# AUGMENTING PRODUCTIVITY USING TQM PRINCIPLES

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**ABSTRACT**

*In the race of meeting the customer's demands several manufacturing industries fail to appreciate the benefits of implementing the quality tools in production process. The primary aim of the TQM tools such as SIX SIGMA and LEAN MANUFACTURING is to improvise the productivity by providing the customer satisfaction. This article is focused on implementing lean six sigma in a manufacturing industry, here the six-sigma tool is utilized to reduce the rejection rate of the component. Based on the preliminary studies it can be concluded that the sliding gear component is one which produces more defects. In order to reduce the rejection rate of the component a new methodology is proposed by implementing Six sigma tools. Also, the proposed new methodology contributes to the industry by reducing the rejection rate and production time thereby improvising the productivity of the company.*

**Key words:** Six Sigma, Lean manufacturing, Value stream mapping, TQM, Implementation.

## 1. INTRODUCTION

Total quality management originated as a philosophy in late 1970s in UK. However, Deming and other Japanese industrialists can be perceived as pioneers in maintaining quality standards in Japanese Industries. The success of the Japanese in improving their quality standards became a major concern for the remaining manufacturers in the rest of the world. Production Industries faces many potential hurdles in successfully implementing TQM concept in their manufacturing processes, since the requirement of the costumers is increasing as time progresses. It is very hard to meet out the costumer's market and quality demands as time to time delivery of the goods is mandate in any production industries. In order to ensure the timely delivery of the goods to the customers by reducing the rejection the causes for the defects has to be identified. TQM is an organizational wide effort to implement a permanent system that helps the organization to continuously improves its ability to delivery high quality products and service to the customers. Lean six sigma is one of the techniques that has been identified by the major manufacturing companies to explore world class capabilities. Lean Six sigma has capability to reduce the manufacturing lead time and material handling cost simultaneously improving the quality of the product with other benefits. 5S, root cause analysis, bottle neck analysis and value stream mapping are some of the lean six sigma methods that can be implemented in any company to establish TQM.

Protik Basu and Pranab K. Dan studied to enhance the output of a manufacturing setup by identifying and reducing the wastes the extends the production lines. Value stream mapping (VSM) methodology has been used as a data-driven decision-making tool to identify the constraints in the current state and following states. The future state has been achieved in stages using VSM tool of lean manufacturing, the underlying problem of capacity enhancement has been addressed using lean principles and the optimum feasible option has been designed.[1] Sean P. Goffnett , et al. presented the framework to define the coordinated use of the socio-economic approach to management (SEAM) and Lean Six Sigma (LSS) to enable process change. Their study uses action research and thematic analysis to reconnoiter the augmentation of current process. The main goal of the paper is to expose this deficiency [2]. Vujica Herzog, Natasa, et al. in there mail goat to expose the deficiency due to which VSM tool is not widely used in manufacturing industry and also understands the capability of rh VSM process in material and information flow, along with key data[3].

Shawkat Imam Shakil and Mahmud Parvez successfully applied VSM technique to improve OEE and other performance in a sewing line of a textile industry. Improvement scopes have been identified from the current state map, and rough set theory has been adopted to identify focused areas and improvement strategy regarding where and how lean control should be approached. Finally, OEE improved from 45 to 53.75% [4]. Danilo Ribamar et al demonstrated the use of VSM toll in maintenance engineering department of the company which is called as MFVSM. Their work focused in applying the MFVSM technique in a thermoplastic company. Their results proved that MFVSM is a powerful technique in lean maintenance which deliberately helps in increasing production of the plant [5]. Ton Nguyen Trong Hien and Gareth Jones developed a value stream mapping for ETP ion Detect TM company to show the possibilities in improvement by seeing the sources of waste. Which lead to shortening of the lead time, and reduced the inventory [6]. Lakhan Patidar et al in their research identified the interdependencies among all the selected VSM activities and analyzed the key dependency that drives to the organizational successes. A to segmented process was implemented for achieving this the former part of the research was dedicated to study the literature and the latter part was to prepare an ISM based framework to analyze the VSM activities through MICMAC. Findings of this study reveal that lead time and cycle time reduction are a matter of concern and need maximum attention for successful VSM implementation [7]. Ioannis Belekoukiasa, et al. investigated on the impact of 5 most important lean methodologies such as JIT, Automation, Kaizen, Total productive maintenance and Value Stream mapping. A linear regression-based model was developed to correlate the importance of these parameters on the operational performance of 140 manufacturing industries around the world. Their results showed that JIT and automation have strongest effect in altering the operational performance of the production plant while JIT, TPM and VSM seems to have lesser or even negative effects in certain cases[8].

