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# Case Study of Application of Line Balancing to Value Stream Mapping for Process Improvement

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***Abstract: This paper explores the possibilities of value stream mapping in batch production using line balancing to reduce the non value added time in production process and leading to improvement of the process. Value Stream Mapping is a powerful tool used to map out both the material and information flow for any manufacturing or administrative process. This tool allows companies to map the flow of products from raw material, through all manufacturing steps, till the finished product. Line balancing is done to minimize the idle time and improve cycle efficiency by reducing the Number. of work stations. By incorporating improvements a future state map is constructed. Reducing non value added time, increases percentage of value added time and reduction of in-process inventory .This work is done for Kerala electrical and allied limited (KEL), Kundara unit, which producing Brushless Alternator.***
***Keywords: Value stream mapping, line balancing, value added time***

## I. INTRODUCTION

In the wake of Globalisation, liberalisation and privatization, the major organisations in different industrial sectors are trying hard to cut down the cost of production in order to survive in the highly competitive market . They were undergone application of various modern production management tools like downsizing, restructuring etc. to increase the productivity by reducing the cost of production and reducing the lead time and thereby sustain the competitive advantage in the competitive global market. In order to sustain its core competency of the product, the companies have to look for ways to cut down its cost of production and lead time reduction in order to compete with the other competitors. Here value stream mapping and Line balancing play a major role by stream lining the process and thereby reducing lead time and reducing the total cycle time of the product and cost of production. The companies can reduce the various industrial wastes by to improve the processes such that the non value added time and thus total throughput time can be reduced. Value stream mapping is a method of visualizing the flow of a service, a product, or information. It provides a system's view of the flow of work, involving multiple processes. After differentiating the value added time and non value added time by applying value stream mapping on selected product. Line balancing was done to improve the cycle efficiency by reducing the no of work stations and thereby decreasing the manpower required. Incorporating the improvements in the future state value stream mapping total cycle time could be reduced considerably and thereby the process could be improved.

## II. LITERATURE SURVEY

### *A. History of Value Stream Mapping (VSM)*

For achieving competitive advantage in organizations using waste removal the efforts were pioneered in the 1980s by Toyota's chief engineer, Taiichi Ohno, and sensei Shigeo Shingo and was oriented fundamentally to productivity rather than to quality. The improved productivity leads to leaner operations which help to identify waste and quality problems in the system. Thereby the systematic effort on waste removal is also a systematic improvement on the factors underlying poor quality and fundamental management problems.

Taiichi Ohno is regarded as the founder of the Toyota Production System (TPS) which was developed from 1950 following an excursion to the Rouge Ford plant in the US by Eiji Toyoda, a young engineer who reported his findings on the Ford system back to Ohno.

In the English translation of his book 'TPS – beyond large scale production' Ohno (1988) describes how TPS evolved out of need, as the market place in post war Japan required small quantities of cars to be produced in many varieties. This was very different to the Ford principle of mass-producing the same Automobiles in large production runs. Although TPS began in 1950, it was not until the 1973 oil crisis that other Japanese firms began to take notice, and since this time the system has been studied, copied and implemented across many industries[13].

Womack, Jones and Roos (1990) coined the phrase 'Lean Manufacturing' to describe TPS when they printed the results of a five-year study into the automotive industry in the book 'The Machine That Changed The World'. This gives a pretty good insight into *The History Of Lean Manufacturing.* Even with the massive amount of research that has taken place into the Toyota Production System, fifty one years after it was born, Slack et al (2001, p481) still refer to Lean Manufacturing as a 'radical departure from traditional operations practice'[2]. Ohno (1998) describes the most important objective of the TPS as increasing production efficiency through consistently and thoroughly eliminating waste. Womack et al (2003) define waste as any activity that consumes resource but adds no value as specified by the customer. In order for us to understand the waste within manufacturing activities Ohno (1988) broke waste up into 7 elements. These elements are: Overproduction, Over-processing, Waiting, Transport, Inventory, Motion, and Defects and they are defined from the history of lean manufacturing .

### *B. Value Stream Mapping*

A process is a series of activity steps that move inventory from one step to the next to transform it into the intended output. The output could be a physical item or a service. A process can be any type or size and cover any period of time. Each step in a process also consists of processes within the step. VSM is used to investigate processes to identify improvement opportunities lying in their wastefulness.

