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An Application of Value Stream Mapping In Manufacturing of Taper Roller Bearing For Identification of Bottlenecks

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Abstract

Companies in the manufacturing industry today are faced with intensecompetition in the global market with respect to cost effectiveness and quality of the production systems. Many major companies have adopted lean manufacturing in order to meet the customer demands and the quality standards in the desired time. Lean manufacturing tools are nowadays used in manufacturing industry to find various opportunities for improvements leading to increase in efficiency and throughput of the production system. Value Stream Mapping (VSM) is an effective lean tool used for identification of bottlenecks and wastes in the production system. In this paper, the VSM technique is demonstrated and its application in a Taper Roller Bearing (TRB) manufacturing industry is described. Value Stream Mapping is the main tool used to identify bottlenecks in the manufacturing process of taper roller bearing so that bottlenecks can be improved or eliminated to improve flow through the process leading to increased net throughput of the production system.

Keywords: Process mapping, Value Stream Mapping, Taper Roller Bearing, Bottlenecks

Introduction

In modern manufacturing industry, companies experience increased challenges which are accompanied by shorter product life cycles, intensified cost pressure and rising quality requirements. Lean manufacturing is a major initiative taken by companies to maintain flow through the production system. Manufacturing processes consist of both value added and non-value added activities which are essential to produce the product with desired quality standards. Value Stream Mapping (VSM) is a set of methods to visually display the flow of materials and information through the production process.

This paper describes the application of Value Stream Mapping in a Taper Roller Bearing (TRB) manufacturing industry. The main objective is to identify the bottlenecks in Taper Roller Bearing manufacturing process. The paper begins with explaining the Value Stream Mapping process. In the next part, the Taper Roller Bearing manufacturing process has been described which is followed by applied Value StreamMapping. The paper concludes with the results of Value Stream Mapping and suggested measures to eliminate the bottlenecks to improve flow and efficiency of the production process.

Methodology

Process Mapping

Process Mapping is an effective tool for the visualization of the production processes. A Process Mapping provides a graphical illustration that shows a sequence of activities using flowchart. Process Mapping also provides an aid in identifying the inputs variables and the output variables of the production process. The purpose is to visually represent the process as it is in reality. Process Mapping is carried out by simply walking through the production floor and mapping down the input, processes and outputs in a sequential manner as in the production process. This leads to representation of the production process flow in a graphical map. Process Mapping is a frequently used tool in the Six Sigma methodology.In the DMAIC (Define-Measure-Analyze-Improve-Control) methodology, it is used for visualization of manufacturing process within the Measure phase.

Process Mapping is an efficient tool for visualization of process flow. However it does not take into account the material flow, information flow, quality related aspects such as defects, rework, inspection processes and quality related costs.

Value Stream Mapping

Value Stream Mapping (VSM) is a tool used to find lean opportunities within the manufacturing process. The tool helps to reduce lead time, Work-in-Process (WIP) inventory, improve quality and production flow and achieve better on-time deliveries and utilisation of resources. It detects bottlenecks and inter-dependencies in the processes. VSM provides significant contribution in cost reduction, improving flow and meet customer demands. VSM mainly consist of four main steps namely: (i) Define the value (ii) Identify the value Stream (iii) Flow the product (iv) Strive for perfection [7].

Defining the Value

The first step is to determine what value is as described by the customer. Value is the information or product that the customer is willing to pay for and can only be defined by the ultimate customer [7]. When customers are not satisfied with the product, various techniques are used by the producer such as added value (feature) or lower pricing.

Identifying the Value Stream

A Value Stream consists of all the activities that are Value-Adding as well as Non-Value-Adding. Identifying value streams helps to understand the how the process operates with all the material flow and the information flow through the production process. Various parameters such as cycle time, rework and scrap, Work-in-Process (WIP) are observed and noted down. It helps to plan improvements that make easier to make customer demands [7].The Current State Map (CSM) charts the flow of information and material as a product goes through the manufacturing process. It is created by walking down the production channel.The analysis of Value Stream Mapping is done to identify bottlenecks and wastes in the manufacturing process. The Future State Map (FSM) chart uses lean manufacturing techniques to eliminate bottlenecks, reduce or eliminate wastes. It is used to identify root causes and through process improvements. These improvements are then carried out according to an implementation plan which consist of details and actions needed to improve the production process.

