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IMPROVEMENT IN PRODUCTIVITY BY PROPER UTILISATION OF AVAILABLE RESOURCES

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Abstract

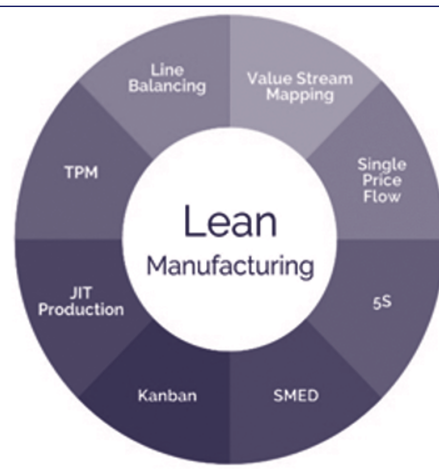
This project aims to improve the efficiency of a manual assembly line by employing operations analysis within the framework of Lean production. A methodology for increasing the productivity of any production process is proposed. The methodology includes the selection of a product or product family to be investigated, followed by an analysis of the current process. After documenting the present process, all assembly activities must be timed using time study techniques. Operations analysis facilitates the reduction of non-productive jobs and yields a collection of standardised work elements as well as a set of standard operating procedures. Assembly line balance and the associated operations analysis contribute to the construction or reconfiguration of an assembly system, which is the most important stage in enhancing the overall performance of an assembly line. In accordance with this methodology, two manual assembly line configurations (single stage parallel line and five-step serial line) are created for a case study. The results demonstrate that by switching to a single-stage assembly line arrangement, operator productivity is increased by removal of non-value-added tasks to the current assembly approach. Minimization of the number of workstations and maximization of the production rate are the most common goals. This report presents the reviews of different works in the area of assembly line balancing and tries to find out latest developments and trends available in industries in order to minimize the total equipment cost and number of workstations.

Keywords- Assembly line balancing, Productivity, Productivity, Lean Production, Non-Value Added.

INTRODUCTION

Assembly lines are one of the most common production methods. Utilizing the available resources, the productivity of a production system is the quantity of work that can be completed per unit of time [1]. Assembly line productivity is defined as the efficiency with which a manufacturing system utilizes its resources to achieve production goals at optimal costs. Conventional productivity measurements, such as throughput and utilization rate, provide a major assessment of an assembly line's success. These two indicators are insufficient to fully characterize the behaviour of a production system. In addition to throughput and utilization rate, the performance of a production system is characterized by a variety of other metrics, including assembly line capacity, production lead time, the number of value-added (VA) and non-value-added (NVA) activities, work-in-process, material handling, operator motion distances, line configuration, and others. By optimizing all these elements, a production line achieves optimum performance. In order to establish productive and competitive manufacturing processes, adaptability and suppleness are crucial. With manual assembly techniques, this level of adaptability can be easily attained for products needing light manufacture and assembly [2]. Manual assembly lines are the most prevalent and conventional type of assembly line, and they continue to be an attractive and adequate method of production for products that require fewer manufacturing steps and straightforward assembly processes. Global competition is compelling businesses to reduce production costs while simultaneously improving quality and shortening production lead times. With the adoption of Lean Manufacturing, which systematically and continually detects and removes waste at all levels of a production system, it is possible to effectively execute several improvement possibilities that dramatically increase assembly line productivity. Lean manufacturing is a methodology that focuses on minimizing waste within manufacturing systems while simultaneously maximizing productivity. Waste is seen as anything that customers do not believe adds value and are not willing to pay for. Some of the benefits of lean manufacturing can include reduced lead times, reduced operating costs and improved product quality. Lean manufacturing, also known as lean production, or lean, is a practice that organizations from numerous fields can enable. Some well-known companies that use lean include Toyota, Intel, John Deere, and Nike.

Fig. 1.1 Lean manufacturing



Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. The processes that have this common theme, controlled material removal, are today collectively known as subtractive manufacturing, in distinction from processes of controlled material addition, which are known as additive manufacturing. Machining is a part of the manufacture of many metal products, but it can also be used on materials such as wood, plastic, ceramic, and composites. A room, building, or company where machining is done is called a machine shop. Much of modern-day machining is carried out by computer numerical control (CNC), in which computers are used to control the movement and operation of the mills, lathes, and other cutting machines.

LITERATURE REVIEW

Esra Can and Adalet Öner et. al, (2021), In this project, an assembly line was analysed. At the end of the literature review and researches, some methods were determined to solve the assembly line balancing problem. The RPW method and the mathematical modelling methods were used. These methods were compared and it was found that the results like each other. As a result of these studies, after line balancing balance efficiency is improved.

Lakhdar Belkharroubi, Khadidja Yahyaoui et. al, (2021), In this paper, the mixed model assembly line balancing problem type 2 is addressed, and the objective is to find the best assignment of tasks among workstations to minimize the cycle time. A Greedy randomized adaptive search procedure based Ranked positional weight heuristic is proposed in order to seed the initial population of the genetic algorithm, and a numerical example that represents a mixed model assembly line that assembles two different products is used to test the proposed hybridization.

Qidong Yin, Xiaochuan Luo, Julien Hohenstein et. al, (2021), this study verifies the effectiveness of using the column generation method to solve the TALBz problems. A B&P algorithm is presented to deal with the TALBz problem for the first time. The published models cannot be directly applied to implement a column generation procedure. Thus, Dantzig–Wolfe decomposition of the original model is conducted. Models of the master problem and subproblems are reformulated. The proposed branching strategy is demonstrated to be effective in obtaining an integer solution.

Iqbal Hussain Zaidi, Muhammad Ali Khan et. al, (2021), This paper is the presentation of review of literature on the topic of lean manufacturing which is the famous waste reducing technique for the manufacturing, process, and service industries. It was indicated from the literature review nowadays lean manufacturing if being implemented at the large scale in manufacturing industries and at the same time, the bakeries are also reported to be user of lean manufacturing. From this slowly and gradually the small, medium, and large businesses are compelled to simplify their process for the survival in this diversified market. Since, it is the popular waste eliminating technique thus it was used for the elimination of non-value-added activities.

