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An mprovement in assembly line balancing problem using critical path model

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Abstract
Due to of high capital necessities when introducing or upgrading a line, its con-figuration arranging is of incredible importance for specialists. Accordingly, this attracted attention of many researchers, who tried to support real-world configuration planning by suited optimization models (assembly line balancing problems). Disregarding the tremendous scholastic exertion in sequential construction system adjusting, there remains an impressive hole between necessities of genuine setup issues and the status of research. A Critical Path Method (CPM) based approach for assembly line has been applied for assigning the task to the work stations for assembly line layout. Results show that the CPM based approach performs better and improve the labor productivity of assembly line layout. In this Research we will use the proposed new approach to solve different types of ALBPs including the traditional straight-line ALBP and ALBP with parallel workstations. Numerical results of illustrative examples show the effectiveness of the proposed new approach.

Keywords: heuristic methods, assembly line balancing problem, critical path method, and simple assembly line-balancing

1. Introduction

Assembly line balancing (ALB) and sequencing is an active area of optimization research in operations management. The idea of a mechanical production system (AL) went to the reality when the completed item is slanted to the view of item seclusion. Usually interchangeable parts of the final product are assembled in sequence using best possibly designed logistics in an AL. The underlying phase of arranging and outlining an AL was centered around taken a toll effective large scale manufacturing of institutionalized items. This resulted in high specialization of labour and the corresponding learning effects. Be that as it may, the current pattern picked up the understanding of the makers of moving the AL setup to low volume get together of altered items, mass customization. The strategic shift took effect due to the diversified customer needs along with the individualization of products. This in the end set off the exploration on AL adjusting and sequencing for modified items on a similar line in an intermix situation, which is described as blended model mechanical production system adjusting.

2. Literature Review

Sivasankaran and Shahabudeen [1] developed a hybrid mathematical model for the single-model assembly line balancing problem. In the first stage, the objective of minimizing the number of workstations for a given cycle time is achieved, and for the number of workstations that is determined in the first stage, the objective of minimizing the cycle time is achieved in the second stage.. Kilincci [2] considered the SALB-2 problem in which the objective is to minimize the variations in workloads among the workstations for a given number of workstations. The author developed a Petri net heuristic for this problem. The heuristic decides accessible undertakings and allot them to current workstation by utilizing reachability investigation, one of the principle properties of Petri nets and token development. To improve the solution, a binary search procedure is implemented between the first feasible solution and the last infeasible solution. Petri-net calculations Kilincci and Bayhan [3] considered the SALB-1 issue, in which the goal is to expand the adjusting effectiveness for a given process duration. They built up a Petri net approach for this issue, which seeks empowered changes (or assignable undertakings) in the Petri net model of priority relations amongst errands, and after that the assignment which limits the sit out of gear time is doled out to the arrangement under thought. The Petri net is a scientific and graphical instrument to display and examine discrete occasion frameworks. Future work might be coordinated to contrast this calculation and a branch and bound calculation. Further, this calculation might be striven for SALB-2 issue, in which the goal is to limit the process duration for a given number of workstations. Two-sided mechanical production system adjusting is picking up significance in which diverse sets of stations will be composed. The stations in the combine of stations confronting each other are alluded to as a mated station. Lee *et al.* [7] outlined a gathering task method, which appoints a gathering of errands at any given moment as opposed to relegating a unit undertaking while at the same time framing stations in the straightforward sequential construction system adjusting issue with deterministic assignment times. Their approach intended to amplify work relatedness and also errand slackness.

Jiao *et al.* [8] built up a Web-based intelligent counsel for mechanical production system adjusting of hard circle sequential construction system including various criteria in which the principle model is to limit the quantity of abundance stations. The Web-based counselor will create a timetable in light of different heuristics installed in its library.

3. Case Study

In this case study part we have taken a data from XYZ Company and Compare the data by applying three method

1. RPM (Rank Positioning Method)
2. SPT (Shortest Processing Time)
3. CPM (Critical Path Method)

3.1 Collected data shown in tabular form

Table 1: Task details of Single Phase Assembly line of XYZ Company

S. No.	Station name	Task time (T_E)	Preceded by
01	Bearing pressing on rotor shaft	44.99	-
02	Gas kit, plastic cap, PVC flue fitting and capacitor soldering	20.36	-
03	Wire cut, lug attachment and clamping	26.12	02
04	Terminal board attachment, fitting the capacitor, Tightening nut and bolt	41.22	03
05	Rotor shaft pressing on mounting casing and motor body placement	57.24	01,04
06	Tightening the rod and rod and NDE pressing	51.40	05
07	Final tightening of the tie rod and turning of motor body	60.6	06
08	Motor run test	60.72	07
09	Impeller fitment	54.29	08
10	Delivery casing fitment	57.48	09
11	Delivery side seal fitment	36.44	10
12	Air leakage test	52.08	11
13	Suction flange fitment	45.96	12
14	Delivery flange fitment	46.32	13
15	Terminal box cover fitment	57.18	14
16	Loading to painting conveyor	58.36	15

