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Optimization of Production Process and Machining Time in CNC Cell through the Execution of Different Lean Tools

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Abstract

Lean manufacturing is a continuous enhancement technique and a new management approach for small and medium scale manufacturing industries. The primary focus on lean production system is the systematic elimination of non-value added activities from the production process. Value stream mapping is used to map the current state and then helps to identify the sources of wastes in the present system. After identifying the wastes in the current system proper lean tools may be suggested to eliminate these wastes. Work standardization is an important in all manufacturing sector which will give better work procedure, manufacturing flow and solution for variability during production. The main aim of this research is to study the present line balancing layout in CNC machining cell and to develop the proposed line balancing layout to increase the workers utilization. Work standardization was carried out by using the time study and work study with the help of video analysis. Then the non-value added activities were categorized and about 120 minutes of floor to floor cycle time was reduced. Line balancing was carried out to in a machining cell to maximize the operators' utilization by using the one operator- two machine methods. From results it was found that, the man power utilization was increased about 70%. Hence, the total cycle time and non-value added time has been reduced and also the overall productivity was increased to meet the customer demand at the right time.

Keywords: VSM; Work Standardization; Line Balancing; CNC Cell; Lead Time; ARENA

INTRODUCTION

Increasing demand in global markets leads to high variety of products, reducing cost in manufacturing, lesser lead time and perfect quality. This makes manufacturing industries to adapt lean concepts. Lean philosophy is universal and can be applied to manufacturing, design, quality control, administration, order taking, accounts receivable or any activity that needs to be improved. Lean has been recognized as one of the key approaches in enhancing the productivity. Lean is nothing but manufacturing without waste, lean is centered on preserving value with less work "A systematic approach to identifying and eliminating waste called non-value added activities through continuous improvement by flow the product at the pull of the customer in pursuit of perfection. Lean manufacturing concepts also focusing on reduction of cost by eliminating the non value added activities (NVA) and reduction of necessary non value added activities (NNVA). Value added activity means that physically changes the material and non-value added activity means that takes time, space, material but does not changes the physical material. This paper focuses on work in CNC machine cell area, where the cell produces the gearbox housing unit. Already lean tools like 5S, continuous flow, just-in time, overall equipment effectiveness are implemented in this CNC manufacturing cell. The study focuses on work standardization by creating the standard operating procedures (SOP) with line balancing layout optimization. A brainstorming session was also carried out with the process engineers, team leader, cell brigadier and operators regarding the issues faced in the machining cell and identified the bottleneck area, which is essential to enhance the overall productivity to meet the customer demand at right time.

LITERATURE SURVEY

Toyota production system was developed at Toyota motor company that describes to provide world class quality and service to the customer by using the various lean techniques [1-4]. The goal of lean manufacturing is to increase the profit and competitiveness by increasing, decreasing cost by eliminating waste and reducing cycle time [5-9]. Current state value stream mapping (VSM) is used to identify the problem and future stage VSM is used to eliminate NVA and NNVA to enhance the productivity then make the SOP in production

line by reducing lead time and improving method study [10-14]. This tool is used to reduce the bottleneck for making continuous flow. Continuous improvement is another fundamental principle of lean manufacturing [15-17]. Kaizen is a systematic approach to gradual, orderly and continuous improvement method [18-20]. Waste could be in the form of scrap, defects, raw materials, unneeded items and old broken tools. The very important principle of waste elimination is the standardization of work actions. Standardized work basically ensures that each job is organized and is carried out in most effective manner. Standardization work in manufacturing industry leads to decrease in lead time, cycle time and setup time with higher quality [21-24]. A model was proposed to achieve success in the agile based supply chain where the system should adapt to changes immediately and an idea was initiated to examine the different defects of cast iron foundry and proposed a supply chain model to present the necessity of quality in a medium scale industry of cast iron foundry [25-27]. The application of VSM and line balancing in a manufacturing industry brings an idea of setup time and cycle time reduction. Case study helps to balance the work load between the operators by eliminating idle time. Sustainability is very important factor for attaining competitiveness to meet the customer demand at right time [28-32]. During selection of the best supplier, many criteria are to be considered that may be different for different approaches for manufacturing [33-36]. Based on the above, the VSM study was carried out in a CNC machining cell located at Chennai along with line balancing and work standardization.

