THE APPLICATION OF THEORY OF CONSTRAIN (TOC) IN AN ORGANISATION TO RESOLVE PROBLEMS AND TO BOOST PRODUCTIVITY.

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ABSTRACT

The theory of constraints (TOC) identifies constraints which are otherwise labelled as waste by lean. It isolates these constraints and provide resources in order to buffer and/or eliminate them completely. Its underlying premise is that organisations can be measured and controlled by variation on three measures which are throughput, operational expense and inventory. TOC challenges managers to rethink some of their fundamental assumptions about how to achieve the goals of their organizations, what they consider productive actions, and about the real purpose of cost management in order to maximize throughput through sales. It is about understanding bottlenecks to a process and better managing these bottlenecks to create an efficient process. The paper identifies inputs that are causing constraints. It explains the methodology to isolates them and how and when to apply TOC in minimising their impact. In order to prove this, a research was carried out in the Bakwena mine in South Africa where TOC was used to resolve recurring problems. The end results has shown that when problem area are isolated, conditions observed, resources allocated at the problem area and action taken to address problems immediately, positive results can be achieved.

Key words: Constrains, processes, resources, productivity, mining

INTRODUCTION

When running a successive company, it is imperative that management focusses on those issues that will create profit, minimise cost and may cause harm or slow production. Most companies put profit as the mayor factor in business success. They understand the fact that when cost are minimised, profit will increase. Many factors do lead to slow production and it is the duty of a manager to manage such activities. This paper will focus mainly on issues that may slow or cause harm to the company leading to bottleneck.

A bottleneck is a constraint or choke point that limits production output. A bottleneck is a stage in a process that causes the entire process to slow down or stop. In a communications context, a bottleneck is a point in the enterprise where the flow of data is impaired or stopped entirely(Rouse. M. 2014). Many manufacturing operations suffer from bottlenecks caused by one or more machines and the bottleneck may change depending upon the actual product being manufactured. Identifying and managing manufacturing bottlenecks can have a major impact on output and profits. A bottleneck restricts all production and time lost at the bottleneck can never be recovered. Attention and resources should therefore be focussed on bottleneck to ensure that machines continue to run as long as possible(Rouse. M. 2014).

On the other hand a constraint is a factor that limits a company's ability to achieve more of its goal. It is therefore imperative for businesses to identify and manage constraints. Because a constraint is a factor that limits the system from getting more of whatever it strives for. A business manager who wants more profits must manage constraints in order to improve business. There is really is no choice in the matter (Bates. S. 2014Either you manage constraints or they manage you (Smith, N. M. 1995).

The Theory of Constrain (TOC).

The theory of constraints (TOC) is a management philosophy developed by Dr Eliyahu Goldratt (Goldratt, E. M. and J. Cox. 1986). It is a systems approach based on the assumption that every organization has at least one factor that inhibits the organization's ability to meet its objectives. TOC emphasizes the maximization of profit by assuring that the factor that limits production is used most efficiently. Once the constraining factor has been identified, the next step is to determine the throughput (the rate of production or rate at which something can be processed) per unit of the constraining factor. This is done by dividing the throughput per unit of product by units of the constraining factor required to produce each unit of product. The key to maximizing profit is to concentrate on selling and producing products that provide the highest throughput per unit of constraining factor.

According to the TOC, the goal of an industrial organization is to make money in the present and in the future. TOC uses the commonly used financial measures to quantify its overall goal of making money: net profit, return on investment and cash flow (Cox, Jeff; Goldratt, Eliyahu M. 1986). These financial goals are translated to operational. In order to make money in the present as well as in the future, an operating system should increase its throughput and simultaneously reduce its inventory and operating expenses (Goldratt EM, Cox J(1993, Rand GK(1990).