Flow the Product

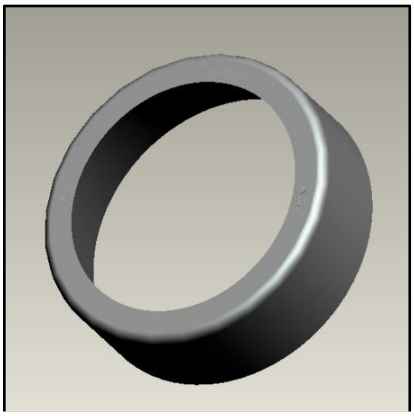
Flow is the progressive achievement of tasks along the value stream so that once started, the product proceeds from raw material into the hands of the customer with no stoppages or backflows [7]. Value addition to product should be maximized and non-value addition should be minimized or eliminated. All blockages to continuous flow must be removed as product should continuously undergo processing till the final finished stage.

Strive for Perfection

It is a continuous improvement process to reduce wastes and improve processes and quality of the product. The goal is always to achieve perfection through continuous improvements in the production system.

Taper Roller Bearing (TRB)

Tapered roller bearings are bearings that can take large axial forces (i.e., they are good thrust bearings) as well as being able to sustain large radial forces. The inner and outer ring raceways are segments of cones and the rollers are also made with a taper so that the conical surfaces of the raceways and the roller axes if projected, would all meet at a common point on the main axis of the bearing. The basic components of a tapered roller bearing are: Outer Ring or Cup, Inner Ring, Cage, Roller and Cone which consists of assembly of Inner Ring, Cage and Roller.



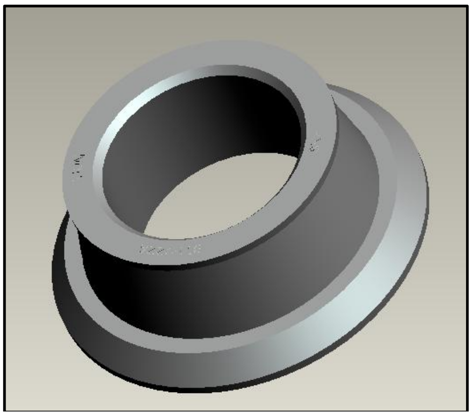
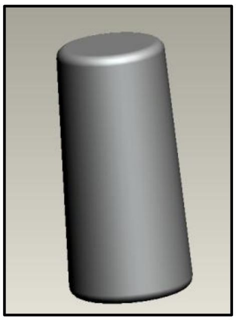


Figure: Outer Ring

Figure Inner Ring



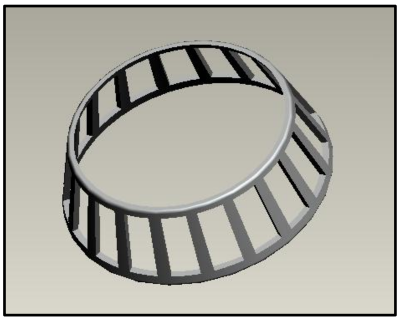
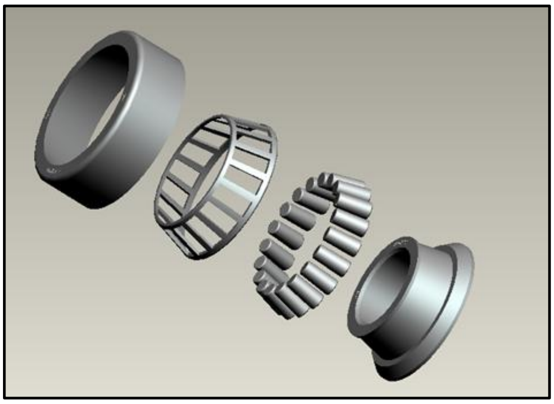