Bhuvana Ramkumar & Varshitha Harish et. al, (2021), The new developments in the global economy have demanded a paradigm change from profit maximization to customer satisfaction in the manufacturing sector. One such processoriented approach for achieving sustainability in competitive markets is LM techniques. Our research provides a precedent that creates an opportunity to propose a repository of information to encourage LM-related studies. The bibliometric analysis was performed on the data using the open-source R code and visualized using VOS viewer. Mostly increasing growth pattern of the LM subject is found based on previous publications.

Neena Sinha, Misha Matharu et. al, (2019), Systematic review of literature indicates that the most dominant theme found in literature is lean adoption, followed by lean and its relation to performance. Lean is also emerging as an important dimension in organizational theory literature but there is a need for further consolidation. Compatibility of lean with sustainability and green practices is also reflected in the contemporary literature. The superiority of lean as process improvement methodology led to conformance by the manufacturers globally to the paradigm. The present business environment with its rapid changes in market, rise in its economic, technical, and socio-psychological complexities has paved way for acceptance of lean as an operating strategy in a pervasive manner.

Richa Rashmi Sarmah and Debashish Gogoi et. al, (2019), From the study of the assembly line, it can be summarized that, through logical planning and proper distribution of total job between the work stations a balanced assembly line can be obtained. In order to, achieve that, certain factors like the number of work stations, cycle time, takt time, total cost imposed and productivity must be given special attention. Therefore, we must arrange the work stations in such an optimal way that higher productivity can be achieved for an organization at a comparatively low cost.

Muhammad Waseem Bari, Meng Fanchen and Muhammad Awais Baloch et. al, (2016), This study examines the direct and indirect effect of TQM on soft job satisfaction practices in the context of the Pakistani banking sector. The relational psychological contract mediates the relationship between gentle TQM practices and job satisfaction. A questionnaire was designed and distributed to 400 employees of different management levels. The helpful response rate was 74%. The data were analyzed using the SEM-PLS technique. The main findings were as follows: (1) Three gentle TQM practices (teamwork, rewards and recognition, and education and training) had a significant direct and indirect effect on job satisfaction. Organizational culture (OC) does not have a direct effect on job satisfaction; however, PRC participates significantly in the indirect effect of CO on job satisfaction.

Mohd Ghazali Maarof and Fatimah Mahmud et. al, (2016), This paper reviews some selected factors that contribute to the successful implementation of Kaizen and its challenges among small and medium-sized businesses. Factors such as good communication between senior management and their employees, a clear corporate strategy, the presence of a Kaizen champion staff in the organization, good knowledge management, and employee empowerment were found to contribute to the successful implementation of Kaizen. The review also found that resistance to change, lack of employee motivation, lack of understanding of companies' strategic path, and difficulties in managing continuous improvement formed some of the challenges in implementing Kaizen. It seems that there are 18 some similarities between small and medium-sized companies and large companies in terms of the factors that contribute to the implementation of Kaizen. Therefore, this document can provide some ideas on the factors that contribute to the successful implementation of Kaizen and their challenges.

Gulin Idil Sonmezturk Bolatana, Sitki Gozlub, Lutfihak Alpkanc and Selim Zaimd et. al, (2016), The aim of this research was to define the critical factors of technology transfer performance and to measure its impact on quality performance and total quality management. In this study, a questionnaire form was designed and later conducted face to face with manufacturing managers or quality managers of manufacturing companies in Turkey. Two hundred organizations of the 1000 largest enterprises according to the classification of the Istanbul Chamber of Industry were assessed. A model was developed to study the relationships between technology transfer performance, quality performance and total quality management based on theoretical considerations. Technology transfer performance had a positive and strong impact on total quality management, but it did not have a significant impact on quality performance. A positive and solid relationship has been established between total quality management and quality performance. The relationship between technology transfer performance and quality performance has become significant with the mediating role of total quality management.

Ignatio Madanhirea and Charles Mbohwab et. al, (2016), This research focused on the study of statistical process control, i.e., the TQM tool in manufacturing systems, with the general objective of updating them to improve quality and profitability. This is an attempt to fill the gaps in the literature on the implementation of TQM. With a focus on early detection and prevention of problems, TQM has proven to have a clear advantage over quality methods such as final product inspection. It was necessary to check the meters and machines and determine the need for maintenance or overhaul, as faulty machines could not produce good quality products. Operators had to be trained, new documents produced and actions agreed for the future. A system should be in place to review progress and monitor results with as much priority as financial results.

Mohd Ghazali Maarof and Fatimah Mahmud et. al, (2016), The This paper reviews some selected factors that contribute to the successful implementation of Kaizen and its challenges among small and medium-sized businesses. Factors such as good communication between senior management and their employees, a clear corporate strategy, the presence of a Kaizen champion staff in the organization, good knowledge management, and employee empowerment were found to contribute to the successful implementation of Kaizen. The review also found that resistance to change, lack of employee motivation, lack of understanding of companies' strategic path, and difficulties in managing continuous improvement formed some of the challenges in implementing Kaizen. It seems that there are 18 some similarities between small and medium-sized companies and large companies in terms of the factors that contribute to the implementation of Kaizen. Therefore, this document can provide some ideas on the factors that contribute to the successful implementation of Kaizen and their challenges.

G.R.Esmaeilian, F.Ghanbarian et. al, (2015), In this paper, we study and modeled the PMMALB/D problem with two objectives: reducing the number of workstations required and reducing the cost of labor. Moreover, a computational test, which was done using the prominent dataset in this field, was evaluated.

Jayant, Mohd. Azhar and Priya Singh et. al, (2015), The main objective of this document was to provide an updated and structured overview of the recent review of the literature related to interpretive structural modeling and its implementation to model variables of supply chain management and other related fields. The ISM literature is examined in three ways. First, phase of study of the concept of ISM and examination of ISM as a modeling technique. In the second phase, application of it to model supply chain management. Third, phase of the ISM technique by researchers in their modeling work in different fields. All this description of the literature provides a good basis and a clear guide for researchers on the ISM methodology. Using the ISM methodology, the researcher and industry manager can develop the model from variables from different domains, which improves the performance of those domains.