Value is from the customer's perspective, the customer being the person who uses the output. Value-adding actions and resources are those which create value for the customer. Non-value-adding is everything done in the process which contributes no value for the customer but which they are forced to pay for when they buy the product or service. Necessary non-value-adding are those actions in a process that must be done to make the product but create no value for the customer. Unnecessary non-value-adding is removed and necessary non-value-adding is minimised to the least possible [1]

### *C. Introduction to Line Balancing*

Line balancing is an effective tool to improve the throughput of assembly lines and work cells while reducing manpower requirements and costs. Assembly Line Balancing, or simply Line Balancing (LB), is the problem of assigning operations to workstations along an assembly line, in such a way that the assignment be optimal in some sense. Ever since Henry Ford's introduction of assembly lines, LB has been an optimization problem of significant industrial importance: the efficiency difference between an optimal and a sub-optimal assignment can yield economies (or waste) reaching millions of dollars per year[6].

LB is a classic Operations Research (OR) optimization problem, having been tackled by OR over several decades. Many algorithms have been proposed for the problem. Yet despite the practical importance of the problem, and the OR efforts that have been made to tackle it, little commercially available software is available to help industry in optimizing their lines. In fact, according to a recent survey by Becker and Scholl (2004), there appear to be currently just two commercially available packages featuring both a state of the art optimization algorithm and a user-friendly interface for data management. Furthermore, one of those packages appears to handle only the "clean" formulation of the problem (Simple Assembly Line Balancing Problem, or SALBP), which leaves only one package available for industries such as automotive. This situation appears to be paradoxical, or at least unexpected: given the huge economies LB can generate, one would expect several software packages vying to grab a part of those economies.

It appears that the gap between the available OR results and their dissemination in today's industry, is probably due to a misalignment between the academic LB problem addressed by most of the OR approaches, and the actual problem being faced by the industry. LB is a difficult optimization problem (even its simplest forms are NP-hard – see Garey and Johnson, 1979), so the approach taken by OR has typically been to simplify it, in order to bring it to a level of complexity amenable to OR tools. While this is a perfectly valid approach in general, in the particular case of LB it led to some definitions of the problem that ignore many aspects of the real-world problem. Unfortunately, many of the aspects that have been left out in the OR approach are in fact crucial to industries such as automotive, in the sense that any solution ignoring (violating) those aspects becomes unusable in the industry.

In the sequel, we first briefly recall classic OR definitions of LB, and then review how the actual line balancing problem faced by the industry differs from them, and why a solution to the classic OR problem may be unusable in some industries. Thus, we used line balancing technique to achieve:

1) The minimization of the number of workstations;
2) The minimization of cycle time;
3) The maximization of workload smoothness;
4) The maximization of work relatedness.

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## III.FOCUS OF STUDY

The study was done at Kerala Electrical and Allied Engineering Co Ltd. Kundara. unit, which is a fully government owned public sector organization, which produces Brushless alternator and its accessories and brushless DC fans mainly for Indian Railways. The main components of the alternators are rotor, stator and end plates etc. This study is about the manufacturing processes of rotor manufacturing of 4.5 KW alternators which amounts to more than 50% of the total production of the company.

## IV. METHODOLOGY

In VSM we follow a process from start to finish monitoring and measuring what happens within, and between, each process step. For each process step we record the variety of resources used in the step, the amount of their usage and the range of times each resource is in use as a block of information specific to that step. The measured variables are collected together in a 'variable block' .From the information collected during data gathering the process is drawn as a flow diagram showing the times and resources used at each step and the time delay between each step. This diagram is called the 'current state map'. Inventory movements between steps are identified by the 'I' inside a triangle. The rate of throughput is identification of the bottleneck steps. The bottlenecks can be redesigned to lift their capacity and so increase the output rate of the whole process. The reengineered process is drawn on a new flow chart known as the 'future state map'. It shows all the steps and information flows in a redesigned, simplified and more efficient process.

