

Improvement of productivity by theory of constraints and line balancing

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Abstract

This paper reveals the application of Theory of Constraints to improve the productivity of component under consideration. Company was facing problem for delivering the targeted component after increase in demand from their customer. The past data of housing component manufacturing process, resources required, work in process inventory and raw material inventory was collected. When analyzed the past data, constraints were observed on two machines in the production line which were needed to be focused. Eliminating the bottlenecks on these resources was the solution to cope up with the increased demand and also to minimize the raw material inventory as well as work in process inventory.

The concepts described in Theory of Constraints were applied to overcome the bottlenecks on the constraint resources. The results obtained were at satisfactory level. The actual performance against the targeted level was measured and observed that productivity improved with considerable reduction in work in process as well as raw material inventories.

Keywords: manufacturing process, TOC, OTD, HMC 2 machine, VTL 2 machine

1. Introduction

Concept of Theory of Constraints

Dr. Eliyahu Goldratt introduced the concept of Theory of Constraints (TOC) to improve the performance and procedure for the implementing DBR. The five Focusing steps of TOC provide a simple and effective approach to continuous improvement in cases where the constraint is fairly clearly identifiable.

Step 1: Identify the systems constraint or bottleneck.

Identify the operation that is limiting the productivity of the system. This may be a physical or policy constraint.

Step 2: Decide how to exploit the bottlenecks.

Achieve the best possible output from the constraint. Remove limitations that constrain the flow and reduce non-productive time, so that the constraint is used in the most effective way possible.

Step 3: Subordinate everything else to the above decision.

Link the output of other operations to suit the constraint. Smooth work flow and avoid buildup of work-in-process inventory. Avoid making the constraint wait for operation.

Step 4: Elevate the system's bottlenecks.

In situations where the system constraint still does not have sufficient output invest in new equipment or increase staff numbers to increase output.

Step 5: If in a previous step a bottleneck has been broken go back to step 1.

Assess to see if another operation or policy has become the system constraint.

2. Problem Definition

Company was facing problem for delivering the flywheel housing product number (39.468) after increase in demand from their customer. After studying the past data of housing component such as, manufacturing process, resources required, work in process inventory and raw material inventory, we found problems regarding dispatch and inventory control for the component. The problems are listed below,

1. Problems associated with dispatch.
2. Problems associated with Work-in-process inventory.
3. Problems associated with Raw material inventory.

The concepts described in Theory of Constraints were applied to overcome the bottlenecks on the constraint resources. The results obtained were at satisfactory level. The actual performance against the targeted level was measured and observed that productivity improved with considerable reduction in work in process as well as raw material inventories.

According to TOC methodology, buffer stock should be maintaining in front of constraint resources.

The fig.1 shows layout of housing production line. In this production line two constraint resources are identified i.e. HMC 2 machine and VTL 2 machine, because limited capacity with respect to demand placed on these resources. Layout of housing production line before implementation of theory of constraints is shown in fig1.

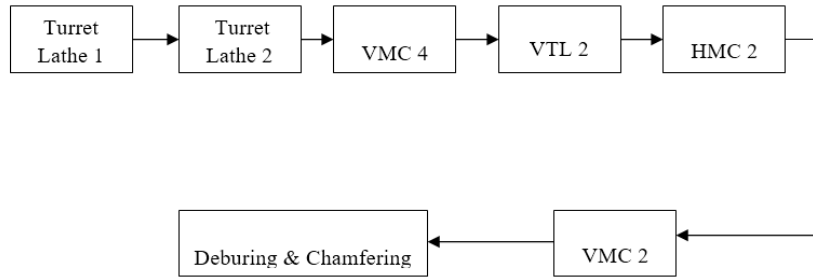


Fig 1: Layout of Housing Production Line before Implementation of TOC

3. Implementation of TOC

a) Solved HMC 2 constraint resource

According to TOC methodology, the resource whose capacity less than demand this resource identified as constraint resource and also the resource in front of maximum WIP inventory identified as constraint resource. Available capacity of the each resource in the housing production line is 1230 minutes per day (3 shifts). The demand placed on HMC 2 machine was 1500 minutes per day before TOC. This means that capacity of HMC 2 machine was less than demand placed on it and maximum number of WIP inventory accumulated in front of HMC 2 machine. Hence HMC 2 machine has identified as constraint resource. For achieving the production

target 40 parts are required from each resource in housing production line per shift, but because of limited capacity HMC 2 machine it produces about 32 parts per shift. Hence there was shortage of about 8 parts per shift. HMC 2 machine utilized for side milling, side drilling, tapping and counter boring operations on selected housing product. For these operations, cycle time required on HMC 2 machine was 12.5 minutes. To overcome this problem, we introduced Tap Fast 1 (TM L1) machine. The tapping and chamfering operations of HMC 2 machine shifted on Tap Fast 1 machine. Therefore HMC 2 machine now utilizes only for side milling and side drilling operations.

