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Increasing profitability in a South African mining supply company by applying the theory of constraints

Macauley, Denzyl James

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Increasing profitability in a South African mining supply company by applying the Theory of Constraints

Denzyl Macauley

1747928

A consultancy report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

Johannesburg, [2018]

DECLARATION

I, Denzyl James Macauley, declare that this consultancy report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Denzyl James Macauley

Signed at …**Kempton Park**…On the ……**7th**…….. day of **……December……2018**…..

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Mr Rhodes Nelson (President Screening)

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Acknowledge data gathering by the supervisors of the IM PU factory and all other employees who have contributed.

SUPPLEMENTARY INFORMATION

Supervisor:	Mr AJ Rothman
Word count †:	13 173
Supplementary files:	A desktop study was conducted but the data is confidential and remains the property of Multotec Manufacturing (Pty) Ltd. It can be made available on request.

EXECUTIVE SUMMARY

This project was identified as the applied research project to fulfil my qualification for the Master of Business Administration. The focus is grounded on the Theory of Constraints as depicted in the book entitled “The Goal” by Eliyahu M. Goldratt and Jeff Cox.

The aim of this work was to establish ways to grow the injection moulding screen panel manufacturing business post the next 3 years by evaluating opportunities to increase throughput. Data was collected to determine lost time in production processes and the impact it has on throughput. Time lost contributing to production downtime was found to be as a result of machine tool changes, meetings and machine breakdowns. After establishing the throughput which could be realised by addressing these areas of consideration, recommendations were made to improve follow up activities to cope with additional throughput.

When inventory was evaluated, it was found that a substantial amount of money is tied up due to a raw material overstock situation existing. Discussions will be held with suppliers to take ownership of management of raw materials and this can have a positive effect on the cash flow of the business as a whole.

The Theory of Constraints is grounded on the fact that any changes made to a bottleneck in a process must have a meaningful financial contribution towards the operation of a production facility and all other prior and follow up activities. Even though most individuals within the organisation including myself feels that a reduction in downtime to increase throughput in this particular scenario can have a meaningful contribution to grow the business, it was found to not be true due to the effect on operating profit.

If Multotec want to grow their business by 10% year on year for the next 3 years, it is recommended to invest in machines to generate throughput in order to have a meaningful profit contribution. In addition to this, a continuous 24 hour shift cycle inclusive of weekends & holidays will have a similar effect on profit without requiring investment in immediate terms.

Post the 3 year term, Multotec will have to penetrate global markets aggressively as a growth strategy to further exploit financial benefit in the screening mining markets, and the best way to do this is to partner with sister companies having existing footprint.

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1. INTRODUCTION

Multotec Manufacturing (Pty) Ltd. was established in South Africa in 1974 as a manufacturer and supplier of polyurethane (PU) screening media, to the mining industry, more commonly known as screen panels. Over the past 50 years, Multotec have diversified their product range to include in addition to screen panels, a range of metallurgical process equipment such as hydro-cyclones, rubber mill linings, industrial ceramics, automated samplers, centrifuges and filter presses, thus covering most mining process plant applications.

The screening media division remained the most profitable and financial growth was constant year on year except during the commodity crunch in 2008. Multotec was not the industry leader for the supply of screening media prior to1994, but rather its biggest competitor named Screenex (SNX) during that time period. SNX was seen to be lagging due to poor business decisions to foster growth whereas Multotec continuously reinvested profits to enhance organisational growth.

21 Years ago, Multotec started manufacturing PU screening media using injection moulding (IM) machines. Currently there are 7 machines fully in production manufacturing 305mm square units in various thicknesses.

In 2017 Multotec manufactured on average, approximately 53017 standard injection moulded screen panels per month. Output varies over the 12 month period due to late start-up in January, the Easter public holidays in April and the rush of clients placing purchase orders prior to the shut-down in December. Even though the machines vary between newer and older models, the unit per hour output has been established to be similar.

An IM PU screen panel consists of a steel internal frame embedded in polyurethane with a predetermined quantity of holes. These holes allow a certain size of material to pass through it depending on the metallurgical process requirement to beneficiate minerals from gravel i.e. gold, platinum, diamonds, coal, chrome, etc. The internal frame is locally supplied by a steel manufacturer whilst the PU in its raw state is procured and shipped from Europe

and Asia. The PU raw material is procured in bulk at 400 tons per quarter at a cost of R35.00 per kg, whilst the steel frames are kept on site as consignment stock. At the reorder point, R7 million in cash is tied up by the holding stock of PU raw materials. The procurement of PU raw material is insourced whilst bulk of the stock is held at an outsourced warehouse about 30 kilometres off site.

Capacity constraints results in an increase in lead time of products supplied to the market which occurs mostly due to an increase in market demand. Predicting an increase in demand remains a challenge and can be as a result of numerous reasons. For example, should there be a shortage of coal in the global market; mining operations will exploit this by supplying huge volumes at higher prices which will lead to increased demand for screening media. Another reason could be the subsequent start-up of new mining operations and then discovering that the mineralogy of feed material has changed which leads to a full change-over of the installed screen panels in a very short period of time. It is very difficult to predetermine these situations and organisations should be flexible to react in these circumstances in order to maintain a competitive advantage. Multotec Manufacturing is one of few, if not the only company who is able to react to unforeseen market demand due to their economies of scale.

It is important to note that when unforeseen urgent enquiries arise, it affects the entire planned production schedule. In most cases this sudden change to the production schedule results in orders being pushed out and completed only after its scheduled due date. This is a clear indication of a lack in flexibility within the production process. Multotec aims to maintain the standard lead time for completed products to 10 working days. Whenever the standard lead time was on the increase, a new machine was added to the shop floor to increase capacity and maintain the promised 10 days lead time.

Another factor, which cannot, be ignored, is global demand for screening media for Multotec approximately exports 50% of total screen panels locally manufactured. Even though Multotec established international manufacturing facilities, global supply relies largely on South African operations.

This project will focus on the entire value chain form the procurement of raw materials, to the shipping of the end product. The end goal is to streamline operations with one thing in mind, improve the bottom line of the entire operation through identification and exploitation of process constraints.

1.1 The Operation

The supply chain consists of: internal and external sales, planning, production, packaging and shipping. The external sales personnel are responsible for visiting customer sites and generating purchase orders. The internal sales department process purchase orders on an enterprise resource planning software (ERP) system named JD Edwards (JDE). Each finished product has a specific part number linked to its routing which is related to a bill of materials. Once an order is completed, the goods are moved to the packaging department who packs the items into cardboard boxes which is labelled and moved to the shipping department. The shipping department either contacts the customer directly to collect or goods are transported using in-house transport depending on the load and location of the customer. Shipping of urgent orders are mostly outsourced and export orders are coordinated by the exports department.

PU raw materials in the form of granules are shipped in 50kg bags from Europe or Asia and held in a warehouse in Gauteng. Stock is shipped form the warehouse to the on-site store based on the requirement which is approximately 100 tons per month. Steel frames are manufactured in bulk by a local supplier and kept on Multotec premises as consignment stock i.e. paid for monthly dependant on usage.