TOC supports a continuous improvement philosophy. In order to accomplish these tasks, the following questions should be asked (Rand. G.K. 1990);

1. What to change: every organization in a real environment is overwhelmed with problems and/or opportunities which need the managers' attention and/or corrective actions. However, limited time, effort and resources make it difficult to act on all such problems or opportunities. Hence, the manager has to find what should be changed, to effectively improve the performance.
2. To what to change to: once the core problems have been identified, the next step is to find the solutions. If sincere effort is not directed towards finding solutions to the core problems chaos and panic will result.
3. How to cause the change: perhaps the most difficult of the three questions is to find out how to cause the change in a system. In addition to the time, effort and capital required, managers often face the problem of emotional resistance by people in the organization who perceive change as a threat to their security. If 'to what to change to' is identified, but it is not possible to cause that change, then the solution is not of much use.

The Theory of Constraints suggests the following five steps to answer the above three questions and to continue the process of ongoing improvements(Goldratt. E.M, Cox J.1993, Rand GK. 1990).

1. Identify the system's constraints.
2. Decide how to exploit the system's constraints.
3. Subordinate everything else to the above decision.
4. Elevate the system's constraints.
5. If in the previous steps a constraint has been broken, go back to the first step.

These are all implicitly assumed to be fixed (Doran. J. 2005). This assumption leads many commentators to the conclusion that TOC measures have a short run time horizon (Gholam R.K. et al)

Drum-Buffer-Rope Scheduling (DBR).

Drum-buffer-rope is a manufacturing execution methodology, named for its three components. The drum is the physical constraint of the plant: the work center or machine or operation that limits the ability of the entire system to produce more. The rest of the plant follows the beat of the drum. They make sure the drum has work and that anything the drum has processed does not get wasted. The buffer protects the drum, so that it always has work flowing to it. Buffers in DBR have time as their unit of measure, rather than quantity of material. This makes the priority system operate strictly based on the time an order is expected to be at the drum.

Drum-Buffer-Rope Scheduling (DBR) is an approach to synchronized manufacturing. It assures that the inventory buffer in front of a capacity constrained resource remains at adequate levels without being too large (Goldratt, 1984, Goldratt, E. M. and J. Cox. 1986).). The constrained resource becomes the drum that determines the timing for the system. The buffer is the time related to supply of inventory before the constrained resource that assures the constrained resource will not be idled by fluctuations in the system leading up to it. The rope is "tied" between the constrained resource and the lead operation in the system assuring that too much inventory does not develop in front of the constraint, as shown in fig 1 below.

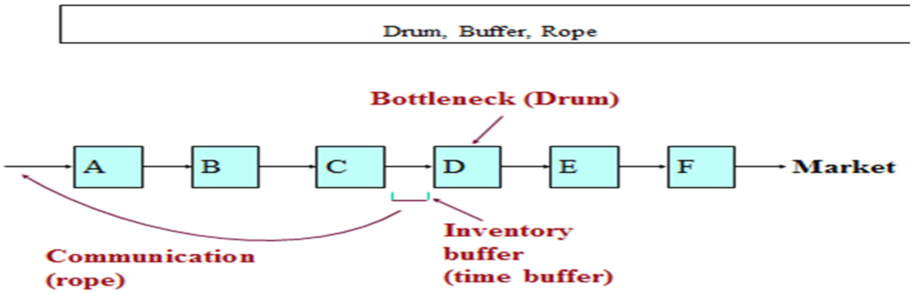

Fig 1: Drum-Buffer-Rope Scheduling (DBR) approach

Traditional DBR usually calls for buffers at several points in the system: the constraint, synchronization points at shipping(movement). S-DBR has a buffer at shipping and manages the flow of work across the drum through a load planning mechanism. The rope is the work release mechanism for the plant. Orders are released to the shop floor at one "buffer time" before they are due. In other words, if the buffer is 5 days, the order is released 5 days before it is due at the constraint. Putting work into the system earlier than this buffer time is likely to generate too-high work-in-process and slow down the entire system.

Within manufacturing operations and operations management, the solution seeks to pull materials through the system, rather than push them into the system.

