Lean Methodology Practices With Reference to Manufacturing Unit – An Experimental Analysis

Author Details: Dr. N. Venkateswaran-Professor
Panimalar Engineering College-Department of Management Studies
Chennai 600 123

Abstract
The purpose of this research paper is to examine how efficient improvement in productivity can be achieved in a selected industry by deploying Lean Manufacturing Principles & Tools. Current shop floor scenarios of the Main assembly process were discussed and improvement areas were identified were lean techniques were used to reduce the production lead time. The study used most efficient Lean methodologies such as Root cause analysis, Kaizen, MUDA & TAKT time for eliminating wastes, controlling quality and improving overall performance of the more time consuming operations of the various Main assembly processes. Time study also performed to identify the more time consuming sub processes of each of the Main assembly processes. QC tools such as Pareto chart and Cause & effect diagram were used for analysing collected data. The main aspect is to reduce the production lead time through lean techniques. After application of Lean techniques in more time consuming areas of the Main assembly process in the selected industry, there was reduction in lead time of about 20% i.e. 5 to 4 days/unit and reduction in Man hour rate of 14.3% from 112 Man Hours to 96 Man Hours Overall the production capacity was increased to 16.7% (1.2 to 1.4 Units/day) by adopting Lean methodology.
Keywords: *Man hours, pitch time, line-balancing, Muda, Takt time*

1.0 INTRODUCTION

At present scenario, global competition in the manufacturing sector mirrors Darwin's theory of survival of the fittest. Organizations that can meet or exceed customer's expectation have a higher chance of survival. As the past strategies seem not to be working today many organizations have realized the essential need to adopt the lean philosophy instead of the traditional mass production concept in order to stay competitive and survive in the global rivalry situation. Hence, adoption of production standards and strategies such as lean manufacturing has become a key survival technique for many companies across the world. The manufacturing industry in India must also look to leverage its advantages, its large domestic market, good conditions in terms of raw materials and skilled labor, and the quality focus.

The manufacturing industry is one of the core industries playing a key role in the development of a country. It has strong linkage to other sectors like construction, transportation, coal, fuel and power. The industry is characterized by high levels of consumption of more time and man power of the production cost. It is therefore very important that manufacturing companies embrace ides that will guarantee their survival and profitability in the market.

2.0 IDENTIFIED PROBLEM

There are nearly 20 Sub Assembly stations for sub assembly to manufacture different parts of the Dump Truck. The study has listed the major sub-assembly stations below. In the Sub-assembly stations all the related parts are assembled using a standard procedure and with help of many Gig, Fixtures and tools. Some of the major sub-assembly stations are *Engine Sub Assembly, Transmission Sub Assembly, Cabin Sub Assembly, Rear Axle Sub Assembly, Fuel Tank and Hydraulic Tank Sub Assembly, Radiator Sub Assembly, Battery Box Sub Assembly, Tire Sub Assembly and Platform Sub Assembly.*

The main assembly section consists of 4 Stations. In these stations the entire Sub assembled parts and other major parts get assembled to the Main frame. At the 4th station the Dump Truck gets is final structure, standing on the tires mounted to it. The Production Pitch time of the main assembly station is 1.2 Machine / Day. After

the assembly get complete, the engine get its first ignition in final station of the main assembly section and it get driven to the modification area.

Main Assembly is one of the most important processes in the production of Dump Truck. It's only after Main Assembly process the Product gets its true value. Hence this is the area that adds value to the Final Product (Dump Truck). Value creating actions are most possible in the Main Assembly process. Reduction of Lead Time for Main Assembly process could have an adverse effect on the production Lead Time of the Dump Truck.
The six stations in the Main Assembly process to manufacture Dump Truck are:

- **Station 1**: Assembly of Front Axle, Fuel Tank & Rear Suspension
- **Station 2**: Assembly of Engine, Pump, Transmission & Braking systems
- **Station 3**: Assembly of Radiator, Steering cylinder, Turbocharger.
- **Station 4**: Assembly of Cabin, Electrical Harness
- **Station 5**: Assembly of Rear Axle, Platform & Hood
- **Station 6**: Assembly of Tires and filling of oils & brake bleeding