Table 1: Time Study of the HMC 2 and Tap Fast 1 Machine Resources

Part No: 39.468		Part Name- Flywheel Housing.		
Resource	Date	Remark		Total Cycle Time
HMC 2	04/11/2012	Cycle Time		
		10.00 min	----	10.00 min
		10.00 min	----	10.00 min
		10.00 min	----	10.00 min
		10.00 min	----	10.00 min
Tap Fast 1	05/11/2012	2.48 min	2.53 min	5.01 min
		2.51 min	2.50 min	5.01 min
		2.49 min	2.51 min	5.00 min
		2.5 min	2.49 min	4.99 min
		2.5 min	2.50 min	5.00 min

After involving Tap Fast 1 machine (TM L1), the HMC 2 machine utilizes only for side milling and side drilling operations. For these side milling and side drilling operations 10 minute cycle time require for machining on the HMC 2 machine. The Tap Fast 1 machine utilizes only for tapping and chamfering operations. Cycle time on (TM L1) is 5 minutes per job for tapping and chamfering operations. Time

study of HMC 2 machine and Tap Fast 1 machine is shown in table 1. Therefore, HMC 2 machine has converted constraint resource (CR) into capacity constraint resource (CCR), if it is not properly scheduled it will again converts into constraint resource. Layout of Housing production line after involving Tap Fast machine is shown in figure 2.

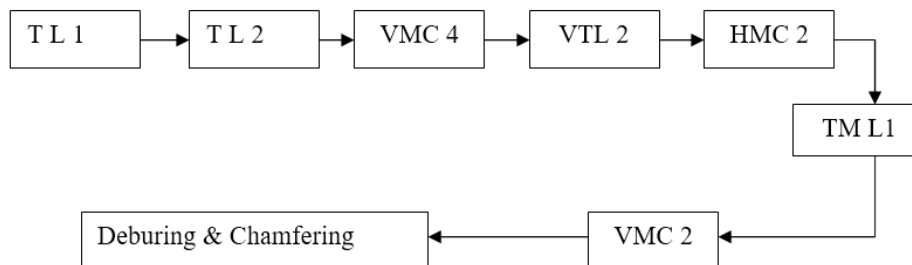


Fig 2: Layout of Housing Production Line after Involving (TM L1) Machine

b) Solved VTL 2 constraint resource

After HMC 2 machine has converted constraint resource (CR) into capacity constraint resource (CCR), the performance of

housing production line has measured. After performance of housing production line measured by introducing Tap Fast 1 machine, it is found that, VTL 2 machine has constraint

resource because its capacity less than demand. Also in front of VTL 2 machine huge WIP inventory accumulated. The capacity of the each resource in housing production line is 1230 minutes per day. The demand of VTL 2 machine is 1380 minutes per day. This means that, capacity of VTL 2 machine less than demand placed on it. In front of VTL 2 machine we observed 5 parts WIP inventory accumulated per shift; hence VTL 2 machine identified as constraint resource. Because of limited capacity of VTL 2 machine there was disruption of the product flow in the housing production line. The buffer stock should be maintained in front of the constraint resource to avoid any disruption in the flow. For achieving the production target, 40 parts are required from

each resource in housing production line per shift. But, because of limited capacity VTL 2 machine it produces 34 to 35 parts. Hence there was shortage of 5 parts per shift. To overcome this problem, by introducing Turret Lathe 3 (TL 3) machine. Turret lathe 3 machine has maintained 5 housing parts (capacity buffer stock) in front of the VTL 2 machine and balance the production line. Total cycle time of (TL 3) machine has 16 minutes per job. After involving (TL 3) machine, it provided 5 parts per shift and line has balanced. Each shift TL3 utilize up to 80 to 90 minutes. Remaining 320 minutes TL3 utilized for machining of other housing products and development work. Time study data of Turret Lathe 3 machine is shown in table 2.

