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Applying Theory of Constraint Philosophy for Lead Time Reduction

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Abstract: Theory of Constraint (TOC) philosophy was first introduced by Eli Goldratt in 1988 aiming at improving the weakest links of a chain considering a fact that the performance of any production system is limited by the bottleneck and focusing on eliminating these bottlenecks can improve the efficiency of a system. The fierce competition in today's business environment makes it necessary to reduce non-productive time and thus reducing the delivery time. The problem of larger delivery time faced by a leading toggle clamp manufacturers have been addressed in this paper. In order to reduce lead time, the five steps methodology of Theory of Constraint Concepts is suggested for implementation. On analysing the Value Stream Map, plating process was identified as a constraint. Hence erecting the new in-house plating plant was considered as a solution in order to reduce the waiting time before the plating process and thus reducing the lead time. The study concludes possible estimated reduction of 75% in lead time by observing future state Value Stream Map developed considering the alternative of new in-house plating plant erection.

Keywords: TOC, Lead Time, Non-productive time, Value Stream Map, Toggle Clamp

I. INTRODUCTION

Today's businesses are competing based on delivery time and quality of product. To survive in this fierce competition, they have to produce better quality products in shorter throughput time. Thus in order to fulfil customer's requirement within the shortest possible time, there is a need of proper utilization of the capacity of production facilities. The output of a system is a function of the entire system and not just of single process and when the system is seen as a whole, it can be seen that the output is a function of the weakest link of the system's process flow. This weakest link is nothing but the constraint. The aim of every organization is to achieve higher profits and each of them has at least one constraint that prevent it from achieving its final goal of improved profitability. Thus it is vital for any business to identify and manage these constraints in order to achieve higher profits. Focusing on improving an entire system rather than improving bottleneck constraint, does not impact output of the overall system. Most organizations have to accomplish many things with limited resources. Thus in order to make real progress towards the goal, it is necessary to be focussed on the constraint rather than the entire system. Given this perspective, Theory of Constraint's 5-step process offers a systematic and focused approach that can be used by the organization to successfully pursue ongoing improvement. Theory of Constraints (TOC) aims at identifying the weakest link, or the bottleneck and focusing on eliminating these constraints and hence leads to increase in the efficiency of a system.

Theory of constraint Philosophy has been typically used in almost all the sectors of business environment. Trumone Sims et.al. proposed three new methods for Constraint identification namely, flow Constraint analysis, effective utilization analysis and quick effective utilization analysis for moving assembly lines in order to determine the true Constraint [1]. Azar Izmailov et. al. studied TOC tools for planning and project management and found that implementing TOC methodology may yield reduction of 25 to 50% in project duration & 95% chances of projects being completed on time [2]. Sherif Mostafa et.al. studied various waste identification tools and a framework consisting of three phases has been suggested for waste elimination by identifying non-value added activities [3]. Sahno Jevgeni et. al. developed and applied a new framework to wind power generator allowing continuous improvement of production process and product throughput by defining and measuring failure of the production process. The results obtained showed reduction in lead time and increase in product throughput with less expenses [4]. Roberto Panizzolo et.al. compared characteristics of TOC with Dispatching, Kanban and daily rate using theoretical investigation & empirical study of five case studies and identified an interpretative framework based on TOC characteristics by highlighting the main differences between them based on nature and scope of these systems [5]. Bahadır GÜLSÜN et. al. applied five steps of TOC in a supplier firm to eliminate the wastes so as to have better system structure. The results showed considerable increase in throughput & hence increase in profit [6]. C. Carl Pegels et.al. studied a case where TOC is applied in a manufacturing plant for resolving operation problem. The collective efforts of four local optimization approaches caused elimination of bottleneck constraint [7]. Prof. ND. Du Preez et.al. described a roadmap approach to successfully implement TOC and to capture & manage the TOC documentation using EDEN (Enterprise Design Navigator) software. Hence providing a plan for effective transition from current state to future state [8]. J. M. Scoggin et. al. studied a case where TOC thinking process tool was applied in manufacturing environment and thus helping in identifying the core conflicts and proposing a solution having realistic applications [9]. Victoria J. Mabin et.al. studied and presented the results of a meta-analysis of over eighty successful TOC applications based on available quantitative data which showed improvement in both operational and financial performances because of TOC implementation [10]. Christoph Roser et.al. provided an active period method for detecting bottlenecks in manufacturing systems based on the duration a machine is active without interruption and then shifting of these bottlenecks [11]. Chiu-Chi Wei et. al. proposed an enhanced method for project scheduling having resource constraint after studying and comparing the benefits & limitations of Traditional Project Management and TOC Project Management. The results showed that Enhanced TOC is better than existing TOC in respect of controlling the project length practically [12]. R. Y. Qassim applied the Operation Research technique of Mathematical Programming to identify the potential of TOC for Automated Manufacturing environment in order to maximize and improve the system performance [13].