OBJECTIVE AND METHODOLOGY

Problem has been defined as weekly demand is not satisfied and operator idle time is high by analyzing the detailed study of housing line and the objective are concluded in brainstorming session as to eliminate the lean waste from the manufacturing process to improve productivity and also to improve the man utilization by line balancing. Data collection was done by using stop watch time study and work study was done by video analysis. TAKT time was calculated based on demand, then compared against cycle time and value stream mapping was developed to analyse the lead time using i-Grafix software. Waste identification was done through video analysis. Value added and non-value added activities are getting optimized. In this non-value added activities the necessary non value added activities were categorized which need to be reduced and other else are to be eliminated by providing the potential measures for non-value added activities are defined by giving improvement activities. Line balancing has done for balancing the workload between operators and to improve the man utilization using ARENA package is used for optimizing results. The entire research work methodology to fulfill the objectives is shown in Figure 1.

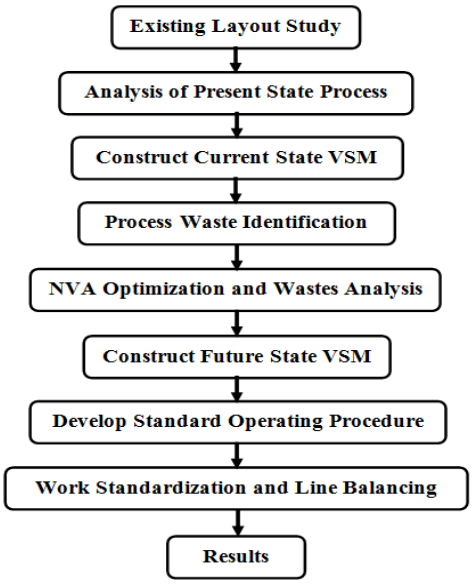

Figure 1: Methodology flow chart

REVIEW ON PRODUCT AND PROCESS

The existing plant layout was studied as the first step of this research methodology. The study was carried out in a gear box manufacturing process and housing cell was identified as the bottleneck for the manufacturing process which needs the improvement. This research focuses in CNC machining cells, where they produce housings for wind mill gear box. The cell produces more than seven models of gear boxes and one model has been chosen for this study purpose. Table 1 shows list of sub parts in housing and process description. Figure 2 shows the process sequences and also it gives overall view of material flow and operation sequences.

Table 1: Product description

Sl. No.	Process	Sub Parts
1	AA	Cover (Upper Housing)
2	BB	Carter (Lower Housing)
3	CC	Housing
4	DD	Inspection

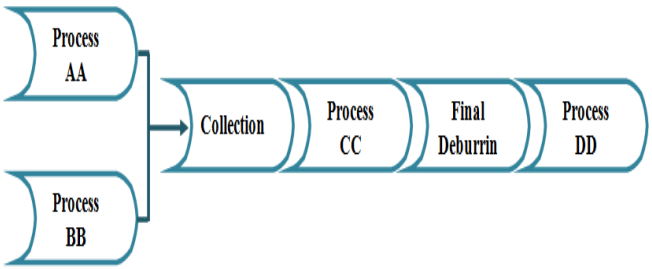

Figure 2: Sequence of processes

Value Stream Mapping

Value stream mapping is a special type of flow chart that used to evaluate the value added and non- value added activities from the process flow. The data collected for building up of current state value stream mapping are includes cycle time, setup time, change over time, number of operators, percentage of value and non-value added activities, demand, inventory, information flow. The current state value stream mapping with necessary information and cell observation is shown in Figure 3. It was found that the total lead time is 2718 minutes for a completion of manufacturing process. Similarly the TAKT time was also calculated as per the current data as follows.

TAKT Time is the time at time to produce the product to meet the customer demand.

Customer Demand = 140 pieces per month

Available time per day = 1440 minutes

= [3shifts x {8hoursx60 minutes-(60minutes)}]

$$\text{TAKT Time} = \frac{\text{Available time/day}}{\text{Customer demand/day}}$$

