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Performance Improvement of Jute Industries using Theory of Constraints (TOC)

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ABSTRACT

Performance improvement of jute industries by applying TOC has been carried out in this research work. The main objective of this research is to improve the productivity and Return on investment (ROI) of jute industries in Bangladesh by proper synchronization of Drum-Buffer-Rope scheduling associated with thinking process and throughput accounting. The bottleneck is identified as the main constraint of the production line. At the same time proper standardization of components and reduction of time has been set up to eliminate bottleneck & maximize the throughput by using the constraints and non-constraints resources. The solution of this constraint identified has shown in two different point of view that is operational measures & financial measures. The implementation of TOC results in managing inventory, work in process and delay on delivery time. Thus it ensures 0.3% increase in the Return on Investment (ROI) and the quality products due to better control over operation of constraint resources.

Key words: Theory of Constraint (TOC), WIP Inventory, Raw Materials Inventory, Constraint Resources, Return on Investment

INTRODUCTION & LITERATURE REVIEW

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. The Theory of Constraints takes a scientific approach to improvement. It hypothesizes that every complex system, including manufacturing processes, consists of multiple linked activities, one of which acts as a constraint upon the entire system (i.e. the constraint activity is the "weakest link in the chain") [1]. Theory of Constraint is one of techniques for productivity improvement by improving manufacturing system performance [2]. In Small Medium Enterprise (SME) manufacturing plant, production line gives high impact to the productivity of the company. Production lines are flow-line production systems which are of great importance in the industrial production of high quantity standardized commodities and more recently even gained importance in low volume production of customized products [3]. Due to the global competition, management issues such as reduced cycle time, increased quality, reduced costs, reduced inventory and increasing sales and market share, have become more important to survive [3]. TOC is systematic management approach that focuses on actively managing bottlenecks that impede a firm's progress toward its goal of maximizing profits and effectively using its resources. The successful enterprises deliver products and services in shorter throughput time and turnover inventory as quickly as possible. Three important approaches to achieve these goals are Materials Requirements Planning (MRPI, MRPII), Just-in-Time (JIT) and Theory of Constraints (TOC).The scheduling system of theory of constraints (TOC) is often referred as drum-buffer-rope (DBR) system. DBR systems operate by developing a schedule for the system's primary resource constraint [4]. By reducing Work in Process (WIP) inventory; cycle time, delivery can be improved. In this case product quality has become the key for maintaining the profitability. There are various techniques like Material Requirement Planning (MRP), Just in Time (JIT) and Line Balancing etc. These techniques are used for performance improvement and eliminate wastage but installation period is high, while in line balancing cost of adding capacity is

high [4]. Rahman and Amin has shown the effective factors of production efficiency that hamper the efficiency of a manufacturing unit and also showed the ways to reduce production problems [5].
TOC has evolved from this simple production scheduling software program into a suite of integrated management tools encompassing three interrelated areas: logistics/ production, performance measurement, and problem solving/thinking tools. Due to its simple yet robust methodology, application of TOC techniques have been discussed in the academic literature and popular press across a variety of operations management sub disciplines [6]. There is an increasing emphasis on the management of processes and the cross-functional nature of processes. TOC emphasizes the cross-functional and interdependent nature of organizational processes by viewing an organization as a chain (or a network of chains) of interdependent functions, processes, departments or resources where a variety of inputs are transformed into a variety of products and services which when sold become throughput [7].
The majority of the applications reported on did not employ the TOC TPs – the systems-thinking-oriented process improvement approach which is now the core of TOC. The advent of the TPs not only broadens the range of applications of TOC, but also broadens the areas of applications [8]. Many researchers have considered the similarities and differences between TQM and TOC [9]. In addition, some researchers have attempted to demonstrate that TQM and TOC are not mutually exclusive, but that the TOC approach can be viewed as building on the foundations established by TQM [10]. One of the major differences between TQM and TOC philosophies is that TQM does not differentiate between the goal and necessary conditions [11]. TQM proponents appear to argue that employee satisfaction leads to company financial success and which in turn provides employees with security and satisfaction [12]. Although Theory of Constraint is often associated with manufacturing, it is also used in logistics, supply chain, healthcare industries and product development [13]. Analyzing previous studies about TOC, the main contributions can be divided into four streams: TOC as a method for production planning and control in manufacturing companies [14-16]; TOC applications in several management areas, such as purchasing, quality and information systems management [17-18]; TOC implementations in service and not-for profit organizations [19-20]; TOC as a method for project scheduling under resource constraints [21-23].
The main objectives of this paper is to performance improvement of Jute Industries using Theory of Constraints (TOC).This paper is organized as follows: Section 1 Introduction & Literature Review Section 2 Basics of TOC Section 3 Methodology Section 4 Result & Discussion Section5 Recommendations and Section 6 Conclusion.