### *A. Steps Involved in Value Stream Mapping*

*1)* Selection of the product
*2)* Current state value stream mapping
*3)* Future state value stream mapping
*4)* Implementation of the future state mapping
*5)* Result analysis

### *B. Details of Processes Involved in the Manufacturing of Rotor*

As per the details collected from the company records, work norms which was based on the Time study conducted by the company and direct observation of the shop floor the following details were obtained. Since the study is mainly concentrated on the manufacturing of Rotor component of the Brushless alternator, The processes involved in sequence and their respective processing times and the manpower required and the output at each stations listed in the Table 1

Table .1
Details Of Processes Of Rotor Manufacturing

| No | ITEM | Crew Size | M/C | No. of Pieces Per shift | Time/piece |
|---|---|---|---|---|---|
| 1 | Shaft marking, Setting& Cutting | 1 | 1 | 22 | 21.818 |
| 2 | Shaft centering | 1 | 1 | 20 | 24 |
| 3 | Shaft turning, Roughing, Side tapering, End threading | 1 | 1 | 3 | 160 |
| 4 | Setting, Shaft milling, Keyway, Slot cutting | 1 | 1 | 7 | 68.571 |
| 5 | Shaft grinding | 1 | 1 | 7 | 68.571 |
| 6 | Rotor Stalking & Pressing | 1 | 1 | 5 | 96 |
| 7 | Rotor Turning | 1 | 1 | 9 | 53.33 |
| 8 | Rotor balancing | 2 | 1 | 9 | 53.33 |

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*C. Current State Value Stream Mapping*

Value stream mapping is a tool, which is created using a predefined set of icons . There are a lot of benefits to draw value stream maps by hand. Manual mapping lets us see what is actually happening in a shop floor value stream, rather than being restrained to a computer. Also, the process of quickly drawing and redrawing a map acts as a plan-do check- act cycle that deepens our understanding of the overall flow of value or lack thereof. Here in this work the product selected is 4.5 KW alternators of which the rotor manufacturing process alone is the scope of this study. The next step is to draw a current state map to take a snapshot of how things are being done now. This is done while walking along the actual pathways from the actual production process. The material flow is drawn at the lower portion of the map. At each process all the critical information including lead-time, cycle time, , inventory levels, etc.are documented. The inventory levels on the map should correspond to levels at the time of the actual mapping and not the average because it is important to use actual figures rather than historical averages provided by the company The second aspect of the current state map is the information flow that indicates how each process will know what to make. The information flow is drawn on the upper portion of the map. The information flow is drawn from right to left on the map and is connected to the material flow previously drawn. After the completion of the map a timeline is drawn below the process boxes to indicate the production lead-time, which is the time that a particular product spends on the shop floor from its arrival until its completion. A second time called the value- added time is then added. This time represents the sum of the processing times for each process. Lead time(Non value added time) is calculated by the way each component will wait on every machine and then total waiting time over the entire process will makes the lead time. Monthly orders are given to suppliers ,in this case one month advance order is given to suppliers of steel shafts and laminations and there is an average of one month lead time to receive these materials after placing the order. The shaft of 80 mm dia are received in the store and after the receipt of the material it is inspected by the quality control department for any defects the good received note is prepared and issued to production department. The transportation of the shafts from the yard to cutting station is the first step, Cutting of the shaft in power hacksaw is the next step by one operator. The shafts are transported to nexy work station using hand trolley; Radial drilling machine No.003 where 20 work pieces are centered which require one operator and is done in one shift cycle time is 24 min and these work pieces transferred to next work station, Lathe where turning operation is done which consists of shaft turning ,roughing I $^{st}$side, II$^{nd}$side tapering and end threading. The cycle time is 160 min which includes setting time and change over time. There are three pieces are being turned per shift. Grinding machine, where Grinding operation is done. . Then there is an inspection and then transported to the workstation for Stalking and pressing followed by Turning of rotor for which at present the same rotor is taken back to machine. for which one operator requires and transported to Balancing machine were dynamic balancing is done for which cycle time is 53 min. and crew size required is two persons. Thereafter there is an inspection after which the rotor will be taken for assembly.