= 1260/5 =252 minutes

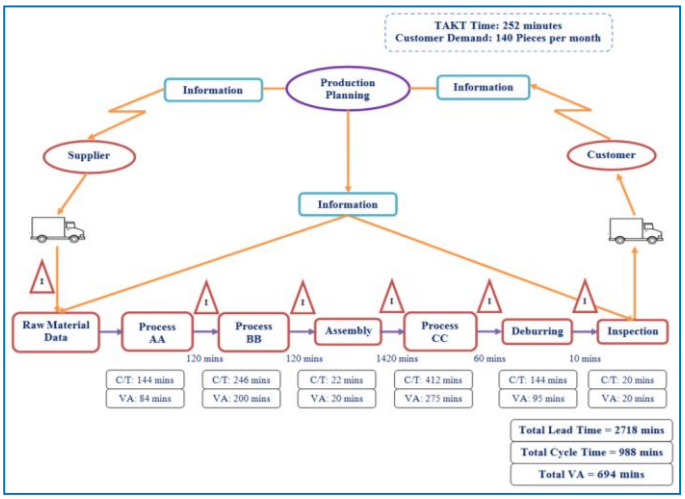

Figure 3: Current state value stream mapping

Future State Value Stream Mapping

The future state VSM was developed based on the existing VSM model and proposes the suggestions for improving the current position of the company as shown in Figure 4. From the future state VSM it was observed that using suitable lean tools the total cycle time was reduced from 988 minutes to 868 minutes. Similarly the lead time was reduced from 2718 minutes to 2598 minutes and the total value added time was also reduced from 694 minutes to 605 minutes after implementation of appropriate lean tools.

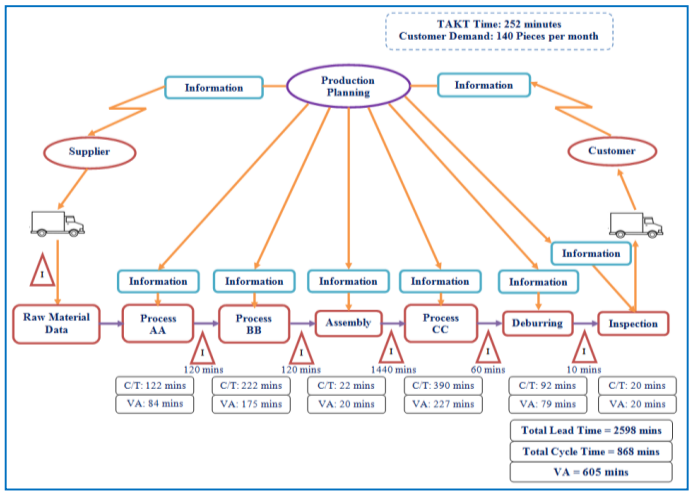

Figure 4: Future state value stream mapping

Work Standardization

Cycle time study

Cycle time study by using stop watch and video analysis has done for single gear box model and get analysed. The cycle time difference between actual and standard cycle time is shown in Figure 5.

Value added and Non-value added activities

Cycle time study and video analyzing helps to optimize value added (VA) activities, which customer willing to pay and to find the percentage of NVA activities present in entire operations.

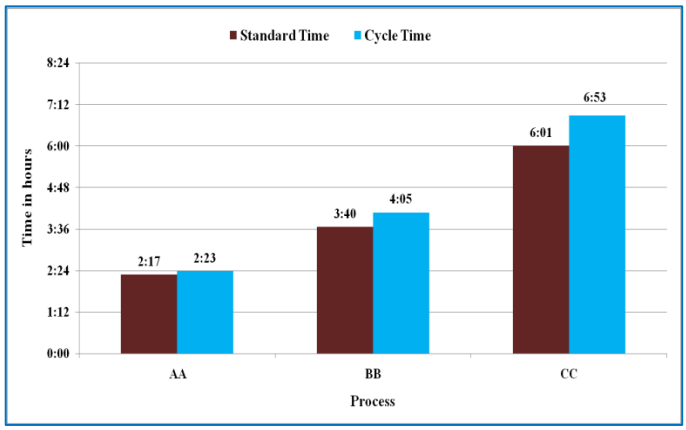

Figure 5: Cycle time difference

Non- value added activities are classified as obvious waste (OW), which need to be eliminated. Hidden waste (HW),

which needs to be reduced and these wastes cannot be eliminated from the process and varies depends on man and material. Material handling (MH), need to check whether it can shift to logistics or combine the process to reduce the cycle time. Periodic activities are the current state in the process. The total process is categorized by value added and non-value added activities for process AA, process BB, process CC and deburring are shown in Figure 6, 7, 8 and 9 respectively.