BASICS OF TOC

The Theory of Constraints takes a scientific approach to improvement. It hypothesizes that every complex system, including manufacturing processes, consists of multiple linked activities, one of which acts as a constraint upon the entire system (i.e. the constraint activity is the "weakest link in the chain"). To make a profit – both in the short term and in the long term. The Theory of Constraints provides a powerful set of tools for helping to achieve that goal, including:

- The Five Focusing Steps: a methodology for identifying and eliminating constraints
- The Thinking Processes: tools for analyzing and resolving problems
- Throughput Accounting: a method for measuring performance and guiding management decisions

The five focusing steps of TOC

The Theory of Constraints provides a specific methodology for identifying and eliminating constraints, referred to as the Five Focusing Steps. As shown in the following diagram **Fig. 1**, it is a cyclical process [24].

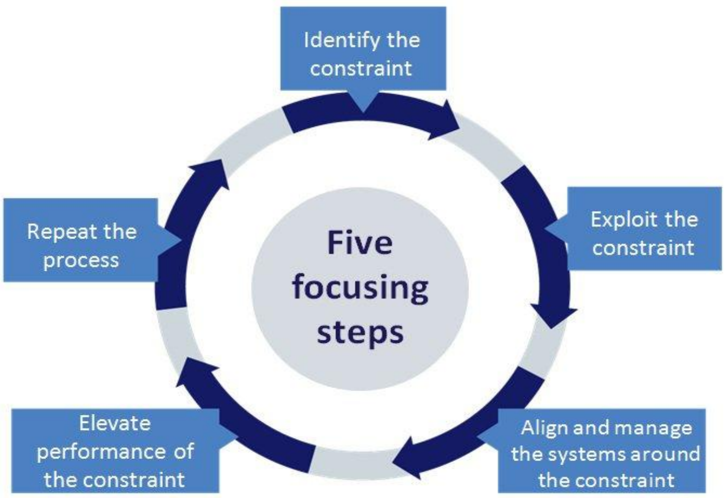

Fig. 1 Five focusing Steps of TOC

The Thinking Processes

The Theory of Constraints includes a sophisticated problem solving methodology called the Thinking Processes. The Thinking Processes are optimized for complex systems with many interdependencies (e.g. manufacturing lines). They are designed as scientific "cause and effect" tools, which strive to first identify the root causes of undesirable effects (referred to as UDEs), and then remove the UDEs without creating new ones [24].

The Thinking Processes are used to answer the following three questions, which are essential to TOC:

- What needs to be changed?
- What should it be changed to?
- What actions will cause the change?

Throughput Accounting

Throughput Accounting is an alternative accounting methodology that attempts to eliminate harmful distortions introduced from traditional accounting practices – distortions that promote behaviors contrary to the goal of increasing profit in the long term.

In addition, Throughput Accounting has four key derived measures: Net Profit, Return on Investment, Productivity, and Investment Turns.

Net Profit = Throughput − Operating Expenses
Return on Investment = Net Profit / Investment
Productivity = Throughput / Operating Expenses
Investment Turns = Throughput / Investment

In general, management decisions are guided by their effect on achieving the following improvements (in order of priority):

- Will Throughput be increased?
- Will Investment be reduced?
- Will Operating Expenses be reduced?