3.0 NEED FOR THE STUDY

The present study deals with the concept of identifying the ways of reducing the lead time of the off highway truck main assembly process of dump truck model ***XXXX***. The main assembly actual working hour is quite high in the manufacturing unit when compared to same process in respective other manufacturing units. The increased assembly time in turn increases the production lead time of the finished goods machines. Reducing supply time of finished product to the customer is an added value to any firm in this competitive world. It is an aspect of **"Competitive Advantage"** to any manufacturing firm. Beside that it could also increase the production capacity of the plant. The study eliminates non-value activities which is a key measure to improve the assembly lead time.

4.0 OBJECTIVES OF THE STUDY

- To analyze the respective Pitch Time of Six Main Assembly Process from Line On ~ Line Off of the Product.
- To examine more time consuming process of each Main Assembly and take necessary countermeasures.
- To improve the Work Procedures to eliminate the Time gap between available and required Lead Time.
- To eliminate all Non-Value Activities to effectively utilize the available time for improving the production efficiency.
- To suggest Value Stream Mapping (VSM), another emerging Lean Tool for the company to improve production efficiency further.

5.0 REVIEW OF LITERATURE

According to **James P. Womack, Daniel T. Jones (2010),** Lean Thinking is a way to specify value, line up value creating actions in the best sequence and perform them more and more effectively. In short, lean thinking is lean because it provides a way to do more and more with less and less human effort, less equipment, less time and less space – while coming closer and closer to providing customers with exactly what they want. It is covert "Muda" into value. The critical starting point for Lean Thinking is Value. Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specific product which meets the customer's needs at a specific price and specific time. Really Important for Japanese firms as they have defined value is fundamentally value from the perspective of the customer.

According to **Arawati Agus, Mohd Shukri Hajinoor, (2012)** there is a strong association between Lean production, product quality performance and business performance. The study reveals that "reduced setup time" appears to be of primary importance in the linkage between lean production, product quality performance and business performance. This implies Lean Production practices improve the level of performances in the industry. The result insists that manufacturing companies must marshal their effort to implement a more effective lean Production in order to improve Product Quality performance and business performance.

According to **Shams Rahman, Tritos Laosirihongthong, Amrik S. Sohal, (2010),** the three high level constructs in lean practices are Just in Time (JIT), Waste Minimization and Flow Management. All the three lean constructs are significantly related to operational performance. The operational performance is measured by four parameters such as quick delivery compared to competitors, unit cost of product, overall productivity and customer satisfaction. JIT has higher level of significance in Large enterprises whereas for Waste minimization there is a higher level of significance for Smaller and Medium enterprises. Flow management has a much lower level of significance for both SMEs and LEs. Most companies do prefer waste management that showed a high level of significance on operational performance

According to **Bhim Singh, S.K. Garg, S.K. Sharma, Chandandeep Grewal, (2010)** remarked in his report that, Lean implementation process quantified the benefits of the production industry. They identified the improvement areas and bridged the gap between existing and required state of the shop floor through lean techniques. Applying lean methods found the reduction in lead time, reduction in processing time, reduction in work –in – process inventory and reduction in manpower requirement. All these reductions finally contributed to rise in Productivity.

According to **Steven Brown, Joerg Domaschke (2011),** Cycle time reduction at Bottleneck areas improves Productivity. Throughput, utilization and cycle time continue to be emphasized as key performance parameters for any existing operations. Managements goal is to process the higher volume, within original cycle time plan, without additional expenditures. Improvements in cycle time creates a shift in Factory performance. The key to success of Cycle time reduction is by working real time with key production personnel for meaningful findings and implementable recommendations. Improvement in cycle time in turn improvement in work station or operation will have a great impact in change on the performance of the overall factory.

