

Application of Theory of Constraints in South Africa: A case study in a platinum mine

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Abstract

The Theory of Constraints has become one of the greatest solutions in industries of developed countries. This multifaceted strategy has become the answer to many organizations that were on a free fall. Developing countries are yet to embrace to grasp the fullness of this great concept and maximize it to transform their economies for the best. Although South Africa being one of the most developed African countries has shown to be a step ahead of the countries in Africa by investing resources in the Theory of Constraints and the academic work therein, there is still a wide gap that needs to be filled in order to maximize the benefits of this theory. Lonmin mine is used as a case study as it has invested a lot of resources in the implementation of the Theory of Constraints.

Keywords

South Africa, Theory of Constraints, Thinking process

1. Introduction

Theory of Constraints (TOC) is a management philosophy that creates a systematic way of improving organizations efficiency. It is a continuous improvement method that aims to resolve the issues that stand at the bottleneck of the organization as they arise, to ensure the organization functions at its most optimum capacity given its available resources. According to Şimşit et al [1], TOC focuses on the weakest ring(s) in the chain to improve the performance of systems. TOC is a multi-faceted systems methodology that has been developed to assist people and organisations to think about their problems, develop breakthrough solutions and implement those solutions successfully [2].

The thinking process (TP) is a TOC tool used as a problem solving mechanism which also encourages people to apply their minds and take responsibility of their work environment. This tool entails the use of structures that provoke critical thinking at every level and area of employment. These structures range from the evaporation cloud, the current reality tree, transition tree, prerequisite tree, future tree and negative branches [3]. TP also has a concept of the strategy and tactics tree, which can be used independently however, still fall under the category of the TP. With a good TP system in place, the process becomes easier to navigate and identify bottlenecks, thus making faster to implement buffers where relevant.

The drum buffer rope (DBR) is a system that is used to provide a buffer at the point of constraint in the process. This is done to ensure that there is always maximum flow at the point of constraint because it is believed that a process can only be as strong as its weakest link, in other words a process at its best performance can only flow as best as the

capacity at the bottle neck. The buffer thus ensures that there is always maximum feed at the point of the constraint so that there is delay in process is minimized.

TOC philosophy requires the process to deploy additional resources at the areas where there are existing bottlenecks and/ or bottleneck causing areas in the process and these resources under these conditions are known as buffers, and they ensure that the capacity is maximized at any given time. This philosophy has found a wide application range especially in production companies and mining industries.

The objective of this paper looks at the application of TOC in South Africa through the various industries and the reception process of this philosophy. A case study of Lonmin mine was further presented in this paper. In addition, this paper will also look briefly at the application of TOC in other developing countries.

2. History of TOC

TOC was developed in 1979 by Dr. Eliyahu M. Goldratt [4], however Goldratt [5] states that this philosophy was developed in the mid-1980s, although the authors differ in the year in which the philosophy was conceived, they seem to agree that it evolved from the OPT (Optimized Production Timetables) system [6] and was later known under the commercial name of Optimized Production Technology (OPT). The evolution of this philosophy has hitherto according to Watson et.al [7] been segmented into five eras which play a significant role in the TOC known today:

- The Optimized Production Technology Era – the secret algorithm.
- The Goal Era – articulating drum-buffer-rope scheduling;
- The Haystack Syndrome Era – articulating the TOC measures.
- The “It is Not Luck Era” – thinking processes applied to various topics.
- The Critical Chain Era – TOC project management.

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 [8].

Rigorous academic testing has validated those early findings revealing that manufacturing systems employing TOC techniques exceed the performance of those using Manufacturing Resource Planning (MRP), Lean Manufacturing, Agile Manufacturing, and Just-in- Time (JIT) [9]-[11].(Cook, 1994; Holt, 1999; Mabin and Balderstone, 2000).

3. Benefits of TOC Application

The most significant benefit of TOC is to improve the responsiveness of the firm to the changes in the marketplace thus providing an advantage in competition. The benefits according to Balderstone and Mabin [12] are:

- Product Cost: is greatly reduced due to reduction of manufacturing cycle time, reduction of waste and inventories and elimination of non-value added operations.
- Quality: is improved because of continuous quality improvement programmes.
- Design: Due to fast response to engineering change, alternative designs can be quickly brought on the shop floor.
- Productivity improvement.
- Higher production system flexibility.
- Administrative ease and simplicity

4. TOC Application in Developing Countries

Third world countries have over the past years made vast efforts to developing their infrastructure, GDP, as well their human development index. These countries have found use for management practices such as lean, JIT and six-sigma; however TOC has not yet been well-embraced by developing countries, especially in Africa. The use of this method which has been in existence for well over 25 years still lacks significant expression in these countries.

TOC and related problem-solving methods can be systematically applied to address problem and proffer effective solutions. With the combination of robust food safety regulations and system, Taiwan applied TOC in restoring her food safety reputation by eliminating any loophole in the food supply chain [13].

