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Application of Work Load Balancing by Optimal Utilization of Man Power and Grouping of Operations

Edwin Joy Pulikkottil[1], Bibin Baby[2]

[1, 2]PG Scholar, Department of Mechanical Engineering, ECET Coimbatore, Tamilnadu, India

Abstract: ***Balancing of workload has been an area of interest in manufacturing and assembly processes of late. Interestingly, quite a lot of proposals for a creative atmosphere where clear shop floor management techniques are applied and proven beneficial have popped up with time. Adhering to the proposed rules like Largest Candidate Rule (LCR) Algorithm helps in arranging the workstations based on the time taken for each job to complete. A grouping of stations would mean maximum utilization of available resources which includes machines, operators and space. Optimum utilization of manpower brings out the best in the people employed. Grouping technique would also bring about significant down trend in the excess capacity produced. This work concentrates on the analysis of the effect of grouping of operations and optimum utilization of manpower and available capacity. Based on the researches, estimated values are calculated which gives a clear picture of the effect of implementing the work as well. All of these point towards an improved and ordered plant functioning with the best efficiency possible which would result, ultimately, in faster processes and better customer satisfaction which, in turn, would add to the growth of the firm. Identification of bottleneck stations and removal of excess capacity would lead to lesser inventories which would control the possibility of accumulating waste resources which would only add to the cost of the firm on a longer run. So balancing and levelling the work load would reduce the wastage of resources and thus, the total cost.***

Keywords: Largest Candidate Rule Algorithm, Grouping of Stations, Levelling of Workload, Bottleneck Station, Manpower Utilization

1. Introduction

Line balancing is an effective technique used to bring out an order in manufacturing and assembly lines. Line balancing can help in identifying bottleneck stations and processes, thereby reducing the chances of excess quantity being produced as well as reducing, or in some cases avoiding, idle time. This is a technique which is widely accepted within manufacturing circles and could meet the need of a speedy and quality output. At the same time, it ensures maximum utilization of available resources.

Prioritization of tasks is a key element of line balancing and hence, the most important task gets completed first and the least, the last. This would, invariably, aid in satisfying customer needs as the required product reaches the customer just in the time specified by them. This, in turn, would motivate the firm to produce more by employing the right people for the right jobs.

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 time should 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 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

Workstations could be grouped so as to bring smoothness in the flow of the entire process of manufacturing of a part. This means that several operations in a manufacturing 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

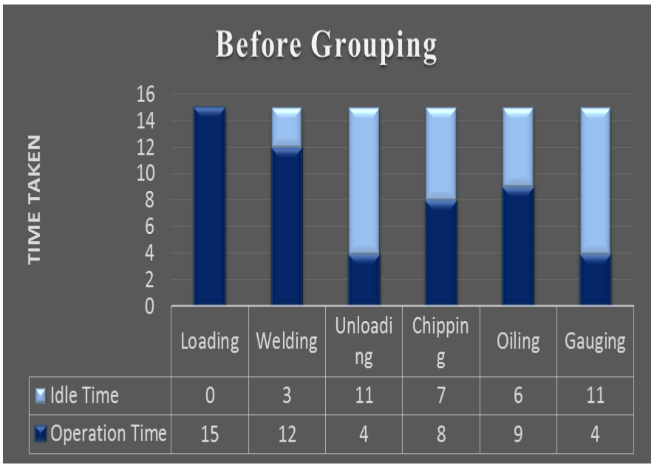

Figure 1: Station Vs Time Taken (Before Grouping)

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

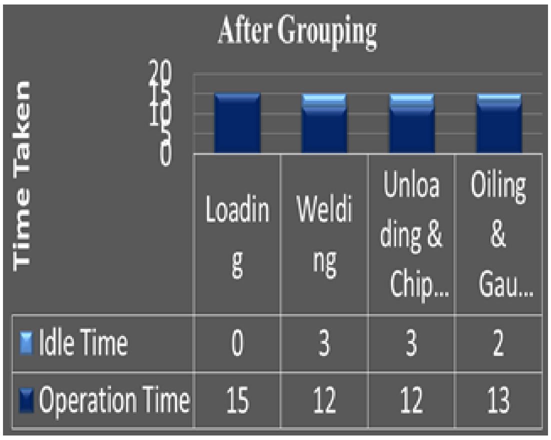

Figure 2: Station Vs Time Taken (After Grouping)

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

3.3 Bottleneck Station Identification

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.

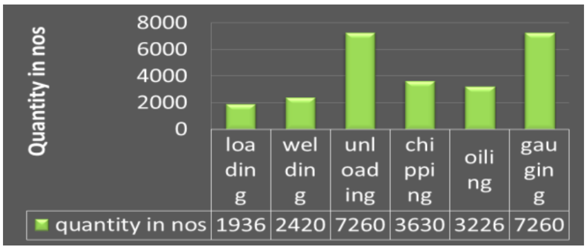

Figure 3: Station vs. Time Taken (Before Balancing)

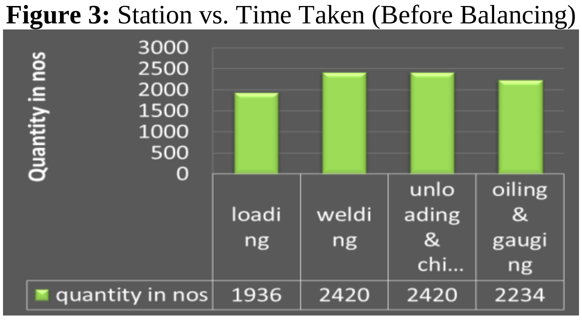

Figure 4: Station Vs Time Taken (After Balancing)

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

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
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 the organization to the economy is assured to be on the higher side.

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Author Profile

Edwin Joy Pulikkottil completed B.Tech in Mechanical Engineering under Calicut University at Jyothi Engineering College. He had 1 year of experience in industry and 2 years of experience in teaching. He is doing Masters in Manufacturing Engineering.

Bibin Baby completed B.E. in Aeronautical Engineering with university 4th rank under Anna University. He had 1 year of experience in teaching and over 2 years of experience in freelance training. He is doing Masters in Manufacturing Engineering.