Figure 1 - Injection Moulding Machine

The PU granules are introduced into the feed hopper of the injection moulding machine (Fig 1). The internal steel frame is positioned into the mould and the PU is injected at high temperature and pressure in a liquid state. After 3 minutes on average, the mould opens up and the end product is de-moulded. Minimal trimming is required to remove excess material and the screen panel end product is ready to be shipped.

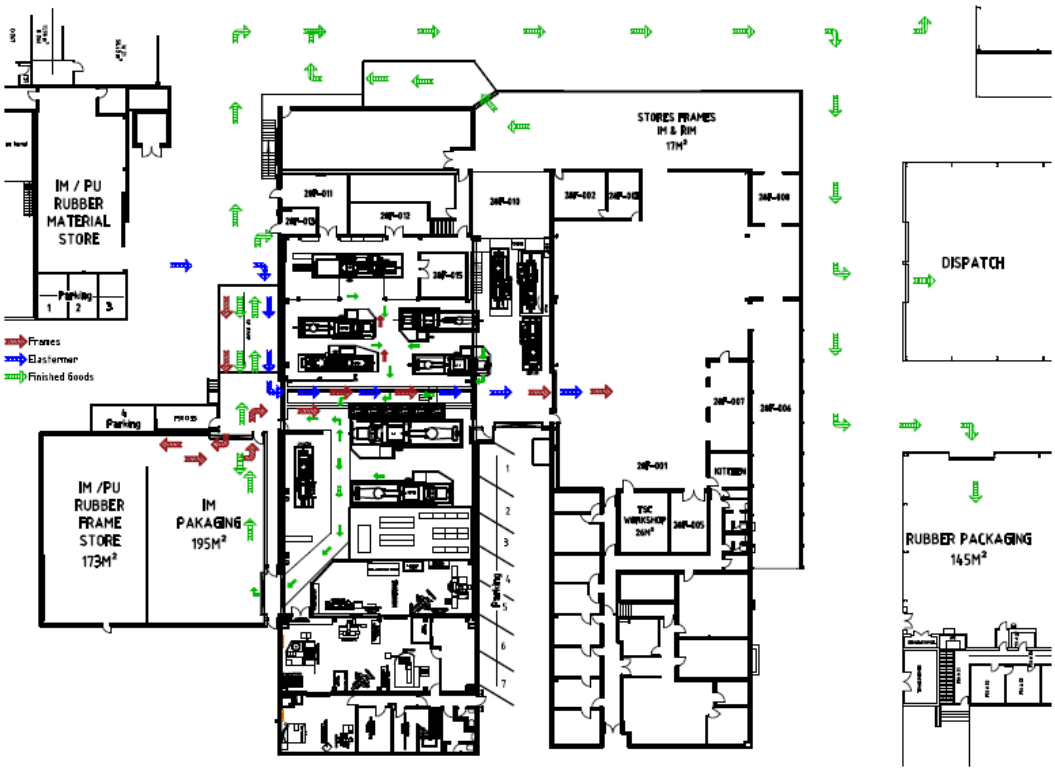

Figure 2 - Factory Layout / Process Flow

The plant is operated on a 3 shift cycle, Monday to Friday. The operators consist of 3 individuals per machine, 2 being operators and 1 responsible for mould changes. Mould changes are recorded as machine downtime which equates to 6-7 hours per machine per month on average. Mould changes are done manually and determined by the production schedule. When the outstanding order book increases resulting in expediting and late or urgent orders, weekend operation is justified. This normally occurs as year-end approaches for the production facility is shut-down over the December holiday period.

Multotec holds minimal inventory of finished goods on site and most items are manufactured per purchase order. Most stock items are goods returned from customers as a result of mistakes resulting in goods being incorrectly manufactured or oversupplied.

1.2 Problem statement

The profitability of the production facility is being questioned with increasing inefficiencies affecting profit.

It was recently discovered that a number of short meetings take place during operation. Production meetings are held once a week to communicate performance and to address issues raised by operations personnel. This meeting is believed to take 30 minutes but was recently measured to take 1.5 hours. Shift change-over is also scheduled to take not more than 8 minutes, but recently it was measured to exceed 30 minutes.

Approximately 10 years ago, Multotec acquired the services of a consulting firm named Competitive Dynamics International (CDI). This project focuses on the set-up of mini-business facilities consisting of working groups to measure operational performance in terms of output and waste. Production functions would have their own measures independent of one another, giving rise to local optimums. Even though a number of improvement areas were identified during the initial stages, the sole focus was on business unit performance irrespective of the impact on the goal of the organisation i.e. impact on profit. It must also be

noted that every shift conducts a meeting during every production cycle which should take no longer than 8 minutes, but it is not the case. In Fact, some meetings were timed to go on for over 30 minutes.

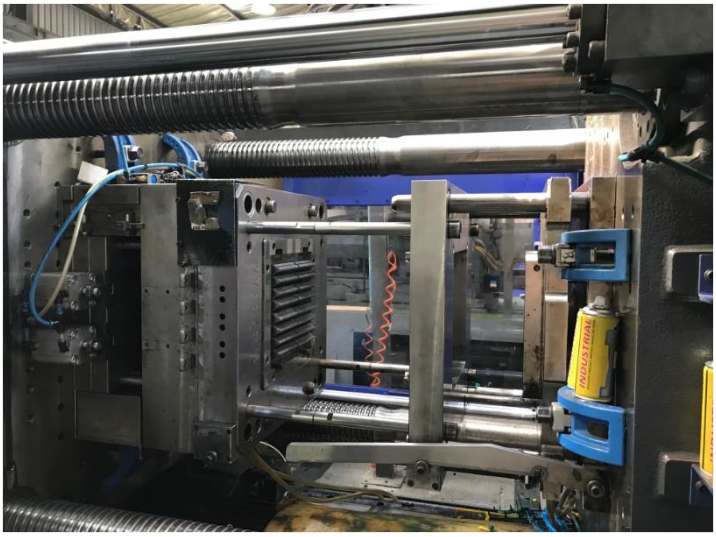

Figure 3 - Mould Showing the Machine Tooling

Tool changes are performed manually and scheduled by the planning department based on the order schedule. This is carried out using manual skilled labour and takes approximately 45 minutes. Mould changes are estimated to consume a minimum of 1800 hours of production time per annum.

Prior to inserting the frame into the mould, spacers are fixed to space the frame. The operator of the machine is responsible for placing the plastic spacers onto the frame prior to insertion. Whilst the machine completes its production cycle and the operator is busy placing spacers onto frames, valuable time ticks away before the following screen panel is being produced. The operator is also responsible for collecting frames by hand for preparation during production cycles.

The current measure of screen panel output per hour equates to 17 off per machine. This quantity is not true for all screen panels for the injection and curing time varies for each specific type of panel being manufactured, depending on the amount of raw material being injected.

