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# Cycle Time Reduction by using Lean Manufacturing

Rahul Rana[1], Vikas Ucharia[2], Akshay Kumar[3]
Student[1, 3], Assistant professor[2]
Department School of Engineering and Technology (Mechanical Engineering)
Bahra University, Solan, India

**Abstract:**
The purpose of this paper is to develop an efficient and effective way of assembling the parts in order to meet the customer demands. The whole papers contains analyzing production in person, and finding the causes behind the higher cycle times and developing an optimized production line based on the current requirements of the company provided. To accomplish the goals, firstly analyses of cycle time and loading/unloading of the part is done by the help of stopwatch. The higher cycle time is gathered, analyze and converted into the description in order to fully understand the purpose of the goals. With the help of production engineer and stopwatch, the data is collected. Cycle time variance analyses method was used to analyze the data. The causes behind the higher cycle time are noted by the help of brainstorming. The question brainstorming method is used to obtain the causes for higher cycles. After analyses of causes behind higher cycle time, the better solution is selected. Setting up ergonomic standards for workstation is done by providing rack for work-piece. As cycle times are reduced, output increases equally. After all the implementation of the solutions, the production line is optimized to have a well-balanced cycle time. By the conclusion of results, a future recommendation is provided to the company for the future work.

## I. INTRODUCTION

**Cycle time:** Cycle time is defined as the time it takes to do a process. It includes the time from when an operator starts a process until the work is ready to be passed on. This cycle time definition is rather simplistic, though, as there are several elements that can cloud the issue. On linked assembly lines, there is often waiting at the end of a line shift. That waiting is typically not considered part of the cycle time, but waiting within the work is generally included. Put simply, the cycle time is the minimum time a stopwatch would have to run to produce a good unit of work.

**Lean manufacturing:** Lean Manufacturing is a manufacturing technique derived from the word "muda" from the Japanese word means "waste" – human action that absorbs resource, but creates no value. Lean thinking provides a way to more work with less human effect, less time, less equipment and less space.

### Delimitation

Delimitation has been made to focus and clarify the boundaries of the project.

1. The company wants to maximize the usefulness of its floor space by keeping it utilized efficiently.
2. The assembly method should be carried out with consideration of ergonomics standard.
3. Material handling such as racks for work-piece should be considered on the production line design with the ergonomics standard.

### Purpose and goals

The purpose and goals of the projects are as following:

1. To reduce the cycle time and efficient use of work area.
2. Cycle time analysis by stopwatch.
3. Apply the cycle time variance analysis.
4. Analyzing the graphs.
5. Finding the causes behind the higher cycles.
6. Giving solutions and implementation of solutions.

### Tool Used

The tool used for analysis is cycle time variance analysis:
Most small manufacturers simply can't afford to have an MRP system that tracks manufacturing cycle times and the variances between those times. For that, have to analyse the production in person by the help of stopwatch and have to evaluate the causes which are affecting the production system. With this in mind, including a cycle time tracking excel sheet for small manufacturers with a built-in graph that shows average, median and mode cycle times in a given production workstation.

### Data Collection

**Stopwatch:** The time studies of the production line were measured by the help of stopwatch. The different cycle time at the different machine was captured by the help of stopwatch.

**Question Brainstorming:** The most vital information that was collected during the analyses of data was gathered by the help of question brainstorming.

**Production Engineer and Inspection Engineer:** More general questions asked about the production system such as production schedule of rear axle cover. Information regarding the operations at different workstation was collected by interacting with production engineer. Further, data about the ergonomics situation and production complexity of current state was collected.

**Assembly Worker:** Information regarding the causes behind the higher cycle time was gathered. Besides, an overview of ergonomics in term of physical aspect information was collected.

**Analysis**

The demand for rear axle cover is 2000 pieces per month. The cycle time per operation is calculated. The cycle time for each operation is noted for 10 cycles by the help of stopwatch. The process flow diagram for operation is following.