The strongest emphasis (by far) is on increasing Throughput. In essence, TOC is saying to focus less on cutting expenses (Investment and Operating Expenses) and focus more on building sales (Throughput) [24].

METHODOLOGY

Problem Identification & Definition (Case Study)

Aleem Jute Mills, Khulna, Bangladesh has been selected for the case study. This study is carried out based on the selected component which has maximum demand than the capacity. From the data analysis of the industry, the most demanded selected housing part is found to be facing bottlenecks in the production line. These bottlenecks lead to reduce the rate of production. Hence the industry fails to reach required production demand due to the reduction in production rate.

The major problem company facing nowadays during manufacturing of selected housing product is the delay of on time deliveries and floor space requirements which is due to the problems associated with Work-In-Process Inventory and Raw Material Inventory.

The comparison between available capacity and the required capacity (demand) is very useful to identification of constraint resource (CR). This has been carried out using time study method. The resource having capacity less than demand is identified constraint resource (CR). The resource having available capacity more than required capacity (demand) is identified as non-constraint resource (NCR). When the available capacity matches with demand those resources are identified as capacity constraint resource (CCR). Layout of Housing Production Line before Implementation of TOC are shown in the following **Fig.2.**

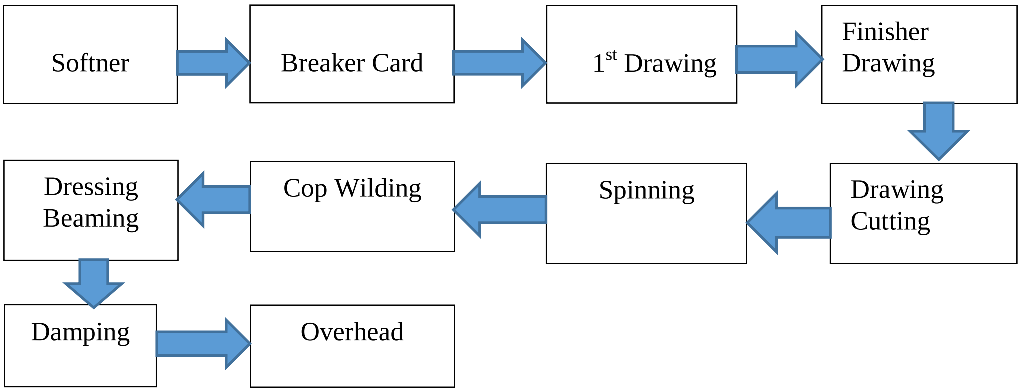

Fig. 2 Layout of Housing Production Line before Implementation of TOC

The used machine associated with their available capacity and daily demand is shown in **table 1**

Table -1 Comparison between available capacity and demand for resources

Sl No.	Machine Resource	Available Capacity (Min)	Demand/Day (Min)	Remark
1	Softner Machine	1200	540	NCR
2	Breaker Card Machine	1200	600	NCR
3	1st Drawing Machine	1200	1080	NCR
4	Finisher Drawing Machine	1200	1140	NCR
5	Drawing Cutting Machine	1200	1320	CR
6	Spinning Frame	1200	600	NCR
7	Cop Winding Machine	1200	540	NCR
8	Dressing Beaming Machine	1200	1440	CR
9	Damping Machine	1200	480	NCR
10	Overhead Machine	1200	1320	CR

Table 1 indicates that available capacity of resources for Softner Machine, Breaker Card Machine, 1st Drawing Machine, Spinning Frame, Cop Winding Machine, Damping Machine is more than demand hence these resources are identified as non-constraint resources (NCR). But available capacity of resources Drawing Cutting Machine, Dressing Beaming Machine and Overhead Machine is less than required capacity (demand), hence Drawing Cutting Machine, Dressing Beaming Machine and Overhead Machine are identified as constraint resources (CR).
Analysis of WIP inventory of selected housing product manufacturing on housing production line was carried out; and observed that WIP inventory associated with Drawing Cutting Machine, Dressing Beaming Machine and Overhead Machine are huge amount.