According to **Anabela C. Alves, José Dinis-Carvalho, Rui M. Sousa, (2012)** explore the lean production paradigm as a promoter of workers creativity and thinking potential, and recognize this human potential as a fundamental asset for companies growth and success, being a major factor to face the disturbing and unpredictable needs of current markets, providing companies with the necessary agility. For a long period and even nowadays, it is common to consider the workers as just another production factor that the companies explore to obtain the maximum utilization. But lean production acts as a work organization model where the worker assumes a position of thinker, continuously looking for improvement and continuously looking for wastes. By reducing wastes, the company will be prepared to accommodate changes in the market.

According to **Raymond N. Cheser, (2010)** Kaizen a Japanese traditional method has resulted in dramatic gains in productivity. While Kaizen clearly employs scientific management techniques, this conversion also appears to result in enriched jobs and increased motivation. It moves employees to higher levels of growth need strength. It is an important pillar of an organizations long-term competitive strategy. It involves all employees from CEO to the Assembly Line. Kaizen is a daily process the purpose of which goes beyond simple productivity improvement. It is a humanized approach to workers and to increasing productivity. It is a culture of continual aligned small improvements and standardization yields large results in terms of overall improvement in productivity.

6.0 RESEARCH GAP

The above all research on Lean principles were aimed at improving productivity by reducing lead-time of process or operation. This was achieved either by eliminating waste (Muda) or through Kaizen activity. Wastes generally referred to non-value activities in terms of time and motion. Kaizen refers to continuous improvement in any process. The available research article either uses any one of the techniques. However, there is no research combining both the techniques, hence in this study we use the technique of "**Lean-Kaizen"** the combination of waste management with continuous improvement. Waste management eliminates waste and through continuous improvement further such wastes can be avoided for better product.

7.0 RESEARCH METHODOLOGY

The study adopted **experimental research design** where the study carried out by collecting data from various shop floor experts and directly participates in measuring the time involved in various assembly processes. Data are taken from Time study conducted in the rear axle assembly area without any verification physical verification. This research study is based on work measurement conducted during ***April 2017 to June 2017***.

The study collected secondary data from the company's first quarter annual production report and monthly kaizen activities by using cause and effect analysis and work study analysis of each stations of main assembly process. Data were collected based on the time study method (Video study) to calculate the Pitch time and Man hour rate at each stations. First the actual pitch time of each station and Man Hours for each station based on the average value of Assembly of 3 Machines were collected. This helps to identify the Time gap for both pitch time & man hrs. to be reduced for each Station in Assembly process. There is numerous process involved in each station. Hence as a macro study grouped the various processes under below given four categories and found their contributions for the study.

Time Study collected the Man hours for each 6 Stations of the Main Assembly process and the Man hours for all the process involved in the corresponding stations. Based on the collected data need to identify the more time consuming process and analyze them in order to find their root causes and use Lean techniques to eliminate them.

The study make use of lean tools for data analysis like root cause analysis, ***Kaizen, Muda, Gemba, Takt time, time study (work measurement)*** and QC tools like ***Pareto chart and Cause and effect diagram***. Suggestions and clarifications were sought from the manufacturing unit in case of any missing or wrong data and the same was assumed to be correct without any further investigations.

8.0 DATA ANALYSIS AND INTERPRETATION

	Capacity Units/day		ML01	ML02	ML03	ML04	ML05	ML06	Total
Current	1.2	Pitch Time	6.00	6.17	6.14	6.17	6.17	6.70	37.34
		Man Hours	18.00	18.51	18.42	18.51	18.51	20.10	112.05
Target	1.4	Pitch Time	5.35	5.35	5.35	5.35	5.35	5.35	32.10
		Man Hours	16.05	16.05	16.05	16.05	16.05	16.05	96.30
Kaizen Hrs		Pitch Time	0.65	0.82	0.79	0.82	0.82	1.35	5.24
		Man Hours	1.95	2.46	2.37	2.46	2.46	4.05	15.75

Table 8.1: Current Pitch Time & Man Hours for each Assembly Station & Target Value