Due to the layout of the production facility, a limitation of space exists. This leads to the fact that screen panel batches are moved to a separate packing facility where the goods are packed in boxes on pallets, and labelled prior to further movement to the dispatch facility.

Continuous operation during weekends and public holidays are not performed due to issues related to transportation availability for employees and shift supervision of the production facility. Management further believes that availability of weekends and holidays create a safety buffer should the need arise for additional capacity. Continuous weekend operation can equate to additional production capacity, which needs to be established taking equipment downtime into consideration, which is currently not measured. This should be further studied to accurately determine the effect on profit due to costs incurred.

As per local market surveys conducted annually, Multotec approximately holds 70% market share of the local screen panel business. If 50% of the total output is currently exported, that means that the screen panels business which is locally owned by competitors equates to R 42.8 million of sales.

Multotec Manufacturing is the second biggest player in the screening business worldwide. The biggest player currently is the US based company named Polydeck. Whilst Multotec and associated sister companies i.e.: Steinhaus, Tema Isenmann and Krieger currently dominate the European and African screening markets, Polydeck dominates the North and South Americas. During a global screening workshop held in 2016 at Multotec in South Africa, it was estimated that the screening business in China and the Americas equates to 60% of the global screening market, with minimum Multotec market share. As a result of this, an opportunity currently exists to increase the screening media global footprint

2. Literature review

Most organisations have product lines they call “stars” which are those in high demand with exceptional margins, whilst low margin products may no longer be offered in the future (Blackstone, 2001). In the Multotec Group of Companies,

the screen panels' business unit manufactures products with relatively high margins thus qualifying them as "stars".

The key to success in many organisations is a keen understanding of how processes work (Krajewski et al, 2010). The operation of any manufacturing facility consists of departments which have its own set of objectives; a process view has a much more relevant picture of how the firm actually works, since a production facility is only as effective as its prior and following processes.

As per Fisher (1997), the improvement of supply chain performance relies predominantly on the application of technology in modern times. Customer resource management (CRM) tools allow data to be captured at the point of sale and interchange it allowing all stages of the supply chain to react using flexible manufacturing, automation and logistics. Quick efficient and accurate market responses, mass customisation, lean and agile manufacturing offers models to improve performance through the application of technology, but if poor internal departmental relationships together with substandard industry practices within an organisation exists, then latest technological applications becomes irrelevant to minimise operational costs.

A study conducted in the US food industry estimated that somewhat $30 billion was being wasted annually through poor coordination between supply chain partners (Fisher, 1997). A US department store discovered in exit interviews that most customers left their store empty handed due to a certain product not being in stock, whilst at the same time they were marking down merchandise to clear unwanted goods. The inability to predict demand will result in stock-outs and/or shortages.

Fisher (1997) further depicts that the first step in designing an effective supply chain is to consider the nature of demand for the product to be supplied. The percentage of demand to be filled from in-stock goods takes into consideration the product life-cycle and variability, demand predictability, lead times and service standards determined by the market. A product demand pattern determines its product category which is either functional or innovative, which then determines the type of supply chain to adapt. A mismatch between the

type of product and supply chain, is mostly the root cause of problems encountered in many manufacturing environments. (Fisher, 1997)

Functional products satisfy basic needs which do not change much over time hence it is easy to replicate, such as grocery and convenience items which generally have a predictable long life cycle and stable demand. As a result of this, the barriers to entry are low resulting in increased competition driving margins downwards. To counter low margins, companies introduce innovation and technology as a diversification strategy to entice customers by providing additional reasons to purchase the product.

Three important approaches have evolved for companies to achieve competitive advantage since the early 1970's, thus challenging assumptions and the old way of doing things (Rahman, 1998). These are material requirements planning (MRP), just-in-time (JIT) and developed by Eli Goldratt in the mid 1980's; the theory of constraints (TOC). However it was witnessed that applying TOC in manufacturing systems showed improved performance than those adopting MRP and JIT as per previous literature reviewed (Chou et al, 2012). MRP later gave birth to MRP (II) which then evolved into enterprise resource planning (ERP), which has the power and capability to eliminate significant limitations.

Glodratt (1992) indicated in his novel that production processes are constrained by variety of limitations and managers chose to manage their systems according to local optimums as a result of this, leading to the opposite of global optimization (Umble et al, 2001). Managing an organisation according to local optimums such as measuring local operating efficiencies at non-constraint areas is contradictory to TOC (Umble et al, 2001). Such long standing organisational rules are difficult to eliminate and can sometimes be found to be embedded in the logic of the ERP software (Umble et al, 2001).

In 1979 the development of the Theory of Constraints (TOC) management philosophy began with production timetables and scheduling software to further evolve into a suite of integrated management tools encompassing the whole value chain from logistics to problem solving (Watson et al, 2007). The

application of TOC techniques have been discussed in a variety of operations management disciplines due to its simple yet robust methodology (Watson et al, 2007). Evidence have been reported through studies conducted by early adopters that the application of TOC techniques could result in increased throughput while reducing inventory and cycle time, and this was validated through rigorous academic testing (Watson et al, 2007).

The owner of a system is assumed to establish its goal, whilst the goal of any business is to make money now and in the future (Simatupang et al, 2004). Whilst other stakeholders may make decisions to meet conditions resulting in continuing operation, TOC encourages management to identify and find solutions to overcome limitations from moving towards their goals (Simatupang et al, 2004). TOC is now used worldwide by companies of all sizes although evolving from a production scheduling technique to a systems methodology in managing change (Mabin, 2015).

Alternative paradigms to traditional cost based accounting systems are represented by Activity Based Costing (ABC) and TOC (Kee & Schmidt, 2000). Decisions to overcome resource allocation limitations are improved using ABC and TOC as compared to traditional cost based systems (Kee & Schmidt, 2000). Whilst ABC models the casual relationship between products and resources, TOC represents an application to optimize production using general systems theory (Kee & Schmidt, 2000).

2.1 Inventory

The managing of the flow of materials through inventory control is a fundamental purpose of supply chain design, for more than 60% of total sales income is spent on purchased services and materials by a manufacturer (Krajewski et al, 2010). Therefore a large cost reduction can be realised by a small reduction in cost of materials.

Hau L. Lee, (1993) describes that even though operating characteristics may be guided by policy regarding assumptions made in relation to demand and cost

structure, mathematical models are designed to address the frequency and quantity of placing replenishment orders.

Ford Harris (1913) discovered the original Economic Order Quantity (EOQ) which formed the basis of an inventory system which was marketed and sparked later studies in years to come. An EOQ is finding the optimum cycle inventory level, which is the lot size that minimises total annual stock turn and ordering costs, depending on the following assumptions (Krajewski et al, 2010); a) The demand rate and lead time is constant and known, and no constraints are placed on lot sizes, b) Only inventory holding and fixed cost per lot for ordering are relevant, c) Individual item decisions are made independently with no gain for combining several items.