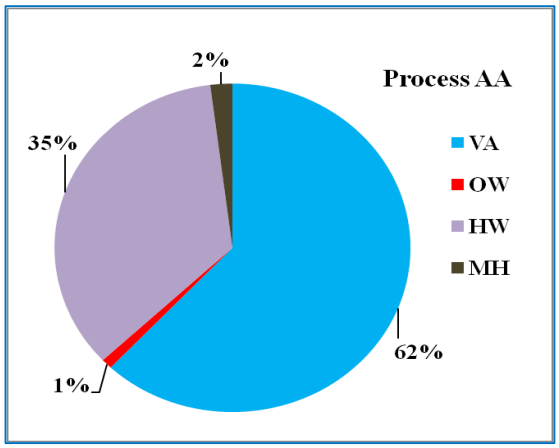

Figure 6: NVA in process AA

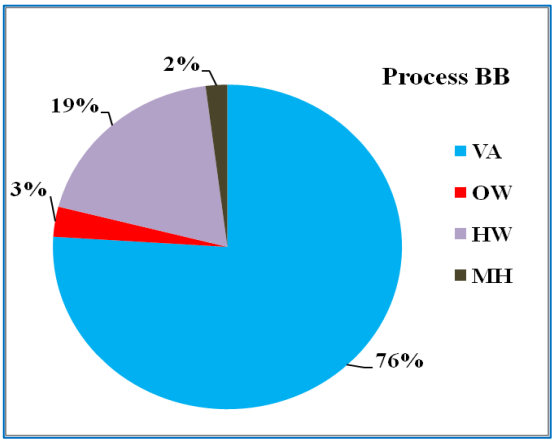

Figure 7: NVA in process BB

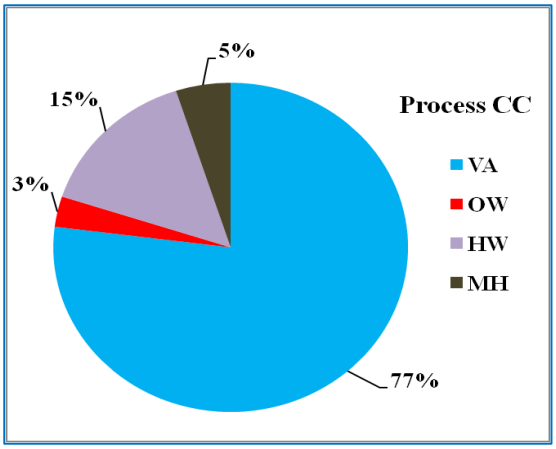

Figure 8: NVA in process CC

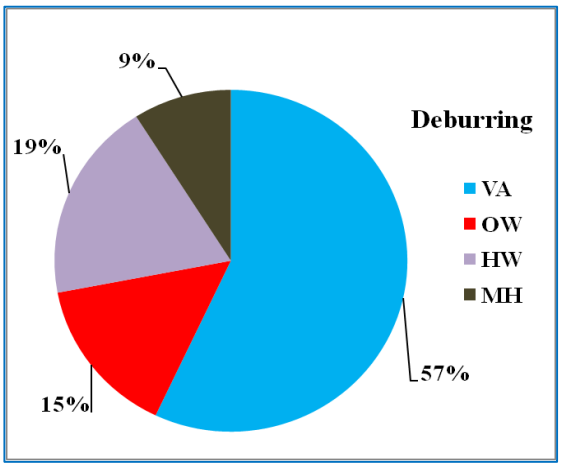

Figure 9: NVA in deburring

Work Standardization

Work standardization is needed for appropriate plan and position of employees, materials, machines, supporting elements and facilities for the perfection in manufacturing environment. The work standardization methodology implemented in this research is shown in Figure 10. Standardization of the operations is carried out as per the methodology mentioned earlier. Three cycles are performed for time study during the data collection. About twenty improvement ideas were identified and Kaizen's were suggested to improve the value in process. Reduction of about 120 minutes in cycle time and potential measures for improvements was suggested. By adapting the standard operating procedure in housing cell, which12% of NVA has been reduced from current process. Standard operating procedure is created based on 92% efficiency of operator with 8% of allowances per shift. The results of floor to floor (FTF) cycle time reduction in process AA, BB, CC and deburring are shown in Figure 11, 12, 13 and 14 respectively.

