



## **Productivity Improvement Using Line Balancing Heuristic Algorithms- A Review**

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### **ABSTRACT**

In this paper, we have studied various recent research articles for finding out the parameters, variables and factors which affects the productivity of a manufacturing organization. Most of the author are used Line balancing method. It is a method which is frequently used in manufacturing units to arrange the proper sequence and to minimize the number of workstations. Line balancing algorithms help in improving the line efficiency which in turn increases the productivity of the manufacturing unit. Work Study and Lean Manufacturing Methods, Industrial Engineering Tools, Assembly Line Balancing, Time Study and Time Measurement and Waste Reduction technologies are identified as the key tools for improvement in the productivity of a manufacturing organization.

**Keywords-** productivity improvement, line balancing, industrial engineering tools.

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### **1. INTRODUCTION**

The assembly line is a manufacturing process (often called a step-by-step assembly) that includes components (usually changing parts), while it acts as a workstation for a smooth assembly workstation. General Chat Lounge. Which includes this final arrangement until the final assembly is ready. As these components are mechanically transferred to the work of this assembly and are moving to move this semi-finished assembly to the workstation, move the finished product to a more stable part to achieve the assembly. The difference between fast and low wages can be linked to labor. Assembly lines are common methods of assembling complex items such as automobiles and other transportation equipment, household appliances and electronic goods. Assembly lines are designed for the sequential organization of workers, tools or machines, and parts. The motion of workers is minimized to the extent possible. All parts or assemblies are handled either by conveyors or motorized vehicles such as fork lifts, or gravity, with no manual trucking. Heavy lifting is done by machines such as overhead cranes or forklifts. Each worker typically performs one simple operation. The assembly lines are designed to achieve a rating organization that includes personnel, equipment or machinery and parts. For workers, this speed can be reduced to some extent. All parts or assemblies are safe without conveyor, conveyor or motor vehicles, such as forklifts or gravity. Heavy lifting is done in the form of machines such as overhead cranes or forklifts. Each worker usually performs a simple process.

The principles of the Assembly are:

- (1) Arrange this device in the order of these gentlemen and gentlemen so that at the completion of the steps the minimum possible distance from each part of the body should be kept.
- (2) Use job slides or any other work so that the employee will always leave when he or she finishes their job. This place is most comfortable for his hands. - And join it if possible. The appeal of this class will take it to its next crafts.
- (3) Use slider deposit lines provided at easy distances to assemble these sections. [1]

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### **2. FACTORS AFFECTING PRODUCTIVITY OF MANUFACTURING INDUSTRY**

After studying various research articles of different authors we have found out these parameters and factors which can be further optimized for improving the productivity of manufacturing unit

#### ***Work Study and Lean Manufacturing Methods***

**Nurul Nazeerah Mishan & Masine Md Tap** [1], presented a study so as toward aims toward increase this productivity & efficiency containing a food processing line into a company. This selected line is this bun production line because this line contributes this highest demand. This method selected toward improve this line is a combination containing production line scheduling & work study methods.

**Ahmad Naufal Adnan, Nurul Ain Arbaai & Azianti Ismail [2]**, presented optimum efficiency improvement containing this automotive jack assembly production line as containing using production line scheduling into Autokeen Sdn. Bhd. (AKSB). Implementation containing Lean toward regulate works on floor has increase this manufacturing performance.

**Akshay D. Wankhade & Dr. Achal S. Shahare [3]**, studied toward present an overview on a new combined methodology to get this efficient improvement into productivity among this help containing various tools, techniques & principles. Work study is one containing this most influential & effective methodologies to get eliminating obstructions into plant layout, machinery & flow process & thus obtain maximum productivity.

**Yotsuda Buranasing & Juthamas Choomlucksana[4]**, concluded so as toward Lean manufacturing & work study are both popular & include been widely applied toward achieve quality & productivity improvement into several industrial sectors (automotive, health care, & etc.) among high success. Previous studies found so as toward some researchers apply lean manufacturing techniques only, whereas others apply only work study. However not all, some studies include used both techniques to get productivity improvement. Therefore, a number containing question remain concerning this gap between this applications containing these two techniques.