Martin Melin implemented lean production technique, particularly VSM in dairy farm to create a action plan. In the two-to-three-year period following the VSM project, specific improvements were observed in milk production/quality and animal health. The results also reveal that while Lean principles are relevant given the repetitive nature of agriculture routines and tasks, the VSM element of lead-time reduction is less relevant owing to the unique value adding biological processes in the agriculture sector [9]. Qingqi Liu , et al. in their study examined a Chinese food processing plant with various processing capacities and processing times for each and every production line and identified a feasible production process for attaining minimal processing times. The conclusions indicate that the optimal cycle time of each process in such cases cannot be determined simply based on the Takt time of the production line. The traditional value stream analysis technique should be altered when processing capacity and time are suggestively different for each process [10]. S Samant and R Prakash in their research studied the drawbacks of the VSM tool through an innovative framework involving the usage of discrete event simulation, box score, and life cycle assessment (lca) [11].

Manufacturing lead time can be reduced by effectively utilizing the working area, 5S is the lean manufacturing technique that is used to organize the working area. It eliminates the waste that arises as a result of poorly organized work space and keeps it clean enabling to provide superior working envorinment.

Root cause analysis is an effective problem-solving methodology that is employed for identifying and resolving the underlying problem. RCA methodology provides permanent solution to the problems instead of giving quick fixes It helps to ensure that a problem is truly eliminated by applying corrective actions to the root cause of the problem.

Bottle neck analysis is primarily done in order to identify the part of the process which limits the overall productivity of the entire manufacturing plant. This analysis will provide the information about the major problem causing area and potentially weak area in the manufacturing process.

Value stream mapping is a visual aid used to map the flow of part and process in the production plant. It gives the information about the current and future state of the process highlighting the opportunities for improvement. VSM process also exposes the waste in the current process and provides guidelines for improvement and preparation of future state map. This future state map thus obtained will be implemented in the manufacturing process.

This article also focuses on implementing the TQM concepts for improvement in process flow and reducing wastes, since rejection and waste are the major losses that is being faced in the order-based manufacturing industry. This study is done in BASCET Engineering and Services manufacturers of accessories for UPVC doors and windows.

### 1.1. Current state analysis

The flow of raw material from start to finish have been analyzed during the visit to the company. The flow of work between machines and movement of the workers have been studied using Value stream mapping which provided sufficient information for understanding the process done. By this basic information obtained from the critical observation the process flow chart for the components were drawn showing all the required information about sequence of the operations that has to be conducted and also movement of the worker between the machines. By analyzing the data of all the component manufactured in a company the number of components defective were determined.

### 1.2. Yield and Sigma Analysis

The yield calculations and sigma ratings of the components is shown in the table 1. Yield of the component can be recognized as the ratio of the components without defects to total number of components produced. Sigma rating of the components can be identified from the standard Sigma table given in appendix. The ratings are taken from the corresponding yield percentage. Form the table1 it has been identified that the sigma rating of the tooth brush component is very poor when compared with other components produced.

**Table 1:** Sigma rating of the components

| Component | Number of parts with defects per 1000 parts | Number of parts without defects per 1000 parts | Yield | Percentage Yield | Sigma Rating |
|---|---|---|---|---|---|
| Plane band espags base | 22 | 978 | 0.978 | 97.8 | 3.5 |
| Plane band espags inner | 6 | 994 | 0.994 | 99.4 | 4.3 |
| SS reciever | 30 | 970 | 0.97 | 97 | 3.4 |
| Double roller bracket | 13 | 987 | 0.987 | 98.7 | 3.7 |
| Runner block | 3 | 997 | 0.997 | 99.7 | 4.3 |
| Tooth brush | 279 | 730 | 0.73 | 73 | 2.1 |
| U band espags base | 41 | 959 | 0.959 | 95.9 | 3.2 |
| U band espags inner | 50 | 950 | 0.95 | 95 | 3.2 |

### 1.3. Root cause analysis of tooth brush

Since, the sigma rating of the tooth brush component is least root cause analysis has been done to the component to determine the major source for the defect. In order to determine the root cause of the failure the process of manufacturing as shown in the figure 1 has been studied and the critical process causing the defect have been identified. The component diagram and defective component has been shown in the figure 2 . from the information available at this stage it has been identified that the square cutting operation is causing the major defects in the component.

