending list.
Step 2. To assign elements to the first work station, it starts at the top of the list and the work done, by selecting the first vital element for positioning in the station. A feasible element is one that meets the above requirements and causes the sum of the Texas station value exceeds the cycle time Tc.
Step 3. Repeat step 2
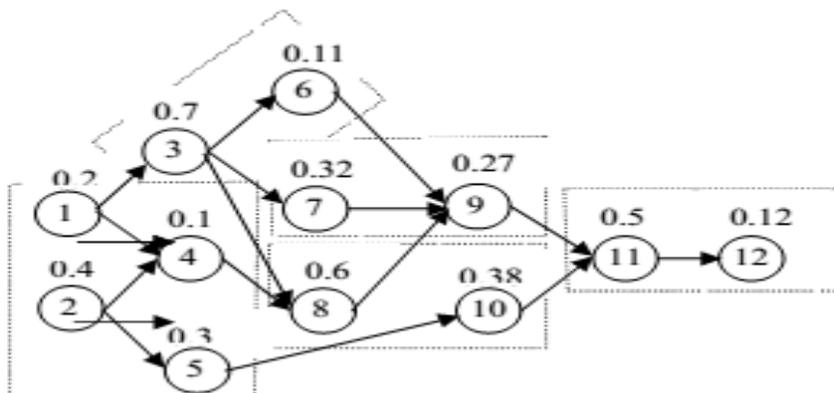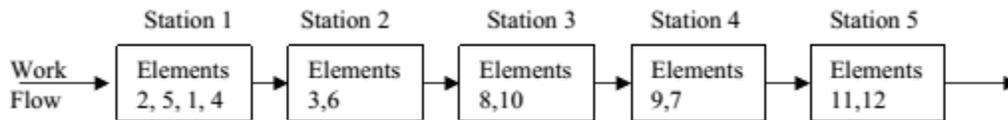
Kilbride and Wester method (KWM)

* E 'a heuristic procedure selected work items for assignment of base stations to their position in the above diagram.
* This solves one of the problems with the greatest candidate rule (LCR), with which the elements of the end previously diagram could be the first candidate to be considered simply because their values are large.

Procedure:

Step 1. Scheme previously torso, so these nodes represent the work items of the same priority are arranged vertically in columns.
Step 2. list the items in order of its columns, column I top the list. If an item can be placed in more than one column, a list of all the columns for the item to show the ability to transfer voice.
Step 3. To assign items to workstations, starting with the elements of the column. continuing allocation steps in the order number column until the cycle (Tc).

Step 1
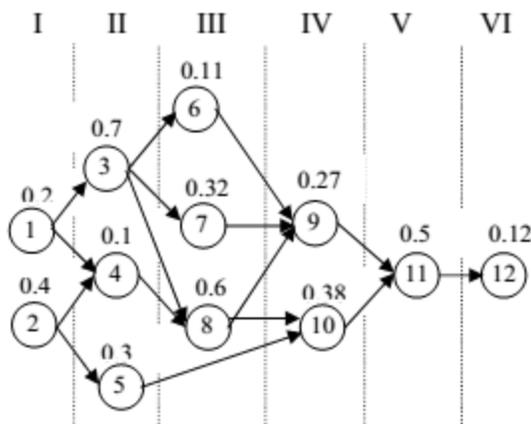
* In addition, for stations that have the same elements of the sequence in which the identical elements are assigned it is not necessary.

* The delay balance is the same LCR d = 20%.

Method Positional Ranking Weight (DPC)
* Introduction by Helgeson & Birnie in 1961.
* Combined LCR and KW methods.
* The DPC takes into account both the value of the element Te and its position in the earlier diagram.
Then elements are assigned to the work stations according to the general order of their DPC values.

Procedure:
Step 1. Calculate the DPC for each element by summing the elements with TeTe values for the entire following elements chain arrow in the diagram above.
Phase 2 list the items in order of DPC, DPC largest high on the list. For convenience,understand the value of Te and

immediate precursors for each item.

Step 3. Assign stations articles according RPW avoiding precedence constraint and cycle time violations.

step 1. Example of calculation:

* For the element 1, the elements that follow arrow chain are 3, 4, 6, 7, 8, 9, 10, 11 and 12.

* The DPC for the item 1 is the sum of s for all these elements TE ', plus tea for the item 1.

Step 2.

Work element	RPW	T_e	immediate predecessors
1	3.3	0.2	–
3	3	0.7	1
2	2.67	0.4	–
4	1.97	0.1	1,2
8	1.87	0.6	3,4
5	1.3	0.3	2
7	1.21	0.32	3
6	1.00	0.11	3
10	1.00	0.38	5,8
9	0.89	0.27	6,7,8
11	0.62	0.5	9,10
12	0.12	0.12	11

Step 3. Work element assigned to stations

Station	Element	T_e	$\sum T_e$ at station
1	1	0.2	
	3	0.7	0.9
2	2	0.4	
	4	0.1	
	5	0.3	
	6	0.11	0.91
3	8	0.6	
	7	0.32	0.92
4	10	0.38	
	9	0.27	0.65
5	11	0.5	
	12	0.11	0.62

* By registering RPW lines, the number of stations required is five, but the maximum. Station time is 0.92 minutes process in number line could be operated according to a Tc = 0.92 cycle time instead of 1.0 minutes.

6. Conclusion
The quality of a product and its ability to meet customers' demands are important and not neglect to take into account, in particular, small and medium industries. Companies need to understand that their performance depends on the quality of the production chain in terms of production. The adoption of the balance of the assembly line in the evolution of the production is very essential. In general, the assembly line is a manufacturing process in which the parts and components of the nomenclature are assembled in one unit order ordered by a number of workers to create a semi-finished product.

The balance of the assembly line also be loosely defined as the assignment process sequentially a working group, so that all the workstations are assigned more or less the same amount of workloads, so as to optimize the measurement performance, i.e, minimize the time, bottlenecks and costs, a higher product production speed. For example, a car company may decide to change the layout of its assembly line to speed up the pace of production, and then consider the number of workstations that a transition product manufactured or has to go before completion, and the time needed for each activity. Naturally Point. The balance of the complex may also guide the decision-making process according to the multitude of variables that can affect the manufacturing process. Naturally Point. The balance of the complex may also guide the decision-making process according to the multitude of variables that can affect the manufacturing process. Naturally Point. The balance of the complex may also guide the decision-making process according to the multitude of variables that can affect the manufacturing process.

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