By analyzing previous data of the jute industry the following information has been obtained. The average amount of work in process inventory of last three month is observably high. The average amount of WIP inventory before implementation was 204 housings. The average Percentage of on Time Deliveries of last three month is remarkably less. The average amount of on time delivers before implementation was 75%.The average amount of raw material inventory of last three month is observable. The average amount of raw material inventory before implementation was 241 housings.

Implementation of Theory of Constraints (TOC)

The Areas of Capacity Constraint Resources

According to TOC methodology, buffer stock should be maintaining in front of constraint resources. The **Fig.2** shows layout of housing production line. In this production line there are three constraint resources identified i.e. Drawing cutting machine, Dressing beam machine and Heracle machine, because limited capacity with respect to demand placed on these resources.

Solving the Supply-Demand problem of Drawing Cutting Machine

Drawing Cutting machine is used for lining straight the milk shed, thinning it and at the same time folding and cutting operation in accumulated tap on selected housing product. The selected production line holds a system of available capacity of each resources are 1200 minutes per day (3 shifts). It is clearly seen that drawing cutting machine constitute the characteristics of constraint resources because of the over crossed demand resulting in huge amount of WIP inventory in front of it. In order to gather the production target 40 parts are required from the particular resource in selected housing production line per shift. But Drawing Cutting Machine produced 36 parts per shifts resulting in shortage of about 4 parts per shift due to limited capacity.
The total cycle time required on Drawing Cutting machine is 11 minutes where 4 minutes for final drawing operation and 7 minutes for cutting operations. To overcome this problem we have added Finisher Drawing machine in front of the Drawing Cutting machine. To shift final drawing operation to Finisher Drawing machine saves the time of finish drawing previously done on Drawing Cutting machine. Therefore Drawing Cutting machine's operation time is reduced to 7.5 minutes after done final drawing in 2 minutes in Finisher Drawing machine. So the total time is reduced to 9.5 minutes from 11 minutes and at the same time work-in-process inventory is reduced also. None the less 1.5 minutes time reduction in production line is huge beneficial in obtaining more throughput.

Solving the Supply-Demand problem of Dressing Beaming Machine

As TOC is a process informing of constraint resources, our next look is over the Dressing Beaming machine. We can see from **table 1** that indicating as a constraint resources, Dressing Beaming machine constitute the shortage of 240 minutes per day resulting in a shortage of producing 7 parts per shift. The machine possess huge number of WIP inventory. The demand of Dressing Beaming machine is 1440 minutes per day each part operation time of 12 minutes

per day. So the balancing have to be maintained in front of the constraint resource so that the shortage can be recovered per shift.
Introducing Dry Beaming machine can serve us to a great extent as Dry Beaming machine remain idle due to boiler. If we use Dressing Beaming and Dry Beaming at the same time it will work thoroughly. Dressing Beaming machine is used for making beam of yarn from the bobbin and spool of yarn. Dry Beaming machine can be used both for making beam of yarn and for clear starching. The machining time of Dry Beaming machine is 12 minutes per housing. In case of operating 40 parts, if we can take 25 parts on Dressing Beaming machine each part operation time is 12 minutes and at the same time if we take 15 parts on Dry Beaming machine each operation time of 20 minutes including loading and discharge time of 8 minutes, it will take total 300 minutes. As a result we can save 180 minutes which is a huge saving. This 180 minutes can be also used for provide steam when boiler is available or operation of other housing products and development work.