**Figure1** Processing steps of sliding gear component

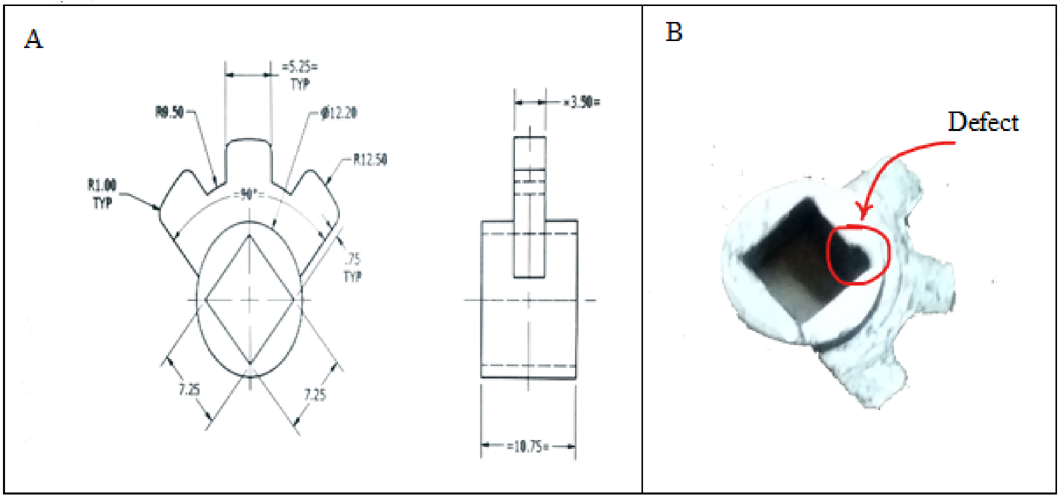


**Figure 2** Component Diagram (A) Defective Component (B)

From the Figure 2 it is visible that the cracks are formed at corners of the component and the edges of the inner square cut. These defects can't be reworked and used, as the damage is beyond rework.

## 1.4. Value stream mapping

The data regarding the defective components and its processes are collected and current state value stream mapping is made. This mapping helps in finding out the opportunities in which the improvements can be made. The figure 3 shows the current state value stream mapping. This mapping requires data such as total number of products per batch, number of defective components, number of workers, setup time and cycle time. The marker parameters of the process are calculated from the collected data using the equations given below.
Defects per unit,
Defects per Opportunity,
First pass yield,
First time yield,
Where Nd= Number of defective units, N= Total Units, Np= Units defect free, Ne= Units entered the process, O= Opportunities, R= Rework.