The theory of constraints (TOC) and Lean.

TOC can be used in conjunction with Lean thinking to leverage even more benefits for the enterprise. Like Theory of Constraints, Lean thinking is a means of enabling a growth strategy. Unlike Theory of Constraints, which primarily focuses on the bottleneck, Lean thinking is focused on reducing waste at all levels and in the process of doing so; it uncovers additional capacity that could be deployed for further growth. TOC and lean manufacturing are two popular business philosophies that have received a great deal of attention in the recent years. Their objective and underlying assumptions are well researched. One of their strength is to provides focuses in worlds of information overload, to guide practioners and to improve the organizational performance.

TOC Implementation.

Bakwena mine is a progressive platinum mine in South Africa. It has seven mining shafts which are (a) Dintwa number 3 shaft, (b) Ketlele, Pendulum, (c) Phakathi, (d) Mzana, (e) Keelinin and (7) Avery. The mine embarked on finding solutions to their efficiency and product output but realized that it was difficult to meet the production levels due to bottlenecks in the operations. The balanced capacity chain on the shaft remained the "Achilles heel" of the shaft. The aim was to increase output of the mine as a whole within a short time. This was difficult to achieve while the mine remained under pressure and at the same time, trying to maintain current performance.

These combined effect of problems encountered, which included: variation in stoppages, human factor, material required, government intervention (section 14 policy), industrial strikes, lead to a number of lost blasts. This loss in production is depicted in Dintwa number 3 shaft which will be used as a case study. (see figure 2 below)

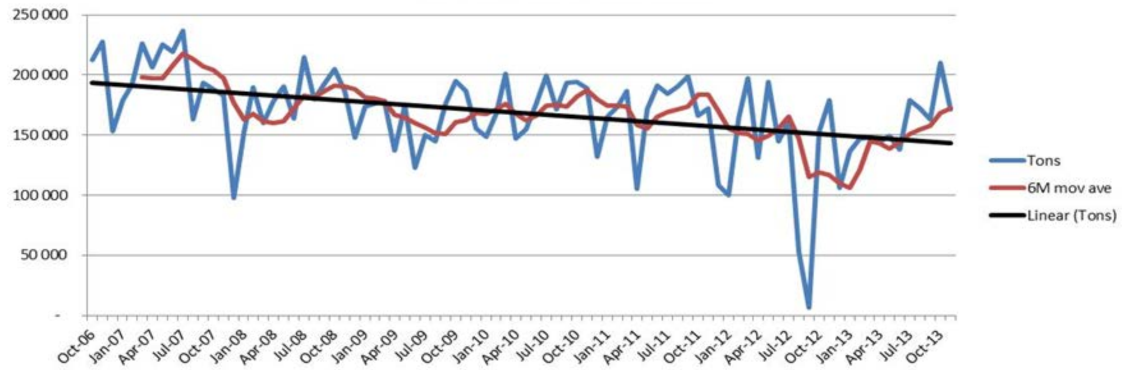

Fig 2. Dintwa Number 3 production output (Source Bakwena mine).

The following main bottlenecks were linked to the decline in production in Dintwa Number 3 shaft, causing constraints;

- Cash Conservation

The way that the cash conservation strategy was being implemented meant that very often managers who had the authority to approve certain expenditure did not do so but rather escalated the decision upwards in the organisation. The result was a much longer and arduous process of getting decisions made regarding putting of necessary protective capacity or buffers in place to support the desired increase in the primary flow. Examples are the length of time that it took to get the underground half level material stores in place, the buffer of skills, and the spare-winch per half level at Dintwa Number 3 Shaft.

- Standard Crew Size Template

The policy of having a standard crew size for stoping (blasts) and development crews ignored many of the factors that influenced whether the crew could achieve a good blast every day. It faied to take into account the amount of time the crew spend travelling to the work place, the quality and pressure of the compressed air available at the face, the quality and reliability of the rock drills, the specific geological conditions, what the crew was expected to do besides drilling, blasting, supporting and cleaning. The standard crew size was built into the budgets and into the SAP system. Once it was in the SAP system, it was once again a long and arduous process to change it.