Filiz Eryılmaza and Mehmet Eymen Eryılmaza et. al, (2015), The middle-income trap based on per capita income and measuring per capita income in dollars and primarily against purchasing power parity indicates the vicious circle in which a country enters at a certain level of income. Thus, countries caught in the middle-income trap remain in this cycle for long periods of time and have not been able to reach the next income level, the high-income group. Several ways out of this trap for countries have been proposed in the literature highlighting the importance of incentives and support that the state could provide to the private sector. The objective of this study was to discuss the possible changes that the incentives provided by the State based on R&D innovations could initiate in particular in the competitive strategies of large companies and to present two proposals based on this discussion on all aspects such as as Value Stream Mapping (VSM), Cellular Manufacturing (CM), U-line System, Line Balancing, Inventory Control, One Minute Die Swap (SMED), Pull System, Kanban, Production Leveling, etc. a lean roadmap for the organization to implement the lean manufacturing system. Analyzes of the scoping survey results have been summarized in this article to illustrate the sequence of implementing lean elements in a volatile business environment and the findings of this review have been synthesized to develop a unified theory for the implementation. lean elements.

Akhil Kumar et. al, (2014), This paper shows that one the major difficulties companies encounter in attempting to apply lean is not knowledge of tools and techniques, perhaps lack of comprehensive and suitable lean knowledge related to probable problems within the companies by the managers, direction, gap and a lack of recognition of lean culture in whole of the organization and planning cause the fails within the implementations. Additionally, some managers try to enhance the implementation by some of the lean tools and mostly try to only implement the "continuous improvement" and explicitly forget another basic lean principle, "respect for people". The managers should know that lean thinking won't derive during a short time, and they should prepare the context of implementations before every decision making. Lack of Planning, Lack of top management commitment, Lack of Methodology, Unwillingness to learn and see and Human Aspects are the main barriers or problems which can be faced while implementing the Lean Manufacturing. These have already been discussed in the previous section.

Dr. Nitin Upadhye, Devendra Singh Awana and Sandeep Mathur et. al, (2014), This study had attempted to find the catalysts from the literature review and expert opinions from the corrugated packaging industries and developed the matrix of relationships to see the driving power and dependence between them. In this study, a modeling was carried out in order to know the interrelationships between the catalysts using interpretive structural modeling and the multiplication of the cross-impact matrix applied to the classification, i.e., MICMAC analysis for the performance of the Indian corrugated packaging industries.

Dr. Meenakshi Tyagi et. al, (2014), Small and medium-sized enterprises have played an important role in the growth process of the Indian economy since independence, despite stiff competition from the large sector and lackluster support from the government. The essence of the argument that comes to mind was that although they play a crucial role in contributing enormously to job creation in the country, SMEs are not well equipped and work in the traditional way to do so. facing the challenges of global competition. Due to globalization, the competition was very stiff and the big players have a strong hold on the market because they are prosperous in every area be it money, management, machines or methods. They must work with TQM components to meet the challenges in today's competitive global 24 environment. The objective of this document was to declare the urgency of TQM to improve the productivity and quality level of SMEs by showing the result of companies that have successfully implemented TQM. This study was able to present the importance of the TQM approach and provides a positive direction for future work.

Raj Kumar et. al, (2014), He focused on improving quality and productivity significantly to improve the competitiveness of an organization. Organizational leadership plays a vital role in affecting the efficiency and productivity of a particular organization and the management of employees and workers involved. But the quality of business leadership was another problem in implementing TQM in these companies. This document has tried to find out what are the factors that hinder the implementation of the total quality management of small and medium-sized companies for a continuous process of business development. Data had been collected from 100 units of small and medium-sized enterprises located in rural or urban areas. For data reduction, the factorial analysis technique was used. After data collection, the model was developed.

Suresh Prasad and S.K. Sharma et. al, (2014), Operations management has long been focused on waste reduction, so modern management programs like Lean Manufacturing represent today's best practices in operation management. Even without explicitly targeting environmental results, lean efforts can yield sufficient environmental benefits. However, because environmental wastes and pollution are not the main focal points, this achievement may not be maximized in the normal scheme of lean. Thus, it is concluded that the two strategies (lean and green) can be integrated and offered simultaneously in the operation management to reduce both waste and pollution.

PROBLEM STATEMENT

Assembly line balancing (ALB) problems mainly deal with proper allocation of tasks to the workstations in a balanced manner without violating the precedence relationship and optimizing a given objective function. This problem mainly occurs in a continuous production line and is classified as one of the hard optimization problems. Since the installation of assembly line is a long-term decision and highly cost intensive, there is a proper need of designing the assembly line and balancing the workload at the workstations. The assembly line balancing problem (ALBP) consists of assigning tasks to an ordered sequence of stations such that the precedence relations among the tasks are satisfied and some performance measure is optimized.

OBJECTIVES

- To minimize the number of work stations for a given cycle time.
- To minimize the cycle time for a given number of workstations, to reduce the cost & to maximise the profit.
- To improve the productivity of the process with less nos of non-value-added activities.
- Proper utilization of the space & to avoid the unnecessary movements.

METHODOLOGY

Step 1: - A reliable stopwatch to perform time study.

Step2: - A data collection sheet to record work elements and corresponding times.

Step 3: - The obvious problems are taken care of first. There is no reason to spend time describing and timing work elements that are obviously unnecessary or redundant.

Step 4: - The time study analyst should familiarize with the assembly operations before documenting the elemental times. Also, there should be plenty of communication between assembly operator and the time study analyst. The operator participation must be encouraged and their ideas must be captured.

Step 5: - Start the study capturing all work elements first (VA and NVA) – once all work elements have been captured, and then proceed to time them one by one. Trying to do both simultaneously can be overwhelming and confusing.

EXPERIMENTAL PROCEDURE:

The Time Sheet data in Table 5.1 shows the no. of work element steps enlisted in the study. The below table distinguishes the type of activity & their respective avg. time taken for the respective activity & the standard time for it. The activities are distinguished in five ways, set-up tasks, actual processing tasks, administrative system tools, non-value added, value-added. The following table 5.1 shows the distribution of Value added, non-value added, set-up tasks, administrative tasks, actual processing tasks & their respective Std. time & average time from the selected study.