The results confirm that if one constraint could not be overcome, another constraint may be triggered. For example in UAE, if the method of disposing wastage threatens the environment, by breaking the regulations, companies may need to spend money to deal with the wastage in a legal way. The project budget may not be enough as a result of this spending, thus economic constraint is encountered [14].

For unbalanced manufacturing systems, TOC constitutes a useful strategy for maximising and improving system performance. It has been shown that the operational research technique of mathematical programming provides a systematic basis for the implementation of TOC in practice. For example in Brazil, a substantial scope exists for developing mathematical models of TOC in automated manufacturing systems and their validation in industrial practice [15].

A simulation of a flow shop operation was done by the use of Extend 6 software in India. The model is allowed to run for 30000 time units as warm-up period and the data collection period consists of next 60,000 time units. An attempt has been made to establish a relation between the system throughput and the parameters affecting it. The results are compared with the conventional production system and are reported to be matching with the literature. Simulation studies suggest that the performance of DBR results in lower in process inventory compared to conventional production system.

A generalized analytical formula for throughput estimation (jobs per hour) of a DBR production line with variable processing times and limited buffer capacity happens to be difficult. Therefore, a methodology has been proposed using neural networks based on back propagation algorithm for accurate prediction of throughput considering mean processing time, coefficient of variation, buffer size, number of stations and signal buffer.

In order to reduce training time, the five input parameters are converted into two principal components and normalized principal components are used as inputs rather than actual parameters. The results obtained from the neural network training are found to be within the acceptable error limit. The throughput obtained from the neural network model almost matches with the throughput calculated from the DBR system using simulation. Lastly it can be concluded that DBR system hardly demands the costly affair of organizational change prevalent in JIT or in lean system. It is simply based on scheduling of the capacity constraint resource [16].

5. TOC Application in South Africa

South Africa is one of the limited developing countries that are adapting the concept of TOC its industries. Substantial work is being done to in this area on the implementation, adaptation, and the effectiveness of TOC in this country. TOC in South Africa is still in the introductory stages and adaptation is still being nurtured, however there has been great potential that has been shown in research work that could be yielded once the system has been made a culture in the various industries.

In the mining industry, Sasol has some of the mines that have encouraged the introduction of TOC. They used the 5 steps that govern TOC continuous improvement [17] and determine the capacity constraint resource in one of their coal mines. Van Heerden [18] used the pareto principle to identify and utilize the 20% that will be needed to cause the 80% improvement. Having identified that time lost in 3 different forms (start and end of shift, breakdown, and non-measurable) sits the capacity constraint resource at 44.19% he states in his work that this could be turned to uptime and yield a 73.4% utilization.

Smith and Pretotious [19] illustrated how applying TOC in a business can increase economic value adding (EVA) by the use of the future reality tree. They conclude that if a company is managed according to TOC principles, the EVA of the company will improve. This is due to the fact that net profit, return on investment and cash flow will increase due to the focus on the constraints of the company. At the same time, the asset risk, operating risk, size & diversity risk and the strategic risk of the company will be reduced. Therefore the risk factors that influence the cost of capital of the company will be reduced, leading to a reduction in the cost of capital. Both terms (return on investment and

cost of capital) that form part of the EVA equation is therefore influenced in favourable directions by applying TOC management principles [20].

The above investigation shows that it is important to consider mine system constraints when attempting to optimize mechanised machine solutions. A substantial expense can be incurred by focusing on perceived constraints which may not ultimately form the overall system bottleneck. It is therefore essential to assess each mine as a system, step through the processes involved utilizing a process mapping approach, and apply a methodology similar to Goldratt's theory of constraints in order to optimize a particular operation. The initiatives highlighted above attempt to optimize machine cycle by the activities associated with the cycle as well as the environment which the machinery operates. Although several machine constraints have been addressed, additional effort is to fully justify the proposed mine solution to ensure that it suitably addresses safety, operational and economic constraints. It is felt that the incorporation of such a layout will, however, ultimately alleviate the next hurdle/bottleneck related to panel availability, thereby shifting the bottleneck and providing the opportunity for further optimization to take place [21].

6. Lonmin Mine: Case Study

6.1 The wide W-effect that has been observed over time

Theory of constraints (TOC) was introduced to the Lonmin SAAFY Shaft in 2014, after there had been significant non-performance instabilities (known as the "W-effect" because of their appearance on a graph) with a wide range noted in the production review. These instabilities resulted in a loss with regards to the production throughput which had been observed over a few years. The introduction of TOC lead to an increase of about 5.1 % in the production output at Lonmin Rowland shaft [22]. Figure 1 shows the production output (Tons) from the Rowland shaft, with the comparison between the production performance before and after the implementation of TOC. Before the increase, there was a trend of decrease in the average production output, whereas, a reverse of trend was observed with TOC application.