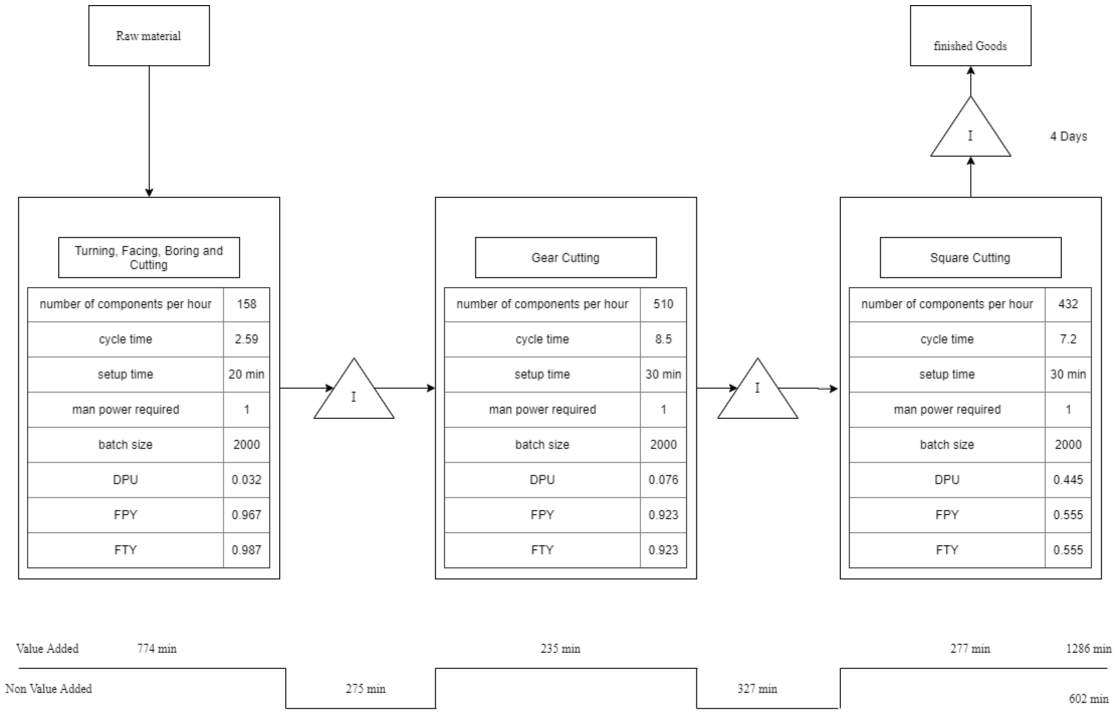


**Figure 3** Current state value stream mapping

From the figure 3 and calculation, it is evident that FTY and FPY are same as the defects from the operation cannot be reworked since the size of the component is small. Also, the defects caused in the operation is large and cannot be undone by rework hence the defective components are sent to scrap. For the current state VSM it is evident that the opportunities identified are the inventory time between processes and from the VSM the DPU of every process is calculated. The quality of the component and the production can be greatly improved if we reduce the defect in the square cutting operation since, DPU of the square cutting operation is very low.

## 2. PROPOSED METHODOLOGY

From the current state VSM, the opportunities are identified and analyzed for alternative methods and options. To reduce the inventory time between the processes and work in progress time, the work can be scheduled with 2 workers. So that the inventory time can be reduced by half its current state value. This also improves the work in progress time by twice its actual time.

As identified the DPU of square cutting operation has the highest DPU of 0.445 which shows that the defects produced are nearly half the number of products manufactured. This means that half the energy and time spend on the manufacturing of the component is wasted. To eliminate this waste two methods were proposed, one using broaching tool for cutting operation and other is manufacturing of the component using zinc die casting.

## 2.1. Proposed VSM using broaching tool

Form the detailed analysis of the defective component it is evident that the defects are mainly caused by square cutting operation. It is also identified that the tool and method used for the square cutting is the root cause of the problem. The square cutting operation is proposed to be done by using broaching tool in order to reduce the defects. The broaching tool reduces the defects by removing the material in a step by step process which uses a specially designed tool for this purpose.