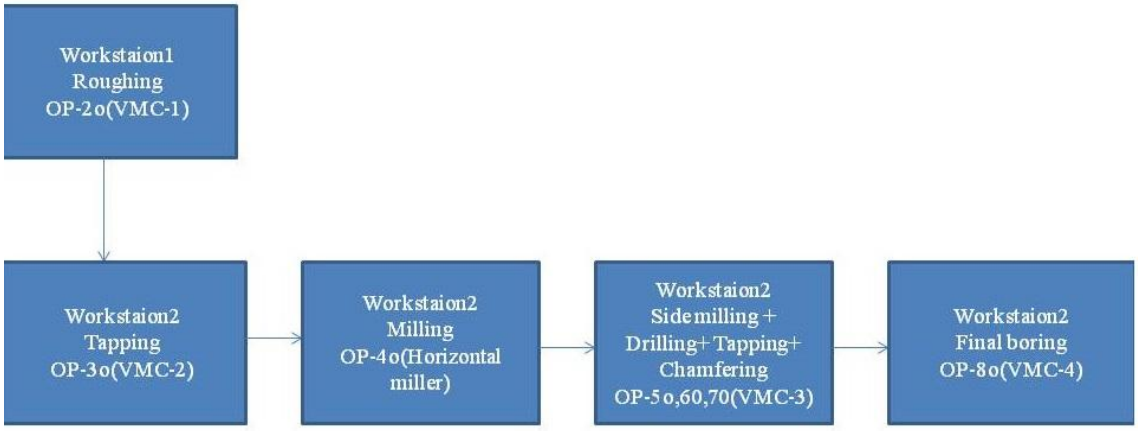



**Table.1. Average cycle time of operations and work of operation**

| Component | Operation | Work of operation | Machining cycle time (min) | Loading/unloading time (min) |
|---|---|---|---|---|
| Rear axle | 20 | Roughing | 7min 1s | 1min 35s |
| Rear axle | 30 | Tapping | 15min 39s | 1min 40s |
| Rear axle | 40 | Milling | 1min 50s | 1min 5s |
| Rear axle | 50 | Side milling + Drilling + Tapping + Chamfering | 4min 24s | 2min 10s |
| Rear axle | 60 | Same operation as op-50 in opposite side | 4min 24s | 2min 10s |
| Rear axle | 70 | Back side drilling + Tapping | 2min 51s | 2min 28s |
| Rear axle | 80 | Final boring | 15min 46s | 59s |

The sample sheet below allows capturing the causes behind the higher cycle time for each and every operation is tracked. According to work cell or work-station, the types of operation being tacked as follow.

**Average mean time**: Calculating the average simply involves totaling up all the 10 cycles of times and dividing it by the number of operations.

**Median time:** To calculate the median, rewrite the entire sequence of times in ascending order. It's simply another measurement of average.

{(n+1) / 2}

N= sample size: which in our case is 10 operations
Median: {(10+1) / 2} = 5.5
This will be the 6th no. from the order.

**Mode time**: This is simply the time that occurs the most often in the sequence. The mode time is straight green horizontal line on the graph.

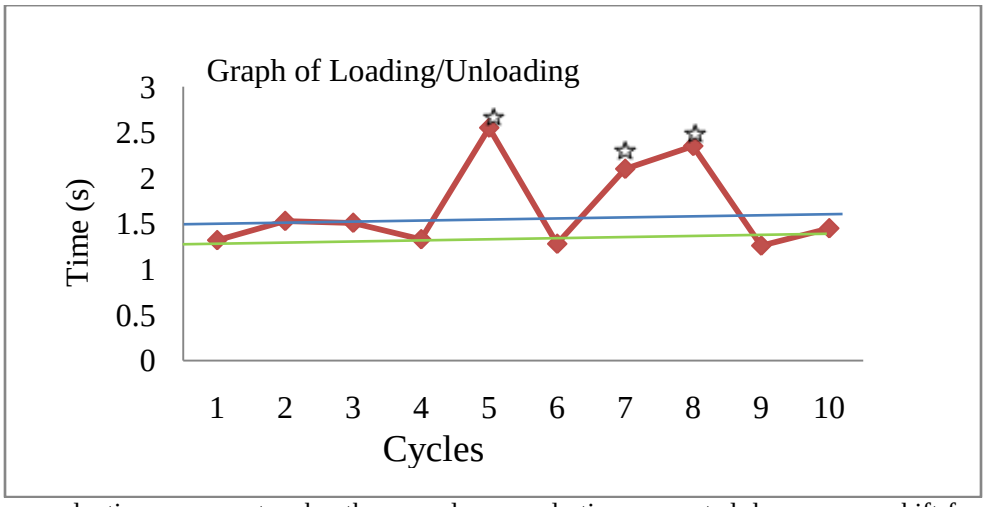
**Table.2. Loading/Unloading time of at workstation 1 and list of causes**

| Loading/Unloading Time Analysis | Worsktation1 | | |
|---|---|---|---|
| Operation 20 | Roughing | | |
| Unit of Measure | Loading/Unloading time in Minutes (converted to seconds) | | |
| Product | Rear axle | | |
| Number of Work Operations | Loading/Unloading time | Ascending Order | What are the reasons for high time consumption? |
| 1 | 1.32 | 1.26 | |
| 2 | 1.53 | 1.28 | |
| 3 | 1.51 | 1.32 | |
| 4 | 1.33 | 1.33 | |
| 5 | 2.55 | 1.45 | Cleaning of dust from part |
| 6 | 1.28 | 1.51 | |
| 7 | 2.10 | 1.53 | |
| 8 | 2.35 | 2.10 | Ergonomically issue |
| 9 | 1.26 | 2.35 | |
| 10 | 1.45 | 2.55 | |