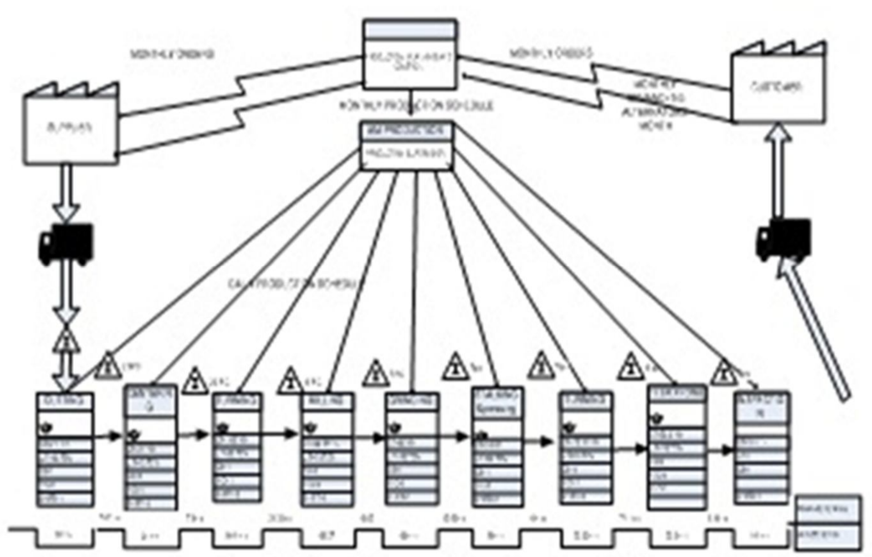

Fig 1 Current Value Stream Ampping

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TABLE-2
Observations Of Current Value Stream Mapping

| `Operation | Value added time(min) | No of m/c | Crew size | No of shifts | In process inventory | Non value added time(min) |
|---|---|---|---|---|---|---|
| Shaft cutting | 21.818 | 1 | 1 | 1 | 22 | 15 |
| Centering | 24 | 1 | 1 | 1 | 20 | 459 |
| Shaft turning | 160 | 1 | 1 | 3 | 9 | 456 |
| Shaft milling | 68.57 | 1 | 1 | 1 | 7 | 1280 |
| Shaft grinding | 68 | 1 | 1 | 1 | 7 | 411 |
| Stalking and pressing | 96 | 1 | 1 | 2 | 10 | 901.6 |
| Rotor turning | 53.33 | 1 | 1 | 1 | 9 | 384 |
| Dy.balancing | 53.33 | 1 | 2 | 1 | 9 | 426.6 |
| Total | 545.048 | 8 | 9 | | 93 | 4333.2 |

*D. Line Balancing*

Current value stream mapping shows that there are a lot of variations in processing times. In order to make the processes lean ,it is imperative that the processing times of different stations should be minimum and as far as possible there should be continuous flow material to decrease the non value added time and in-process inventories which really add cost to the product but no benefit .And also cycle efficiency and total no of manpower required also can be reduced [6].

Objectives of line balancing

*1)* Reduce number of work stations
*2)* Improve cycle efficiency
*3)* Reduce idle time
*4)* Reduce in-process inventories.
*5)* Reduce the number of workers required.

Line balancing can be done using the following heuristics

*a)* Ranked Positional weight method
*b)* COMSOAL

As per RPW method the positional weights are as given below Table 3

Table 3 Positional Weights

| DETAILS OF WORK ELEMENTS | | | | |
|---|---|---|---|---|
| SL NO | Operations | No of Predecessors | Cycle time | Positional weights |
| 1 | Cutting | 0 | 21.818 | 545.626 |
| 2 | Centering | 1 | 24 | 523.808 |
| 3 | Turning | 2 | 160 | 499.808 |
| 4 | Milling | 3 | 68.571 | 339.808 |
| 5 | Grinding | 4 | 68.571 | 271.237 |
| 6 | Stalking&pressing | 5 | 96 | 202.666 |
| 7 | Turning | 6 | 53.333 | 106.666 |
| 8 | Dy balancing | 7 | 53.333 | 53.333 |

The line balancing can be validated using the software called V.3 Flexible line balancing.

Table-4
Results of Line Balancing

| RESULTS | | |
|---|---|---|
| STN. NUMBER | WORK ELEMENTS | CYCLE TIME |
| 1 | 1,2 | 45.818 |
| 2 | 3 | 160 |
| 3 | 4,5 | 137.142 |
| 4 | 6,7 | 149.33 |
| 5 | 8 | 53.33 |

Table No.5
Benefits From Line Balancing

| Description | Before applying LB | After LB | Percentage INCREASE/DECREASE |
|---|---|---|---|
| Cycle Efficiency % | 42.46 | 67.9 | +60% |
| IDLE TIME (min) | 736.46 | 254.38 | -65.45% |
| MAN POWER(Nos) | 9 | 6 | -33.33% |

### *E. Future State Value Stream Mapping*

Incorporating the results of line balancing a future state value stream mapping can be done as follows. In the current state value stream mapping There were almost 8 times non value added time as compared to value added time . There were too much in-process inventory. Thus by adopting lean principles the non value added time and non value added activities can be reduced. The load should be levelled as much as possible. The queues should be minimized to decrease in process inventory.