Solving the Supply-Demand problem of Overhead Machine
Layout of housing production line after implementation of TOC is shown in **Fig. 3.**

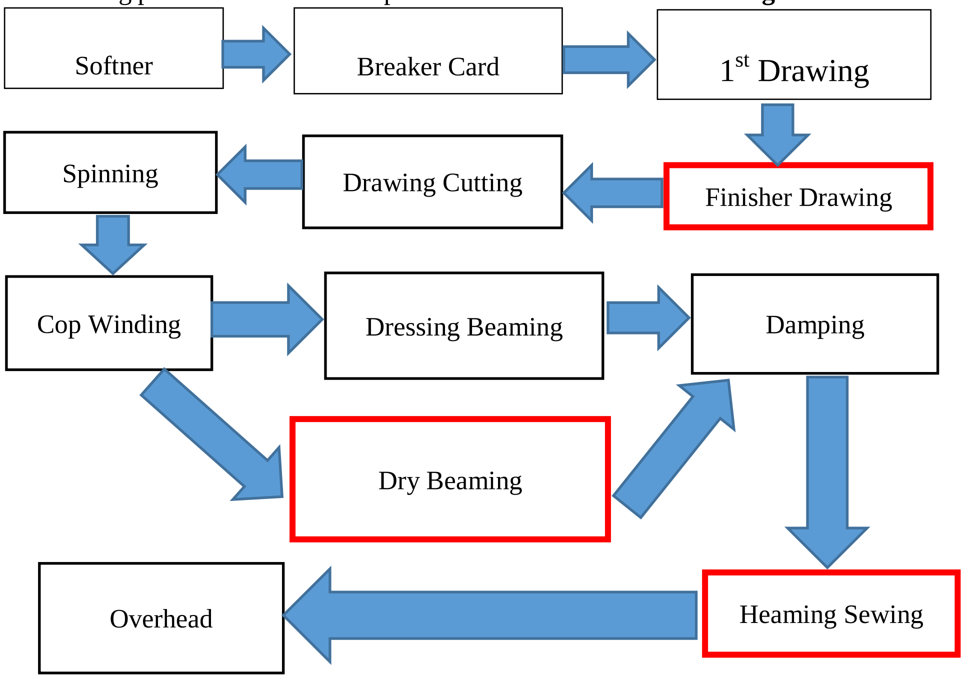

Fig. 3 Layout of Housing Production Line after Implementation of TOC

After Structuring the mentioned two constraint resources there was a problem in associating the demand and capacity of the overhead machine. As become of a constraint resources the demand is 120 minutes more than the capacity of the overhead machine. The production target is 40 parts per shifts whereas Overhead machine possess a shortage of 4 parts operating 36 parts per shift.
Overhead machine is used for sewing the mouth and side of a jute bag. For these operations, cycle time required on Overhead machine is 11 minutes where 4 minutes for mouth sewing and 7 minutes for side sewing operation. To overcome this problem we have added Heaming sewing machine in front of the Overhead machine. To shift mouth sewing operation to Heaming Sewing machine saves the time of mouth sewing previously done on Overhead machine. Therefore Overhead machine's operation time is reduced to 8 minutes after done mouth sewing in 2 minutes in Heaming Sewing machine. So the total time is reduced to 10 minutes from 11 minutes and at the same time work-in-process inventory is reduced also.

Thinking Process Implementation
The thinking process can be developed by the following table 2.

Table-2 Thinking Process

What Needs To Be Changed	How To Change	How To Cause The Change To Happen
To reduce the operation time of drawing cutting machine	Adding finisher drawing machine and it will work between 1st drawing machine and drawing cutting machine	Cutting time operation reduced to 9.5 min from 11 min

To reduce the inventory before dressing beaming machine	Use dry beaming machine associate with dressing beaming machine	Average inventory reduced to 50 housings from 241 housings
To reduce the operation time of the overhead machine	Use heaming sewing machine between damping machine and overhead machine	Sewing time operation reduced to 10 min from 11 minutes

Throughput Accounting

The financial measures of the performance are interpreted by the throughput accounting calculations. Throughput accounting calculation under the same working day (26 day/month), throughput ($1260/Day) and Investment ($31493040) has been carried out for the research purposes.