**Table.3. Value of mean average, mode and median for op-20**

| Mean Average | Mode | Median |
|---|---|---|
| 1.60 | 1.30 | 1.51 |

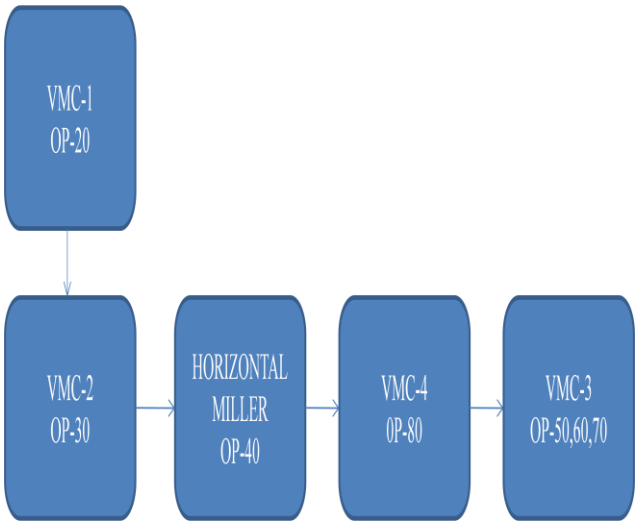
Now median is 1.51(horizontal blue line in graph) which is operator's overhead time.




These stars on higher cycle time represent, why these cycle times are high? What are the causes of these higher cycle time?

**Analysis:** The causes occurring in the production system is analyzed by analyzing the production happening in person. The cycle time are noted down over a shift for 10 cycles by help of stopwatch. The causes behind the higher cycle time are listed down and solutions for the higher cycle time are implemented by various tools.

**Workplace analysis:**
The workplace is analyzed. The current arrangement of machines is as follow




**Ergonomic issues:** The arrangement of racks should be there to minimize worker fatigue. In roughing, process worker has to clean the dust from the part because of no systematic arrangement of the work-piece. As the parts finish the level of fatigue is increased because the worker has to put more effort to take up the work-piece from the ground. To overcome it the arrangement of racks for work-piece should help in great extent.

**Introduction of 4th axis rotary table on VMC:**
The introduction of the 4th axis rotary table will lead to these following benefits

1. Higher part accuracy.
2. Part production time reduction**.**
3. Labor savings.
4. Non-dedicated machine time**.**

**Improvements**
**Workplace analyses:**
The distance between machines can be minimized by rearranging the machines in accordance with operation flow. The future location of machines as follow:

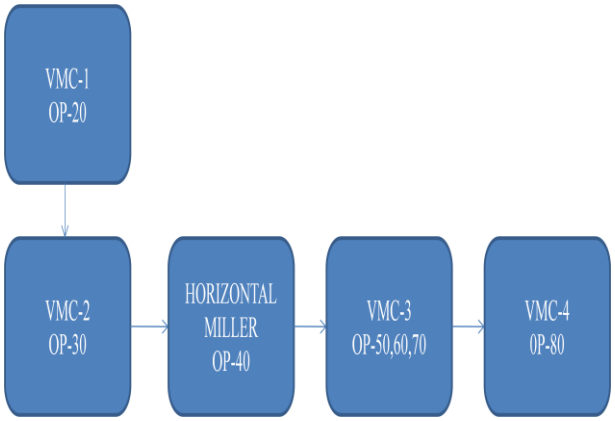



Fig Recommended arrangement of machines
By this arrangement of machines, the distance travel by operator can be reduced 22.5 feet to 17.2 feet (24% improved).

**Change in fixture:** An add-on 4th axis rotary table can convert existing 3-axis machine center into a full 4-axis machining center. The 4th axis rotational table can be introduced in VMC-3 because the no. of operations on VMC-3 is more than rest of machine. The loading and unloading time is reduced up to 5.33 minutes. The sum of average unloading/loading time of operations is 6min 48s. By introduction of 4th axis rotational table ergonomically issues is reduced to a large extent. The average sum of loading/unloading time of operations 50, 60 and 70 is = 2.10+2.10+2.28
= 6.48 minutes
This time could be reduced up to 5.33 minutes after implementation of 4th axis rotational table.

## II. ACKNOWLEDGMENT

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