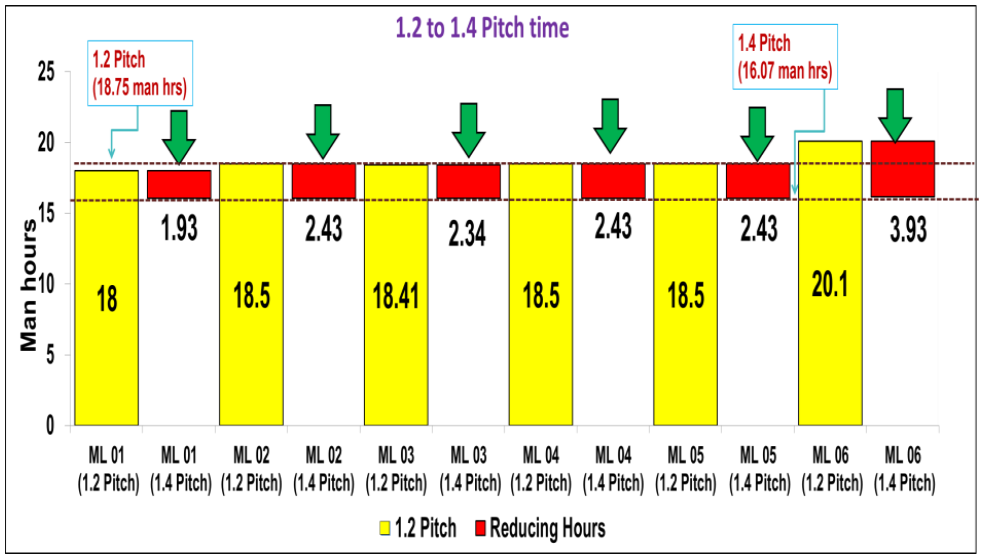


Chart 8.1: Current Man Hours Station wise and Man Hours

From the above table & chart it was inferred that in order to achieve the Target Pitch Time (32.10 Hours) & Man Hours (96.30 Man Hours) we need to reduce the Current Pitch Time & Man hours by 5.24 Hours and 15.75 Man Hours This reduction time is referred as the Kaizen hours as they lead to improvements in assembly line.

Table 8.2: Time study & on various sub-process of assembly process after Kaizen activity

Process	Man Hrs after Kaizen	Reduced Man hrs
Steering & Tie rod Assy	1.67	0.57
Cab Assembly	1.92	0.18
Brake bleeding	1.71	0.19
Bush processing	1.35	0.15
Cat Walk	1.35	0.15
Unit moving	1.35	0.15
Outer Platform	1.22	0.14
Radius rod ring	1.11	0.12
R.Axle Assy	1.06	0.14
Both Front Axle Mtg	0.92	0.13
Rear Support Mtg	0.75	0.10
Suspension Mtg	0.75	0.10
All mtg Brkt	0.70	0.10
Tyre Mtg	0.70	0.10
Hood Mtg	0.70	0.10
Eng Mtg	0.68	0.08
Others	1.91	0.64