After applying line balancing in the current state the above value stream mapping for the future state was made .From which we got the following results

Table .6
Future State Value Stream Mapping

| operation | Value addeingd Time(Min) | No of M/c | Crew size | No. Of shifts | In Process Inventory | Non value added Time(min) |
|---|---|---|---|---|---|---|
| Shaft cutting | 21.818 | 1 | 1 | 1 | 3 | 15 |
| Centering | 24 | 1 | 1 | 1 | 19 | 5 |
| Shaft turning | 160 | 1 | 1 | 1 | 9 | 435 |
| Shaft Milling | 68.57 | 1 | 1 | 1 | 7 | 1279.8 |
| Grinding | 68 | 1 | 1 | 1 | 6 | 5 |
| Stalking and Pressing | 96 | 1 | 1 | 1 | 3 | 343.2 |
| Rotor Turning | 53.33 | 1 | 1 | 1 | 7 | 5 |
| Dynanmic Balancing | 53.33 | 1 | 1 | 1 | 7 | 330.6 |
| TOTAL | 545.048 | | | | 61 | 2418.6 |

## V. RESULTS

After comparing the current state value stream mapping before applying line balancing and after applying line balancing there was a considerable reduction in non value added time which will definitely add value to the product and cost of production is reduced due to reduction in manpower and in-process inventory as shown in the table 6

Table No.7 Results Of Future State Value Stream Mapping

| Description | Current VSM Before LB (min) | Future VSM After LB | %REDUCTION/INCREASE |
|---|---|---|---|
| Non value added time | 4333.2 | 2418.6 | 44.18 % Decrease |
| In-process inventory | 93 | 61 | 34.41 %Decrease |
| Manpower | 9 | 6 | 33.33 Decrease |

## VI. CONCLUSION

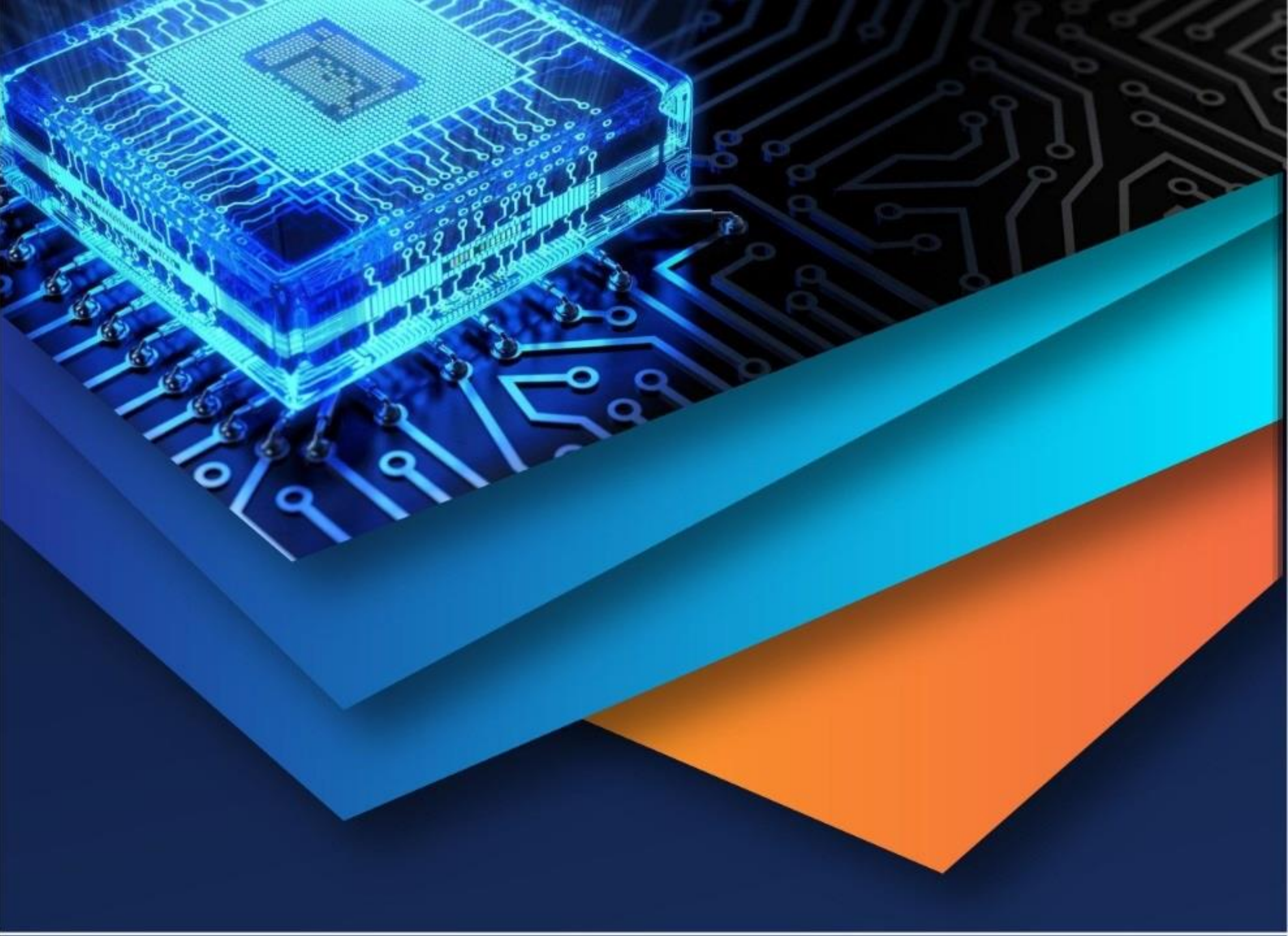
The values stream mapping along with line balancing applied in the above said work has been very much effective in reducing non value added time, in process-inventory and also manpower. Value stream mapping along with line balancing applied is an effective tool to reduce the non value added time and thereby improving the process; The same tool can be applied in any type of organisation irrespective of batch production and mass production to identify the areas to be worked upon to make improvements in the process by reducing the non value added time .