3.2 Collected data shown in tabular form of Single Phase Assembly line of XYZ Company

Table 2: Task details of XYZ Company

Task no.	Task description	Task time	Precedence
01	Spot Projection Welding	2.30	-
02	Longitudnal Assembly	3.20	-
03	Floor Channel Assembly	5.40	1,2
04	Floor Panel	5.36	3
05	Mig Welding	4.28	4
06	Bulk Head Panel	5.68	5
07	Sit Mountings	3.36	-
08	Final Assembly	4.36	7
09	Head Light Assembly	4.00	6,8
10	Paint Shop	5.24	9
11	Loose Parts	2.33	-
12	Indicator (Lh) And (Rh)	3.24	11
13	Brake Paddle	3.00	12
14	Cluster,Wiper Motor	4.48	13
15	Steering Chain Assembly	2.42	10,14

1 RPM (Rank Positioning Method)

Steps involved in RPW method

- **Step 1:** Draw the precedence diagram
- **Step 2:** For each work element, determine the positional weight. It is the total time on the longest path from the beginning of operation to the last operation of the network.
- **Step 3:** Rank the work elements in descending order of ranked positional weight (R.P.W).
- **Step 4:** Assign the work element to a station. Choose the highest RPW element. Then, select the next one. Continue till cycle time is not violated. Follow the precedence constraints also.
- **Step 5:** Repeat step 4 till all operations are allotted to one station.

These steps are followed for solving the problem of cashew nut shelling machine line balancing.

3.3 Arrange according to decreasing order of their positional weight

Table 3: Calculation by RPM of single face assembly line of XYZ Company

S. No.	Station name	Task time (T_E)	Preceded by	Positional weight
01	Bearing pressing on rotor shaft	43.99	-	683.06
02	Gas kit, plastic cap, PVC flue fitting and capacitor soldering	20.36	-	726.77
03	Wire cut, lug attachment and clamping	26.12	02	706.41
04	Terminal board attachment, fitting the capacitor, Tightening nut and bolt	41.22	03	680.29
05	Rotor shaft pressing on mounting casing and motor body placement	56.24	01,04	639.07
06	Tightening the rod and rod and NDE pressing	51.40	05	582.83
07	Final tightening of the tie rod and turning of motor body	60.6	06	531.43
08	Motor run test	66.72	07	470.83
09	Impeller fitment	54.29	08	404.11
10	Delivery casing fitment	56.48	09	349.82
11	Delivery side seal fitment	36.44	10	293.34
12	Air leakage test	52.08	11	256.9
13	Suction flange fitment	44.96	12	204.82
14	Delivery flange fitment	45.32	13	159.86
15	Terminal box cover fitment	56.18	14	114.54
16	Loading to painting conveyor	58.36	15	58.36

3.4 Arrange according to decreasing order of their rank

Table 4: Calculation by RPW of single face assembly line of XYZ Company

S. No.	Task time ()	Preceded by	Positional weight	Rank
02	20.36	-	726.77	01
03	26.12	02	706.41	02
01	43.99	-	683.06	03
04	41.22	03	680.29	04
05	56.24	01,04	639.07	05
06	51.40	05	582.83	06
07	60.6	06	531.43	07
08	66.72	07	470.83	08
09	54.29	08	404.11	09
10	56.48	09	349.82	10
11	36.44	10	293.34	11
12	52.08	11	256.9	12
13	44.96	12	204.82	13
14	45.32	13	159.86	14
15	56.18	14	114.54	15
16	58.36	15	58.36	16

2 SPT (Shortest Processing Time)

1. Firstly, the user will input the number of jobs, the job names, the processing time and the due date of each job or use the data values given at the starting point.
2. The second step is sorting out the shortest processing time among the jobs.
3. Thirdly, calculate the flow time of each job by using the processing time. The flow time is the accumulations of processing time each job by each job.
4. The delays is calculated from the flow time and due date. The formula is:

Delay = Flow time - due date

However, there are two conditions for calculating the delays although applies the formula already:
If the delays calculated is less than flow time, then the delays = zero.
If the delays calculated is more than flow time, then the delays = the value of (flow time - due date).
The next step is calculating the total processing time, total flow time and total delays from the accumulations processing time, the accumulations flow time and the accumulations delays.
Then, using the total flow time, total processing time, and total delays for calculating the average completion time, the utilization, the average number of jobs in the system and the average job delays.
The formulas for calculation are below:
Average completion time = sum of total flow / no. of jobs
Utilization = total processing time / sum of total flow
Average no. of jobs = total flow time / total processing time
Average job delays = total delays / no. of jobs
These above are the steps for using the SPT priority rules.