**Balaji Rathod, et. al. [5]**, analyzed so as toward among this importance containing being competitive into today's market, many companies are adopting various methods toward improve their productivity. One way toward achieve this is toward adopt lean manufacturing techniques. Among this mind-set containing building products cheaper, faster, & better toward gain a competitive edge into this market, Company ABC Ltd. has used lean techniques such motion study & line balancing.

**Sleem S.N., Helal M. & Ellassal A.M. [6]**, described about this process containing transforming an assembly line toward work among lean concepts. A methodology has been developed & used as a framework toward utilize various lean manufacturing tools into analyzing this configuration & performance containing this assembly line & identify this present forms containing waste & their causes.

**Maciej Pieńkowski [7]**, introduced a suggestion containing a waste measurement system, as solutions toward difficulties, which most companies struggle toward overcome: identifying entire waste, quantifying it & using gain knowledge toward improve. this paper stresses this significance containing complex waste analysis, which contains not only Muda, however also Mura & Muri. Presented formulas to get this 3 Mu's metrics calculations may be useful into many companies & provide them among important information about their processes. this presented waste measurement system, if properly applied, may bring plenty containing benefits toward a company. It is necessary however toward be aware about containing limitations.

### ***Industrial Engineering Tools***

Mr. Satish Keru Raut, Prof. Kedar M. Relekar & Mr. Vikas Sarjerao Dhane[8], presented a case study into this development & application containing a time study into a engine block manufacturing plant. this two products include similar production processes. this study's most important finding is so as toward this time containing producing a unit containing product is directly proportional toward this number containing production stages involved & this time spent at each stage. Jaana Koistinen[9], studied about this automation into automobile industries & implemented it. As this result containing this automation there is got a lot containing cost savings. this savings concerned opera- tor resources, material costs & working time. This quality containing this soldering results became much better & work time (takt time) more standardized as containing this automation. All this hand assembly phases will be now checked into Oulu toward see if there is a possibility toward make something else more automatically.

Shravan Dhanpal Harinath & Shakeel Ahmed Siddique[10] studied a case study toward collect all this required data toward achieve this results. Initially among this literature review few generic algorithms which may solve this multi model single sided straight-line balancing problems among an objective toward balance this work load are suggested. Later using other data collection techniques such as inter- views, observations & historical analysis we arrived at this data required toward design this guidelines among regards toward production line scheduling software features

Amol Nayakappa Patil & M Prabhakaran[11] studied so as toward market trends & consumer requirements get modernize into relatively fast compartment. Globalization developed trade opportunities toward fulfill consumer needs, however along also resulted into competition, improved quality & increased productivity. this quality & quantity is being realized as containing changing conventional manufacturing toward automated manufacturing among minimum labour supervision, which is more feasible to get large industries & MNCs. But, SMEs backbone containing country economy cannot afford to get radical process changes as it requires huge investment. planning is useful in controlling the problem. Using these two methods, increasing the number of outputs and the percentage of line balancing is expected to be obtained. Focused on identifying and reducing of wastes and improving productivity. Case study methodology has been applied to collect and analyze data by direct observation. Wastes are identified by using value stream mapping. This research extracts the common scenario of the garments sector of Bangladesh by depicting the existing pictures of the value stream. System simulation has been applied to measure the proposed system's performance. Arena 10 soft- ware has been used for system simulation. Again AutoCAD 2004 has been used for layout analysis. Finally, the research work proposes some recom- mendations for the studied organizations to improve the performance [16]. Presented a case study aims to redesign a hand bag assembly line to reach maximum line efficiency with an optimum number of workstation for a constant cycle time. Three heuristic assembly line balancing algorithms known as "Kilbridge and Wester Column", "Rank Positional Weight" and "Largest Candidate Rule" are applied to design this single model assembly line. Yamazumi chart is used to the visual representation of workload on each workstation. Best two solution models are then simulated in Arena to check the feasibility. By comparing analytical and simulation report one best solution model is recommended to implement. The evaluation of the proposed solution model shows that the production line efficiency increased from 49 percent to 77 percent, number of manpower reduced from 23 workers to 16 workers and provides more balanced workload on each

worker. Therefore, this paper can contribute to meet the same amount of customer demand with a minimized operator cost by higher utilization of worker [17].

