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Research Paper

PRODUCTIVITY IMPROVEMENT IN INTERNATIONAL TRACTORS LIMITED USING THEORY OF CONSTRAINTS: A CASE STUDY

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This report illustrates the application of Theory of Constraints thinking process to a manufacturing organization. It discusses topic of theory of constraints and applies it to a manufacturing organization, International Tractors Limited. Here I take up one line of gear division for my analysis of productivity improvement. This department is making more than 76,000 parts but it is still short of nearly 20,000 parts required to meet the production capacity. So, company needs to outsource this much number of components. Gear division has seven lines making different components. Now, one line for which the outsourcing of components is maximum is taken up for productivity improvement. Here I apply Theory of constraints step by step. The first step is to identify the constraint. Constraint is a resource which has capacity less than or equal to the demand placed on it. Then after identifying the constraint try to exploit the time available on it. This is done by giving the breaks for workers in each shift on rotation basis; one for person working on capacity constrained resource and one for persons working on non critical machines. Other option could be installation of UPS (uninterrupted power supply), which could increase the actual time available. In manufacturing organization the time available is split in two head, actual processing time and time involved in making set up. So if the set up time could be reduced we can increase the processing time. This is done by changing the production schedule and doing the set up in a well co-ordinated manner like using SMED (single minute exchange die) system for set up. Next step is to subordinate everything else to the capacity constraint resource. By this we mean that the operations performed on constraint should be given the top priority. Last step is to elevate the constraint.

Keywords: Theory of constraints, Manufacturing, Gear division, SMED

INTRODUCTION

This is the latest model followed by manufacturing industries to solve various problems related to either technology; manpower handling or human resources related problems faced in various industrial units. This concept was given by Eliyahu M Goldratt. He was the chairman of a software company. In 1982, his company was sixth fastest growing company in United States of

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America. But still he was a frustrated man as the production scheduling software which his company was offering at that time was quite revolutionary, but the number of clients was not as per his expectations. The main emphasis of his concept was to increase the throughput and due date performance of any plant. As the name suggests the prime objective of this management technique is to identify the constraints in a manufacturing unit and make optimum use of the constraints. It suggests that constraints are neither good nor bad, they merely exist in any system and we have to view them as a reality only. This system calls for major changes in costing policies of various companies.

The literature provided for this topic is mainly in form of novels. First a novel named 'The Goal' was written by Eli Goldratt which was a grand success. Actually when Goldratt started to write 'The Goal' most of the people in his own company did not like the idea but they were forced to change their view when they saw the kind of recognition which Goldratt got from this book after this Goal2 was released by same author. Both of these novels were taken quite seriously by academicians related to industrial engineering. The next book to follow was 'The Race'. Traditional methods used in industry calls for maintaining a huge inventory which meant a lot of capital spent to maintain inventory. Then inventory was cut to more realistic by next concept of Economic Order Quantity. A new concept introduced in respect to further reduce the inventory was just in time approach. The latest theory came where inventory was balanced with throughput. This concept was that of Theory of Constraints. This theory stresses that partial automation of any plant cannot lead to increase in productivity. In contrast to the popular belief that automation increases the productivity, partial automation puts extra load on other sections of the industrial unit which are still functioning manually thus bringing down their efficiency level. The other main postulate of this theory is that we try our best to balance the plant with load but this theory proves that this concept is self destructing. We should try to balance the plant with throughput. A brief summary of different terms used in this theory are as follows:

Bottleneck Resource

It is the resource whose capacity is less than or equal to the demand placed on it.

Capacity Constrained Resources

These are the resources that have the capacity slightly more than that of bottlenecks & can sometimes be responsible for the shipment delays if not managed effectively. So, one has to concentrate on planning, control and efficiency improvement of such resources as well. There is a difference between a bottleneck resource and a constraint resource. But these terms have been used interchangeably in most of the research papers to denote bottleneck. In our work also, we have used these terms interchangeably to denote bottleneck.

Ways to Identify Bottleneck

The managers generally face difficulty in identifying the bottlenecks. Variation in the product-mix and production volume over a period of time further adds to this difficulty. Some of the guidelines that can be used for the identification of bottlenecks are given below

a. Search through the production database

b. Prepare a list of items that generally reaches late at assembly line. These are the parts that usually pass through the bottleneck operations.

c. The operation in front of which there is always a heap of unprocessed inventory.