Figure: Roller

Figure: Cage



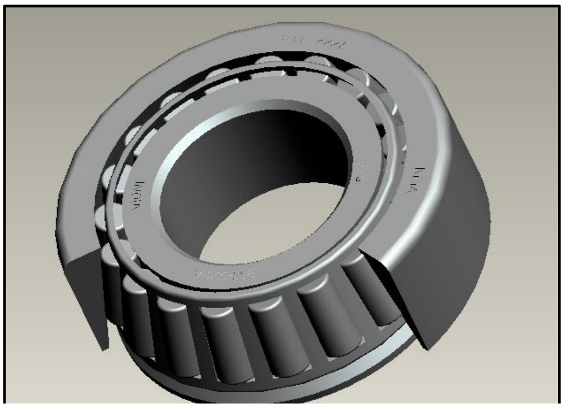


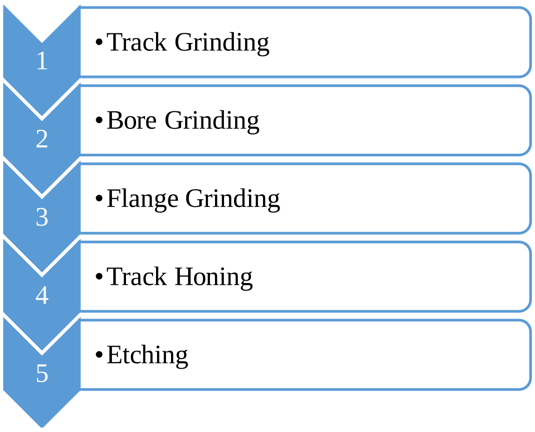
Figure: Parts of a TRB

Figure: Taper Roller Bearing (TRB)

Manufacturing of Taper Roller Bearing

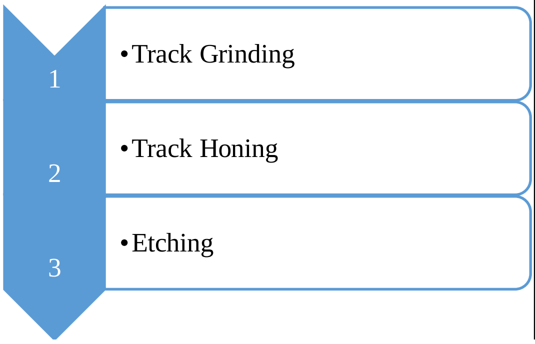
The Taper Roller Bearing manufacturing basically consist of four processing stages as follows:

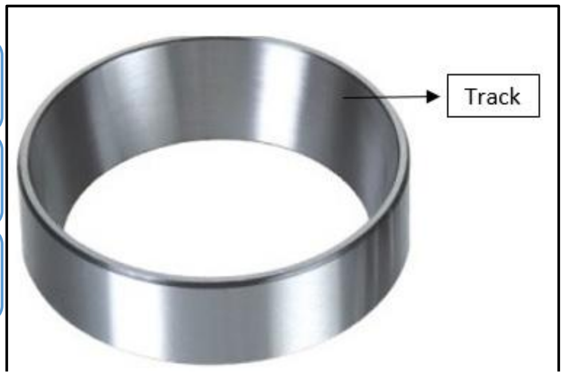
Processing of Inner Ring



Grinding and Honing are the two main operations performed on the inner ring of TRB for achieving smooth surface finish. These operations are performed on various surfaces on the inner ring such as Track, Bore and Flange in a sequential manner. The process is followed by etching used to mark the surface of inner ring.