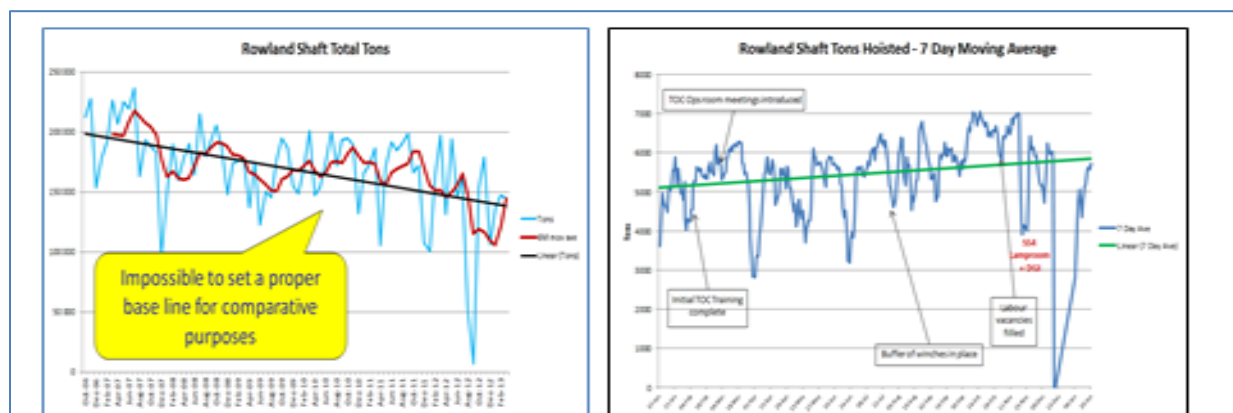


Figure 1. Rowland Shaft Lonmin mine production output [23]

The key drivers and principles in the successful implementation of TOC in Rowland shaft is described below [23];

- Managing in Silos rather the flow of the system as a whole;
- Efficiency management rather production flow principle;
- Budget management rather than manage by constraints;
- Individual KPI rather than Buffer management;
- Behaviour management (Leader not as a BOSS).
- Management by numbers rather than management by means;

6.2 The production down time

In a shaft, just as in any production plant, time is among the most valuable “inventory” that needs to be strategically used in order to maximize its outcome. It becomes very crucial to know where to draw a line in order to be able integrate the operations management tools. Lean is a good tool in operations management however if not used wisely can become a hazard to the profitability of the organization. Having observed the system over a short period of time minor issues which appear to be masked as “reducing waste” have occurred which wallow away production time. One striking example was the repair and replacement of winches in the shaft: the winches have to be removed and take all the way out of the shaft to the engineering department for the engineers to assess whether to replace or repair the winch. Then the winch will be transported back to the shaft and put back in place for operation. This is a very time consuming process which in turn costs the company lots of money, all because the company aims to “reduce waste”. The other of such examples is the ordering of materials required for blasting, this is yet another time consuming process which has also lead to the people being openly dishonest in a very obvious way just because the system requirements are not considerate of the type of working environment.

6.3 The degree to which the people are empowered to make decisions and take decisive actions independently

One of the key elements which are working against the logical progress of the shaft is the way the system has been programmed. The people at the lower levels have the greatest insight of what is happening in the shaft, especially as far as their area of operation is concerned. Many of them have over time acquired the expertise of knowing how to detect certain faults and address the basics in their designated fields because of their experience gained. However the current method of operation does not allow the people at this level to take decisive actions or empower them to do so at all, rather it makes them so dependant that it paralyzes their ability to apply their minds. As a result of this, the people at this level begin to feel redundant and lose the zeal to work. The people then shift the blame to cover up for their lack of commitment. They cannot be held accountable for anything if they are not entrusted with anything. At this rate the only thing that drives them for progress is a bonus at the end of the month.

7. Future trends of TOC

A comprehensive review of academic literature on the TOC, including papers published in referred and non-referred journals and books enables us to classify them on the basis of the TOC philosophy and its application in business disciplines. The review shows that the vast majority of the papers have concentrated on the concept and philosophy enhancement of TOC. Several articles have been published in the production sector also. But very little work has been done on service sector. In the application category a number of articles report the application of TOC concepts in the area of production and management accounting. Few papers have been published on the comparison of TOC with various existing theories such as TQM, JIT etc. Much work remains to be done in terms of developing measures of the three dimensions of the throughput orientation construct and empirically testing the hypothesis. Future research could be directed towards the simulation of the case studies of organizations by identifying the bottleneck stations and developing a detail schedule for it with the application of finite scheduling method [16].

8. Conclusion

There is a wide gap in TOC documented research based on developing countries, this could be mean the introduction of TOC in these countries is slow, or the academic side of TOC in these countries needs to be encouraged. South Africa has shown great potential where TOC application is concerned as it has highly developing industries and an extremely competitive market.

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Biography

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