### *Assembly Line Balancing*

Studied with mixed-model assembly line balancing and used Yamazumi chart to break down the work element in to the value added & Non-value added part to reduce the waste & increase the productivity. The strategy & techniques adapted at Automobile Company were based on Toyota Production System (TPS) and can be applied to other companies especially those involved in continuous assembly line. After doing mixed model line balancing by mutation & cross over operation between team & station with considering all constraint & precedence relationship. As Toyota Production System is based on "Pull" the Takt Time of the preceding station has to be the same as that of the following station The man-power requirement reduced from 69 to 58 only in the general assembly shop. Also increase the man-power utilization on average from the 60% to 80 % [18]. Focused on improving the overall productivity of 'Rear Seat Belt' assembly line by working on cycle time, non-value added activities, distribution of workload at each workstation by line balancing technique. With these improvements, the company managed to reduce the total time required to complete 2300 product units per day, from 170.54 seconds down to 162.26 seconds. This study also proposes assembly line improvements, by focusing on a Material Handling Operator solution. The material handling operator moves around the assembly line for a standard time to replenish the raw assembly parts and transfer the boxed containers of the assembled parts at the needed workstations, so that the operators at each workstation can concentrate on their own tasks [19].

### *Time Study and Time Measurement*

Concluded that the findings from the research have pointed out a number of key issues which need to be addressed if real, and sustainable benefits from the application of productivity improvement tools and management methodologies are to be achieved. The research has also magnified the consequences of poor implementation and inappropriate selection of productivity improvement tools, as well as poor selection of productivity improvement projects. In essence, it would appear that a number of textile companies are potentially wasting valuable and scarce resources and effort by implementing a range of productivity improvement tools which are failing to deliver the results expected. A number of related factors would appear to be contributing to this position [20]. Conducted a case study at a quality control line of a cutting tool manufacturer in Malaysia aimed to improve the line balancing and maximize the productivity. Line Balancing (LB) plays an important role to enhance the productivity and efficiency of a production line. Current situation at the line is considered very critical since the operator exhibits high tendency to skip a few procedures while performing the inspection processes. The data collected are then analyzed by using the takt time calculation, Yamazumi Chart and a new layout of the quality control line are designed and proposed. Apart from that, a pre-filled check sheet acts as a Lean Manufacturing (LM) approach named Poka-Yoke is also introduced with regard to eliminate a few wastes existed in the line. As a result, the productivity and efficiency of the quality control line recorded an increment up to 9.73% and 89.94% respectively. With the aid of this study, it is greatly help the company to establish a better monitoring system to thoroughly utilize the resources especially in terms of time and manpower needed for the line [21]. Presented about optimum efficiency improvement of the automotive transmission assembly production line by using line balancing. 3 assembly stations were selected to optimize where waste management requirements are not met for achieving the production capacity. Several measures were proposed on the assembly lines concerned to reduce operations by using eliminating unnecessary activities of the assembly processes, reducing the cycle time, and balancing manpower workload using line balancing through Yamazumi chart and Takt time. The results of the proposed measures were compared with the current situation in terms of increasing the efficiency of the production line [22].

### *Waste Reduction*

Studied for the aim of study the current capacity, analyze it to find areas of improvement and make an improvement proposal to meet the forecasted increase in demand. This thesis presents the current performance of outputs and capacity of the plant calculated using continuous data collected in shop floor. In each workstation the processing time is different and the longest time consumption workstation will be identified as a bottleneck workstation. The identified bottleneck station will be analyzed to reduce the processing time which increases production rate [23]. Studied that automobile manufacturing organizations are currently encountering a necessity to respond to rapidly changing customer needs, desires and fluctuating market demand. Markets are affected by diverse customer needs, which demand higher quality, shorter delivery time, higher customer service level and lower prices. This requirement is focusing on optimization of cycle time, reduction non value added work (3M-Muda, Muri, Mura), Kaizen: Continuous Improvement. In Japanese Kaizen is for continuous automated improvement designed to eliminate waste on resources of manufacturing system i.e. machinery, material, worker and production methods [24]. Provided a basic step-by-step guide to developing a waste management program and can help to estimate the current cost of waste disposal. Used in conjunction with the 'Nursery waste self-assessment form' and the 'Waste management cost calculation worksheet' it can help to identifying alternative waste management options. This process will step you through a waste audit and help calculate waste quantities and disposal costs. Identify what alternative waste disposal options are available to reduce waste disposal costs. Compare your current waste management and disposal costs to the estimated costs associated with alternative waste practices. Implement new waste management practices and monitor on a regular basis. Re-assess waste generation after 12 months and re-evaluate disposal options and waste services in your area [25].