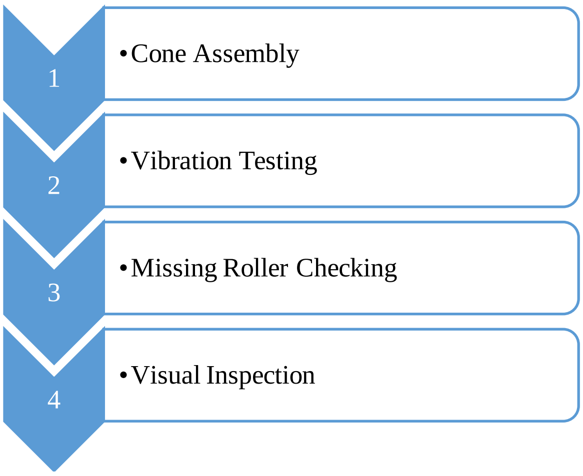
Processing of Outer Ring





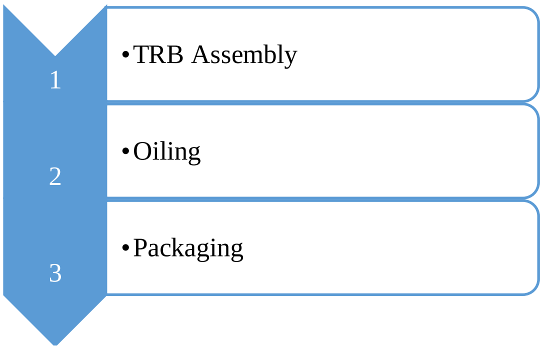
Grinding and Honing are the two main operations performed on the outer ring of TRB for achieving smooth surface finish. These operations are performed on track surface in a sequential manner. The process is followed by etching used to mark the surface of outer ring.

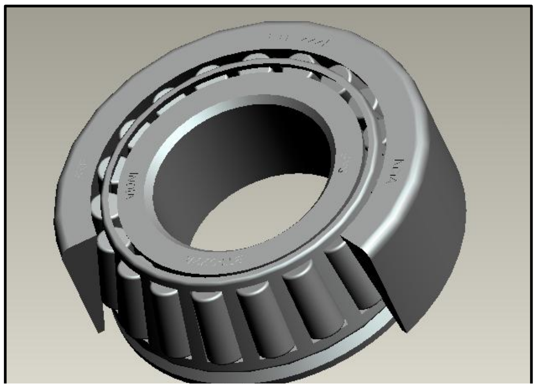
Cone Assembly



The Cone assembly stage first consist of an assembly of inner ring, cage and roller to produce cone. It is then followed by vibration testing process and missing roller checking and lastly a visual inspection process for any defects or marks.

Taper Roller Bearing Assembly





The final stage consist of assembly of outer ring or cup with cone to produce a Taper Roller Bearingwhich is followed by oiling of TRB and finally packaging.

Process Mapping

Process Mapping of the TRB production line was conducted and the process flow was represented as shown in fig. 1 and fig. 2.