The throughput accounting before and after TOC applications are given below:

Table-3 Performance Improvement through Throughput Accounting

Before Implementing TOC(Mar'17-May'17)	After Implementing TOC(June'17-Aug'17)	Performance Measure
Production=7.8 metric ton/day	Production=10.5 metric ton/day	Production increased by 34.61% per day
Total throughput = 7.8×26×1260 = $255528/month	Total throughput=10.5×26×1260 =$343980/month	Total throughput increased by 34.42% per month
Operating Expenses=$13800/month	Operating Expenses=$16200/month	Operating Expenses increased by 17.39% per month
Net Profit = $242092/month	Net Profit =$327780/month	Net Profit increased by 35.39 % per month
ROI=.007 =.7% per month	ROI =.01 =1% per month	ROI increased by 0.3% per month
Investment Turns = 0.008 = .8%	Investment Turns = 0.011 = 1.1%	Investment Turns increased by 0.3%

The **table 3** has shown both the total throughput, production and net profit is increased respectively by 34.42% per month, 34.61% per day and 35.39% per month after implementing TOC. Return on investment and investment turns has also in significant percentages. But there is only one problem that is increase in operating expenses which may be ignored with respect to performance improvement.

RESULT & DISCUSSION

The performance improvement of TOC are shown in both operational and financial measures. The operational performance measure are shown by the following graph **(Fig. 4 to Fig. 6)**. The period from March 2017 to May 2017 represent pre-implementation period and post implementation period from June 2017 to August 2017.

Effect of TOC Methodology on Percentage of on Time Deliveries

From the following **Fig.4** it has shown that the average amount of on time delivers before implementation was 75%. This improves 97% after implementation that is 22% increment in on time deliveries after implementation of TOC. This consequently resulted in improved throughput.

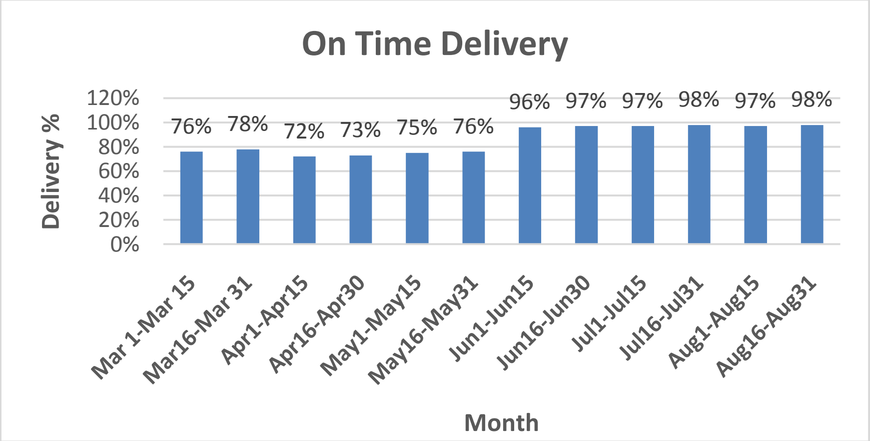

Fig. 4 Percentage of on Time Deliveries after Implementation

Effect of TOC Methodology on Average WIP Inventory

Average amount of reduction of WIP inventory due to the implementation of TOC for selected housing product is graphically represented shown in **Fig. 5.** The average amount of WIP inventory before implementation was 204 housings. This reduced to 52 housings per month after implementation of TOC.