The value stream mapping along with application of line balancing is an effective tool in reducing the cost of production by cutting down the non value added time, in process-inventory and man power to make the process and supply chain of any organisation lean. The process improvement by implementing the improvements to reduce cost of production will reduce total production lead time which will improve company image and customer satisfaction.

The work resulted in separating out non value added time and value added time which helped to address the different problems individually which enable improvements. The various areas were identified and worked upon which resulted in decreasing the non value added time. reduced by reducing the idle time . Altogether the cost production of the product could be reduced to a great extend.

## REFERENCES

[1] Liker, Jeffery K., „The Toyota Way – 14 Management Principles from the World‟s Greatest Manufacturer‟, Page 27, McGraw Hill, 2004 .
[2] Rother, M. and J. Shook.( 1999). Learning to See: Value Stream Mapping to Add Value and Eliminate Muda, Lean Enterprise Institute, Brookline, MA.
[3] Drew .A.Loacher.(2008)Value stream mapping for lean enterprise. A productivity pressbook.
[4] Richard L. MacInnes(.2002). The Lean enterprise Memory jogger. GOAL/QPC
[5] Sayed masood.(2006).Line balancing and simulation of an automated production transfer line, Presented in Assembly Automation , (2006) Emerald Group Publishing Limited
[6] Lim Chuan Pei,Masine Md. Tap(.2002). Improving productivity through line Balancing - a case study. Jumal Mekanikal,
[7] Chandandeep S. Grewal.and Kuldeep K Sareen,(2006)Development of model for lean improvement: A case study of automobile industry, Industrial Engineering
[8] Lamming, R., Johnsen, T., Zheng, J. and Harland, C,(2000) An initial classification of supply networks. International Journal of Operations and Production Management, 2000, 8 Feld, W.M., Lean Manufacturing Tools and Techniques and How to Use Them, .
[9] Brett W. Braiden and Kenneth R Morrison(1996) Lean manufacturing optimization of automotive motor compartment system, Computers and industrial Engineering,
[10] Richard B. Detty and Jon C. Yingling(2000), Quantifying benefits of conversion to lean manufacturing with discrete event simulation: A case study, InternationalJournal Of Production Research
[11] Panizzolo, R., "Applying the lessons learned from lean manufacturers-The relevance of relationships management," International Journal of Production Economics.
[12] Womack, J.P., and D.T. Jones,(1994) "From Lean production to the Lean nterprise," Harvard Business
[13] Ohno, T.(1997) Toyota Production System: Beyond largescale production 1997 WEB SITES
[14] www.strategosinc.com/value-stream-mapping-3.htm
[15] www.12manage.com/methods value -stream- mapping.html
[16] www.1stcourses.com/value-stream-mapping.html

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