- Standard Bill Of Material (BOM)

The Standard BOM for stoping and development crews also failed to take into account specific conditions under which each crew was operating, for example, geological conditions, the quality of the materials supplied, etc. The Standard BOM could be over ridden but this again required many signatures and was time consuming. This resulted in crew members not getting materials that they required.

- Inflexible Budgets

If there was a need to spend some money for something that was not in the budget, it is again a long and arduous process to get the expenditure approved.

- Recruitment Process

The recruitment process was very long (80+ days). However, it was difficult for them to start the process without there being a vacancy allocated by SAP system. This process of getting the vacancy into the SAP system and the approval to fill it could be long and arduous and only once this has been completed, could recruitment process start.

- Balanced Score Card

Although efficiencies could no longer form part of the balanced score card, there were situations where managers delay or refuse to make decision which would in the long term be of benefit to them. Furthermore some managers complained that they had no idea, until the end of the year, as to how they were performing with regard to the balanced score card. This substantially reduced the effectiveness of the balanced score card as a tool to drive the desired behaviour.

- Standard Manning/Staffing Template

The current standard template did not cater for the refresher training when mining personnel returned from their annual leave. There was a delay in days spent in admin and other days in medical centre bringing the total days that the person was not available to production, to 11 days.

- Bonus system

There were two things about the bonus schemes that were problematic:

    The fact that the bonuses are capped meant that high performers are not motivated to perform above the maximum.

- Meetings

There was a general tendency throughout the organisation to arrange and to cancel meetings at a very short notice resulting in important discussions and decisions being delayed.

Operations.

From Jan 2007 the mine was losing production at a rate of 15% per anum resulting in loss of profit. It had to apply retrenchment policy and reverted to cost saving exercise.

The mine decided to hold a strategic strategy review that took place in 2012 with the intention of increasing production and improve the profitability. On the 23rd October 2012, a presentation was made on the Theory of Constraints (TOC) Production Flow Solution for Mining. Resulting from this presentation, it was decided to introduce TOC at Bakwena mine. The desired outcome was to ensure constant flow and an overall reduction in the unit cost and to ensure successful implementation of the TOC philosophy which would ensure increased production volumes from the mining operations, consistent and stable production flow. An initial improvement in production output of between 5% and 10% was targeted.

By making use of five TOC steps as stipulated in TOC (see section 2, the mine focused mainly on the DBR approach system. They identified wickest links, where constraints were occurring. Decisions were made to apply buffers at these areas. They decided to exploit the system by using these buffers as banks of physical objects before a work centre. They used two buffering systems: **stock buffer** and **time buffer**. The purpose of the stock buffer as shown in fig 3 was to provide the next chunk of the flow (the one that consumes from this stock buffer) with availability of raw material, semi-finished products and components or finished goods without too much excess inventory.

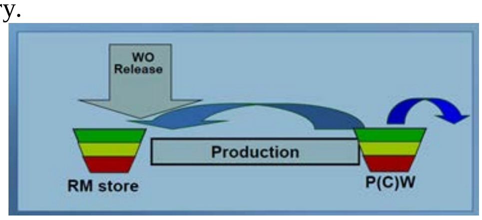

Fig 3. Stock Buffer production flow system.

When production was about to be constrained due to material shortage, production personnel implemented the stock buffer in order to allow production to flow.

Time Buffer is assigned to the Customer Order which is the elapsed time for the works order(WO) to be processed in the production area and it is parts that are necessary for the customer's order. The Rope mechanism is used for Material Release and is determined by deducting the Production Buffer from the Due Date (DD).

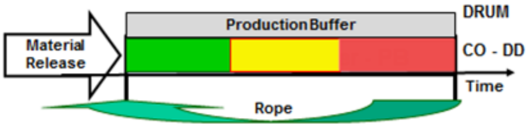

Fig 4. Time Buffer production flow system.

