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Use of Operational Grouping for Work Load Balancing and Human Resource Optimization

Abstract: Recently, there has been a lot of focus on workload balance in manufacturing and assembly processes. Interestingly, throughout the years, a number of proposals for a fresh context in which efficient shop floor management techniques might be put into play have emerged. With the use of algorithms like the Largest Candidate Rule (LCR) Algorithm, workstations may be arranged in a way that takes the time to complete each activity. Clustering stations may help find the sweet spot for space, personnel, and machines. Workers give their all when their capabilities are fully used. As an additional benefit, the grouping technique would significantly cut down on the excess capacity that is created. The purpose of this research is to find out what happens when processes are combined and available resources and human resources are used as efficiently as possible. The research provides a clear image of the effect of completing the activity, from which the estimated values are produced. The building seems to be in need of some organization and efficiency upgrades. This would greatly benefit the firm's growth by streamlining operations and making customers happier. Eliminating bottleneck stations and excess capacity would lead to reduced inventory levels, which in turn would reduce the chance of resources being wasted and the expenses connected with it for the organization in the long run. Therefore, we could save money and reduce resource waste if everyone was doing their weight.

Keywords: Algorithm for the Largest Candidate, Workload Leveling, Bottleneck Station, Station Grouping, and Manpower Utilization

1. Introduction

In production and assembly lines, line balancing is a powerful tool for bringing out orders. Line balancing is useful for finding bottleneck stations and processes, which in turn decreases the likelihood of producing too much and, in certain situations, eliminates idle time altogether. The necessity for rapid, high-quality production might be satisfied by this method, which has widespread support in the industry community. Simultaneously, it guarantees the full usage of all resources.

One of the most crucial parts of line balancing is setting priorities, so you do the most critical jobs first and the least important ones last. Since the necessary goods would arrive at the customer's doorstep precisely at the time they indicated, this would inevitably help in meeting their demands. This would encourage the company to hire the most qualified candidates for open positions, which would lead to increased output.

2. Largest Candidate Rule Algorithm

It is not so possible to get the ideal scenario of perfectly and efficiently balancing the workload among the workers or among the workstations. However, closer-to-efficient results could be obtained if standard methods are used. Largest Candidate Rule (LCR) Algorithm is one such method which could even out the tasks of any workstation to the maximum possible efficiency. It relates the differences in Minimum Rational work element time and the precedence constraints between the elements. The Largest Candidate Rule (LCR) Accounts for work elements to be arranged in descending order, with reference to the station time and operation, for each station cycle time. After grouping, the operation timeshould not exceed the allowable preceded next operation. The procedure to apply LCR Algorithm is as follows:

1) Arrange the cycle time as per the sequence of operation
2) Combine the operations in the work stations
3) The combined cycle time should not exceed the highest cycle time (bottle neck station)
4) Combined station time should be closer or lesser than the highest cycle time
5) If required, eliminate the Non-Value Added (NVA) time or designed station time which are same or lesser than that of the bottleneck station.

3. Line Balancing Application

Line balancing could be applied to a wide range of manufacturing processes and industries. There is a growing demand with the emergence of new industries and processes to have a speedy and sequential arrangement of processes so that the competitive market is well dealt with.

Some of the industries and processes employing line balancing technology are: automotive industry, food manufacturing

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industry, bus body manufacturing, two wheeler manufacturing, spare parts manufacturing and assembly, aircraft manufacturing and assembly, rail coach manufacturing, gear manufacturing, textile manufacturing and packaging.

3.1 Grouping of workstations

process line could be clubbed together in the order of their station time with an eye on the individual cycle times. Those operations which take a combined time much lesser as compared to the total cycle time could be grouped into one station to ease out the process. Table I shows the various parameters in a welding work shop before grouping of operations.

Table 1: Parameters before grouping

Sl. No.	*Operation Name*	*Cycle time (sec)*	*No. of operators*	*Station No.*	*Station cycle time (sec)*
1	Loading	15	1	1	15
2	Welding	12	1	2	12
3	Unloading	4	1	3	4
4	Chipping	8	1	4	8
5	Oiling	9	1	5	9
6	Gauging	4	1	6	4