Table 5.1 Work Element Sheet with Time Data

Sq. No.	Work Element	Type of Activity					Time	
		S	P	A	VA	NVA	Avg.	SD
1	Take Master Box	ü						
2	Take Mixer Body	ü						
3	Attach the rotating switch from inside & screw it.	ü						
4	Fit the indicator	ü						
5	Take accessories		ü				0.82	0.21
6	Fit small rubber on top of the body		ü				3.10	1.91
7	Check the test lamp					ü	2.80	1.06
8	Check the motor wiring by the intensity of bulb to assure the 1^{st}, 2^{nd} & 3^{rd} speed.		ü				7.82	1.89
9	Attach the motor to the body		ü				1.42	0.61
10	Drill the center of the top					ü	1.91	0.50
11	Add washer on top					ü	1.93	0.74
12	Fix the motor by means of screw & washer		ü				3.89	1.55
13	Take rubber base at bottom		ü				3.56	1.88
14	Do oiling on the rubber base				ü		1.87	0.55
15	Fit them in the respective hole		ü				2.44	0.82
16	Take overload circuit breaker		ü				1.05	0.50
17	Fix the circuit breaker at the body base					ü	0.80	0.32
18	Take the knob in the rotary switch					ü	0.57	0.16
19	Check the test lamp for speed					ü	0.69	0.24
20	Connect a 3-inch wire in point O of rotary switch.		ü				2.36	1.05
21	Check again the speed		ü				1.78	0.65
22	Check for point 1,2,3					ü	0.76	0.34
23	Attach rotary switch O to speed point 1 of motor		ü				5.49	2.53

24	Attach 1st speed of the motor point connect to the point 1 of rotary switch					ü	1.43	0.75
25	Attach 2nd point of speed of motor point to the end point of the rotary switch					ü	1.00	0.82
26	Take the mains lead					ü	1.29	0.69
27	Cut the wire points		ü				2.01	0.51
28	L side of the mains lead & one side of the indicator will connect to the pole point P of the rotary switch		ü				1.69	0.45
29	Joint the points by the soldering process		ü				14.53	44.56
30	Join the tip of the wire on the second point of the indicator		ü				1.70	0.69
31	connect side of indicator & side of the mains lead will connect to circuit breaker		ü				2.21	1.52
32	Join the wires by soldering					ü	0.71	0.39
33	Neutral side of the motor will connect to another side of the circuit breaker				ü		1.40	0.66
34	Join the wires by soldering					ü	0.76	0.30
35	Neutral side of the motor will connect to another side of the circuit breaker				ü		2.12	0.98
36	Earthing wire of the mains lead will connect to the body of the mixer motor		ü				2.96	1.54
37	Make a gap for mains lead		ü				1.87	0.86
38	Bottom side of the body attached to the upper section body of the screws		ü				0.98	0.59
39	Check the mixer operation by the electricity source		ü				2.41	0.73
40	Fix the coupler on the top section of the coupler		ü				3.10	1.32
41	Again, check the operation & rotation of the coupler		ü				7.09	1.53
42	Attach the mixer jar to the mixer body					ü	0.77	0.40
43	Check the working of the mixer by attaching the jar		ü				0.78	0.21
44	Wound the wire		ü				4.02	1.88
45	Place it in the wrapper		ü				6.72	3.44
46	Place the package in box		ü				1.36	0.43
47	Tape master box	ü						
48	Move to storage	ü						
Total							107.99	seconds

Table 5.2 The relation between cumulative annual usage and cumulative value of items