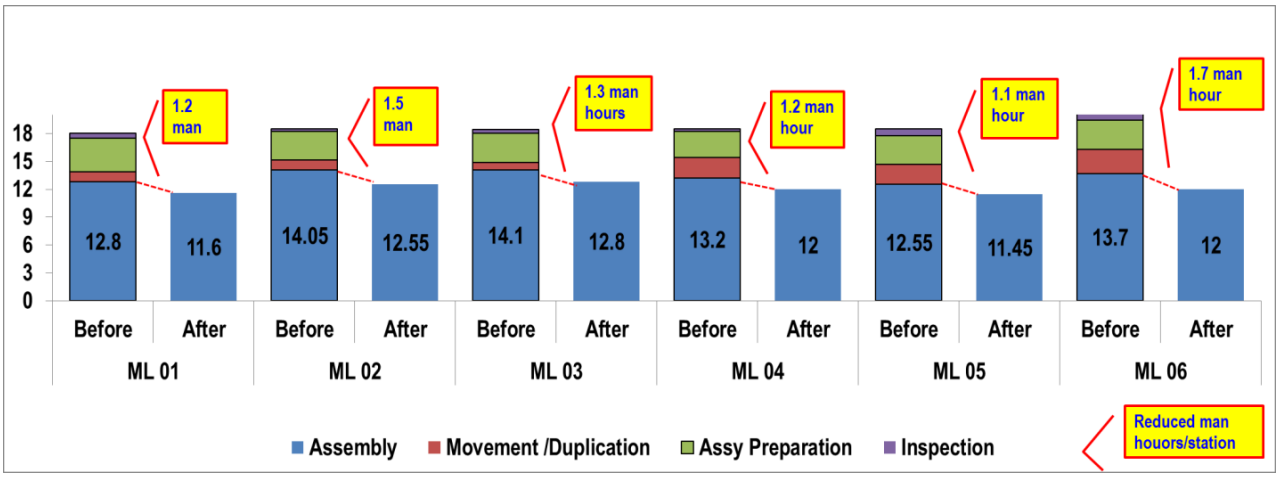


Chart 8.2.1 Effect of Kaizen on reduction of Man Hours in Assembly process – Station wise

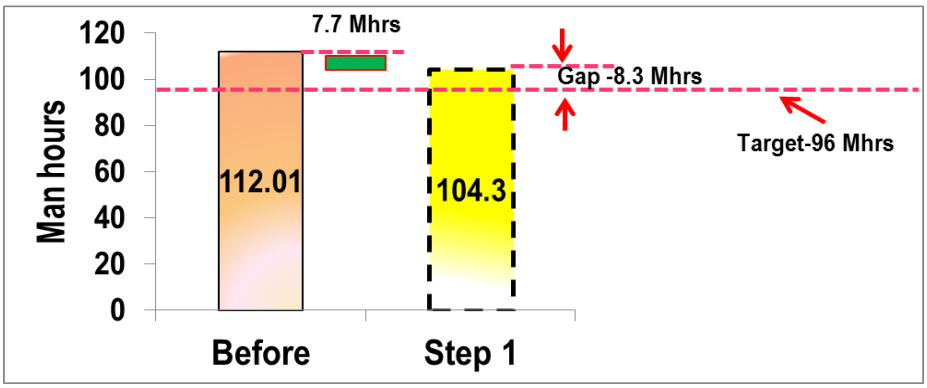


Chart 8.2.2 Effect of Kaizen on Man hours for Overall Main Assembly Process

From the above table and chart it was inferred that by effective use of possible Kaizen activity has reduced the man hours for the Assembly process at each station. Also it has an adverse effect on the overall man hours rate of the Main Assembly process, there is reduction of about 7.7 man hours. Hence now the Current Man Hours for all 6 stations is 104.3.

Table 8.3 Time study on bulk kitting after elimination of Muda

Process	Man Hrs after Muda	Reduced Man hrs
Bulk rekitting & bulk issues	2.1	5.4
Tools Preparation	1.5	0
Duplication work	1	0
Unit moving	1	0
L/T Loading	0.95	0
Transport	0.8	0
Others	6.25	0.63