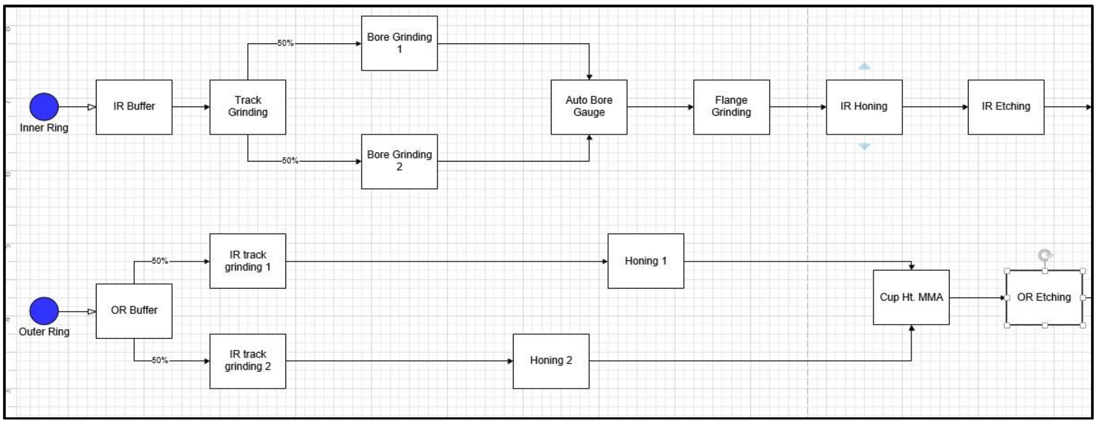


Figure 1: Process Mapping for Inner Ring and Outer Ring

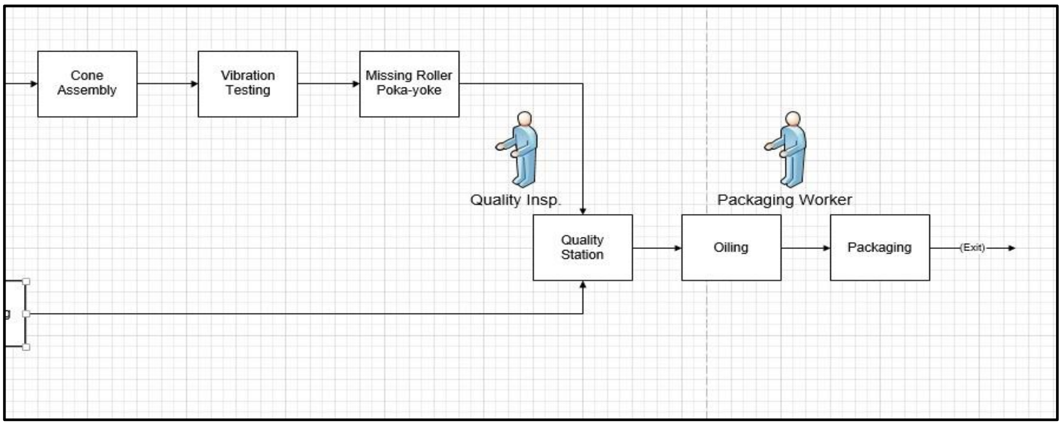


Figure 2: Process Mapping for TRB Assembly

Value Stream Mapping

Value Stream Mapping of the Taper Roller Bearing production line was done and represented as shown in fig. 3, fig. 4 and fig. 5. The Cycle time for each operation was observed and noted along with scrap and rework for each processes. The Value-added (VA) time and Non-value added (NVA) was also determined along with Work-in-Process (WIP) inventory.