Work Element Sequence No.	Work Element	Time Samples												Avg. Time	Std. Dev.	Standard Error
		1	2	3	4	5	6	7	8	9	10	11	12			
5	Take accessories															
6	Fit small rubber on top of the body															
7	Check the test lamp															
8`	Check the motor wiring by the intensity of bulb to assure the 1st, 2nd & 3rd speed.															
9	Attach the motor to the body	1.33	1.18	0.68	0.87	1.00	0.87	0.87	0.85	0.89	1.01	0.83	1.17	0.96	0.18	0.05
10	Drill the center of the top	4.24	3.30	3.10	2.68	5.90	2.72	4.62	4.58	4.09	3.97	4.31	2.71	3.85	0.94	0.27
11	Add washer on top	1.13	0.65	0.52	0.63	0.86	0.72	0.62	0.61	0.92	1.30	1.22	0.75	0.83	0.25	0.07
12	Fix the motor by means of screw & washer	1.22	0.67	1.15	0.52	0.74	0.72	0.72	0.94	1.12	1.50	0.69	0.81	0.90	0.28	0.08
13	Take rubber base at bottom	3.78	1.66	1.83	1.68	1.42	1.26	1.36	1.64	1.74	1.25	1.71	1.08	1.70	0.67	0.19
14	Do oiling on the rubber base	2.49	3.31	1.64	1.59	2.40	2.45	2.26	2.40	2.36	1.12	3.73	2.12	2.32	0.68	0.20
15	Fit them in the respective hole	0.95	0.68	0.41	0.70	0.33	1.77	1.38	0.57	0.56	0.56	0.39	0.63	0.74	0.41	0.12
16	Take overload circuit breaker	1.00	0.91	0.59	0.57	1.13	0.68	1.63	0.31	0.43	0.70	0.66	0.64	0.77	0.34	0.10
17	Fix the circuit breaker at the body base	1.12	1.16	1.14	2.09	0.93	0.79	1.43	1.28	1.13	1.24	1.16	1.30	1.23	0.3	0.09
18	Take the knob in the rotary switch	1.08	0.68	1.07	1.09	1.30	1.07	0.76	0.90	1.37	1.02	0.88	0.97	1.02	0.19	0.05
19	Check the test lamp for speed	1.70	1.30	0.73	1.17	0.30	0.86	0.76	0.82	0.80	0.74	0.73	0.74	0.89	0.34	0.10
20	Connect a 3-inch wire in point O of rotary switch.	3.54	3.62	3.88	6.89	2.92	4.19	3.21	3.43	3.47	3.87	3.69	3.72	3.87	0.96	0.28
21	Check again the speed	3.91	7.51	4.53	5.14	4.06	5.39	4.11	3.20	5.10	3.27	3.02	3.57	4.40	1.21	0.35
22	Check for point 1,2,3	2.27	1.37	1.43	1.45	2.26	1.53	1.80	1.63	1.72	1.54	1.97	2.16	1.76	0.32	0.09
23	Attach rswitch O to speed point 1 of motor	0.84	1.48	1.19	2.12	3.23	1.14	1.60	1.56	1.92	1.07	1.17	1.76	1.59	0.61	0.18
24	Attach 1st speed of the motor point connect to the point 1 of rotary switch	1.91	1.83	1.16	1.23	0.98	1.02	1.24	1.14	0.97	0.85	0.91	1.43	1.22	0.33	0.09
25	Attach 2nd point of speed of motor point to the end point of the rotary switch	1.04	0.57	0.83	0.94	1.11	1.06	1.12	1.18	0.89	0.90	0.85	0.96	0.95	0.16	0.05
26	Take the mains lead	0.61	0.65	0.30	0.73	0.80	0.59	0.44	0.64	0.76	0.56	0.65	0.74	0.62	0.14	0.04
27	Cut the wire points	2.42	2.11	1.94	1.98	2.89	3.51	2.96	3.11	3.01	2.62	3.00	2.30	2.65	0.48	0.14
28	L side of the mains lead & one side of the indicator will connect to the pole point P of the rotary switch	1.08	1.27	0.94	1.08	0.70	0.88	1.56	1.91	1.09	1.06	1.80	0.89	1.19	0.36	0.10
29	Joint the points by the soldering process	3.51	2.21	2.06	2.48	2.36	2.89	1.39	3.01	2.01	3.11	2.00	3.32	2.53	0.61	0.18
30	Join the tip of the wire on the second point of the indicator	0.88	0.59	0.72	0.50	0.66	0.62	0.79	0.81	0.67	0.87	1.00	0.73	0.74	0.13	0.04
31	connect side of indicator & side of the mains lead will connect to circuit breaker	2.38	1.81	0.71	0.81	0.80	0.87	0.68	0.81	1.13	0.65	1.18	0.91	1.06	0.5	0.14
32	Join the wires by soldering	2.63	1.78	2.50	1.52	1.55	1.66	2.28	2.69	1.89	0.88	2.34	2.16	1.99	0.52	0.15
33	Neutral side of the motor will connect to another side of the circuit breaker	1.90	1.99	1.47	1.28	1.64	1.56	1.81	1.56	1.86	1.37	2.24	1.50	1.68	0.27	0.08
34	Join the wires by soldering	4.92	4.42	5.12	4.42	2.46	3.64	5.95	4.37	3.20	4.07	3.82	3.74	4.18	0.88	0.25
35	Neutral side of the motor will connect to another side of the circuit breaker	1.56	2.00	2.56	1.06	1.67	1.75	2.10	2.75	4.70	2.13	2.21	2.16	2.22	0.86	0.25
36	Earthing wire of the mains lead will connect to the body of the mixer motor	5.25	4.32	4.50	4.14	3.90	6.86	4.62	4.08	4.19	3.19	4.31	4.78	4.51	0.85	0.25
37	Make a gap for mains lead	1.56	1.18	1.39	1.62	1.62	1.36	1.41	2.35	1.18	1.23	1.31	1.56	1.48	0.3	0.09
38	Bottom side of the body attached to the upper section body of the screws															
39	Check the mixer operation by the electricity source															
	Total Time (Per one individual package)													53.87 seconds		

The mean station times follow a Normal Distribution and the loading and unloading times are estimated to have Triangular Distribution. The distribution is found from the available data for station times. The actual data is not available for loading and unloading times. Hence, it estimated that these times lie between 3 seconds and 5 seconds. MINITAB Statistical Tool is used to draw both the distributions. By using the estimated data, we can conclude the loading and unloading time distribution in Minitab software. Fig. 5.2 shows the loading and unloading time distribution.

Table 5.3 Time Study Data Sheet with Station Times

Sr. No.	Cycle Time inSeconds	Avg. Station Time in Seconds	Std. Dev.
Stn 1		11.31	1.52
Stn 2		11.16	1.72
Stn 3		10.97	1.12
Stn 4		8.04	0.96
Stn 5	10.77	12.39	1.6

Figure 5.1 Station Time Distribution

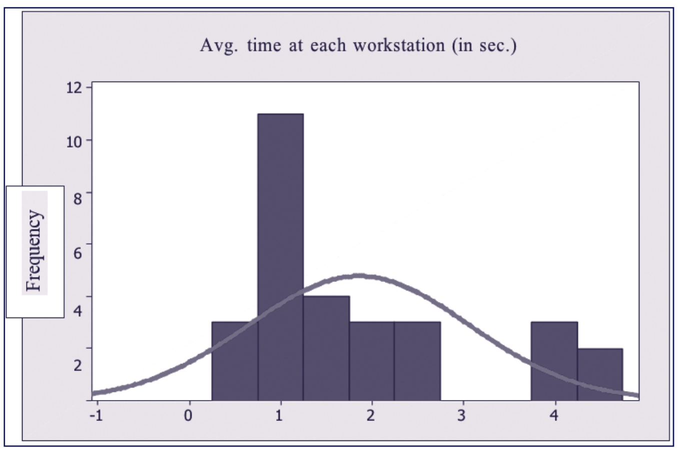
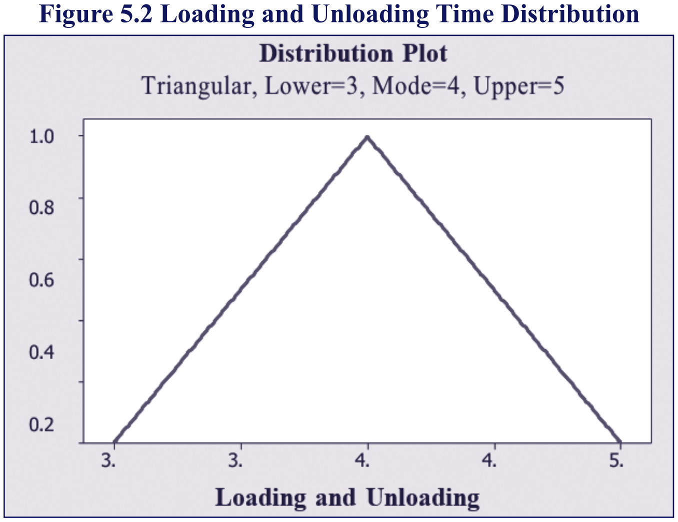
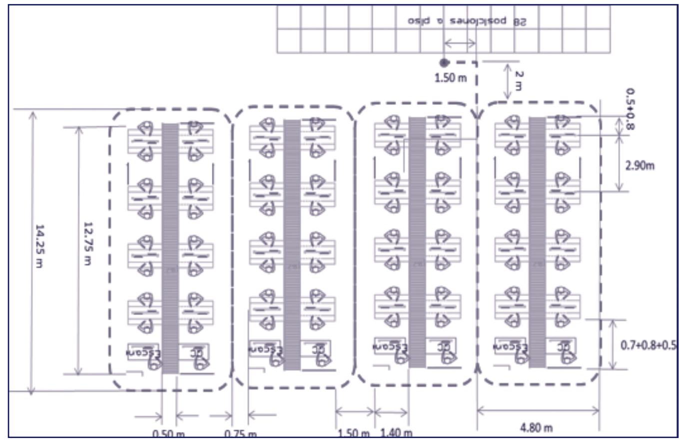