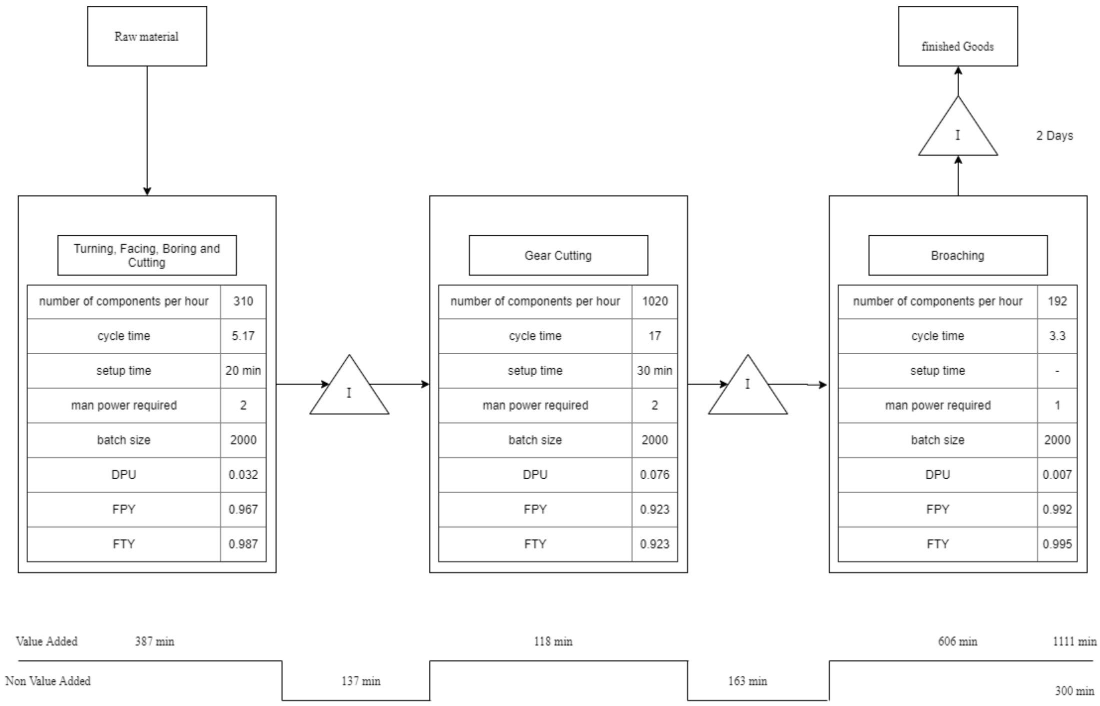


**Figure 4** Proposed value stream mapping using broaching tool

## 2.2. Proposed VSM using zinc die casting

In this proposed method hot chamber diecasting can be used with zinc, magnesium and other low melting alloys using either proprietary multi slide or conventional tooling. The hot chamber machine contains the melting pot, while the cold chamber melt pot is separate and the molten metal has to be ladled into the shot sleeve. With the internal mechanism, it makes the hot chamber the faster of the two processes. Other advantages of the hot chamber process include reduced porosity and longer die life from utilizing alloys that do not erode or dissolve the machine when put under heat or high pressure. The VSM for proposed method is given in figure 5. The material proposed for using in this process is ZAMAK-3 or Zinc alloy 3, which is the most widely used zinc alloy when comes to zinc die casting since it has better balance between desirable physical and mechanical properties, better cast ability, excellent surface finish and excellent vibration attenuation capability than aluminum die cast alloys. The composition and mechanical properties are provided in table 2 and table 3 respectively.

**Table 2** Mechanical properties

| | |
|---|---|
| Material | Zinc |
| Alloy | Zamak 3 |
| Tensile strength | 283 Mpa |
| Yield strength | 221 Mpa |
| ssImpact strength | 51 J |
| Shear strength | 214 Mpa |
| Hardness | 84 BHN |
| Elongation | 10% IN 50mm |
| Process | Hot chamber die casting |

**Table 3** Material composition

| % | Zinc<br>Zamak 3 |
|---|---|
| Aluminium | 3.5-4.3 |
| Copper | 0.25 max |
| Magnesium | 0.02-0.05 |
| Iron(max) | 0.1 |
| Lead(max) | 0.005 |
| Cadmium(max) | 0.004 |
| Tin(max) | 0.003 |
| zinc | Bal |