II. TOC METHODOLOGY

Objective of this case study is to reduce lead time of the process by applying the theory of constraint to a process in order to find and eliminate the wastes in the process. The study was carried out at Steel-Smith which is manufacturer of large variety of toggle clamps. The main issue at Steel-Smith is that the delivery period for the clamp is much more than their competitors. Thus the possibility of loss of future orders is the major concern for them. To overcome above mentioned problems Theory of Constrained Concepts was implemented which includes five steps methodology.

A. *Implementation of TOC*

Implementing TOC to the business organization is carried out using five focussing steps which provides a focus for a continuous improvement process are as follows:

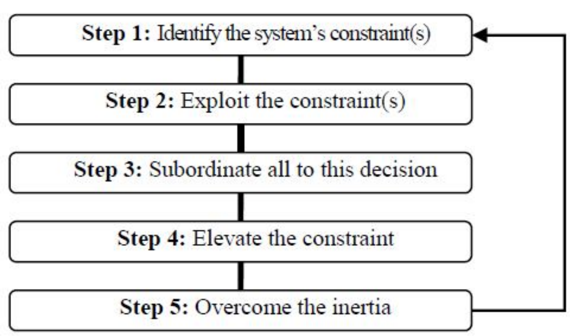

Fig. 1 TOC implementation methodology

1) *Identify the constraint:* Constraints may be Physical (e.g. materials, machines, people, demand etc.) or Managerial (e.g. policies, procedures, rules and methods etc.). The first step aims at identifying these constraints and prioritising them based on their impact on the organisational goals.
2) *Exploit the constraint:* In case of Physical constraint, the objective is to make the constraint as effective as possible. A Managerial constraint should be eliminated and replaced with a policy which will support increased throughput.
3) *Subordinate all to the decision:* After making a decision on how to exploit the system constraint, every other component of the system (non-constraints) must be adjusted to support the maximum effectiveness of the constraint.
4) *Elevate the system's constraint:* If the system constraint is eliminated by subordination, find new constraint and repeat the procedure. If the existing constraints are still the most critical in the system, determine other ways to increase capacity of bottlenecks by either outsourcing or installing new machinery.
5) *Overcome Inertia and Repeat:* This step makes TOC a continuous process whereas it also quotes that no policy (or solution) is appropriate for all time or in every situation. Thus it is essential for the organization to understand that as the business environment changes, business policy has to be changed in order to incorporate of those changes. If subordination does not break the constraint, elevation will likely break it, unless there is a deliberate effort to stop breaking it.

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Value Stream Mapping technique has been used to identify the constraint and a solution has been provided in order to eliminate this constraint. The Product selected to analyse above mentioned problem is VTC-4595-UB which belongs to a product family having wide variety of sizes and also the demand of this product is very high. The Process Flow of the selected product is as shown in figure.

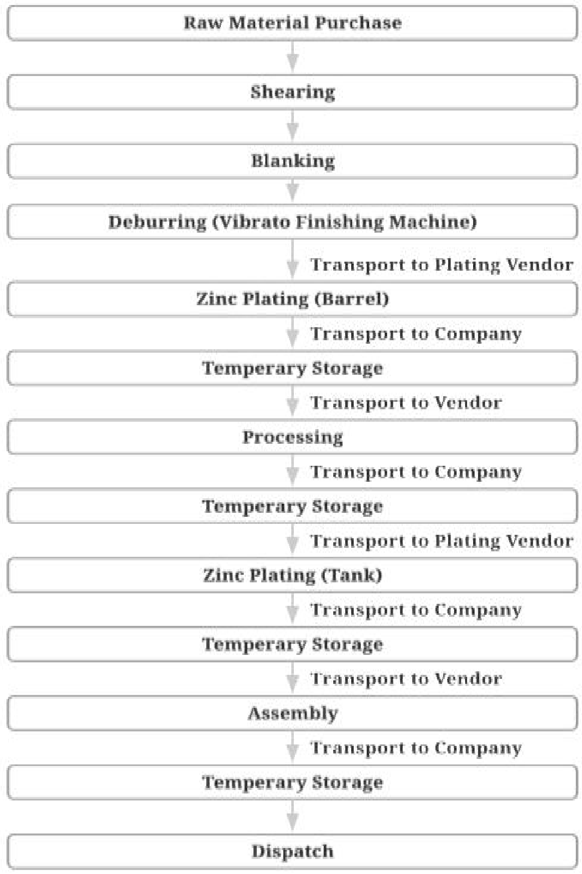

Fig. 2 Process Flow for VTC-4595-UB clamp

1) *Identification of Constraint:* In order to identify the major obstacle in delivering the product within least possible time, a Current State Value Stream Map for processing the selected clamp have been prepared by analysing the time required for each process required for manufacturing the selected clamp.