Time Buffer for Production in fig 4 is called the PRODUCTION BUFFER and it is measured in time, its size is present. For it to work properly, the size of the Red zone should be not less than the cumulative TOYCH TIME needed to process the work order. It serves 3 objectives on different stages of handling a customer order;

(1) to check and determine what completion date can be promised to the client
(sales and production planning)
(2) to determine the work order (WO) release date (production planning)
(3) to give production management "early warning signals" about the risk of the
WO NOT being completed on time and to prompt for corrective actions
(execution control) and
(4) it collects information in Process of Ongoing Improvement (POOGI) (system analysis)

To use time buffers, there should always be enough (but not excessive) work in the time queue before the constraint has adequate offloading space behind the constraint.

These constraints, if properly identified and broken, provide the fastest route to significant improvement of the system and can provide the basis for long term, strategic improvement

Results.

The success of TOC implementation was reflected in the results shown below as shown in fig 5 below.

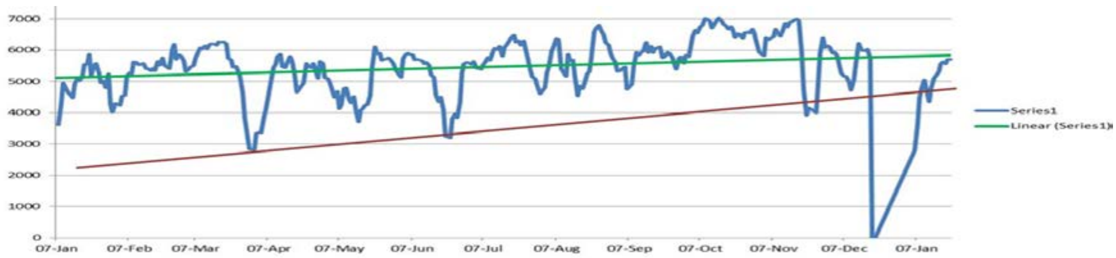

Fig 5. Dintwa Number 3 production output (Source Bakwena mine).

- Costs
  The mine had spent R21,199,081.31 on TOC project. Production improvements during this period rose from 5500 Tons per day to 7500 Tons per day.

- Positives
  - On the issue of safety there was a significant decrease in lost time injury (LTI) which came down to 3.71 which was a 2 year low. Achieving a whopping improvement of 82%
  - The relationship between management and workers improved drastically. This cascaded to mine – union relationship. There was a positive employee morale leading to improvement in absenteeism records.
  - Production improved from 5500 Tons per day to 7500 Tons per day (refer to figure 5)
  - Cost per ton increased in the 2nd half of the year which equated to a variance of 8500 per tons per day
  - Rand per ounce increased in the 2nd half of the year due to TOC implementation.

Conclusion.

It is obvious that TOC has broad applicability in various operations activities. The results have shown improvements in productivity and also in cost saving exercise. It took a while for positive results to show but it was worth the waiting. The introduction of a buffer system provided much support to the operations which alleviated bottlenecks.

A manufacturing bottleneck is a constraint or choke point that limits production output. Many manufacturing operations suffer from bottlenecks caused by one or more machines and the bottleneck may change depending upon the actual product being manufactured. Identifying and managing manufacturing bottlenecks can have a major impact on output and profits.

A bottleneck restricts all production and time lost at the bottleneck can never be recovered. Attention and resources should therefore be focussed on bottleneck machines to ensure that they continue to run as long as possible.

Management of buffers at machines should be an ongoing business. They must be constantly stocked with material. This can be avoided by ensuring that there is a buffer stock in front, upstream and downstream of the bottleneck. Putting a buffer stock in place does increase inventory (WIP) and associated waste and costs, so it should be kept to a minimum. To do this buffers should be monitored and staff should be alerted when stock needs replenishing.

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