Inventory control problems mostly involve multiple products, but single product models are able to capture essential elements of problems thus making it challenging to include the interaction of multiple items into problem formulation (Lee & Nahmias, 1993). The screen panel business unit within Multotec Manufacturing consists of a number of products, with the core being IM screen panels. It was therefore decided to focus purely on a single product model being the IM screen panel only, and replicate the approach for other product lines going forward.

As per Goldratt & Cox (1992), a well balanced plant plant is undesireable and some virtually unavoidable capacity imbalance is necessary (Atwater & Chakravorty, 2002). A Drum-Buffer-Rope system identifies long term resource constraints of a system and develops a detailed schedule for it (Atwater & Chakravorty, 2002). Excess capacity is relied upon to adress problems caused by disruption so that the constraint resource remains on schedule and final product shipping lead times are achieved (Atwater & Chakravorty, 2002).

2.2 Theory of Constraints

In the early 80's Eli Goldratt published a novel which was read by a number of executives, planners and shop floor workers entitled "*The Goal*". The book sets out as to how production should be planned and the methodology was made

available in production planning systems and later broadened into other areas such as marketing and distribution in further novels (Rand, 2000).

Since 1997 the TOC approach was used to develop specific management techniques by applying the principles of project management which founded application in two areas namely; reducing project duration through single project scheduling and allocating resources that are shared by concurrent projects (Steyn, 2002).

Traditional operations management theory suggests the management of processes for transforming inputs into outputs which led to an increase in focus on the management of processes and their cross functional nature (Boyd et al, 2008). In operations management literature, the term “throughput” is associated with the total volume of production provided using resources (Boyd & Gupta, 2004). Goldratt & Cox (1992) have extended this scope by defining it as the rate at which a system generates money through sales, thus implying that money must be made by producing and selling of products (Boyd & Gupta, 2004). TOC views an organisation as a chain of interdependent processes transforming a variety of inputs into outputs that when sold, become throughput (Boyd et al, 2008). With respect to TOC, the role of operations is evaluated in context of the organisation as a whole.

In order to obtain maximum throughput, one of the most important decisions is determining the product mix in a system (Komijan et al, 2004). It has been discovered that even though a number of mathematical models have been developed which is grounded under TOC, neither traditional nor revised algorythms can neccesarily reach the optimum solutions in cases where multiple bottlenecks exist (Komijan et al, 2004). Quantitative revised algorythms will have to be developed depending on the system on a case by case basis to determine the best path to be followed in multiple decision making problems.

According to (TOC), the effectiveness of production throughput in a manufacturing environment is mostly determined by the effectiveness of bottleneck parts and activities (Rose et al., 1995). The equipment on bottleneck

should be first identified because the loss elimination in non-bottleneck equipment increases idle time with no effect on production throughput.

The concept of TOC states that every system must have at least one constraint. As per Goldratt & Cox (1992), a constraint is anything that limits a system to achieve higher performance which should be directly linked to profit. Gradual elevation of system constraints will improve performance; therefore a bottleneck should be seen as an opportunity rather than a hindrance.

Eli Goldratt and Jeff Cox illustrated the concepts linked to TOC in the book entitled “The Goal”. The overall concepts linked with TOC was further refined and it was recognised that most constraints in organisations may not be physical but rather managerial policy related (Rahman, 1998). In 1994 Goldratt developed a generic approach called the “thinking process” which then formed the current paradigm of TOC.

The philosophy which underpins TOC consists of five focussing steps of on-going improvement; the drum-buffer rope (DBR) scheduling methodology and the buffer management information system which are usually referred to as the TOC logistics paradigm. The generic approach of investigating, analysing and solving complex problems is referred to as the thinking process (TP) (Rahman, 1998). TOC prescribes performance measurements which are different from the traditional accounting system which is discussed later.

Goldratt & Cox (1992) identified five focussing steps underpinning TOC philosophy as shown in figure 1 below.

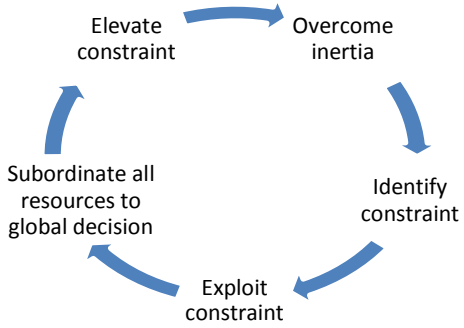

Figure 4 - TOC Philosophy Steps (*Source:* Rahman, 1998)

Table 1 - TOC Five Focusing Steps (*Source:* Rahman, 1998)

1: **Identify the system constraints** - These may be physical or managerial. Physical constraints may be in the form of machines, people or material, whilst managerial may be in the form of policies, procedures, etc. Once identified, these constraints must be prioritised according to their impact on the goal of the organisation.
2: **Decide how to exploit the identified constraints** – Physical constraints should be made as effective as possible whilst managerial constraints should be eliminated or replaced with a policy supporting the goal.
3. **Subordinate everything to the decision in 2 above** – This means that non-constraint activities must be adjusted to support the maximum effectiveness of the constraint. A constraint dictates throughput, therefore resource management in synchronisation with a constraint provides effective utilisation. If non-constraint resources are utilised beyond the productive capacity to support the constraint, they improve inventory rather that throughput.
4. **Elevate the system constraints** – Improvement efforts on constraints will improve performance, and in-turn non constraint resources will be better realised leading to an improvement in the overall system performance. Eventually a new systemic constraint will surface.
5. **Once momentum has been gained and the constraint is eliminated, go back to point 1** – It is important to note that TOC is a continuous improvement process, and that policies are specific to situations. Therefore, it is important for an organisation to recognise that as the business environment changes, business policy need to take these changes into account. This is the most critical step in the process which, if failed to be implemented, the continuous improvement process will fail.

The first two steps supports short term product mix decisions whilst the remainder focus more on capacity planning of the system which is long term in nature (Souren et al, 2005). The number of constraints and their effectiveness influences the product mix decision which leads to optimal solutions given that one of the binding constraints applies to more than one product (Souren et al, 2005). In the case of the Multotec's screen panel manufacturing facility, the product mix decision does not apply due to the fact that the chain of events leads to only one type of product being manufactured.

The return per unit of constraint consumed technique can be quite useful to know and makes intuitive sense when a constraint is exploited (Finch & Luebbe, 2000). The product mix thus providing the greatest return per unit of constrained consumed would be the one exploiting the constraint (Finch & Luebbe, 2000). It should be noted that product mix is only one of the techniques to be considered when exploiting a constraint.

Although the five focusing steps may result in quick wins in a manufacturing environment, it may take the constraint from the factory floor to market, which in this case shifts the constraint from a physical to a policy constraint.

In most cases a constraint may be physical, such as a machine with limited capacity or raw materials, but more often it can also be a policy or behavioural constraint (Mabin & Balderstone, 2003). Policy constraints are usually within the control of management of the organisation and it often arises when the business environment in which a company operates has changed whilst company policies remain unchanged (Mabin & Balderstone, 2003). Behavioural constraints can occur as a result of legacy systems which cause behaviours to be ingrained thus constraining system performance even after policies or measures have been revised (Mabin & Balderstone, 2003).

