Assembly Line Balancing And Workstation Design For A Manufacturing Industry

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Abstract: Assembly line balancing is an essential engineering task for effective production and requires a larger amount of information that is related to the product such as processing method, processing time, precedence on which the work is carried out and flow structure of the work. Two line balancing methods were studied and used to balance the assembly line. The assembly line processing layouts were developed independently based on the above two methods. The best layout was found to be based on the Largest Candidate Rule (LCR), which allows each task to be completed in a single workstation. Traditional batch production was converted to a single piece flow to solve the issues regarding material handling, WIP inventory, cycle time, unbalanced work station, and queues. The above problems were identified using value stream mapping and Pareto chart. Takt time has been reduced from 272 seconds to 115 seconds and Productivity time has been reduced from 14 hours per day to 12 hours per day.

Keywords: Assembly Line Balancing; Value Stream Mapping; Rank Position Weight (RPW); Largest Candidate Rule (LCR); Arena simulation

1. INTRODUCTION

Designing of assembly lines are more preferred in industries for the ordered functioning and arrangement and of workers, tools or machines, and parts. One of the main aims of assembly lines is to minimize the motion of workers to a great extent. The usage of conveyors or motorized vehicles such as forklifts or gravity (without manual trucking) is used for handling machine parts or assemblies along the assembly lines. Overhead cranes or forklifts are mainly used for heavy lifting. One simple operation is to be performed by each worker. Classification of Assembly line based on numbers of models assembled on the line and according to the line pace

I) Single Model Line- Only a single model can be assembled in a single model line. The products produced by such lines have no variations among one another. Several of similar units can be produced by such lines. For all the units the task performed at each station is similar. Products with high demand are intended for this line.

II) Mixed Model Line - More than one model can be produced using the mixed model line. Different products are made simultaneously on the same line. All the stations are allowed to perform their job at the same time. Various tasks are performed in every station which results in the production of any model that moves through it. Most consumer products are assembled more on a mixed – model line.

III) Batch Model Line – Each model is produced in batches in the batch model line. The work stations are often reconstructed accordingly to what model they want to develop at that duration of time. Assembly of products in batches is preferred when the demand for the products is not quite so high. One assembly line is preferred to produce several products in batches, which is even more economical than building a separate line for each model.

To meet the required production rate and to achieve a minimum amount of idle time it is preferred to assign each task to a workstation within an assembly line. In - Line balancing the tasks are assigned to their respective work stations along the assembly line in such a way that each workstation has the same amount of work to be done in spite of considering the reality in which impossible in assigning the same amount of work to each workstation.

2. LITERATIURE SURVEY

Reference [1] have surveyed and given an up-to-date review of different assembly line problems. Reference [2] has stated the necessity of balancing the operations at various work stations to minimize the number of workstations. The primary objectives of their work were to minimize production cost and number of workstations, improve productivity, identify the bottleneck and eliminate and distribute the workload equally along the assembly line. Reference [4] have used three heuristic methods are Largest Candidate Rule (LCR), Ranked positional weight method (RPW) and kilbridge and wester Column Method to minimize the assembly line time of a two stage gearbox. The main aim was to find which method offers better performance by reducing the total time per piece and the number of workstations and increasing the line balancing efficiency and labor efficiency. Reference [5] has used the common procedure of rank position weighted method (RPW) to balance the assembly line and thereby reducing the bottleneck. After the implementation of the RPW method, the production rate was found to be increased by...
38 percent. Reference [3] & [7] has proposed a methodology for the improvement of productivity of the Manual Assembly Line (MLB) by the use of operational analysis in the framework of lean production. The objectives of their work were to improve productivity by the use of lean principles and to establish a material handling system for the assembly line. Reference [9] has addressed about cost oriented assembly line problems and has classified the existing and new heuristic methods to solve the problems. Reference [10] has proposed a new arrangement and design to the related company to increase effective output and decrease lead time with the contrivance of effective lean tools such as 5S, standardized work and quality of the source. Reference [11] have addressed the VSM process into three stages: The first step includes the selection of a particular product for betterment. The second stage is to produce a current state map for understanding how the process is being done and thereby analyzing the process and identifying the weakness. Reference [6] reviewed a case study in engine testing work flow analysis using VSM. The final stage involves the creation of the future state map which represents the process without its inefficiencies. Reference [14] has stated that, VSM is to tool to identify the non-value added activities. Reference [8], [12] & [13] have proposed a simulation model to compare the before and after scenarios of the process thereby reducing work in progress inventory and production lead time.

