# Review of Some Recent Findings for Productivity Improvement Using Line Balancing Heuristic Algorithms

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***Abstract*- In this review paper, we have studied various recent research articles of different authors for finding out the parameters, variables and factors which affects the productivity of a manufacturing organization. Line balancing is a method which is frequently used in manufacturing units to arrange the workstations in a 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.**

**Index Terms- productivity improvement, line balancing, industrial engineering tools.**

## 1. INTRODUCTION

An assembly line is a manufacturing process (often called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced. By mechanically moving the parts to the assembly work and moving the semi-finished assembly from work station to work station, a finished product can be assembled faster and with less labor than by having workers carry parts to a stationary piece for assembly. 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 principles of assembly are Place the tools and the men in the sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing. Then Use work slides or some other form of carrier so that when a workman completes his operation, he drops the part always in the same place which place must always be the most convenient place to his hand and if possible have gravity carry the part to the next workman for his own. Afterward Use sliding assembling lines by which the parts to be assembled are delivered at convenient distances.

## 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

### 2.1 Work Study and Lean Manufacturing Methods

Presented a study that aims to increase the productivity and efficiency of a food processing line in a company. The selected line is the bun production line because the line contributes the highest demand. The method selected to improve this line is a combination of line balancing and work study methods. Line balancing was used to measure the inefficiency of the line and later was used to measure the effectiveness of the proposed solution. Line

balance loss analysis and work study methods specifically method and time study are used to identify opportunity for improvement as well as to evaluate the effectiveness of the proposed improvements. Improved methods were proposed and time study conducted. Evaluation on the effect of the proposed improvements shows that the line balance loss is reduced from 69% to 23% and efficiency of the line is increased from 30% to 76% [1]. Presented optimum efficiency improvement of the automotive jack assembly production line by using line balancing in AutokeenSdn. Bhd. (AKSB). Implementation of Lean to regulate works on floor has increase the manufacturing performance. Several improvement steps have been applied throughout the project to measure impact of improving the current system such as rearranging the arrangement of the parts, 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 improvement have been compared to the current system in term of the value of efficiency of the production line [2]. Studied to present an overview on a new combined methodology for the efficient improvement in productivity with the help of various tools, techniques and principles. Work study is one of the most influential & effective methodologies for eliminating obstructions in plant layout, machinery and flow process and thus obtain maximum productivity. The existing plant layout and the operation process of each department (i.e. Reception dock, processing area, storage area, production area, packaging area and utilities etc.) have been observed and investigate w.r.t plant layout, material flow of each section is identified. Using the improved methods the suitable new proposed plant layout can decrease the distance of material flow [3]. Concluded that Lean manufacturing and work study are both popular and have been widely applied to achieve quality and productivity improvement in several industrial sectors (automotive, health care, and etc.) with high success. Previous studies found that some researchers apply lean manufacturing techniques only, whereas others apply only work study. But not all, some studies have used both techniques for productivity improvement. The case study results indicate the relationships, differences, and similarities between the techniques and the benefits of each. In fact, lean manufacturing techniques provide a good overview of processes, whereas the work study techniques focused on critical areas. The effects of applying these techniques are contrasted. Finally, time spent and costs were reduced at the outbound logistics stations [4]. Analyzed that with the importance of being competitive in today's market, many companies are adopting various methods to improve their productivity. Yamazumi Chart is used for line balancing. Using these tools helped company to develop process with cycle time within the takt time associated with building the product. Having a good understanding of these lean tools allowed for a better understanding of the waste associated with walk and wait that was in the production line and the importance of eliminating it [5]. Described about the process of transforming an assembly line to work with lean concepts. A methodology has been developed and used as a framework to utilize various lean manufacturing tools in analyzing the configuration and performance of the assembly line and identify the present forms of waste and their causes. Converting the assembly line into a lean production system led to cutting off work-in- process by about 82%, reducing the cycle time by 30%, and decreasing the model changeover time from 127.5 min to 11.5 min, in addition, splitting the assembly line into two parallel assembly lines to produce two models concurrently [6]. Introduced a suggestion of a waste measurement system, as solutions to difficulties, which most companies struggle to overcome: identifying entire waste, quantifying it and using gain knowledge to improve. The paper stresses the significance of complex waste analysis, which contains not only Muda, but also Mura and Muri. Presented formulas for the 3 Mu's metrics calculations can be useful in many companies and provide them with important information about their processes. This leads to conclusion, that waste measurement is a key component needed to achieve a successful Lean implementation. After all, as Lord Kelvin's famous quote says: "If you cannot measure it, you cannot improve it" [7].