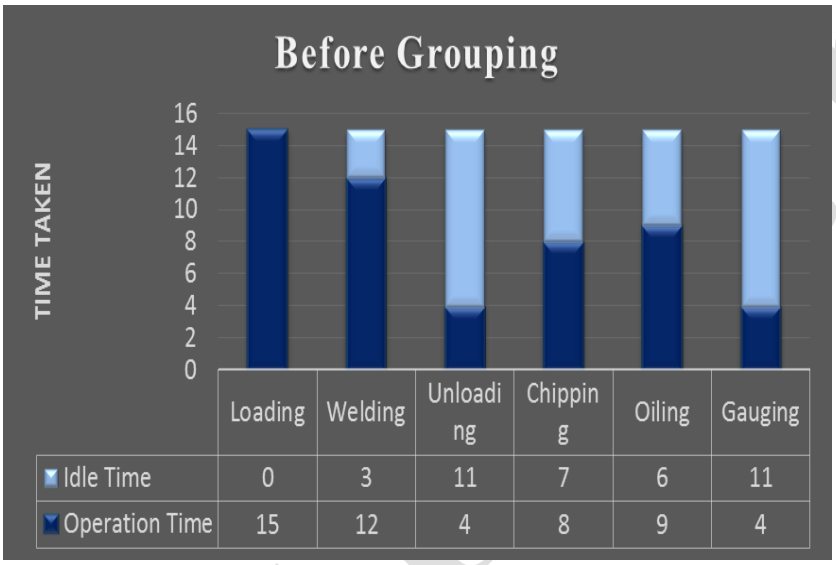

Figure 1: Station Vs Time Taken (Before Grouping)

The following formula could be used to calculate the approximate number of groups possible:
No of Groups = Total cycle time / Max Station Time
= 52/15 =3.5. This could be taken as 4 stations

The application of this formula and the grouping of work stations based on the same is shown in Table II and the graph of the same is in fig.2.

Table 2: Parameters after grouping

Sl. No.	*Operation Name*	*Cycle time (sec)*	*No. of operators*	*Station No.*	*Station time (sec)*
1	*Loading*	*15*	*1*	*1*	*15*
2	*Welding*	*12*	*1*	*2*	*12*

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3	*Unloading* Chipping	*12*	*1*	*3*	*12*
4	Oiling Gauging	13	1	4	13

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Figure 2: Station Vs Time Taken (After Grouping)

The grouping process has its own benefits as is evident from Table 3.

Table 3: Benefits - grouping of stations

Parameters	*Grouping of stations*	
	Before	*After*
No. of operators	6	4
Idle time	38	8
Operator utilization (%)	62	92

3.2 Workload levelling

Once the workstations are grouped, it is important to even out the works and thus, bring out the efficient balancing of workload. This could be done by maintaining equal or close- to-equal station times for each process after combining. It is important to note that the idle time with regard to each station (after grouping) too should be maintained identical. In addition to this, the total idle time would be seen to reduce significantly as compared to the same before grouping. The various parameters when there is no levelling of work being done and the same when the levelling is done are expressed in Table 4 and Table 5.

Table 4: Parameters before levelling

Station	*Cycle time (sec)*	*Idle time (sec)*
Loading	15	0
Welding	12	3
Unloading	4	11
Chipping	8	7
Oiling	9	6
Gauging	4	11
Total	52	38

Table 5: Parameters after levelling

Station	*Cycle time (sec)*	*Idle time (sec)*
Loading	15	0
Welding	12	3
Unloading	12	3
Chipping		
Oiling	13	2
Gauging		
Total	52	8

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3.3 Bottleneck Station Identification

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Identifying bottlenecks is critical for improving efficiency in the production line because it allows you to determine the area where accumulation occurs. The machine or process that accumulates the longest queue is usually a bottleneck, however this isn't always the case. Bottlenecks can be found through: identifying the areas where accumulation occurs, evaluating the throughput, assessing whether each machine is being used at full capacity and finding the machine with the high wait time.

Table 6: Benefits of identifying bottleneck station

Parameters	*Pre-Balancing status*	*Post-Balancing status*
Bottleneck station time (s)	15	15
Station operating time (s)	4 to 15	12 to 15
All the operation times are designed based on 15 sec or lesser		

The major observations from the identification of bottleneck station and the levelling of it has been the reduction in the range of time lost and the reduction in the variation of time required for each station as compared to the bottleneck station. The benefits of identifying bottleneck station are shown in Table 6.

3.4 Excess capacity reduction

A major issue with the unevenness in production is the piling up of materials which will add to inventory costs. This can be reduced only if the bottleneck station is identified and the stations where excess pieces pile up are noted, this would aid in reducing the capacity of the station so that it accommodates close to ideal capacity which the process as well as the plant demands. A clear comparison of the state of the work station before and after the reduction of excess capacity is reflected in fig.3. and fig.4.

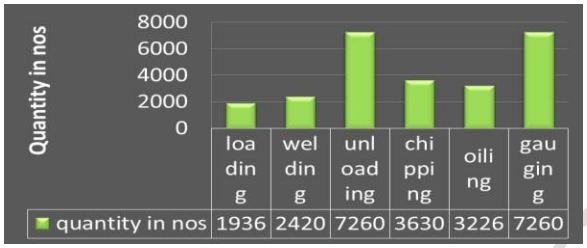

Figure 3: Station vs. Time Taken (Before Balancing)

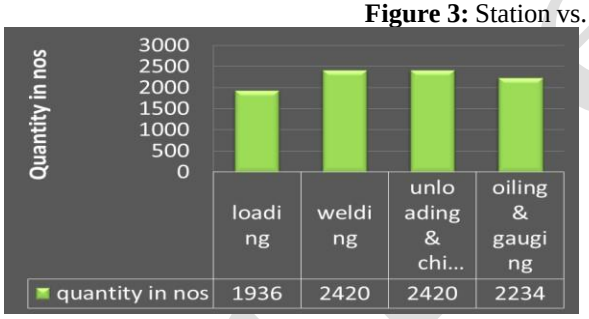

Figure 4: Station Vs Time Taken (After Balancing)

The possible benefits of removing excess capacity in the case taken here are expressed in Table 7. As it could be noticed, a huge reduction in excess capacity from 5324 units to just 484 units is brought about by this approach.