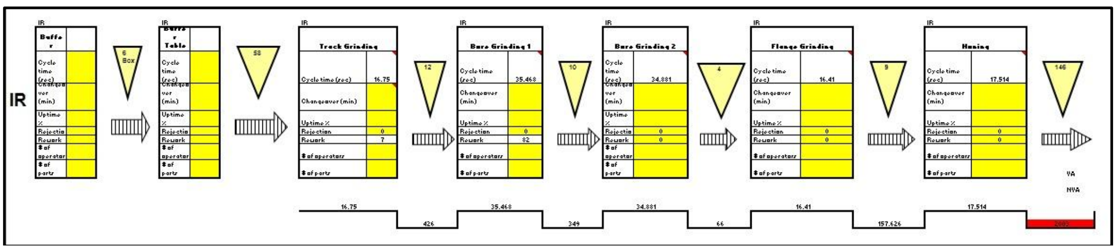


Figure 3: VSM for Inner Ring

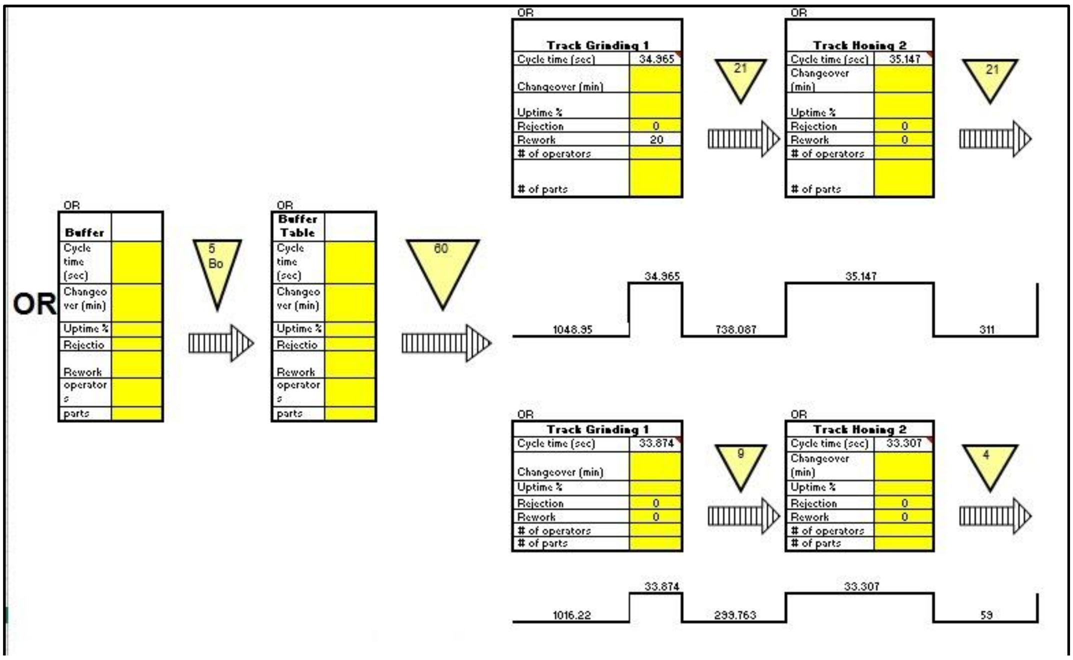


Figure 4: VSM for Outer Ring

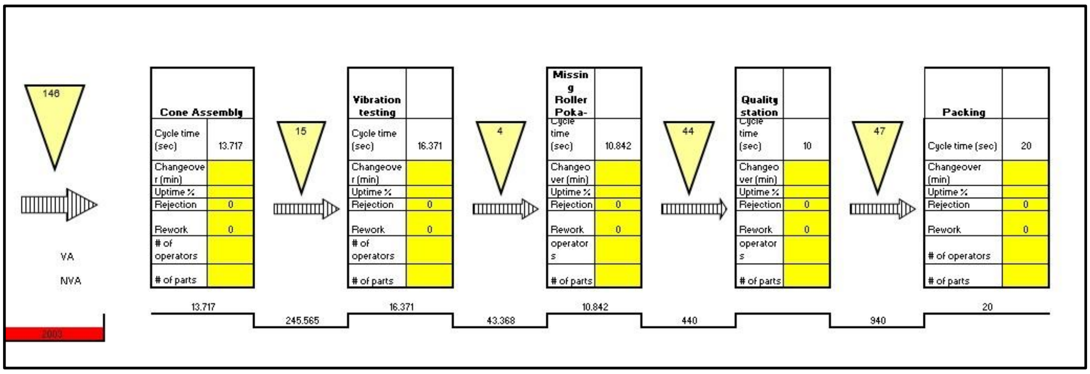


Figure 5: VSM for TRB Assembly

Analysis of Value Stream Mapping

The production line data obtained from Value Stream Mapping the Taper Roller bearing production is as shown in table no. 1.

Table 1: Observed VSM data

Sr. No.	Process	Cycle Time (sec)	Work-in-Process (WIP)	Value added time (VA) (sec)	Non-value added time (NVA) (sec)
1	IR Track Grinding	16.7	58	16.7	971.5
2	IR Bore Grinding 1	35.4	12	35.4	426
3	IR Bore Grinding 2	34.8	10	34.8	349
4	IR Flange Grinding	16.4	4	16.4	66
5	IR Track Honing	17.5	9	17.5	157.6
6	OR Track Grinding 1	34.9	30	34.9	1048.2
7	OR Track Grinding 2	33.8	30	33.8	1016.2
8	OR Track Honing 1	35.1	21	35.1	738.0
9	OR Track Honing 2	33.3	9	33.3	299.76
10	Cone Assembly	13.7	146	13.7	2003.0
11	Vibration testing	16.3	15	16.3	275.5
12	Missing roller checking	10.8	4	10.8	43.13
13	Quality Station	10	44	10	440
14	Oiling and Packaging	20	47	20	940