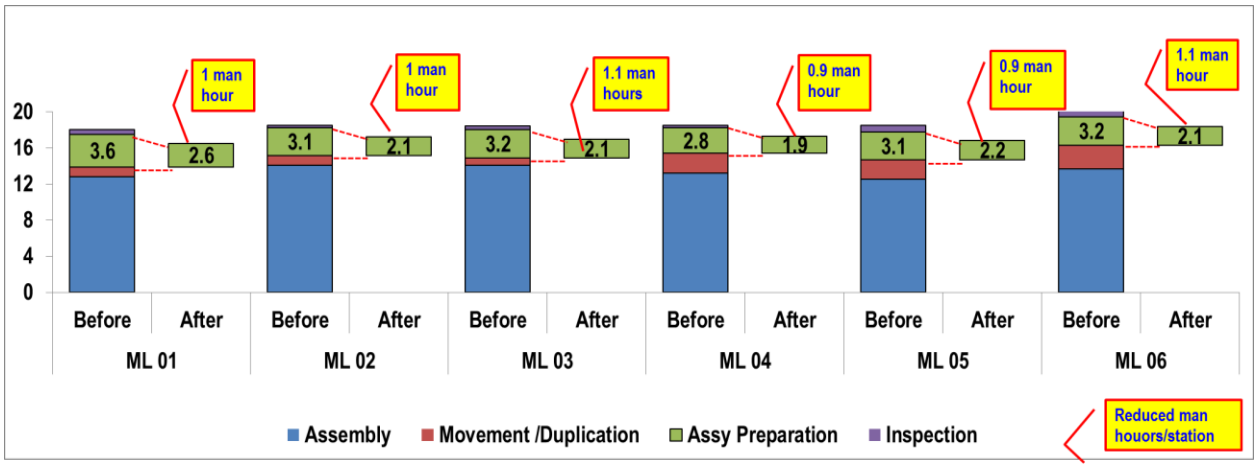


Chart 8.3.1 Effect of Muda on reduction of man hours in assembly preparation process

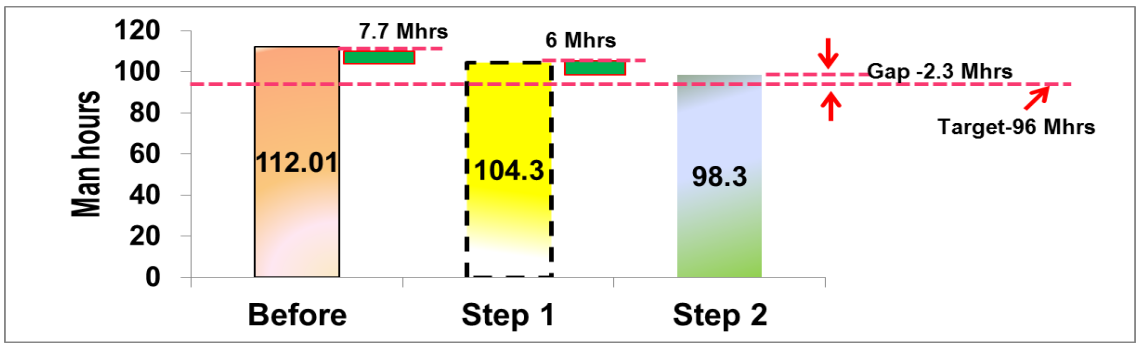


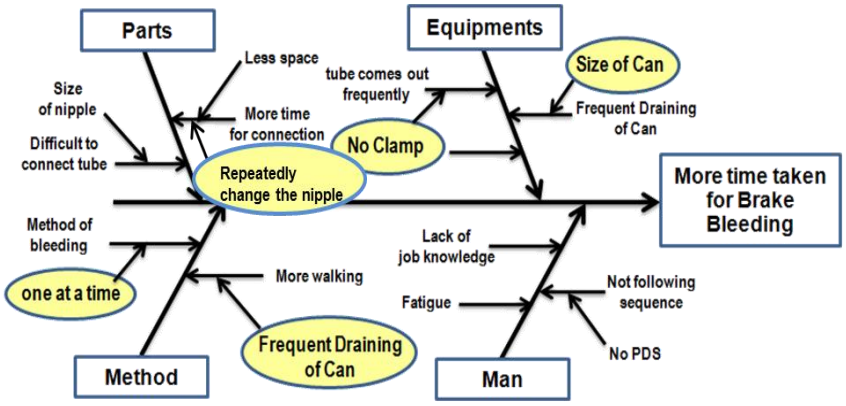
Chart 8.3.2 Effect of Muda elimination on man hours for overall main assembly process

From the above table & Chart it was inferred that by elimination of Muda (Waste motions), there was about saving of 6 Man Hours in the overall Main assembly process reducing it from 104 Man hours to 98 Man Hours

Table 8.4 Validation table on the various causes for more time for brake bleeding process

	Problem Causes	Ranking
Parts	Repeatedly changing the Nipple	**5**
Method	Frequently draining of Can	**3**
	Bleeding once at a time	**4**
Equipments	Size of the can	**2**
	No clamp to hold the bleeding Hose	**1**

Chart 8.4 Analysis of cause of more time for Brake Bleeding Process



From the above Cause and effect diagram it was inferred that absence of proper holding methods has led to more time consumption in the brake bleeding process, hence necessary countermeasures especially kaizen activities has to be initialized to reduce the time consumption which in turn reduces the overall Man hours for the Main Assembly process.