Bottlenecks may change with change in product or volume mix. So, one should not think that a particular resource will always remain a bottleneck. If the buffer stock at any machine starts increasing it is an indication that it is going to become bottleneck. On the other hand, if there is a decrease in the buffer stock at any machine. Then probably some of the previous operations are going to become a bottleneck. Once the production problems are rectified, the marketing may become the next bottleneck. Thus the bottleneck shifts from being inside the system to outside the system.

Effect of Bottleneck on Output and Inventory

A production system is composed of a few bottleneck and a large number of non-bottleneck machines. These equipments are connected to each other by routing of the components. To study the effect of bottlenecks on the total output of a system, the following four simple situations can be drawn

Y (Non-bottleneck) ⟶ (bottleneck)

If a non-bottleneck operation feeds a bottleneck operation as shown above, then increasing the rate of production of Y beyond the rate of production of X results in increase of the WIP (work in process) inventory in front of X and not the throughput. So, schedule the output of Y according to the output of X and let it remain idle for part of the time.

X (bottleneck) ⟶ Y (Non-bottleneck)

If a bottleneck operation feeds a non-bottleneck as shown above the rate of output of X will limit the rate of output of Y. The equipment Y will be forced to remain idle for part of the time depending upon the difference in the rate of output of X and Y.

X (bottleneck) ⟶ Assembly

If a bottleneck feeds the assembly directly, the rate of output at the assembly line will be limited by the rate at which the material is fed to it from X (bottleneck).

Y (Non-bottleneck) ⟶ Assembly

If a non-bottleneck directly feeds the assembly, since it is a non-bottleneck, it's maximum rate of output will be more than the market demand. So, the market demand will be the constraint in this case and will limit the rate of output from Y.

About the Company

International Tractors Limited is an innovative group engaged in making wide range of tractors ranging from as small as 18 HP to as large as 90 HP. It is located at Hoshiarpur city in Punjab which is at the Himalayan foothills. The company is having a huge strength of man power also. The lower management, middle management and upper management comprise of nearly 2000 people directly on the company rolls. And the is around 4000 strong work force coming through two to three contractors. It has a formidable presence in overseas market. Some of its models like 18 HP garden Trac and 90 Hp model with air conditioned driver chamber are fully export oriented models. The history of this company is not so old but its growth has been phenomenal. It has grown from a small company making less than 1000 tractors per year to a large company making around 50,000 tractors per year in a small span of 15 years.

Component Data

International Tractors Limited is making wide range of tractors to cater to the needs of different kind of customers depending on the purchasing capacity, quantity of land and external features of the product. Some models out of them are purely export oriented. To make this wide range of tractors (15 models) and keeping the production rate at 150 per day a huge number of components are to be produced on above mentioned lines.

Grand Total of all the lines = 76,074(based on component data of all the lines)

Components required to meet the production target = 96,000

Number of components required to be out sourced = 96,000-76,047= 19,953

So, approximately 20,000 components require to be out sourced. The target of my work is to reduce this figure as far as possible and to further workout that whether any additional capacity is available with present installation of machinery to increase the production capacity to 200 tractors per day which at present is 150 per day. Out of these 20,000 components or 5,000 components are required to be made on line 1. This is the reason why this line 1 is taken for improvement.

RESEARCH METHODOLOGY

1) Identify the system constraints: Any machine in a manufacturing unit which has the least production capacity obviously becomes a constraint. In some cases the production capacity is high but the operation this machine does is not needed for all the components i.e. we unnecessarily involve this machine in components where its operation is not needed.
2) Decide how to exploit the constraint: Once any constraint is identified its optimum utilization becomes the next step.
3) Subordinate everything else to the above decision: Here we make sure that everything marches to the tune of system constraint.

Elevate the system's constraints: Look for other options available in the plant. Identify whether any other machine can perform the same operation as performed by the system constraint.

According to the type of operation required the components are categorised. In line 1 the majority of components fall into the same category. So the next step is to calculate the time that these components spend on each machine. By this we get to know the machine hours that are available on each machine for production. Time available with all machines considering the availability of machines for 25 days a month and 20 hours per day comes out to be 26,500 minutes which includes processing time plus set up time for each machine plus fixed peak load hours of two hours per day or 3000 minutes per month any other exigency like grid failure etc.