2.2 Industrial Engineering Tools

Presented a case study in the development and application of a time study in a engine block manufacturing plant. The two products have similar production processes. The study's most important

finding is that the time of producing a unit of product is directly proportional to the number of production stages involved and the time spent at each stage with this proposed solution a saving of 2 to 3 man power per cycle was obtained. The paper discusses the use of Industrial Engineering tools used for the purpose of productivity improvement. [8]. Studied about the automation in automobile industries and implemented it. As the result of the automation there was got a lot of cost savings. The savings concerned opera- tor resources, material costs and working time. The quality of the soldering results became much better and work time (takt time) more standardized by the automation. All the hand assembly phases will be now checked in Oulu to see if there is a possibility to make something else more automatically [9]. Studied a case study to collect all the required data to achieve the results. Initially with the literature review few generic algorithms which can solve the multi model single sided straight-line balancing problems with an objective to balance the work load are suggested. Later using other data collection techniques such as inter- views, observations and historical analysis we arrived at the data required to design the guidelines with regards to line balancing software features This research is one of its kind which talks purely about the constraints and desired features only in a specific line balancing scenario. Practitioners can use this as a base for conducting further research on constraints and features pertaining to it, for different line balancing scenarios [10]. Studied that market trends and consumer requirements get modernize in relatively fast comportment. Globalization developed trade opportunities to fulfill consumer needs, but along also resulted in competition, improved quality and increased productivity. The quality and quantity is being realized by changing conventional manufacturing to automated manufacturing with minimum labor supervision, which is more feasible for large industries and MNCs. But, SMEs backbone of country economy cannot afford for radical process changes as it requires huge investment. The idle time is been identified along with the distance travelled; accordingly process layout modification is suggested based on the economic analysis which gives indicative measure of profit leading to increase in productive rate [11]. Analyzed that uncertainty in car market demand affects the preparation of production plans in each automotive industry. Achieving the right amount of actual demand is almost impossible because the request itself is uncertain. As demand increases, additional operators are needed to increase the amount of output and vice versa. Manpower 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. The results of this study confirm that there is an increase in the amount of output, while the percentage of line balancing decreased slightly, but there was a significant increase in monthly output and the percentage of line balancing detected in the workforce planning that used 20 operators [12]. Analyzed a spinning and weaving mill. Today the company has a production capacity of almost 85680 spindles per day. This capacity cannot be utilized properly due to various losses. The project aims at identifying the root cause of these losses and to propose methods to increase the productivity. DMAIC technique is used for productivity increase with why - why analysis in the analysis stage to find out the root causes of losses. Pareto chart is used to plot various factors that affect productivity. This project mainly focuses on reasons for power failure and absenteeism, which is a threat to the organization. In order to improve the productivity of the organization, suggestions were made to manage the power failure and absenteeism, thus a better system was proposed for the organization under study [13]. Analyzed for objective of improving the efficiency of the airbag manufacturing. The side airbag production line has been selected as the pilot study. The production line efficiency improvement is necessary to respond and support the customers' demands as well as increasing the productivity of the company. The side airbag production line under studied was not being able to fulfill the increasing customer demands. The research started by collecting the data represented the existing situation. The data are then analyzed and the Industrial Engineering techniques are applied. The product quality also improved. The defective rate is reduced by 1.99%, from 3.07% to 1.08%. The implementation of the line balancing technique reduces waiting time, so thus the OEE is increased by 9.22%, from 87.72% to 96.94% [14]. Studied for the purpose of reducing work in progress (WIP) between processes at ST (strut) production line in APM Shock Absorber Sdn Bhd. In order to achieve this, all processes that focus on three