Table 7: Benefits of removal of excess capability

Parameters	*Pre-Balancing status*	*Post Balancing status*
Bottleneck Capacity	1936	1936
Excess Capacity	5324	484
Post Balancing, an excess quantity of 484 is to be reduced to 1936		

3.5 Optimum manpower utilization

A proper utilization of manpower means the number of operators used is kept to a minimum. Instead of having multiple operators doing sparely any job, it is advisable to have just about the ideal number of operators who work with full efficiency. This would mean that the work is distributed evenly among the workers which would also pave way for mutual respect. On the labour cost front as well, this would turn out to be a key factor.

Table 8: Manpower details before balancing

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Sl.No.	*Operation*	*Total cycle time(s)*	*Total quantity produced*	*Man Power required*
1	Loading	15	1936	1
2	Welding	12	2420	1
3	Unloading	4	7260	1
4	Chipping	8	3630	1
5	Oiling	9	3226	1
6	Gauging	4	7260	1
		52		6

The details related to different aspects of man power and their effect on the functioning of the work place before and after balancing of work load area shown in Table 8 and Table 9. It could be noticed that a reduction of 2 man power is a direct consequence of balancing.

Table 9: Manpower details after balancing

Sl.No.	*Operation*	*Total cycle time(s)*	*Total quantity produced*	*Man Power required*
1	Loading	15	1936	1
2	Welding	12	2420	1
3	Unloading	12	2420	1
4	Chipping			
5	Oiling	13	2234	1
6	Gauging			
		52		4

Table 10 shows the overall benefits of the same. A huge saving of more than a lakh and a half is the result of man power utilization to the optimum level.

Table 10: Benefits of removal of excess capability

Parameter	*Pre-Balancing status*	*Post Balancing status*	*Quantity saved*
No. of manpower required	6	4	2
Labor cost per piece(Rs.)	23.1	15.4	7.7
Labour cost per day(Rs.)	19,635	13,090	6,545
Yearly Manpower Cost savings: Rs.1,63,625			

3.6 Reduction of walk time

The amount of time spent by an operator to physically move from one place to the other within the plant is called walk time. The major factor contributing to walk time is the event of the operator having to walk back to a previous station to grab the product or go ahead to provide a product after working. This is a time wasted and should be kept to a minimum as possible. When grouping of processes is done, however, this time wasted in walk could very well be taken care of.

Table 11: Walk time observed before balancing

Sl.No.	*Operation*	*Operator Cycle Time*	*Machine Cycle Time*	*Walk Time*
1	Loading	14	0	0
2	Welding	2	8	0
3	Unloading	3	0	0
4	Chipping	4	0	3
5	Oiling	8	0	0
6	Gauging	3	0	0
		34	8	3

A comparison of the walk time before and after balancing are shown in Table 11 and Table 12 which portrays a complete walk time reduction as there is a maximum utilization of available man power.

Table 12: Walk time observed after balancing

Sl.No.	*Operation*	*Operator Cycle Time*	*Machine Cycle Time*	*Walk Time*
1	Loading	14	0	0

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2	Welding	2	8	0
3	Unloading	3	0	0
4	Chipping	7	0	0
5	Oiling	8	0	0
6	Gauging	3	0	0
		37	8	0

4. Results

As is evident from the data collected, the following results have been drawn to effect which when applied could bring about a drastic effect in the final output of the production and/or manufacturing tasks carried out.

1) Reduction of no. of operators from 6 to 4
2) Reduction in idle time from 38 minutes to 8 minutes
3) Optimal use of operators wherein the utilization scales have increased by 30 percent from a moderate 62 percent.
4) A reduction in the range of time distribution from 4 to 15 to 12 to 15 is observed which means a clear levelling of workload has been obtained.
5) The total walk time of the manpower has been kept to almost nil as a result of combining the workstations.

5. Conclusions

The work done in the field of workload balancing throws light into the conclusion that an efficient plant functioning could be obtained which would, on a longer run, help in the growth of the firm and bring about a revolutionary change in the production capacity utilization of the firm. This could also result in larger turn overs and market shares through a hike in customer satisfaction. Further, there would be a clear balance in the tasks assigned which brings about an evenness and value for hiring personnel for an intended operation. This can be beneficial from a human resource management perspective as well. Ultimately, the contribution of theorganization to the economy is assured to be on the higher side.

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