Figure 5.2 Loading and Unloading Time Distribution



The dimensions and the layout used for simulation of Single Stage Parallel Line configuration is given below in figure 5.3 as shown.

Figure 5.3 Assembly Layout with Dimension



The figure 5.4 shows the detailed assembly layout with dimensions & the pattern of assembly table and the sitting pattern of workers. Red dotted line shows the path movement of the material handling.

Figure 5.4 Material Handling Cart Routing Logic

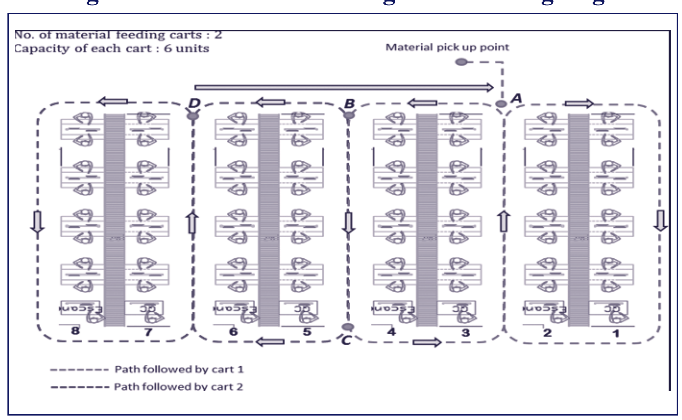


Figure 5.4 shows Cart movement logic in material handling, both the carts 1 & 2 pick-up boxes at the pick-up point and go to A. Path followed by cart 1 & 2 are shown by red and blue dotted line respectively. Firstly, at position A, Cart 1 checks for the total number of boxes across buffers in line 1 and line 4. It then proceeds to the fill the line with a smaller number of boxes as per requirement. Cart 2 directly proceeds to point B. Now at point B, firstly Cart 2 checks for the total number of boxes across buffers in line 5 and line 8. It then proceeds to the fill the line with a smaller number of boxes. At C, Cart 1 proceeds to fill lines 2 and 3. If empty, goes to the pickup point. If cart 2 is empty, it proceeds along line 3 to the pickup point, else goes to fill lines 6 and 7. At D, If cart 2 is empty it directly goes to pick up point to load boxes, else goes to fill line 8. Then, the finished master boxes are moved to bar-coding manually by operators. Now the figure 5.5 shows the improved assembly layout material handling, where bar coding area is connected to the assembly area as to reduce the travelling of material after assembly to barcode area. It will save the material handling time.

Figure 5.5 Five-Stage Serial Line Configuration

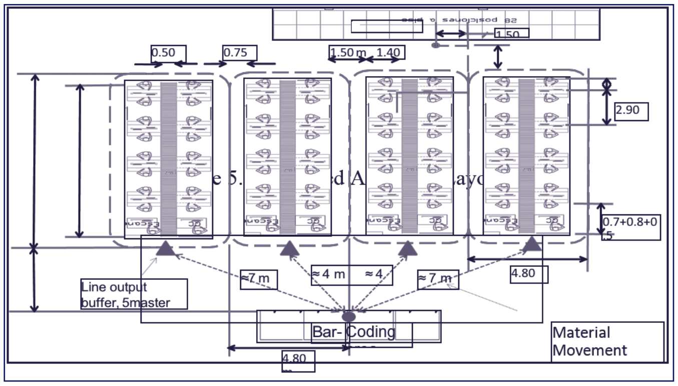
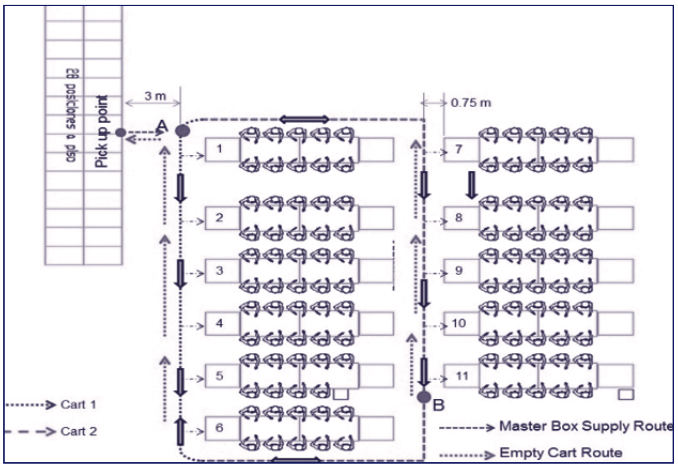
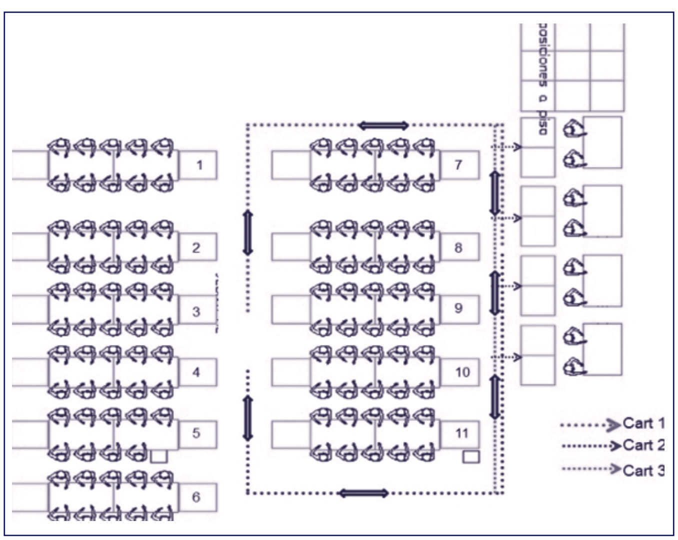