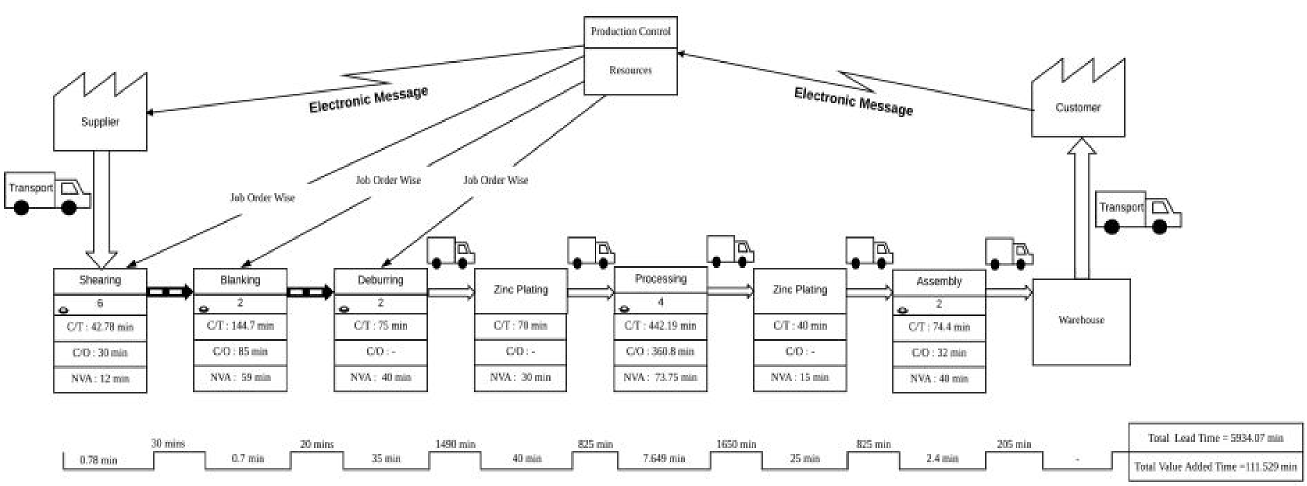

Fig. 3 Current State Value Stream Map

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Table shows value added and non-value added time for various processes that are required for making the entire clamp.

TABLE I
VALUE ADDED AND NON VALUE ADDED TIME (CURRENT STATE)

Process	C/O time	Value Added Time	Non Value Added Time
Shearing	30 min	0.78 min	12 min
Blanking	85 min	0.7 min	59 min
Deburring	-	35 min	40 min
Waiting time before Plating	-	-	1440 min
Zinc Plating (Barrel)	-	40 min	30 min
Waiting time after Plating	-	-	600 min
Processing	360.8 min	7.649 min	73.75 min
Zinc Plating (Tank)	-	25 min	15 min
Assembly	32 min	2.4 min	40 min

From Current State Value Stream Map, it can be easily observed that the repeated transportation to plating plant and waiting time before and after plating process causing unnecessary delays in the process and thus plating process can be treated as bottleneck.

2) *Exploit the constraint:* As the identified constraint lies outside of the company, few alternatives have been suggested so as to exploit the bottleneck. First alternative suggested was to change the main vendor as he is located at Malad which is away from the company's current location thus consuming more time for repeated transportation to plating vendor and company thus ultimately causing the delays in processing. Another alternative is to develop a new plating vendor as the workload at current plating vendor is more thus having more waiting time before and after the plating process.
3) *Subordinate all to this decision*: The suggested alternatives were presented in front of the management in order to make decision. Since the main vendor is with the company since its start, replacing this vendor was refused by the company management. Also the company tried a few plating vendors in nearby premises and found the quality of their plating inferior than the current one and thus eliminating this alternative.
4) *Elevate the Constraint:* In order to eliminate this constraint, the new alternative of erecting in-house plating plant was studied for its feasibility as almost each and every clamp require to be plated before their assembly. Hence a Future State Value Stream Map is generated considering in-house plating process so as to analyse total lead time.