Table 2: Time Study of Turret Lathe 3 Machine

Part no-39.468		Part name - Flywheel housing.		
Resource	Date	Remark		Total Cycle Time
		Cycle Time	Loading/Unloading	
		13.01 min	3.03 min	16.04 min
Turret Lathe 3	11/12/2012	13.02 min	3.00 min	16.02 min
		13.02 min	3.03min	16.05 min
		13.04 min	3.00 min	16.04 min
		13.00 min	3.02 min	16.02 min

Now, the VTL 2 machine resource has converted constraint resource (CR) into capacity constraint resource (CCR).

Layout of Housing production Line after involving Turret Lathe 3 and Tap Fast 1 machines is shown in fig 3.

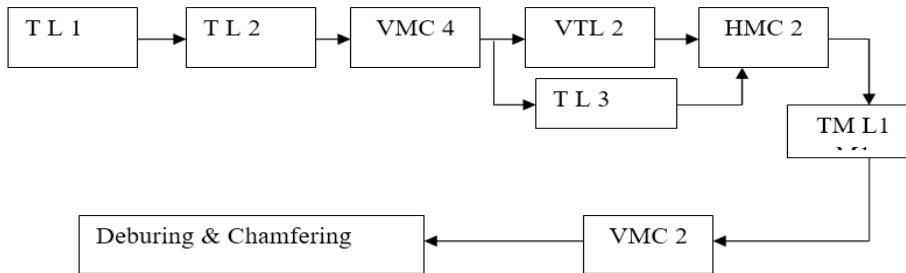


Fig 3: Layout of Housing Production Line after Involving (TL 3) Machine

4. Result and Discussion

Table. 3 shows average number of WIP inventory before and after implementation of Theory of Constraint. From the above

results, it is seen that there is considerable amount of reduction in number of WIP inventory of selected housing product due to implementation of TOC technique.

Table 3: Average Number of WIP before and after TOC

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
Average WIP	235	246	219	161	172	46	38	30	27	32

The average percentage of on time deliveries for selected housing product, before and after implementation of TOC is shown in table 4.

Table 4: Average Percentage of On Time Deliveries before and after TOC

Month	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
OTD	80%	79%	81%	86%	85%	96%	97%	97%	98%	97%

Average Number of Raw Material Inventory before and after Implementation of TOC is shown in table 5.

Table 5: Number of Raw Material Inventory before and after Implementation of TOC

Month	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
RMI	268	276	255	193	204	73	67	56	54	60

Determination of Average of All Performance Measurement Parameters after Application of Theory of Constraint.

Average of all performance measurement parameters after the implementation theory of constraint (TOC) methodology are presented in Table 6.

Table 6: Average of All Performance Measurement Parameters after Implementation of TOC

Performance Parameters	Avg. % of OTD	Avg. WIP	Avg. RMI	Avg. Profit
Housing	97 %	35	62	Rs. 4,14,313/-

After application of theory of constraint (TOC) on the housing production line, all performance measurement parameters have carried out. The on time delivery (OTD) of selected housing component increased by 15%, reduction in WIP inventory by 83%, reduction in raw material inventory by 74% and profit improvement by 17%.

5. Conclusion

After implementation of Theory of constraints, the analysis gives following results.

1. After implementation of Theory of Constraints the demand achieved for selected housing product is increased from 82% to 97%, which has resulted on time delivers improved by 15%.
2. Initially the average amount of production of housing product was 992. After involving machine resources (Turret Lathe Machine 3 and Tap Fast Machine 1) on the suggested place the production of selected housing product is increased up to 1163. This results, increased in production volume by 17%.
3. After implementation of TOC the labour productivity increased by 2.59%, machine productivity increased by 16.94% and material productivity increased by 15.87%.
4. The average amount of work in process inventory for selected housing product is reduced. Before implementation of theory of constraint WIP was 207 housings and it is reduced up to 35 housings after implementation. This gives 83% reduction in work in process inventory.
5. The average amount of raw material inventory has considerably reduced; earlier it was 239 housings while it has come down to 62 housings. This gives 74% reduction in raw material inventory.

6. References

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