Figure 5.6 Material Handling – Supply Side



The below figure 5.6 shows the material handling for five stage assembly line is broken down into two parts based on master box supply and finished master box transport to bar-coding area. Carts 1 & 2 load master boxes at the pickup point and proceed to point A. At point A, cart 1 goes to fill tables numbered from 1 to 6. Cart 2 goes to filltables numbered from 7 to 11. After unloading at each table, if the empty carts go to the pickup point to loadmaster boxes through the path shown in red. Else

Figure 5.7 From Assembly to Bar-Coding

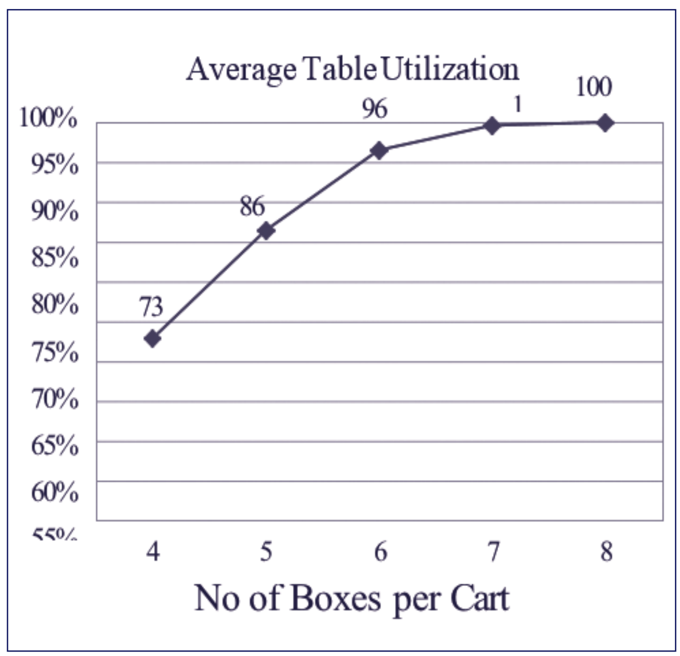


proceeds to the next table at point B, if the cart 2 has enough master boxes goes to fill tables 6 to 1, else goes to the pickup point though the path shown in red. If all the buffers are full, the carts wait at point A Cart 1 is dedicated to tables numbered 1 to 6 and Cart 2 to tables 6 to 11.

Figure 5.7 shows the assembly to bar coding section layout. In the figure 5.5 the movement of the master boxes to the bar coding are is shown in red, blue & pink dotted line from the respective tables. The carts wait until at least one master box is ready at each of the buffers. Cart 1 serves tables1, 2 and 3. Cart 2 serves tables 4, 5 and 6. Cart 3 serves tables 7,8,9,10 and 11. Cart 1 unloads at bar-coding stations BC1, BC2 and in that order. Once empty goes back along the same path to load boxes at tables 1,2 and 3. Cart 2 unloads at bar-coding stations BC4, BC3 and in that order. Once empty goes back along the same path to load boxes at tables 4,5 and 6, Cart 3 starts at table 11 and proceeds to table 7. If full unloads at the corresponding bar-coding station. If it has free space, goes to load at next table and so on. It is assumed that the empty master box is available at the end of table.

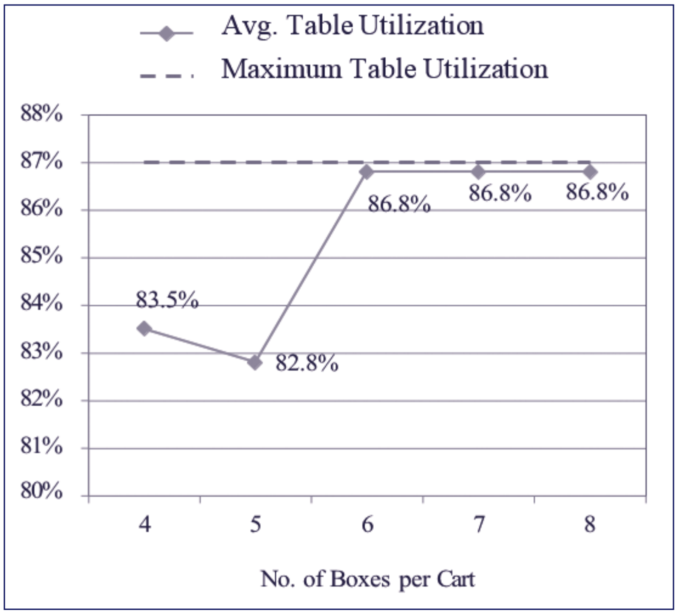
5.4 Material Handling Cart Capacity.For single stage line it can be seen from Figure 5.8 that at cart capacity as 6 boxes maximum utilization is achieved. The idle time for material carts increases when the capacity exceeds 6 units although utilization is 100%, which is not recommended. Similarly for five-stage line, maximum table utilization is observed at a capacity of 6 boxes. So, for both the configurations the material handling cart loads 6 boxes per trip.

Figure 5.8 Cart Capacities for single stage parallel line layout



For five stage serial line layout the green line shows the respective efficiency % for the no. of boxes ^ the box. Table utilization. So, from the graph for both the layouts the material handling cart loads 6 no of boxes for a trip.