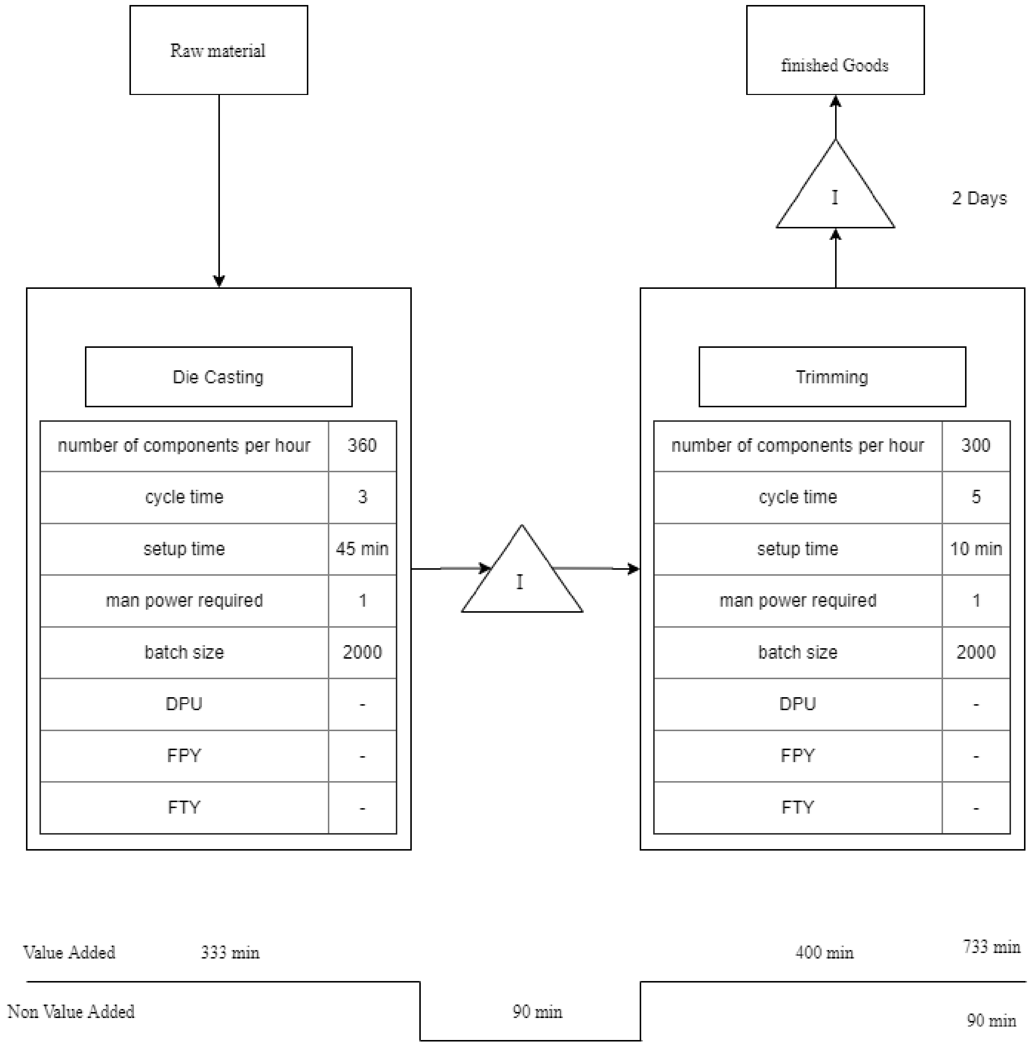


**Figure 5** Proposed VSM using zinc die casting

The above shown VSM was proposed based on the study about the casting methods. This type of casting method was proposed since the component size is small and the component required should withstand longer duration.

## 3. RESULTS AND DISCUSSIONS

Based on the calculations done a graph showing the process time among all the VSM has been plotted in the figure 6. it is evident from the figure 6 that the process involving the die casting has the lowest process time both in case of non-value added and value-added activities. Therefore, it can be considered as the better alternative for the current processes.

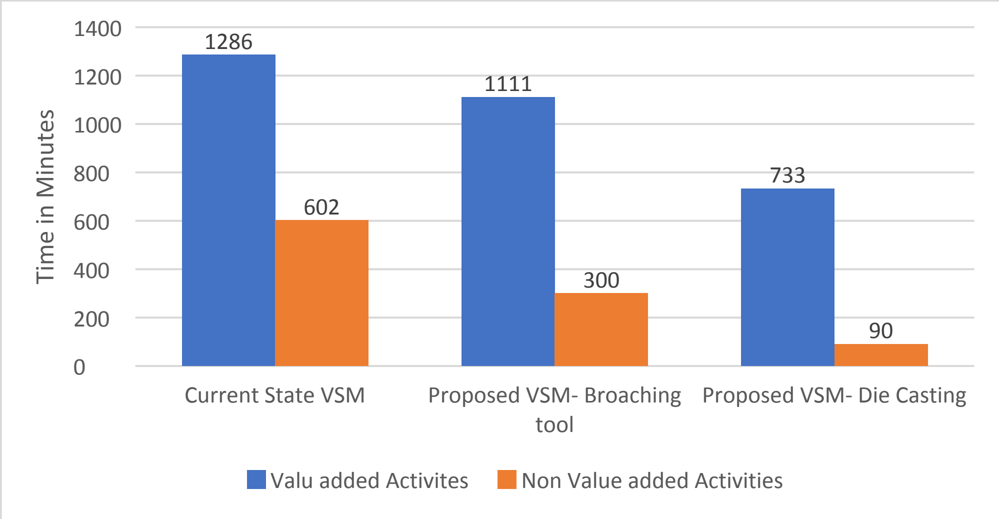


**Figure 6** Comparison between process times among VSM

## 4. CONCLUSION

From the results obtained it is found that, for Tooth Bush component zinc die casting is the suitable manufacturing method. The broaching tool is also the best alternative method for reducing the defects. Comparing the two proposals by considering other parameters such as cost, process simplification, Man power requirements, Zinc die casting is the best suited method for the manufacturing of Tooth Bush component.

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**Appendix**

| Sigma level | Defects per million opportunities | Percentage yield |
|---|---|---|
| 1σ | 6,91,462 | 31 |
| 2σ | 3,08,537 | 69 |
| 3σ | 66,807 | 93.3 |
| 4σ | 6,210 | 99.38 |
| 5σ | 233 | 99.977 |
| 6σ | 3.4 | 99.99966 |