Policy constraints require collaboration across functions for they are difficult to identify and evaluate. Goldratt & Cox (1992) developed an approach using logic, intuitive knowledge and common sense, resulting in managers being

required to make three generic decisions i.e.: a) Decide what to change, b) Decide what to change to, c) Decide how to cause the change (Rahman, 1998).

As much in the same way that the “five focusing steps” focus on improving performance through identifying and managing constraints, the thinking process (TP) also focus on a system achieving its goals (Kim, 2008). The TP first identifies the symptoms that the system is not performing as well as it should, and then introduce tools to deduce those causes followed by recommendations of corrective action using strict logic rules which could be applied to any kind of problem situation in combination with the persons intimate involvement with the problem (Kim, 2008). Therefore decision makers should have thorough knowledge and understanding of the problem in order to tackle it with efficiency and effectiveness using the TP tools available.

Although TOC received a lot of attention from academics, practitioners as well as the press in the early 80’s due to its straightforwardness and simplicity, after several years its influence has worn off (Waitrous et al, 2005). TOC however continues to identify throughput problems and serve as a guide to correct it, and in so doing generate improvements in productivity & efficiency in particularly manufacturing plants (Waitrous et al, 2005). Substantial examples exist in papers reporting successful application of TOC and it also grasped the attention of cost accountants as reported by Atwater and George (1997) and Holmen (1995) (Waitrous et al, 2005).

It was found that TOC can also be applied in conjunction with other continuous improvement projects like Six Sigma (SS) for example. SS makes use of statistical tools to gain knowledge on how to reduce operational costs and services better than that of the competition, whilst the core idea of TOC is that every organisation has at least one constraint which prevents management from achieving its goal (Ehie & Sheu, 2005). As per the case study by Ehie & Sheu (2005), the combination of TOC and SS presents management with a platform for two continuous improvement initiatives to work together thus creating great synergy (Ehie & Sheu, 2005).

2.3 Performance Measures

The techniques of management accounting were developed late in the 19th to the early 20th century when theoretical and practical methods of management accounting were established and widely practised in manufacturing operations. Although technology of operations is ever changing, management accounting standards have remained unchanged (Maskell, 1991). According to Maskell (1991), this has led to the management of a manufacturing facility to be misled into measuring irrelevant targets.

Maskell (1991), states three primary reasons why new performance measures are required in a production facility. 1) Traditional management accounting is no longer relevant for organisational growth, 2) An increase in demand for higher quality, performance and flexibility from customers 3) and management techniques in production plants are continuously changing. These reasons form the basis of new performance measures for companies to be competitive in the current world class manufacturing environment.

It can therefore be substantiated that the measurements of TOC vary considerably from traditional cost accounting standards. Five problem areas were identified by Maskell (1991) associated with traditional cost accounting which is; a lack of relevance, cost distortion, inflexibility, subjection to the needs of financial accounting and impediment to progress in world class manufacturing. As a result of this, a mismatch seems to exist between the goal of an organisation and traditional accounting standards, therefore TOC have been highly recommended to evaluate the performance of an organisation due to managerial actions.

With reference to TOC that the goal of every organisation is to make a profit both now and in the foreseeable future, Goldratt and Cox (1992) prescribed two sets of measurements for an organisation to evaluate in achieving its goal. These are operational and global financial measurements, with the latter dependent on the former.

Goldratt and Cox (1992), states that operational measurements are throughput, inventory and operational expense. Throughput is defined as the rate at which

the system generates money through sales, which is represented as sales minus total variable cost. As per Coman & Ronen (2000), TOC rates the manufacturing benefit of a product based on its throughput per unit time at the bottleneck, where throughput is defined as the sales price of a product less cost of raw materials (Coman & Ronen, 2000). Inventory is represented by all the funds invested in producing saleable products from raw materials to capital equipment etc. Operating expense includes monies spent on labour, interest, supplies, etc. Global measurements are Net Profit, Return on Investment and Cash Flow. Global and operational measurements are therefore interrelated, making it possible to evaluate the impact of each operational measurement on the global measurements.

The general focus from management in operations is to decrease operational expenditure first, followed by throughput then a reduction in inventory (Goldrat & Cox, 1992). Goldratt & Cox (1992) suggests that operational expenditure should be the last priority whilst throughput and inventory should be managed first. This approach is grounded on the theory that increased profit through sales is infinite, and improvements in inventory and expenditure are limited.

3. Data Collection and Analysis

The physical bottleneck in the process from raw material to end product has been assumed to be the injection moulding machines. This assumption is based on the presence of raw material waiting to be processed and any time being lost as a result of downtime affects throughput negatively.

Numerous machine downtime exists which is more expected than unexpected. Expected downtime ranges from times when meetings are held, mould changes and periods of non-operation as in the case of weekend, public and December holidays (Webb, 2018). Data was collected and associated tools were used to analyse the collected data and make the necessary recommendations.

Global market presence is limited due to the footprint of sister entities. A decision rests with the shareholders for Multotec to do business globally via sister entities (Roche, 2016). An opportunity therefore exists for the organisation

to either invest in existing operations to expand the current scope of supply or establish manufacturing facilities in other parts of the world to grow the business in terms of increased profit.

Herewith an overview of the Multotec global manufacturing presence;

- Tema Isenman (USA) predominantly services the stone and quarry markets in the US, with Polydeck dominating the minerals processing market.
- Multotec Chile operations services the western region of South America, with the bulk of the minerals processing business being in Brazil.
- Operations in China have commenced recently.
- Multotec Australia relies largely on supply from RSA due to the economies of scale.

Table 2 - Data Collection and Analysis

Data Collected	Tool for Analysis
The duration of meetings held is not currently recorded as machine downtime, but all machines are out of operation during meetings. Based on a recent desktop analysis it is estimated that machines could be down for the purpose of meetings for 3108 hours in total per annum.	Daily time studies were conducted to confirm the amount of non-production time as a result of meetings, and the subsequent effect on the profit using performance measures as per TOC.

Mould changes equates to lost production time of 1800 hours per annum, which equates to 12 million rand additional revenue at the recorded target of 17 panels per hour per machine. If this downtime could be halved, estimated additional revenue of 6 million rand could be realised.	Improvement in this area was analysed through conducting of interviews and analysing working practices and time accounted for per machine. Effect on profit was investigated through analysis of manufacturing to stock in order to reduce the quantity of mould changes during production cycles using EOQ.
If continuous operations results in additional throughput, it must be established if the system will be able to handle this increase in supply.	Surveys were conducted in the form of interviews, and policies were investigated to determine the absence of continuous operation and the subsequent effect on profits as per TOC performance measures.
Establish the exact size of the global screening market and Multotec market share. This investigation will evaluate the policy constraint for the supply to Global screening markets from South Africa versus the establishment of new or scale up of existing manufacturing facilities i.e.: China, Chile and Australia.	Market survey data was conducted by Australia, China and Americas to establish Multotec global market share and value in comparison to competitors. Interviews were conducted with key stakeholders to establish constraints to actively participate in global markets.