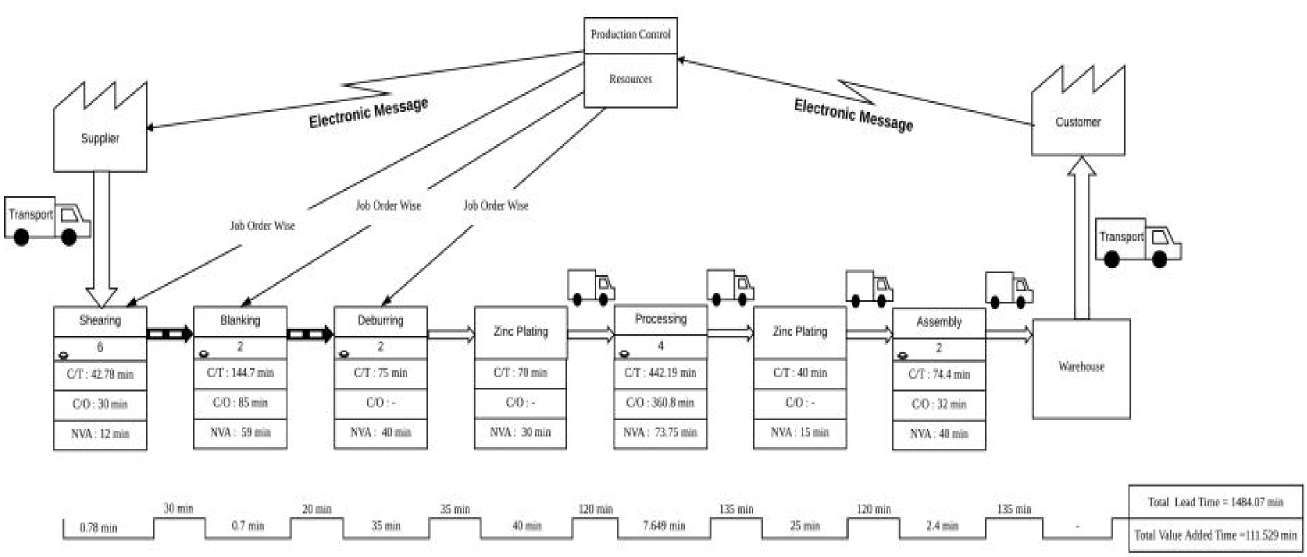

Fig. 4 Future State Value Stream Map

Studying Future State Value Stream Map and comparing it with Current State Value Stream Map, a considerable reduction in waiting time and manufacturing time can be observed.

TABLE II
PLATING PLANT ERECTION COST

Parameter	Estimated Cost
Manually operated plating plant erection	Rs. 3,47,510/ -
Chemical Cost	Rs. 50,000/ -
Acid proof Tiling	Rs. 26,520/ -
Salary of new worker	Rs. 7200/ -
Electricity Bill	Rs. 4000/ -
Total Cost for in-house plating plant erection	Rs. 4,30,030 /-

This cost is compared with the plating cost of in current scenario so as to analyse whether this decision of erecting a new in-house power plant is profitable.

TABLE III
PLATING COST IN CURRENT SCENARIO

Parameter	Estimated Cost
Average Barrel Plating Charges per month	Rs. 59, 385/ -
Average Tank Plating Charges per month	Rs. 1, 03, 324/ -
Transportation to Plating Vendor	Rs. 331.16/ -
Salary of Driver	Rs. 16000/ -
Total Plating Cost	Rs. 1,79,040.14/ -

B. Results and Discussion

TABLE IV
COMPARISON BETWEEN CURRENT STATE AND FUTURE STATE SCENARIO

Parameter	Current State (Before implementing TOC)	Future State (After implementing TOC)
Waiting Time (min)	5045	595
Manufacturing Lead Time (min)	5934	1484

By comparing Future State Value Stream Map with Current State Value Stream Map, it can be observed that total lead time can be reduced from 5934.07 minutes to 1484.07 minutes. Hence total 75 % reduction in lead time can be estimated by erecting in-house plating plant. Also by comparing plating cost in current scenario and cost of erecting in-house plating plant, we can find the total cost of erecting the plant will be equivalent to the total cost of plating for almost 2.4 months. Thus we can conclude that the cost of erecting a new plant can be recovered in 2.4 months and the total savings of around Rs. 1,67,840 / - per month can be done thereafter.

III.CONCLUSION

In this study, the problem faced by the toggle clamp manufacturing company has been analysed using Theory of constraint approach. Value Stream Map for current state identified plating process as the bottleneck. To eliminate this bottleneck, erection of new plating plant is suggested as an alternative and after analysing its feasibility it has been found that erection of new plant may yield following results:

1) Total lead time can be reduced from 5934.07 minutes to 1484.07 minutes. Hence total 75 % reduction in lead time can be obtained.
2) After 2.4 months a savings of Rs. 1,67,840 / - per month approximately can be done.

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