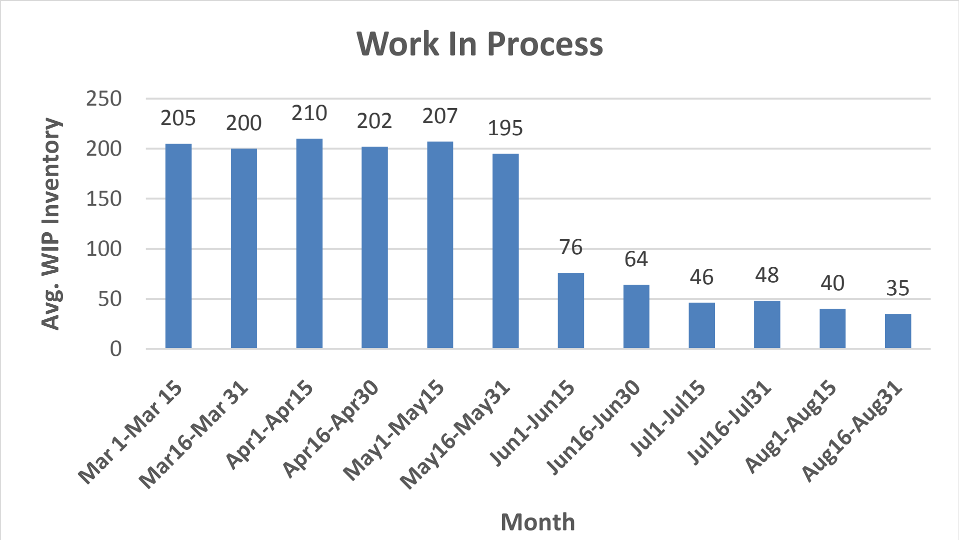

Fig. 5 Average Work in Process Inventory after Implementation

Effect of TOC Implementation, on Raw Material Inventory (RMI)

Average amount of reduction of raw material inventory due to the implementation of TOC for selected housing product is graphically represented shown in **Fig. 6** the average amount of raw material inventory before implementation was 241 housings. This reduced to 50 after implementation.

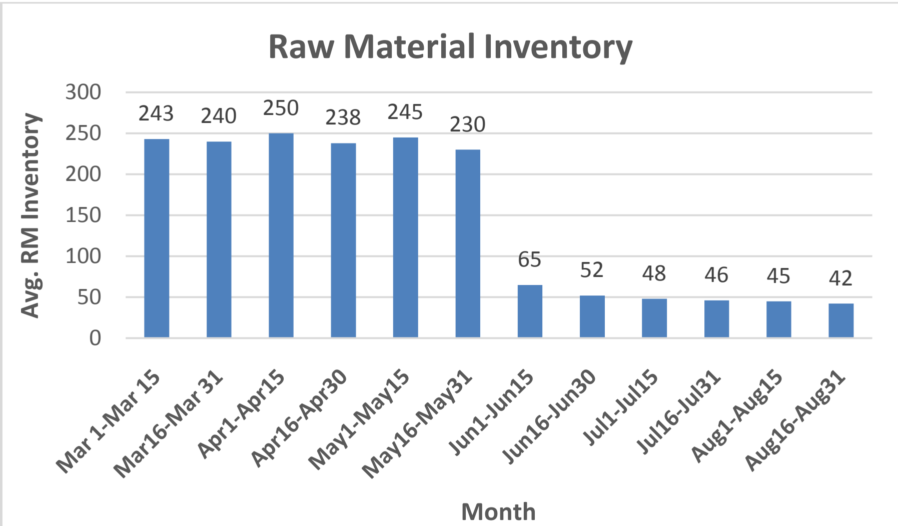

Fig. 6 Amount of Raw Material inventory after Implementation

RECOMMENDATIONS

Two recommendations can be developed after viewing and discussing on this research work:

1. If the capacity of rest of the machine without the bottleneck is almost same, then it is easy and economical to add a machine from outside which has almost the same capacity as the rest.
2. If the bottleneck machine and the machine immediately before and after it, has the almost same capacity and working procedure without the rest of the machine, then is easy and economical to combined the bottleneck and its immediate machine.

CONCLUSION

The research deals us with the successful implementation of Theory of Constraint (TOC) in mitigating the bottleneck. Bottleneck is the hinder of high productivity and marginal profit. At the same time bottleneck manages excess inventory and delays of on time delivery. We have used the technique of Theory of Constraint (TOC) which was challenging to cope with the bottleneck. But Drum-Buffer-Rope scheduling have facilitate the system more conveniently and have improved the system with managing inventory and reducing operation time. After implementing TOC total throughput are increased 34.42% per month that results in 35.59% increase in profit and 0.3% increase in return on investment per month. As a result three main focus was developed: a) Satisfactory level of On Time Delivery b) Space availability in the store as well as the production unit and c) Quality of product due to better control over operation of constraint resources. The ideal time of non-constraint resources are utilized by other purposes of development work.

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