IMPLEMENTATION OF THEORY OF CONSTRAINT PHILOSOPHY FOR PRODUCTIVITY IMPROVEMENT

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Abstract: ***A toggle clamp manufacturer company struggling to keep pace with this increasing competition with a fear to lose the future orders because of their larger delivery time was selected for this study. This research is primarily focused on improving on time deliveries, productivity as well as reducing lead time and inventory levels by implementing five step methodology of Theory of Constraint Philosophy. In order to improve the delivery time, the five steps methodology of Theory of Constrained philosophy provides a better option as it aims at improving the productivity by focusing only at a bottlenecks rather than focusing on an entire process. For this purpose, manual method is used along with critical path analysis and value stream map for identifying the bottleneck resources which causes the problem of larger delivery time. The local optimization techniques are used to eliminate identified bottleneck and thus reducing the delivery time by reducing production lead time. Comparison of productivity, lead time, inventory levels and percentage on time deliveries before and after implementation of TOC philosophy will validate the success of TOC implementation.***

IndexTerms - TOC, Critical Path Analysis, Value Stream Mapping, Lead time, Productivity.

I. INTRODUCTION

Today's businesses are competing increasingly based on reducing delivery time and improved product quality. Hence it is essential for companies to produce high quality products in shorter throughput time and in order to do this, there is a need of utilizing the capacity of the production facilities to the fullest. 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 stands on the path, blocking it from reaching its final goal of improved profitability. Thus it is vital for any business to identify and manage constraints in order to achieve higher profits. Focusing on improving an entire system rather than improving bottleneck constraint, does not impact the overall system output.

The Theory of Constraints is a methodology for identifying the most important limiting factor (i.e. constraint) that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor. In manufacturing, the constraint is often referred to as a bottleneck. In TOC, the machine or station with the lowest capacity is called the constraint, while the rest of the links in the system goes by the term non- constraints. TOC is generally pulled- based system. One of the appealing characteristics of the Theory of Constraints is that it inherently prioritizes improvement activities. The top priority is always the current constraint. In environments where there is an urgent need to improve, TOC offers a highly focused methodology for creating rapid improvement. Some research has found that, the results obtained are not necessarily the typical results of TOC implementation yet the organizations who applied TOC gained considerable improvements in important performance measures such as lead time, cycle time etc. [1]

II. METHODOLOGY

Objective of this research study is to reduce the delivery time to avoid future order loss. HV-500 clamp of HV series was selected for this study as it was the most sold product series and also they had live order of 300 Pcs. To overcome the problem of larger delivery time, Theory of Constraint Concepts was implemented which includes five steps methodology as follows.

Step 1: Identify the Constraint
Step 2: Exploit the Constraint
Step 3: Subordinate everything
Step 4: Elevate the Constraint
Step 5: Overcome Inertia and Repeat

This fifth step in implementation of TOC makes it a cyclic process aiming at continuous improvement.

2.1 Identify the Constraint

The constraint was roughly figure out by walking the floor and questioning the workers. This manual method narrowed down the area of focus to casting handle and arm of selected clamp. The validation of the identified bottleneck was done by applying critical path analysis to the production process so as to identify the most critical path followed by value stream mapping of this path. As value stream mapping is an effective tool for cycle time reduction [2], it is used to identify the process that can be improve so as to increase the productivity of the selected clamp based on reduction in lead time [3]. Fig. 1 shows the network diagram for production process of HV 500.

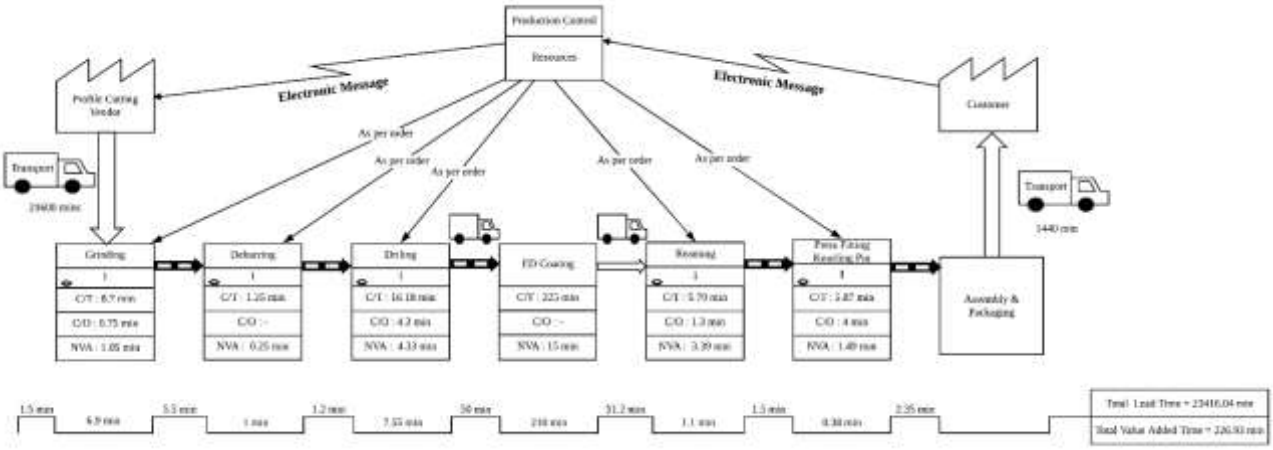

Figure 1 Current state VSM for the most critical path

The current state VSM showed the average lead time of 23416.04 min. which was approximately 16.2 days. The process of was divided into two phases viz. procurement phase and machining phase. It can be clearly seen that the time required by the supplier to supply the profile cut component is considerably large and hence it is our major constraint. Also drilling operation have more cycle time therefore is considered as machining constraint.