3.5 Arrange in increasing order of their task time

Table 5: Calculation by SPT of single face assembly line of XYZ Company

S. No.	Station name	Task time (T_E)	Preceded by
02	Gas kit, plastic cap, PVC flue fitting and capacitor soldering	20.36	-
03	Wire cut, lug attachment and clamping	26.12	02
11	Delivery side seal fitment	36.44	10
04	Terminal board attachment, fitting the capacitor, Tightening nut and bolt	41.22	03
01	Bearing pressing on rotor shaft	43.99	-
13	Suction flange fitment	44.96	12
14	Delivery flange fitment	45.32	13
06	Tightening the rod and rod and NDE pressing	51.40	05
12	Air leakage test	52.08	11
09	Impeller fitment	54.29	08
15	Terminal box cover fitment	56.18	14
05	Rotor shaft pressing on mounting casing and motor body placement	56.24	01,04
10	Delivery casing fitment	56.48	09
16	Loading to painting conveyor	58.36	15
07	Final tightening of the tie rod and turning of motor body	60.6	06
08	Motor run test	60.72	07

4. Critical Path Method

The Critical Path Method is a project scheduling technique developed in the late 1950s by Morgan R. Walker and James E. Kelley. It is the most widely used technique in project scheduling. Critical Path provides the order of project network activities which sum up to the longest overall duration. This, in turn, determines the shortest time to complete the project. In other words, if even one task belonging to the critical path is delayed, then the entire project will be delayed.

The CPM employs a Work Breakdown Structure (WBS) where the projects are divided into individual tasks. These tasks are inter-dependent, and the success and timeliness of the project depends upon how well these tasks are sequenced and how the resources are utilized.

Although CPM has become quite pervasive in the field of project management, the process has come under much opprobrium due to the many shortcomings associated with it. The slowly diminishing faith in Critical Path Analysis (CPA) may be imputed to the following disadvantages:

- As the project expands, i.e. as the number of activities increase, the critical path becomes increasingly convoluted. Thus there lies the ubiquitous risk of making a miscalculation due to over-reliance on the technique.
- People tend to add more safety to each task without considering incentives to finish early.
- The focus is more on task dependencies than on resource dependencies. Resource dependencies are either ignored or considered after the critical path is identified; thereby frequently causing non-critical tasks to become critical.
- The CPM runs on a definite concept, which assumes that the project managers as well as the working staff are well acquainted with the various tasks and inter-dependencies. Unfortunately, practical experience has shown that the principal assumption pertaining to CPM techniques, i.e., the project team‘s ability to reasonably predict the scope schedule and cost of each project is usually far beyond control.
- Critical paths are labile and may change during the project execution.
- Often one might discover multiple critical paths embedded in the same project, which, in turn, complicates situations even further. In many cases, the aforementioned critical paths might be parallel and might feed into a common node in the network diagram. In such cases, it becomes problematic to ascertain the best utilization of resources and technology for the critical paths.

Table 6: Calculation by CPM based heuristic of single face assembly line of XYZ Company

Task number	Task time	Total task time
02	20.36	65.35
01	44.99	
03	26.12	67.34
04	41.22	
05	56.24	56.24
06	51.40	51.40
07	60.6	60.60
08	66.72	66.72
09	54.29	54.29
10	56.48	56.48
11	36.44	36.44
12	52.08	52.08
13	44.96	44.96
14	45.32	45.32
15	56.18	56.18
16	58.36	58.36

5. Result

Results has been taken by applying all three methods Rank positional weight, smallest processing time, heuristic method based on CPM on the data taken from XYZ Company as describe below.