4. Data Collection and analysis

Time studies were conducted in the production facility measuring all activities from product production and downtime. The data was the analysed to determine the product output rate and this was used to evaluate possible additional revenue which could be realised through a reduction in downtime. Recommendations were then made to increase throughput with the main aim to increase profit.

Similar to the output requirement and what could be realised in terms of profit, raw material inventory was analysed to establish what the financial impact is on the storage and procurement of raw materials required. Through reducing and controlling the supply of raw materials through just supplying what is required on a monthly basis can deliver a substantial cash flow injection.

4.1 Output vs Budget

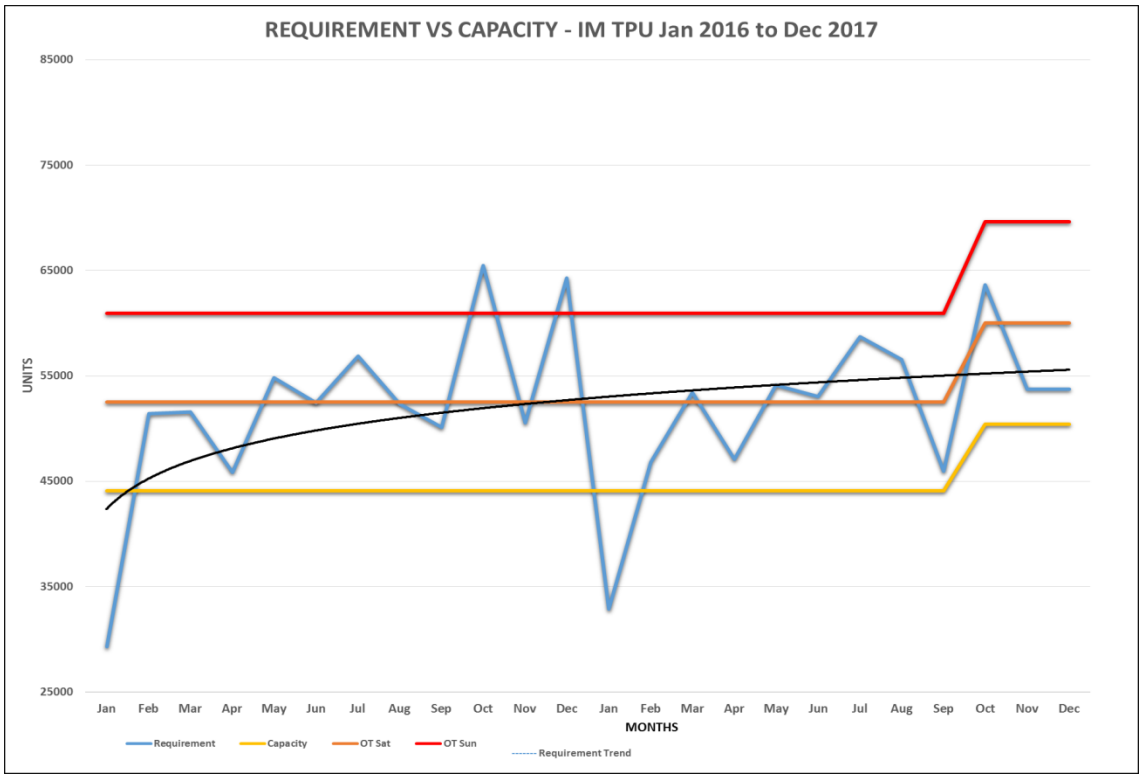

Figure 5 – Screen Panel Output Requirement vs Capacity over past 24 Months

- In 2016 the total unit output was 593 992 with a budget of R168M. This relates to a monthly output of 49 500 per month.

- In 2017 the total output was 637 173 with a budget of R192M relating to a monthly output of 53 097

- The 2018 budget is currently R215M which will equate to an output of approximately 60 000 per month with 90% of screen panel revenue contributing to the budget.

4.2 Machine Throughput

There are over 360 different types of screen panels manufactured using the injection moulding machines. An analyses conducted some years ago established that the average quantity of panels produced per hour is 17, irrespective of the different time taken for each thickness and type.

Aperture type and thickness of screen panels determine the time taken for the final product to be produced. Large aperture and standard thicknesses takes less time to be manufactured when compared to fine aperture and thicker units. It was therefore decided to collect the cycle time of each unit produced during each production cycle for a particular type of screen panel. The measurement started on 12 February 2018 and is continuing throughout the year to construct accurate reliable data of time taken to produce units on a monthly basis. This measurement is believed to put more focus on downtime and address it where present.

During the start of a production run a number of screen panels are wasted which is due to machine settings, for each unit has specific input data to control machine injection and curing time during a panel production run. Currently these settings are manually recorded by the shift supervisors, and the operator manually inputs these data prior to panel manufacture. Correct data input can reduce waste and in turn increase throughput.

4.3 Methodology

To establish the time attributed to machine panel production, it was decided to record the cycle time of each screen panel during a production run, multiply it by the quantity produced to find the time accounted for production. The cycle time was then deducted from available time in a shift to find non production time. Non production i.e.: downtime; subsequently consists of meetings, breakdowns and tool changes. The key performance indicator is to find 100% time accounted for; therefore the time for each element of downtime was recorded as well.

The shift supervisor was responsible for recording the time taken for all activities during a shift cycle and setter is responsible for tool changes. The data collected was analysed to establish the focus areas for opportunities to increase throughput and resulting profit which could be realised. Once these areas were identified, all follow up activities i.e.: packaging and transport was evaluated to ensure sufficient resources are available to cope with the additional throughput in order to streamline the entire process for bottlenecks have a tendency to shift.

The cycle times recorded were analysed to determine the panel production rate at the current output level and it was compared to what was achieved in 2017. The downtime was analysed to determine the production efficiency level as well as the throughput lost as a result. All downtime categories i.e.: tool changes, meetings and breakdowns were analysed individually to establish the amount of units which could have been produced in that time. Even though downtime is inherent and cannot be completely eliminated, recommendations were made to reduce it with the sole aim to increase throughput.

After recommendations were made to increase throughput, follow-up activities were analysed to evaluate whether the increase in throughput will result in bottlenecks moving to other areas of the value chain. Recommendations were made to re-shape follow-up activities in order to cope with the additional throughput to be realised.

In order to conclude this study which is grounded on the Theory of Constraints, the financial impact related to the recommendations to reduce downtime were calculated through evaluating the income statement of the business unit and the effect on operating profit.

5. Results & Discussion

The panels' sales budget was increased to R16 million/month for the business unit for 2018 – up by 18.75% from the previous year. It was determined that this needs to equate to an average of 60000 units per month. This can only be achieved through working weekends at the current output level which was established using the cycle time study over the past 5.5 months. Working a 7 day week continuously to achieve the required output and make budget is risky for it leaves no buffer for sudden increases in demand or unplanned stoppages. At the current operating cycle, an additional machine will need to be added. This machine will then need to be depreciated using the straight line method and the associated operating costs thus affecting profit.