Studied that the true cost of waste is not simply the cost of discarded materials - it encompasses inefficient use of raw materials, unnecessary use of energy and water, faulty products, waste disposal of by-products, waste treatment and wasted labor. The actual cost of such waste for UK companies is typically 4 - 5% of turnover, and can be as high as 10%. In 2004 the UK produced about 335 million tons of waste. This includes 220 million tons of controlled wastes from households, commerce and industry (including construction and demolition wastes). Household wastes represent about 9 per cent of total waste produced in the UK. Therefore there is a significant role for businesses to play in reducing the waste that we produce in the UK [26].

Arranged a model for the improvement of production processes in the electronics factory purposed to increase the productivity of final visual inspection process of suspension products when its productivity was lower than expected. The result presents that the efficiency of suspension increases, which means the productivity of the process increasing 16.23% and Lot Accept Rate (LAR) increasing 1.52%. Moreover, it affects to the reduction of Defect Parts Per Million (DPPM) for 97.0%. After the improvement, the method was extend to the other zones and it was found that the productivity of final visual inspection process increases from 2,895 pcs/hr to 3,257 pcs/hr or 13.13%, resulting in the cost reduction for the manufacture [27].

Concluded that lean tools allow the organization to focus upon elimination of 7 wastes, reducing current lead time, stock levels and cycle times to find out the ratio of value added process to the total lead time of the product line being investigated. The initial step is to generate a current state map to analyze the existing procedure, evaluate and identify the wastes and steps to eliminate the same using suitable tools and techniques. The research work will help to illustrate the existing hidden potential in small scale industry as well as a selection of suitable methods for productivity improvements and its ultimate goal is to eliminate waste and non-value added activities at every stage in order to provide maximum satisfaction to the customer. It will also be useful for the researchers, professionals, academicians and other concerned to understand the significance of improvement methodology [28]. Studied that in this competitive market, companies need to look into many aspects and strategies in order to stay in business. Many companies often neglect basic issues and are faced with difficulties in improving or sustaining the productivity of their operations, especially during periods of rapid growth of the company. Studies have shown that companies could have saved millions of dollars if they had strategically made efforts to reduce waste found in all aspects of their operations. [29], Provided an overview of the reasons and ways to better manage industrial waste. While “recycle” may be a buzzword for an environmentally friendly way to manage waste, a more comprehensive approach to doing so is summarized by the followings. Buy only that much you need because a better way to reduce waste is by not creating it. If you have to acquire goods, try getting used ones or obtaining substitutes. When discarding your waste, find ways to recycle it instead of letting it go to landfill. [30].

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## 2. SUMMARY OF LITERATURE REVIEW

There literature review summarizes that following factors and parameters can be used and analyzed to get the improved productivity of manufacturing industries.

- Work Study and Lean Manufacturing Methods
- Industrial Engineering Tools
- Assembly Line Balancing
- Time Study and Time Measurement
- Waste Reduction

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## 3. CONCLUSION

In this review article we have studied and reviewed various algorithms, technologies, parameters and factors which were used by various authors for the improvement in productivity of the manufacturing units. From the review process it is concluded that Work Study, Lean Manufacturing Methods, Industrial Engineering Tools, Assembly Line Balancing, Time Study, Time Measurement & Waste Reduction are the main parameters and factors which can be further optimized for the line efficiency improvement of any organization and thus can improve the productivity of the organization.

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