***Table 8.5** Takt-Time vs cycle time calculation and line balancing in each station of main assembly*

Takt time Calculation		
No of Working Hrs /day	=	8.5 hrs.
	=	510 min
Non Working Hrs/day	=	1 hr
(Lunch + Break time)	=	60 min
Available production Hrs/day	=	7.5 hrs.
	=	450 min
Takt Time (min/unit)	=	450/1.4
(Production hrs / Demand/day)	=	321 min/ unit

	ML01	ML02	ML03	ML04	ML05	ML06
Takt Time (min/unit)	321	321	321	321	321	321
Current Cycle Time	312	316	320	318	322	330

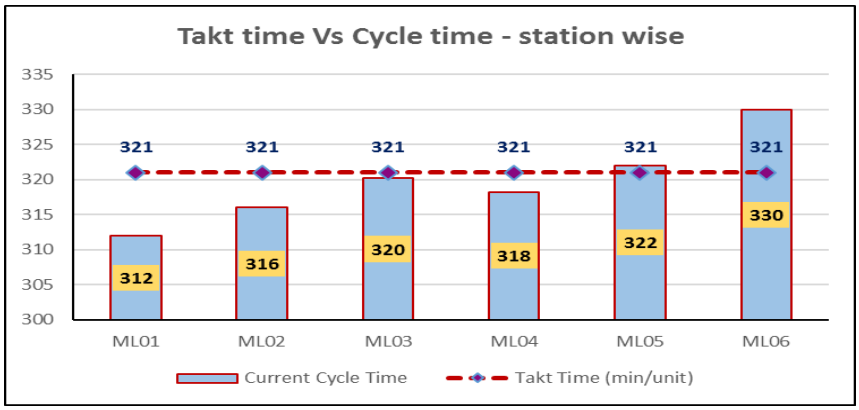


***Chart 8.5** Takt-Time vs cycle time calculation and line balancing in each station of main assembly*

From the above table it was inferred that each station cycle time is not in accordance with TAKT time. For better production efficiency the cycle time /TAKT time should be 1. Hence we need to go for Line Balancing in the stations.

Table 8.6 Takt time vs cycle time calculation after line-balancing

	ML01	ML02	ML03	ML04	ML05	ML06
Takt Time (min/unit)	321	321	321	321	321	321
Current Cycle Time	321	320	321	321	320	321

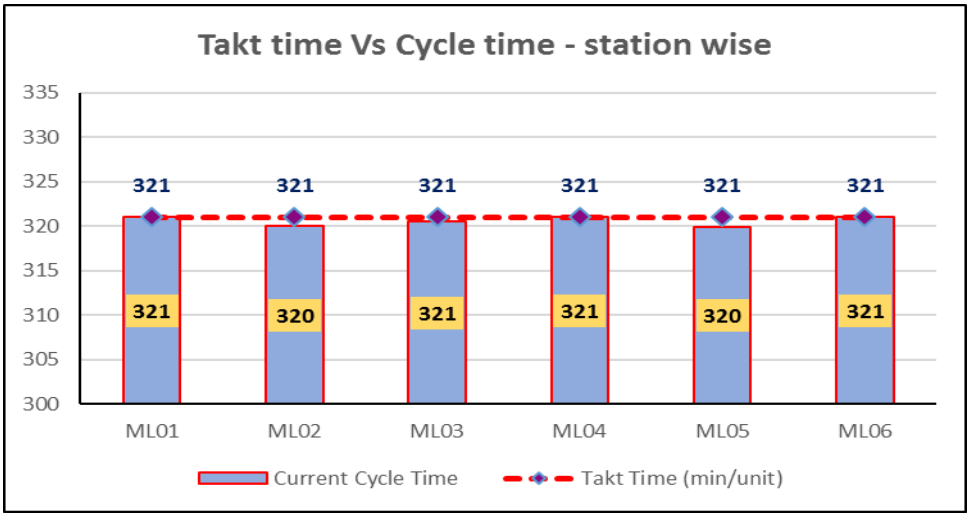


Chart 8.6 Takt time vs cycle time calculation after line-balancing

From the above table it was inferred by accomplishing Lean technique, Line balancing of each 6 stations were made and Line balancing ratio was increased to 99.97%. Also due to Line balancing the cycle time / TAKT time value becomes 1. i.e. the cycle time of each station is same as the TAKT time desired.