A total of 637 173 panels were produced in 2017 as per recorded output data. Based on the now determined output rate of 15 panels per hour per machine, it is fair to conclude that the output rate was calculated to be 12 panels per hour for 2017 using output data relative to the hours worked whilst taking into consideration 82% efficiency with 18% attributed to downtime and 58% of the available weekends utilised as productive time.

If 15 panels per hour are maintained during 2018 without working weekends and public holidays, theoretically a 52 290 panel output per month can be achieved. The 60 000 target per month can only be achieved by utilising 50% of the weekends as productive time, or procuring a new machine, for the output rate of one machine will increase throughput by 8000 panels per month. Prior to purchasing a new machine, we need to establish the impact on throughput by reducing downtime and the subsequent effect on profit.

If Multotec adopts a continuous 12 hour shift cycle at 80% efficiency, the operating hours will be 8760 and the subsequent throughput per annum will

equal 919 800 which is a 16% increase in the extrapolated target to be achieved in 2018. Weekends constitutes 28% production time and provide the possibility to build fast moving stock using current capacity or investment, but holding inventory costs money. Even though a 24 hr shift cycle seems pleasing, it is fair to say that the South African labour unions will counter this type of working schedule with negotiations and possible instability. However, this option should not be overlooked as a means to increase throughput and perhaps include 24 hour operation in parts of the production process.

It is now fair to state that the historical production target of 17 panels per hour per machine seems to have been incorrect for the average calculated using the time accounted for model is 15. This is a 12% deviation from the target set in the past. It is believed that areas for improvement in throughput exist after evaluating the time spent on non-production activities i.e. meetings, tool changes and breakdowns. These areas will be further discussed with a core focus on the loss in throughput. However, it must be noted that although revenue will not immediately be realised, work in progress (WIP) can be reduced thus improving production flexibility, reduction in inventory thus improving cash flow, operational flexibility and lead time. As per TOC, this must be related to an increase in profit.

5.1 Time accounted for (TAF)

Table 3 - Summarized TAF data – Feb to July 2018 (Hrs)

Month 2018	Total Available Time	Cycle Time Used	Breakdown Time	Tool Change Time	Meeting Time	Total Down Time
FEBRUARY	168.00	112.55	19.32	3.30	20.17	42.78
MARCH	3752.00	3297.97	108.88	272.25	104.40	485.53
APRIL	4200.00	3626.74	150.12	357.58	37.47	545.17
MAY	4368.00	3750.24	120.50	304.07	132.92	557.49
JUNE	4536.00	4056.46	71.13	302.44	129.53	503.11
JULY	4320.00	3678.30	394.33	315.65	83.50	793.48

This measurement takes into account the units of production, downtime as a result of tool changes, meetings and machine breakdowns. The target here is to achieve 100% thus making sure all time available was accounted for. The 101% and 104% is a slight distortion related to human error.

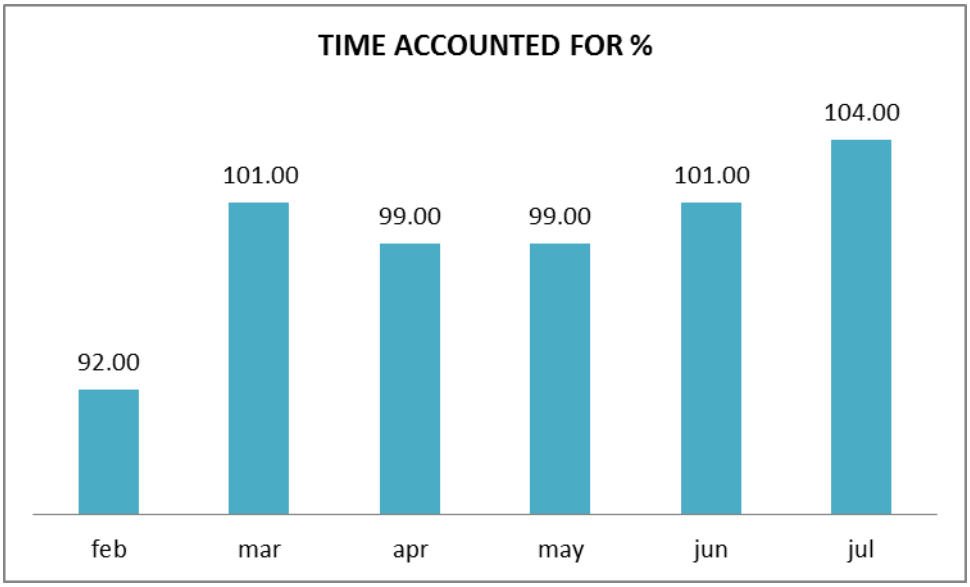

Figure 6 – Monthly TAF Percentage

Since this is a new measure which only started 12 February 2018, there were some change management challenges. It has therefore taken some time before 100% was achieved consistently and this was due to the measurement not being completely well understood by the workforce.

A database is currently being built through recording cycle times of all units of production, time consumed by meetings, tool changes and downtime. The total downtime and cycle time should be equal to the available time to achieve 100% of time accounted for (TAF).

As per the current TAF data utilising the same working hours of 2017, the target of 60 000 panels per month will not be achieved. However the increase in production rate indicates that only implementing the TAF measure have resulted in a change in behaviour and improved efficiency based on past performance. It must be noted that even though an increase in budget increases throughput requirement, it also results in an increase in WIP. Currently the WIP is exactly equal to the monthly budget of the business unit. Any increase in demand will require weekend work to achieve budget thus increasing costs. Reducing downtime can assist in coping with an increase in demand and subsequently reduce the need for overtime to be worked at the current available production capacity.

In the first 5 months of 2018, Multotec have already shown an improvement in the production rate of panels by just measuring time spent on downtime. This has made the production personnel more vigilant and accountable during operating activities. The TAF study has shown that meetings and tool changes might be the low hanging fruit to be realised with the aim to increase throughput.

5.2 Downtime

Downtime takes into account when a machine is not producing as a result of meetings, tool changes and machine breakdowns.