3. PROBLEM STATEMENT

After globalization & industrial revolution, companies dealt with older manufacturing and management techniques, realized the need for cutting edge manufacturing and management technologies, use the resources to the optimum level, cut down the cost to improve their profit. At work-floor environment of a company, there always exists problem related to improper material handling, high work in progress and less production rate. The traditional technique of manufacturing uses batch production. With improvements in technology, the Assembly Line Balancing is carried out with effective measures to reduce work in progress, improve material handling and increase production rate. In the industry existing methodology is batch production. The problem is that the work load is not split equally among the workers; the fatigue experienced by one person is relatively higher than the other. There by the efficiency of the work is reduced relatively and the work output/production rate is affected. This indicates that the industry has a drop in efficiency.

A. Objective of the work

To develop a new layout that converts batch assembly line into single piece flow to reduce the lead time

B. Methodology

The methodology adopted in this study to meet the objective considered is described below

Step1: Data collection for building a model for the current layout

Step2: Analysis of data using Value stream mapping and Pareto Chart

Step3: Identification of bottlenecks from the value stream mapping of the current layout

Step4: Selecting a heuristics methods for line balancing

Step5: Proposing a new layout for improving the assembly line balancing and study the performance measures using discrete event simulation model

Step6: Results and Discussion

Step6: Implementation of new layout design in the assembly shop floor.

Due to present method followed in the assembly sector of the company, the labor and resources in the industry are not utilized to the best of ability. Some resources, machines and labor might have a queue and work in progress where as some might be idle. This will reduce the efficiency of the industry to give out the required output which could be achieved. The company is to develop a system that will help the management to overcome the prevailing issues in the industries, develop an environment which will enable them to improve material handling, reduce work in progress and increase productivity.

This work has been split into two parts. In the first part of the work study time of the existing model will be calculated, with the help of this study time will be calculated for the process based on the value added and non-value added service in the process. Then value stream mapping will be done to calculate work in progress, queue waiting for the particular process. On the second part of the work, work station design will be done to resolve the issues existing in the prevailing model. Station allocation in assembly line balancing will be carried out by following Largest Candidate Rule and Ranked Positional weight Method. Then value stream mapping of the proposed / developed model is done, from which work in progress and idle time is calculated. Then work place and station are designed based on the basic ergonomics principle to create a better environment to work in the industry. After validation of the model its implemented in the company and practical problem if any identified are solved. By following the above steps the problem in the prevailing method Batch production is overcome by adopting the single piece flow obtained by assembly line balancing and work station designing.

4. DATA COLLECTION

C. Precedence diagram of current layout

The diagram shown in the figure 1 that describes the ordering in which work elements should be performed. It shows that some jobs cannot be performed unless their predecessors are completed. The layout of workstations along the assembly line depends on the precedence diagram.
Value Stream Mapping of current layout

Value stream mapping is a process mapping tool employed in Lean Manufacturing for analyzing, designing and managing the flow of materials and information required for a product to reach the customer. This method has received fast acceptance due to its ability to perform all the above tasks in a short time period. Value Stream mapping helps the personnel visualize and understand the processes to differentiate between resource and waste. It helps them create a plan of action for the elimination of these wastes. After identifying the wastes a future state map shows the new process flow that the personnel will see in the future after the wastes have been nullified. As shown in the figure 2, for each station talk time, station time and no of workers required are labeled below in the value stream map.