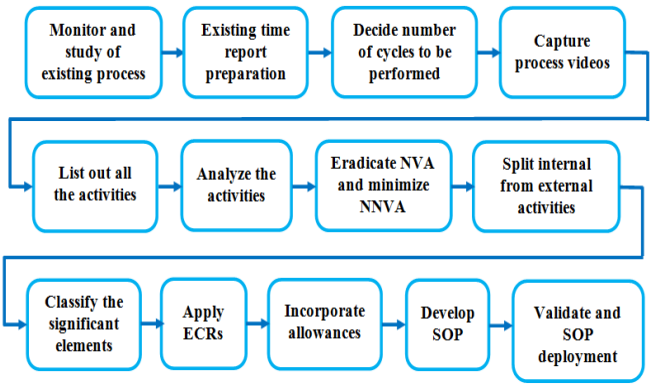

Figure 10: Methodology in work standardization

The entire floor to floor cycle time is considered for study purpose and final deburring operations were carried out by contract labour. A video study has done for deburring process because lead time increases due to slow process and to meet the daily demand in assembly section.

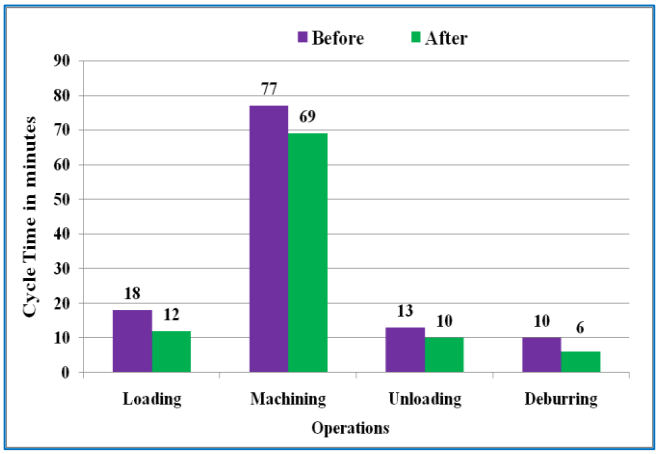

Figure 11: FTF cycle time for process AA

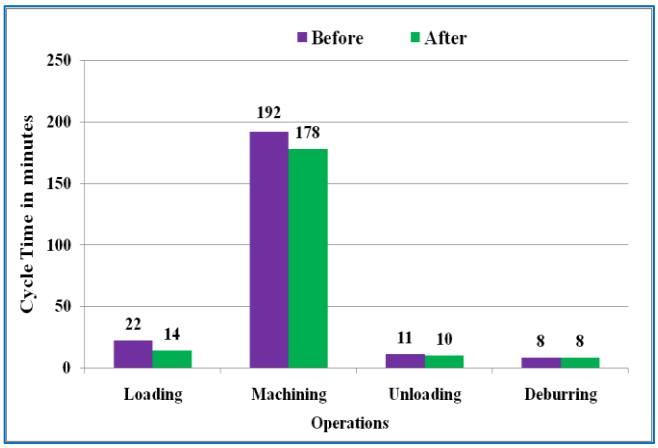

Figure 12: FTF cycle time for process BB

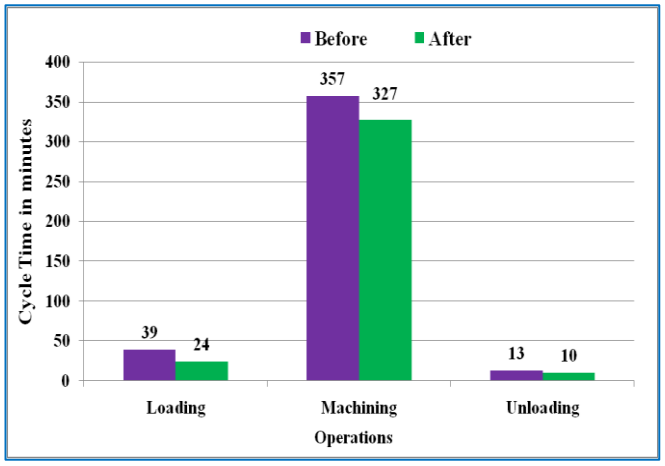

Figure 13: FTF cycle time for process CC

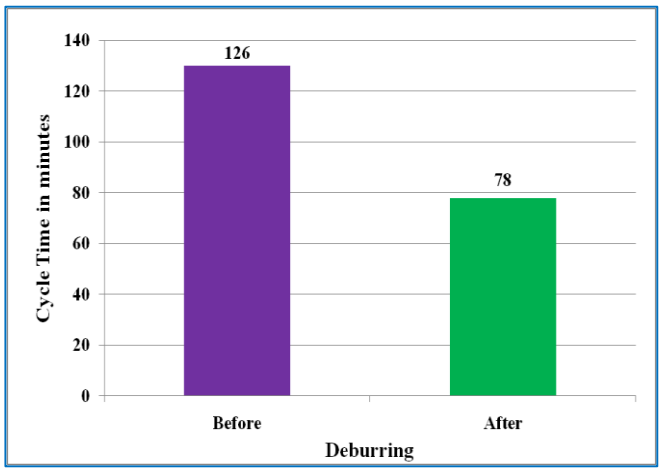

Figure 14: FTF cycle time for deburring

Line Balancing

Line balancing concept was applied in this study to manage workload between operators and to reduce the man idle time which occurs due to high auto machining time. Hence, the schedule for the every operator has been assigned. The study was carried out by using the simulation to optimize the man utilization and to improve productivity by eliminating non-value added activities. For the existing layout, line balancing concepts were applied based on data collected for the standardization operations. In these operators movement and periodic activities are fallowed and new concepts of two machine-one operator concepts were proposed for effective utilization of man power. The existing line balancing layout of the housing area with one machine-one operator concept by reviewing the periodic activities done by each operator in respective machine is shown in Figure 15.

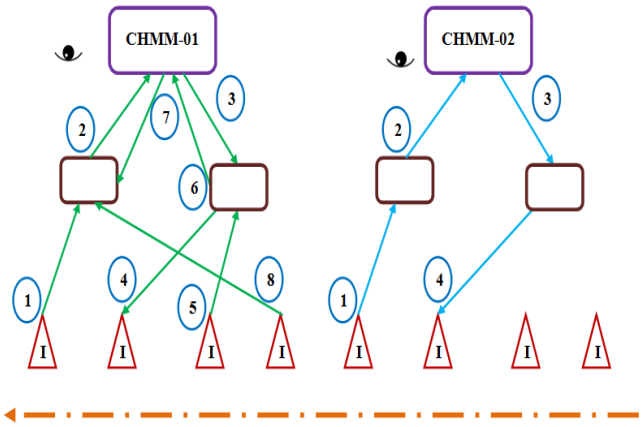

Figure 15: Existing line balancing layout

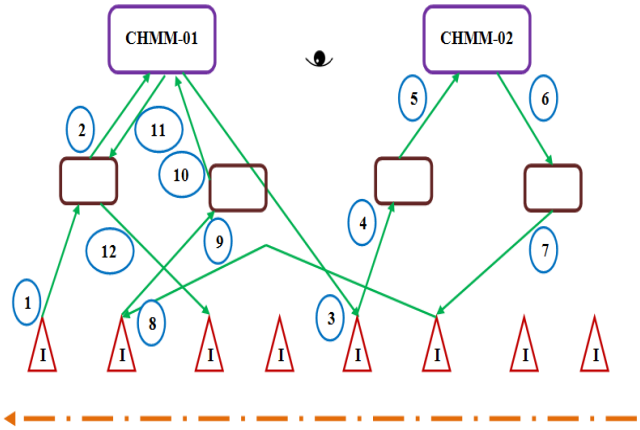

Figure 16: Proposed line balancing layout