2.2 Exploit the Constraint

The second step in TOC implementation is to exploit the constraint that was identified during the first step. Exploiting the constraint basically highlights the utilization of the bottleneck resource to maximum extent possible. As the identified bottleneck is procurement of profile cutting material which is kind of raw material for this case, a fishbone diagram has been constructed in order to identify all possible root causes of delay in procuring material.

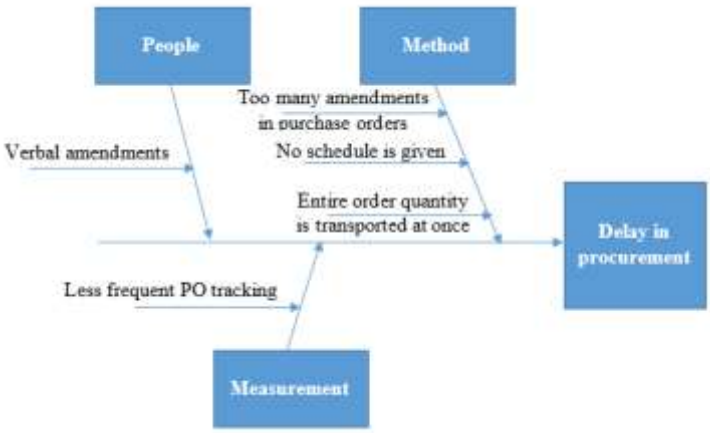

Figure 2 Fishbone diagram for procurement delay

As clamps that require profile cut components are quite a large in number, proper scheduling for each part with each purchase order can be the solution that may break the constraint. Following alternatives were suggested for improvements:

- All the verbal amendments in purchase order are to be restricted.
- Instead of amending same purchase order, a new purchase order is to be prepared.
- The supplier has been asked to supply the quantities in batches, instead of supplying entire order quantity at one time.

2.3 Subordinate everything

In this the non-constraint resources were utilized such that the bottleneck resource was continuously scheduled for operation. Since the company have multiple orders in hand simultaneously and each product might have different bottleneck, hence there was a need of some order status tracking. Therefore, a CONWIP Board was maintained for this purpose. The number of orders in the CONWIP board is based on priority planning for the week and contain eight top priority orders in hand. There is a provision given for rush order in case of extreme emergency. The status of each order is tracked against available time using percentage work completion. The prioritization of the constraint resource was done by displaying the constraint on CONWIP Board along with the order priority and instructions of processing these constraint resources were given to the workers.

The average delivery time for HV 500 Arm was found out to be reduced to 12 days after proper scheduling was done. On studying the critical path considering this delivery time of profile cut component, it was seen that, the identified constraint was not broken therefore the next step was considered and the machining phase was analyzed.

2.4 Elevate the Constraint

From Value Stream Map shown in figure 1, it was also observed that the cycle time for drilling operation was more causing increase in machining lead time of the arm. In order to reduce this, the process was analyzed so as to find any possible improvements. It has been observed that the drilling process was carried out on drilling machine manually with Centre drilling operation followed by drilling operation

causing increase in loading and unloading time which ultimately resulted in increased lead time. Considering the given suggestions, another drill jig have been developed by the production team which can accommodate four components at a time and which can be used on VMC machine causing reduction in lead time.

2.5 Overcome Inertia and Repeat

Since the constraint is broken in previous step, the new constraint was found out by using the five step methodology in this step.

III. Results and Discussion

Based on the implemented five step methodology of TOC, the results obtained and comparison of on time deliveries, reduction in lead time, reduction in inventories and productivity before and after implementation of TOC are as shown below.

3.1 Lead Time

The current state VSM after TOC implementation have been prepared in order to compare before and after case scenario of lead time for Arm of HV 500 clamp.