E. Pareto Chart

The Pareto chart is one of the seven basic tools. From the figure 3 we are able to identify that the problems are caused due to kit assembly, casing yoke, side, packing, painting flange and casing, casing suction side and painting yoke are the 80% effect from 20% cause.
that the station time doesn’t exceed the cycle time.

Step 5 - The above steps is repeated until all work elements are placed in their respective work stations.

Step 6 - After all the work elements are assigned to their respective work stations, the value of efficiency, balance delay, and smoothest index are computed.

Comparison of Largest Candidate Rule, Ranked Positional weight and Method for the modified precedence chart have given the results of the advantages of Largest candidate rule over Ranked positional weight method, the advantages are that the station has work related to the same components (for example casing process is selected in both methods). In the Largest candidate rule, the process related to the particular components can sum up one single station by this; the stress over the labor is reduced, whereas in the Ranked positional method single labor has to do mix up operation in single workstation. In ranked positional weight method paint booth has to be operated by 3 workers from stations 1, 2 and 4 which is placed away from the workstation, this will induce fatigue in the work when compared to the Largest Candidate rule.

A. **Value Stream Mapping of Proposed Layout**

As shown in figure 4 show the new layout designed based on the balanced assembly line and single piece flow principles. In this layout the work is carried out in sequential manner by which the problems faced in current model can be overcome. The station timing allotted for each station is 110 which includes transfer of work piece from one station to another and set up time for work piece in each station. The product is completed in takt time basis.

![Figure 4: Value Stream Mapping- Proposed layout](image)

B. **Precedence diagram of new layout using LCR**

In order to balance the assembly line precedence table has been developed as shown in the figure 5. It gives the sequence in which the component has to flow through in assembly line. The sequencing is done based on the independent process in the assembly line.

![Figure 5: Precedence diagram of new layout using LCR](image)

C. **Simulation Results of New Layout Using Arena**

The figure 6 show below the new layout designed based on the balanced assembly line and single piece flow principles. In this layout the work is carried out in sequential manner by which the problems faced in current model can be overcome. The station timing allotted for each station is 110 which includes transfer of work piece from one station to another and set up time for work piece in each station.

![Figure 6: New Model analysis using ARENA](image)

D. **Simulation Results of Arena**

The simulation for the new model was replicated for 20 days using Arena Software; the following results are generated,

- Number Out
- b) Work In Progress (WIP)
- c) Queue
The figure 7 shows the report which is generated by Arena software. It clearly shows the number of pieces released, for the given simulation time and details. Here we get a total of 260 parts per day, i.e. one shift (8 hours). From the below figure 8, work in progress for yoke has been reduced to average of 2.246 numbers.

![Figure 7 Number out - New model](image)

![Figure 8 Work In progress - New Model Queue](image)

This figure 9 shows the average waiting number of a part. The higher the number waiting, it represented the presence the bottle neck in the process of manufacturing, whereas queuing in this process is almost nil which shows bottle neck is avoided completely.

![Figure 9 Queue of New Model](image)

### 6. DISCUSSION OF RESULTS

On comparing the results of existing model and new model, it’s found that Cycle time has been decreased, work in progress and queuing has been reduced and material handling is improved. In overall view Value Added time has been increased from 28% to

### 7. CONCLUSION

The conversion of a batch assembly line into a single piece assembly line has been successfully completed for a pump manufacturing industry. The following conclusions were drawn.

i. Currently used batch process has been studied using value stream mapping and problems like material handling, WIP inventory, cycle time, unbalanced work station, and queues were reduced.

ii. The processing method has been converted for batch production in to single piece flow production technique.

iii. The above said problem was identified using Value Stream Mapping and Pareto chart.

iv. In the new model, assembly line balancing has been carried out for demand of 5000 per month and work load is split equally between workers.

v. Value stream Mapping is done for new model, following observation has made Takt time has been reduced from 272 seconds to 115 seconds. Productivity time has been reduced from 14 hours per day to 12 hours per day.

### 8. REFERENCES