The proposed line balancing concept was proposed and simulation has done after waste reductions in process with the allocation of resources are shown in Figure 16. From this line balancing concept man idle time is reduced and the man and machine utilization is balanced to 80%. In existing, during process man involved in work is 2 hours and 18 minutes in the total cycle time of 5 hours and 35 minutes which is just around 58% only. So the single operator for two machines can be used, which is nearby balanced with the man and machine utilization. It was observed that around 80% of utilization by both the machine and man utilization is increased up to 72% by the arena simulation.

CONCLUSIONS

The application of lean tools in machining cell was studied and analysed. The objective was to identify and remove the wastes in any activities that do not value added to the final product in the manufacturing process and also to reduce the overall lead time. Based on the study and analysis the following conclusions were arrived.

- Lean tools like work standardization has been applied to eliminate non value added activities in manufacturing area.
- By implementing standard operating procedure, 118 minutes of floor to floor cycle time was reduced which covers about 12% of reduction in total NVA.
- From the results, it was observed that the total output was increased from 5 to 6 components per day after implementing the proposed line balancing.
- One operator-two machine line balancing concept has been suggested to ensure better utilization of man in working area.
- Using Arena packages non- value added activities were eliminated in CNC machining cells and also productivity of gear box can get improved to meet the customer demand.

This research was focused based on value stream mapping only in CNC machining chamber. This could be more extended in the operations of parallel manufacturing parts with additional lean tools like TPM, SMED etc.

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