processes only which is ABW ABF, CO2 welding, and LET KHP. Another observation that was derived from the Yamazumi chart is the bottlenecks can be derived and waste at ST line can be eliminated by having Kaizen activity such as reduce waiting time and position the machine comfortably for the operator doing their process. Some other recommended changes based on applying TPS are reduction of work in process inventory (WIP), reduction of waiting time, stop the process to build in quality, collect more information, and implementation of the 5S methodology. By implementing these changes, the future state of WIP can be reducing in between of the process and smooth production flow can occur [15]. 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].

2.3 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].

2.4 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].

2.5 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].

## 3. 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

## 4. 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.

## REFERENCES

[1] Nurul Nazeerah Mishan and Masine Md Tap, “Increasing Line Efficiency By Using Timestudy And Line Balancing In A Food Manufacturing Company”, Jurnal Mekanikal, Vol 38, 32-43, DEC 2015.

[2] Ahmad Naufal Adnan, Nurul Ain Arbaai And Azianti Ismail, “Improvement Of Overall Efficiency Of Production Line By Using Line Balancing”, ARPN Journal Of Engineering And Applied Sciences, Vol. 11, No. 12, June 2016.

[3] Akshay D. Wankhade & Dr. Achal S. Shahare, “Productivity Improvement by Optimum Utilization of Plant Layout: A Case Study”, International Research Journal of Engineering

and Technology, Volume 04, Issue 06, June - 2017.

[4] Yotsuda Buranasing and Juthamas Choomlucksana, "Lean Manufacturing and Work Study: Analysis and Integration in an Outbound Logistics Case Study", Journal of Engineering and Science Research, volume 2, issue 2, pp 17-25, 2018.

[5] Balaji Rathod, Prasad Shinde, Darshan Raut & Govind Waghmare, "Optimization of Cycle Time by Lean Manufacturing Techniques Line Balancing Approach", International Journal For Research In Applied Science & EngineeringTechnology, Volume 4 Issue V, May 2016.

[6] Sleem S.N., Helal M. and Elassal A.M., "Using Computer Simulation in Lean Manufacturing Implementation", Benha Faculty of Engineering, Benha University, Mechanical Engineering Technology, EGYPT.

[7] Maciej Pieńkowski, "Waste Measurement Techniques For Lean Companies", International Journal Of Lean Thinking ,Volume 5, Issue 1,December 2014.

[8] Mr. Satish Keru Raut, Prof. Kedar M. Relekar and Mr. Vikas Sarjerao Dhane, "A Case Study of Productivity Improvement by using IE Tools", International Journal Of Innovations In Engineering Research And Technology [IJIERT], volume 1, issue 1 NOV 2014.

[9] Jaana Koistinen, "Automation Of Pre Assembly Cell And Improvement Of Material Flow", Management Oulu University Of Applied Sciences, 2015.

[10] Shravan Dhanpal Harinath and Shakeel Ahmed Siddique , "Identifying specific line balancing criteria for an efficient line balancing software", Production Development and Management, January 2018.

[11] Amol Nayakappa Patil And M Prabhakaran, "Labor Productivity Improvement By Work Study Tools Of Fiber Composite Company", International Journal Of Research In Engineering And Technology, Volume: 05 Issue: 09, Sep-2016.

[12] Amal S Das & P V Gopinadhan, "Productivity Improvement Using Industrial Engineering Tools – Case Study Of a Typical Spinning Mill", International Journal of Engineering Development and Research, Volume 4, Issue 3 , 2016.

[13] Chyntia Ramadina and Ineu Widaningsih Sosodoro, "Manpower Planning of Assembly Line Part A005TG2991ZJ at PT. Mitsubishi Electric Automotive Indonesia, Jawa Barat", Faculty of Engineering, Industrial Engineering Department, President University, J. Ki Hajar Dewantara Kota Jababeka,Cikarang, Bekasi – Indonesia.