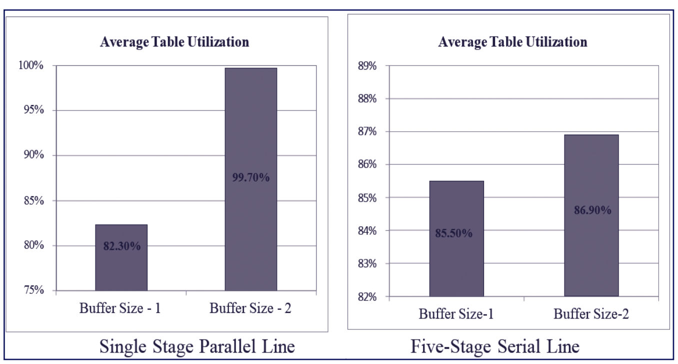
Figure 5.9 Cart Capacities for five-stage serial Line Layout



5.5 Material Handlers Required – Supply Side With the cart capacity fixed as 6 units, iterations are run by varying the cart quantities. For both the configurations, 2 carts are required to supply master boxes to input buffers.

5.6 Input Buffer Size- The assembly tables yield maximum utilization when the input buffer size is 2 units. Figure 5.10 gives the analysis of changing buffer sizes on the average table utilization.

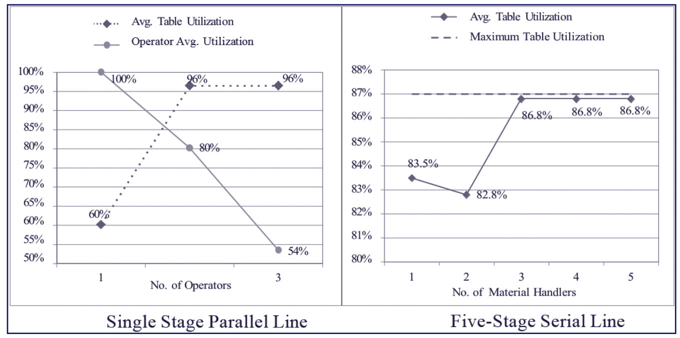
Figure 5.10 Buffer Sizes for Both Configurations



5.7 Output Buffer Size- The output buffer size is determined by performing iterations by varying the output buffer capacity for fixed input buffer sizes, cart capacity and quantity. The output buffer capacity is obtained for single stage line as 5 units and for five-stage line as 2 units per table.

5.8 Material Handlers Required – Bar Coding Side-The single stage line requires two operators to carry finished master boxes to bar coding area. The five-stage line requires three material handlers with carts to transfer master boxes to bar coding area. This is determined based on how the finished box removal from output buffer affects the assembly utilization. The material handling requirements based on the table utilization is shown in figure 5.11.

Figure 5.11 No. of Material Handlers Required



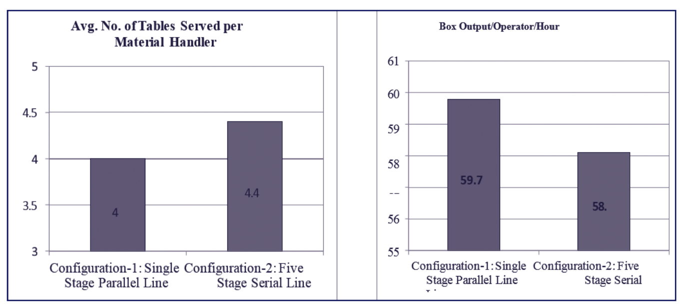
RESULT

The table 5.4 compares the results for the two assembly configurations tested.

Table 5.4 Consolidated Results

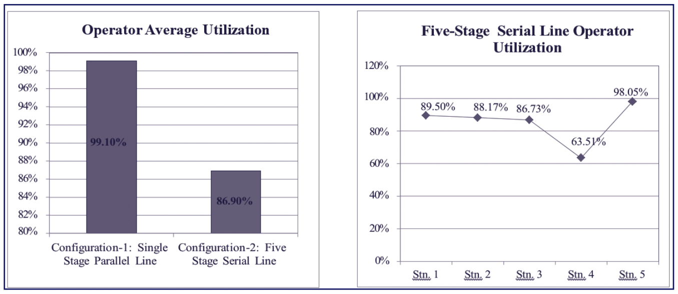
Parameter	Single Stage Parallel Line	Five Stage Serial Line
No. of material handlers required – Supply side	Carts with operators 2	Carts with 2 operators
No of material handlers required – Bar coding side	Operators 2	Carts with 3 operators
Cart capacity	Boxes 6	Boxes 6
Input buffer size	Boxes 2	Boxes 2
Output buffer size	Boxes 5	Boxes 2

Figure 5.12 Results Comparing Two Configurations



The consolidated results comparing the two assembly line configurations are as follows. Fig. 5.12 shows avg. no of tables Served Per Material Handler**:** Number of tables served by each material handling unit is higher for five stage serial line configuration. Fig 5.13 shows that the five-stage serial line requires less material handlers than the single stage line. The number of tables to be served is lesser in five stage configurations compared to the single stage configuration. But it can be observed that the difference is not highly dominating. Productivity: The single stage configuration gives output as 59.7 boxes/operator/hour where as five stage line gives 58 boxes/operator/hour. There is a considerable improvement in productivity in both the assembly lines from the original method. Operator Utilization**:** Figure 5.13 shows that the average operator utilization for single stage line is about 99% and for five stage line is 86.9%. For a five- stage line all the operators at different stages of assembly line are not uniformly utilized.

Figure 5.13 Operator Utilization



While solving an assembly line balancing problem, certain amount of imbalance in station times is inevitable. In this case, the level of imbalance has a great impact on the assembly line utilization. It is recommended to implement the single stage parallel line in order to achieve higher productivity and better overall assembly performance.

CONCLUSION

From The current study is used Assembly Line Balancing tool for increasing the productivity of manufacturing industries. Technological advances have driven dramatic increases in industrial productivity since the dawn of the Industrial Revolution. The three-step methodology incorporating Lean principles is applied to a case study problem and two different assembly configurations are developed and compared, namely Single Stage Parallel Line and Five Stage Serial Line. Based on the simulation performance results, the Single Stage Parallel Line is suggested to be implemented. From fig. 6.1 it can be observed that the proposed system results in doubled productivity.The improved assembly line gives an output of 59.8 boxes/operator/hour, which is about a 90% increase in operator productivity from the original method. Also, with this Single Stage Parallel Line, the floor space usage is reduced by half compared to original method.

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