So, according to the time available on each machine we find that shaper machine (1) is the bottle neck machine for most of the total load. In the next step it is intended that the time available on the bottleneck machine should be utilized to the fullest.

PROPOSALS FOR IMPROVEMENT

For the improvement of the system the proposals given are as follows:

1. After identifying the bottleneck machine in each line we try to exploit the time available on it in best possible way. Carrying on the study we see that shaper machine (1) is the main constraint on line 1 and free time is available on shaper machine (2) and hobbing (1). So the operator working on shaper machine (2) or hobbing machine (1) can be trained to work on the shaper (1). It is further proposed that 30 minutes break and ten minute tea break twice in one shift and another 30 minutes per shift for other personal needs provided in each shift should be given to the workers in two slots. One slot for the workers of bottle neck machines of each line. During this time any trained operator of shaper (2) or hobbing (1) machine should operate the critical one whose operator is taking break. Once these operators are back on duty they can continue with their job. Now second lot of operators can take a break. During this period shaper (2) or hobbing (1) machines will remain idle, but this does not pose any problem on line efficiency as a lot of free time is available with them. By carrying on this exercise an extra 80 minutes will be made available on each shift, which means a total of 04 hours per day. This means by doing this small exercise productivity improvement of 20% can be made. The operator working on shaper (2) machine who is trained to work on critical machine can be paid an extra compensation for additional assignment. For the peak load hours it is proposed that company should go for UPS (uninterrupted power supply). Initially the company officials were reluctant to consider this proposal as it involved huge costs but it was further suggested that they could consider UPS only for the critical machines for which the cost incurred is not much. This was more appealing to the Sr. Manager of gear division.

2. The other proposal is regarding the production schedule followed during the month. Around 15 kinds of models are produced in ITL (International Tractors Limited). These are 18 HP, 24 HP, 30 HP, 32 HP, 34 HP, 35 HP, 40 HP, 42 HP, 45 HP, 47 HP, 50 HP, 55 HP, 60 HP, 75 HP and 90 HP. These 15 models are produced. Here, it was observed that if we make the schedule in such a way that all the types of input shafts are produced first, then the connecting shafts then different kinds of axles. In this way we can save another 750 minutes stipulated for set up which is presently 2560 minutes per month taking normal set up time of 160 minutes per set up & total 16 no. of set ups. This means the around 25% of the set time can be reduced by slight rescheduling the production plan.

3. My next proposal is regarding the kind of man power involved in doing the set up. The operators working on various

S.No.	Points For Checking	Status
1	Right person is available for doing the set up.	Available/ Unavailable
2	Before doing set up whether activity is informed to shift in charge or not.	Yes/No
3	Safety permit issued for set up or not.	Yes/No
4	Tool kit is available with foreman or not.	Available/ Unavailable
5	Tool kit is loaded with correct spanners for doing the required set up or not.	Available/ Unavailable
6	All the bolts should be opened with spanners of matching size and not by pipe wrench.	Available/ Unavailable
7	The machine on which set up is taking place should be cordoned off.	Available/ Unavailable
8	Spares if any should be available at the place of set up before time. SMED system (Single Minute Exchange Die) should be followed in latter and spirit.	Available/ Unavailable
9	Whether set up done in stipulated time of 2 hours and 40 minutes or not.	Yes/No
6.	Write correct time taken for set up	
7.	(Shift In Charge)	
8.	*If set up is not done in stipulated time then mention the reasons of delay. (To be filled by shift in charge).	
(Production Manager)		

machines are not direct employees of company; the man power belongs to the contractor. The person doing set up belongs to same category. Now if set up time is increased by even a small time this will disturb the whole production schedule and to keep this schedule intact the company will have to pay overtime. It was observed that set up was usually delayed beyond the stipulated time period. This is highly unacceptable, so it was proposed that company officials should use SMED system (Single Minute Exchange Die) for doing set up. So, it is proposed that one person per shift involved in set up should be a direct employee of the company so that he is a little bit concerned about the delay and in case of deliberate delays he could be questioned for the delay.

4. Further it is proposed that machine set up should be done in a systematic and well co-ordinated manner. For this it is proposed to make an SOP (Standard Operating Procedure) for doing set up and the machine set up should be done with active involvement of shift in charge. The proposed format of the SOP is as follows:

5. Standard Operating Procedure (SOP) for Machine Set Up

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