4.1 Calculation from given data from XYZ COMPANY

Delay % $= \frac{NT_C - T_E}{NT_C}$

= 16*70-725.48/16*70

= 35.25%

Efficiency = 100- Balance delay

= 64.75%%

Smoothness index= 97.71

Mean absolute deviation= 10.205

4.2 Comparison of results for single phase assembly line of XYZ Company from RPW, SPT, Method Based on CPM

Table 7: Comparison of results for single phase assembly line between RPW, SPT and CPM based Method

S. No	Description	Present method	RPW Method	SPT Method	CPM
1	Cycle time	70	70	70	70
2	Line efficiency	64.75%	69.09%	69.09%	74.02%
3	No. of work Station	16	15	15	14
4	Smoothness Index	97.71	74.100	74.100	64.05
5	Mean absolute deviation	10.205	7.2526	7.2526	7.3285

4.3 Comparison Graph between RPW, SPT, CPM Method

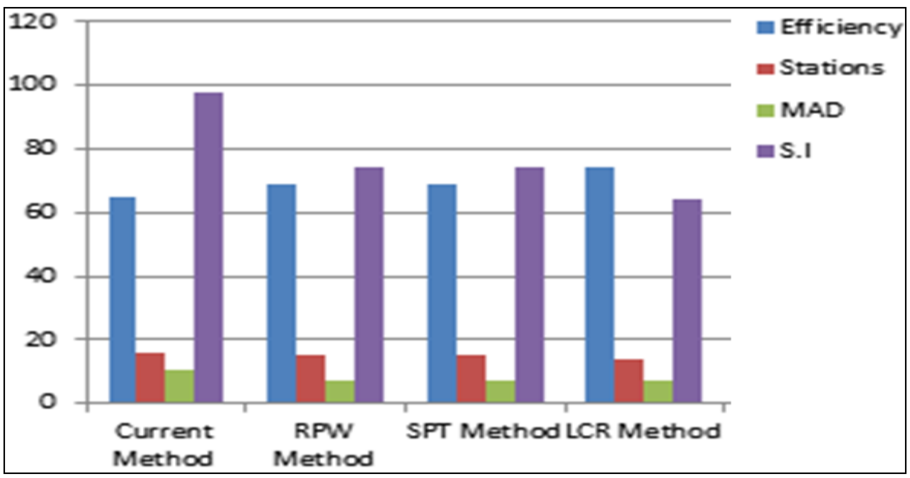

Fig 1: Comparison Graph between RPW, SPT CPM Based Method

4.4 Comparison Graph between RPW, SPT, CPM Method

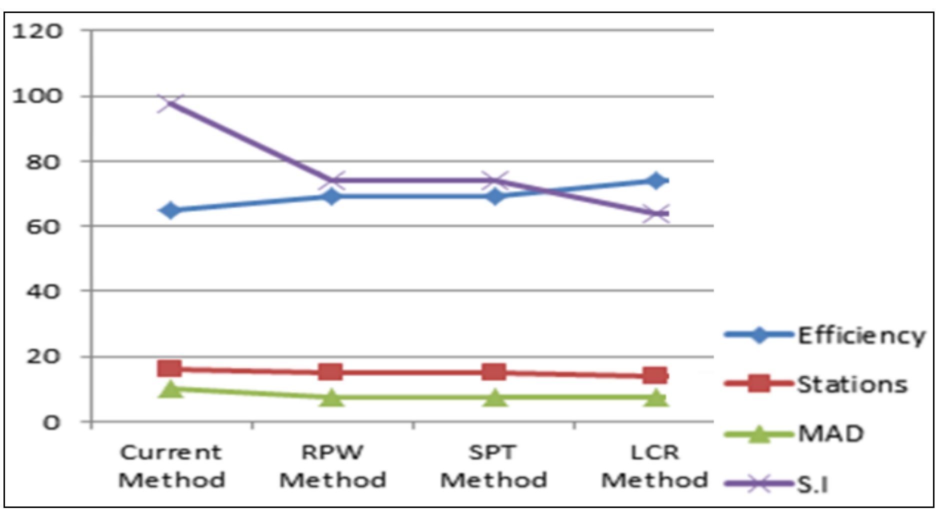

Fig 2: Comparison Graph between RPW, SPT, and CPM Method

5. Conclusion

Now a day, CPM based approach have been utilized in many assembly lines in place of the traditional straight line. This is just because of the use of just-in time principles in production industries. The CPM method improves visibility and allows the worker to perform tasks on both sides of the line. As compared to straight assembly line,this unique feature of CPM, combined with cross-trained workers and provide much more flexibility in designing of workstation. The heuristic based on critical path method has been proposed for the assignment of tasks to the workstations on industry application. The heuristic is capable to reduce the minimum number of required workstations for assignment of the tasks in assembly line layout as compared to traditional straight line layout. It also improves the productivity level of the labor. The results show improvements when using the proposed heuristic in terms of minimum number of required workstation and labor productivity. The scope of future work may include modification of the proposed heuristic with stochastic task time. Further improvements for the effectiveness and extension of the proposed heuristic may be considered with other performance measures such as product quality, cost, speed, and flexibility.

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