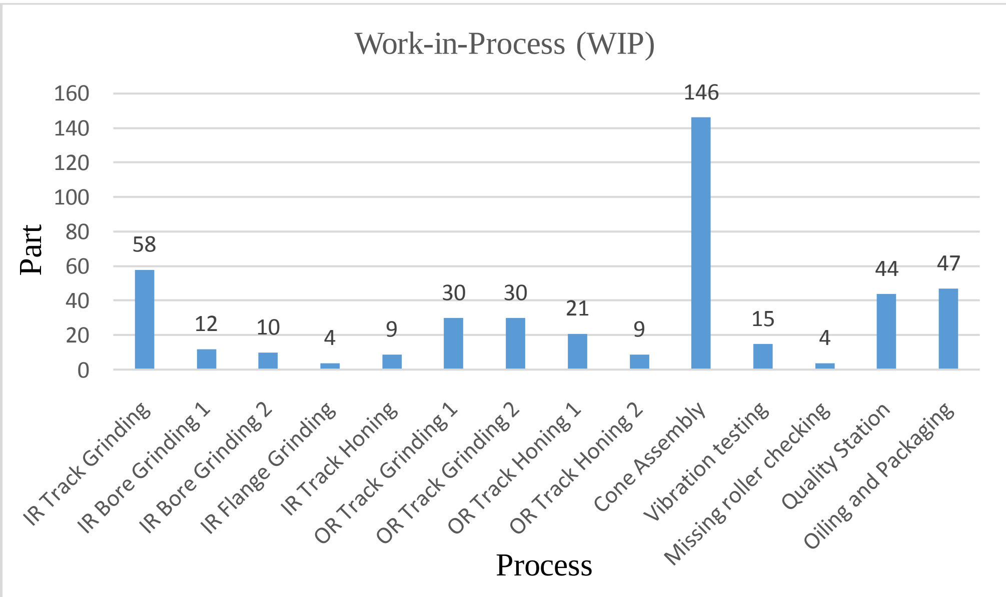


Figure 6: Work-in-Process Inventory

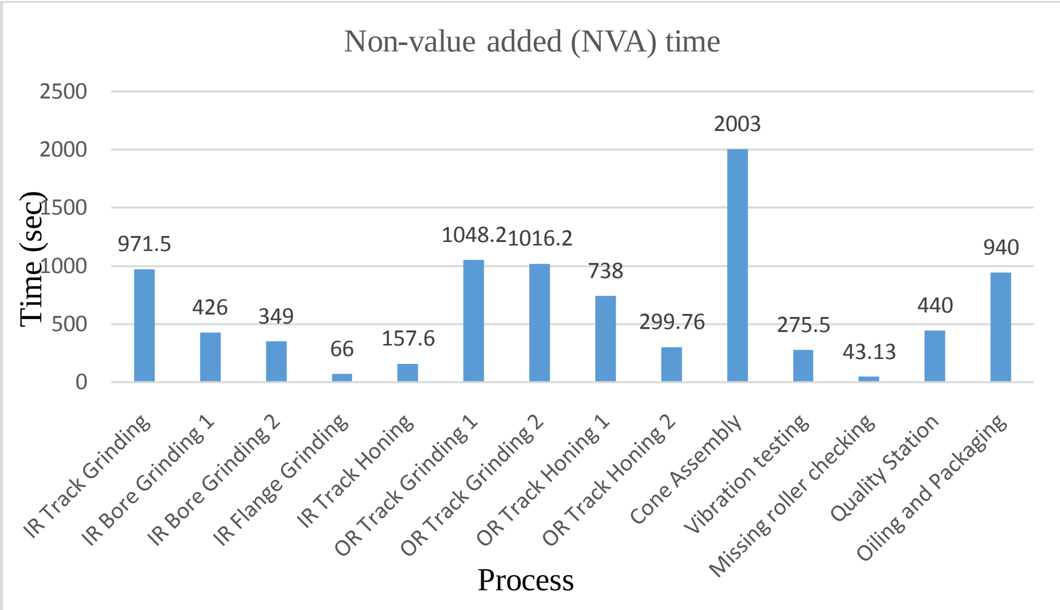


Figure 7: Non-value added (NVA) time

From fig. 6 and fig.7, it can be seen that the non-value added time for the cone assembly machine is the highest followed by OR Track Grinding 1 machine and OR Track Grinding 2 machine. Also the Work-in-Process (WIP) inventory for the cone assembly machine is the highest. From this we can state that the Cone Assembly machine is the main bottleneck machine. Due to the cone assembly machine, the flow through the production line is slow. Also during the VSM, the Standard Operating Procedure (SOP) was found to be in faded and unreadable condition thus affecting the operators' quality of work.

Conclusion

The Cone Assembly machine is found to be main bottleneck machine. This bottleneck can be removed or eliminated to improve flow through the production line. To eliminate or remove this bottleneck, various lean tools can be used such as Root Cause Analysis and Kiazen. This will not only improve flow but also the net throughput of the production line. New updated SOP with pictorial guide can be established and located on a stand within the operator view range to improve understanding and quality of operators work. The use of VSM on the Taper Roller Bearing production line has led to identification of lean opportunities on the production floor. Also the SOP could be a key driver in continuous improvement sustainability on the production line. Further improvements can be done by eliminating or minimizing other wastes that affect the flow of the production system. Also this tool can be applied in other manufacturing industry to improve the efficiency of the production system.

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