[14] Thosapon Thongchai & Pichit Sukchareonpong, "The Improvement of the Airbag Manufacturing: A Case Study of the Automotive Safety Equipment", Journal of Engineering and Technology, Volume 5, issue1, January - June 2017.

[15] Nur Nadiah Binti Mohammad Alwudin, "The Reduction Of Work In Progress Between Process In Strut Production Line Of A Manufacturing Factory", Faculty Of Manufacturing Engineering University Malaysia Pahang , June 2012.

[16] Masudul Haque Talukder, Mohammad Ali Afzal, MD.Abdur Rahim & Mohd.Rifat Khan, "Waste Reduction and Productivity Improvement through Lean Tools", International Journal of Scientific & Engineering Research, Volume 4, Issue 11, November-2013.

[17] Subrata Talapatra, Sharif-Al-Mahmud & Imran Kabir, "Overall Efficiency Improvement of a Production Line by Using Yamazumi Chart: A Case Study", Proceedings of the International Conference on Industrial Engineering and Operations Management Paris, France, July 26-27, 2018.

[18] Bhavik Shaileshkumar Sheth, Tanmay Swaroop & Rabinder Henry , "A Case Study On Improving The Productivity Using Ie Tools" , International Journal Of Mechanical And Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Volume-2, Issue-2, 2012.

[19] Akashdeep Singh Gandhi, "Productivity Improvement through Time Study (Work Measurement) and Line Balancing at Automotive Seat Belts Manufacturer", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 7, Issue 7, July 2018.

[20] 20. H. Mapfaira, M. Mutingi, V.P. Kommula, K. Mashaba, M. Malema, and T. Selema, "The Use

of Productivity Improvement Tools and Techniques in the Botswana Textile Industry", International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME), Volume 3, Issue 3 2015.

[21] Muhammad Farhan Mohd Suhaimi and Noor Azlina Mohd Salleh, "A Case Study On The Improvement Of Productivity And Efficiency Of A Quality Control Line For A Cutting Tool Manufacturer" , Journal of Mechanical Engineering , Vol SI 5(1), 222-239, 2018 .

[22] Dušan Sabadka, Vieroslav Molnár, Gabriel Fedorko & Tomasz Jachowicz, "Optimization Of Production Processes Using The Yamazumi Method", Advances In Science And Technology Research Journal, Volume 11, Issue 4, Pages 175–182, December 2017.

[23] B. Naveen and Dr. T. Ramesh Babu, "Productivity Improvement in Manufacturing Industry Using Industrial Engineering Tools", IOSR Journal of Mechanical and Civil Engineering, p-ISSN: 2320-334X, PP 11-18.

[24] Sandip K. Kumbhar, Niranjan M. R and Sanjay T. Satpute, "Assembly Line Production Improvement by Optimization of Cycle Time", International Journal of Mechanical and Production Engineering, Volume- 2, Issue-8, Aug.-2014.

[25] EHR Consultants, "NGIA Waste assessment project (NY13003)", 2014.

[26] Ottman J. "Green Marketing Opportunity for Innovation 2nd Edition NTC Business", Chicago ,(1998)

[27] Wutichai Promsuwan, and Jeerapat Ngaoprasertwong, "Increase Productivity with Lean Concept in Final Visual Inspection Process of Hard Disk's Suspension", International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME) ,Volume 3, Issue 4 (2015).

[28] Dhruv Shah & Mr. Pritesh Patel, "Productivity Improvement by Implementing Lean Manufacturing Tools In Manufacturing Industry", International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 03, Mar-2018.

[29] Kelvin Chan, "Productivity methodologies, tools, and techniques", Teian Consulting International Pte Ltd, Development of Productivity Practitioners ,Singapore.

[30] Fahzy Abdul-Rahman, "Reduce, Reuse, Recycle: Alternatives for Waste Management", Extension Family Resource Management Specialist, Department of Extension Family and Consumer Sciences, New Mexico State University, January 2014.