RESEARCH RESULTS

- In order to achieve the Target Pitch Time (32.10 Hours) & Man Hours (96.30 Man Hours) we need to reduce the Current Pitch Time & Man hours by **5.24 Hours** and **15.75 Man Hours** This reduction time is referred as the **Kaizen Hours** as they lead to improvements in assembly line.
- Effective use of possible Kaizen activity has reduced the Man Hours for the Assembly process at each station. Also it has an adverse effect on the overall Man Hours rate of the Main Assembly process, there is reduction of about **7.7 Man Hours** Hence now the Current Man Hours for all 6 stations is **104.3 Man Hours**
- Inferred that absence of proper holding methods has led to more time consumption in the brake bleeding process, hence necessary countermeasures especially kaizen activities has to be initialized to reduce the time consumption which in turn reduces the overall Man Hours for the Main Assembly process.
- Elimination of Muda (Waste motions) & Kaizen in duplication processes there was about **saving of 2.1 Man Hours** in the overall Main assembly process reducing it from 98 Man Hours to **96 Man Hours** (**Required Target**)
- By accomplishing of Lean techniques, Line balancing of each 6 stations were made and the Line balancing ratio was increased to **99.97%.** Also due to Line balancing the cycle time / takt time value becomes 1.i.e. the cycle time of each station is same as the takt time desired.
- Interprets that by using **Lean Techniques** the company's Main Assembly process **production lead time was reduced and improved the delivery** of the Final Product pertain to Customers demand.

CONCLUSIONS AND FUTURE DIRECTION

This research aimed to understand main problems limiting non-repetitive companies in implementing Lean approach. It is therefore necessary to deepen the knowledge of such characteristics and to develop new knowledge in how to implement lean to a full extent in non-repetitive firms.

REFERENCES

i. *Anabela C. Alves, José Dinis-Carvalho, Rui M. Sousa, (2012) "Lean production as promoter of thinkers to achieve companies' agility", The Learning Organization, Vol. 19 Issue: 3, pp.219-237.*
ii. *Arawati Agus, MohdShukriHajinoor, (2012) "Lean production supply chain management as driver towards enhancing product quality and business performance: Case study of manufacturing companies in Malaysia", International Journal of Quality & Reliability Management, Vol. 29 Issue: 1, pp.92-121.*
iii. *Bhim Singh, S.K. Garg, S.K. Sharma, Chandandeep Grewal, (2010) "Lean implementation and its benefits to production industry", International Journal of Lean Six Sigma, Vol. 1 Issue: 2, pp.157-168.*
iv. *Khalil A. El-Namrouty, Mohammed S. AbuShaaban, (2013) "Seven wastes elimination targeted by lean manufacturing case study "gaza strip manufacturing firms'', International Journal of Economics, Finance and Management Sciences.*
v. *JP Womack, DT Jones – (2010) "Lean Thinking: Banish Waste and Create Wealth in you Corporation", International Journal of Operation Management, Vol 30, Issue: 2, pp 180- 217.*
vi. *Raymond N. Cheser, (2010) "THE EFFECT OF JAPANESE KAIZEN ON EMPLOYEE MOTIVATION IN U.S. MANUFACTURING", The International Journal of Organizational Analysis, Vol. 6 Issue: 3, pp.197-217.*
vii. *Shams Rahman, TritosLaosirihongthong, Amrik S. Sohal, (2010) "Impact of lean strategy on operational performance: a study of Thai manufacturing companies", Journal of Manufacturing Technology Management, Vol. 21 Issue: 7, pp.839-852.*
viii. *Steven Brown, JoergDomaschke (2011) 'Cycle Time Reductions for Test Area Bottleneck Equipment 'Journal of Business and Management' Volume 16, Issue 4. Ver. III, pp. 65-69*