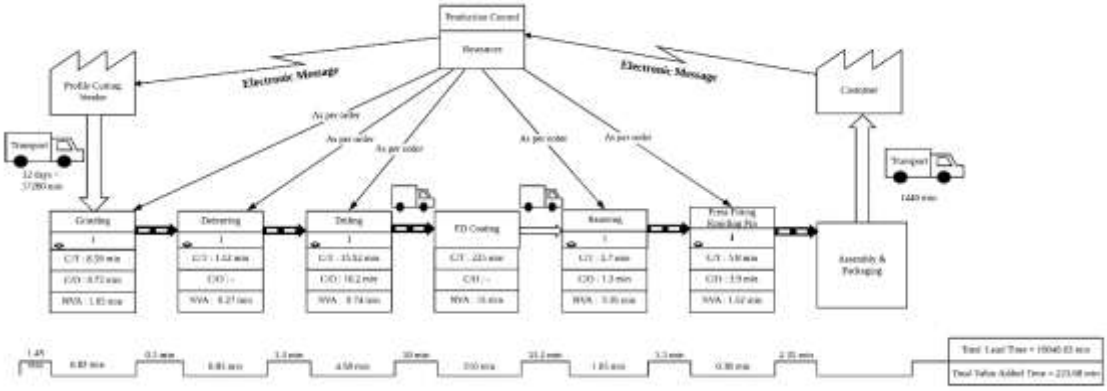

Figure 3 Current state value state map after TOC implementation

From the current state value stream map after TOC implementation, it can be seen that the total lead time for producing the arm is reduced to 19040.03 min which is approximately 13.2 days. The comparison between average supply time and lead time have been shown in following table.

Table 1 Comparison of supply time and lead time before and after TOC implementation

Sr. No.	Parameter	Before TOC	After TOC	% Improvement
1	Average Supply time for Arm	15 days	12 days	20 %
2	Average lead time	16.2 days	13.2 days	18.5 %

3.2 On Time Deliveries

On time delivery of the goods is one of the factors considered for customer satisfaction. As mentioned previously that the reason behind all the improvements and re-planning of the process is being done due to larger delivery time of heavy duty clamps and possibility of future order loss. Using lead time reduction techniques and use of CONWIP Board have done the impressive job resulting in increased percentage of on time deliveries. The graph shows the target value and percentage on time deliveries for each month during project span before and after TOC implementation.

Figure 4 Percentage on time delivery

3.3 Inventory Level

Before implementing the theory of constraints the company was suffering from the high WIP inventory for each part required to produce the clamp. After using the theory and changing the planning and procuring process for their parts, substantial reduction in inventories was seen as shown in figure 5.

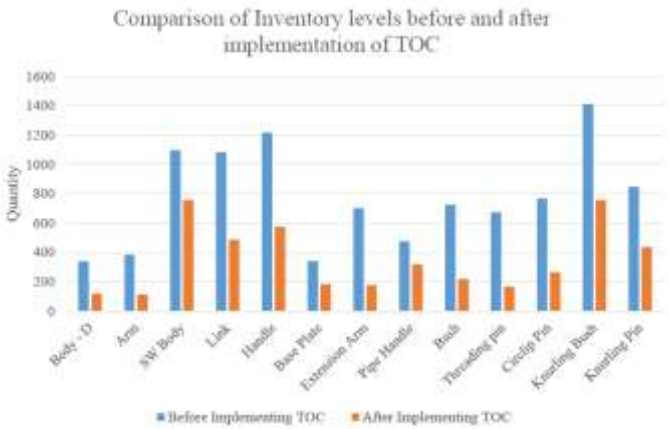

Figure 5 Inventory levels before and after implementation of TOC

3.4 Productivity

Productivity is the most important factor in production performance of any company. It represents the efficiency of the company. Even small changes in way of doing things or processes increase productivity of the firm. Here, the productivity is measured in terms of number of complete units produced per unit labor hour i.e. 11 working hours. Manufacturing cycle time before and after implementing TOC have been identified from time study and summarized in table below along with no. of parts that can be produced per day (i.e Productivity).

Table 2 Cycle time of each component of HV 500 clamp

Component	Before TOC		After TOC	
	Mfg. cycle time	No. of parts produced / day	Mfg. cycle time	No. of parts produced / day
Body - D	12.29 min	52	12.29 min	52
Arm	19.58 min	33	12.26 min	52
SW Body	2.88 min	212	2.88 min	212
Link	0.39 min	1656	0.39 min	1656
Handle	13.86 min	45	13.86 min	45
Base Plate	11.72 min	56	11.72 min	56
Extension Arm	6.91 min	93	6.91 min	93
Pipe Handle	1.6 min	411	1.6 min	411
Maximum no. of clamps produced per day	33 Nos		45 Nos	

From the above table, it can be seen that the maximum clamps that can be produced per day after implementing TOC philosophy are more. This indicates the increase in productivity of HV 500 clamp.

IV. Conclusion

From the results obtained, following conclusions were drawn.

- Providing schedule to supplier along with the purchase order has helped them to plan their supplies according to the priorities and hence avoiding possible confusion regarding the supply of various particulars in the purchase order resulting in reduction in the supply time.
- Use of CONWIP Board have helped workers to concentrate on the top priority orders resulting in improved on time deliveries.
- Using critical path analysis helped production team to concentrate their attention on Improving the most critical path rather than entire process.
- Displaying the identified bottleneck along with each order has helped workers to prioritize the machining of the constraint resource and hence reducing the lead time substantially.
- Identifying and eliminating the bottleneck have resulted in increased productivity of the selected clamp.
- As TOC is a companywide approach it has brought in all people working in the organization right from operators to managers to work together as a team.

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