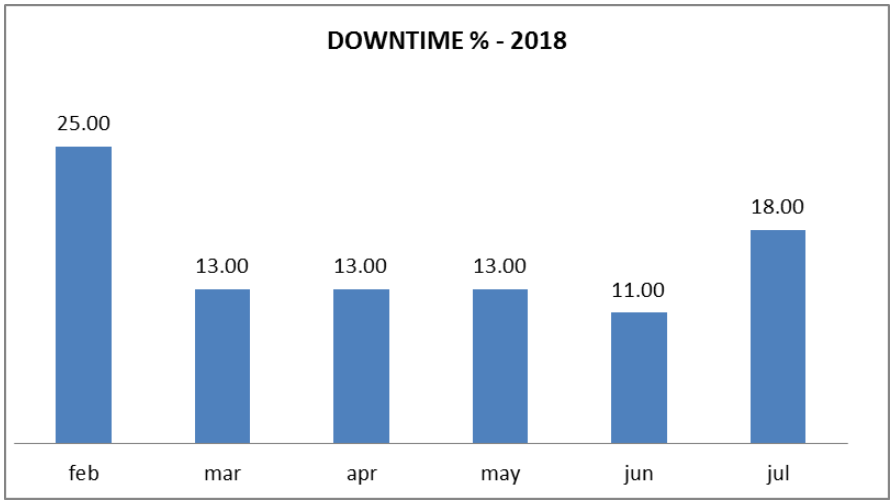

Figure 7 – Monthly Downtime Percentage

The measure was only implemented In February 2018 and had to be understood first, hence the 25% can be seen as an outlier. As TAF started to reach 100% consistently, the downtime measure became more realistic.

Time taken to execute tool changes vary due to a number of factors related to the variables involved producing various panels. Meetings should take place, but it might be a policy constraint which leads to the excessive time spent on meetings. Machine breakdowns are inherent but an improvement can be realised through executing preventative maintenance. The amount of panels which could have been produced in the time attributed to downtime equates to 7691 panels per month over the period of 5.5 months, which is what an additional machine would add to the current monthly output.

5.3 Downtime per activity

In February 2018, the meeting times were very high due to measurement implementation. In the following months the measurement started to become more representable which confirms the skewness in the total downtime and time accounted for percentage results. It is evident that tool changes accounts for the majority of the downtime as seen in figure 4 below.

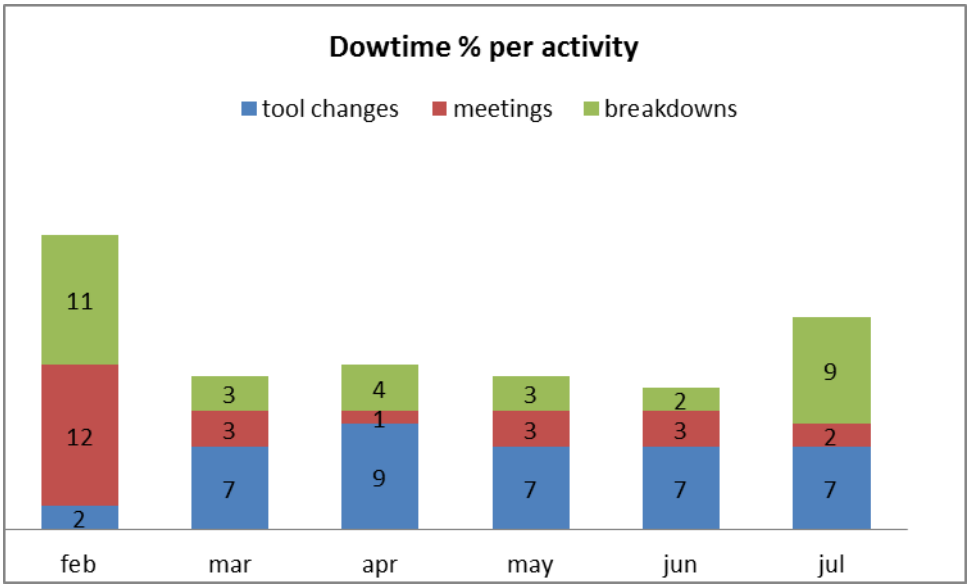

Figure 8 – Monthly Downtime Percentage per Activity

5.4 Tool Changes

Tool changes occur as a result of production scheduling, customer urgencies, as well as product quality defects identified during packaging and delivery. The planning department schedules orders according to the standard lead time which is currently 13 working days. Once a customer experience a stock out, the production schedule must be amended to react to this. This results in an increase in tool changes thus increasing total downtime. Tool changes currently have the most significant effect on total downtime.

Time spent on tool changes vary between 15 to 45 minutes depending on the type of change. Hand tools are used to loosen and tighten screws instead of electrical or pneumatic power tools. Sometimes 1 person does it, and sometimes 2 for there are 3 setters per shift executing tool changes over the 7

machines in production. The factory floor space is limited thus handling and transporting of tools are done by crane. Tool changes constitute the majority of machine downtime which is 6% on average for 2018 year to date.

The time spent equates to 4000 panels per month. Evaluating the different type of panels manufactured per month will give a good idea of the number of tool changes carried out. It can be evaluated to introduce machines to produce fast moving stock thus reducing the number of tool changes in a normal production cycle, but as mentioned before, this might increase inventory.

Time taken for each change must be measured to evaluate the contributing factors to the time spent. Floor space is currently being made available to improve transportation of tools and a hand tool list is currently being compiled. Once the tool list is finalised and evaluated, necessary changes will be made with regards to increasing the speed of the different types of tool changes.

If the time spent on tool changes are halved, the effect on revenue will increase by 2% and subsequently increasing operating profit by 3%. This indicates that a substantial improvement in tool changes will need to be done to justify a meaningful increase in operating profit.

5.5 Meetings

Daily meetings are seen to be important and it should happen. The 3 shift cycle each have a MDW team meeting consisting of 8 minutes as per policy. Every Wednesday morning a production meeting takes place for approximately 30 minutes. This equates to 8.8hrs over the 5.5 months period theoretically. The actual time spent on meetings over this same period is 72hrs.

As mentioned previously, a total of 72 hours were spent on meetings over the 5.5 month period. As per company policy the total meeting time to be spent should have been 11hrs approximately, with the month of March being an exception for the measure was implemented late February 2018. Meeting time reduced considerably during April but increased again for May and June. This indicates that there is no control or structure in terms of the time allocated for

meetings as per company policy. Whilst only 2hrs should be attributed to meeting time per month, currently 13hrs are being spent. This attributes to over 1072 panels at the 15 panel per hour production rate.

If meetings are held outside of production time it can add additional 1100 panels per month to throughput thus increasing revenue by 2%. This will increase operating profit by 2% after adding the expenditure to compensate the workers for an additional hour per day. If meetings are held on the scheduled time it will only increase operating profit by 1%. This indicates that meeting times currently have very little effect on increase in profit.

5.6 Breakdowns

This comes as a result of mechanical machine breakdowns other than non-production time as a result of meetings and tool changes. In February and subsequently July 2018, excessive breakdowns occurred.

A total of 2 265 panels were lost with regards to machine breakdowns affecting production time at the 15 panel per hour rate. Machine breakdowns are currently not controlled using preventative maintenance techniques resulting in a reactive approach.

A screw collapsed on one of the machines during the month of July as the increase can be seen on the downtime per activity chart. This occurred due to the heater of the PU being faulty resulting in the PU stalling and the increase in viscosity resulted in the screw collapsing. In general, Machine breakdowns consist mostly of minor mechanical and electrical issues; however major breakdowns do occur from time to time.

5.7 Scrap

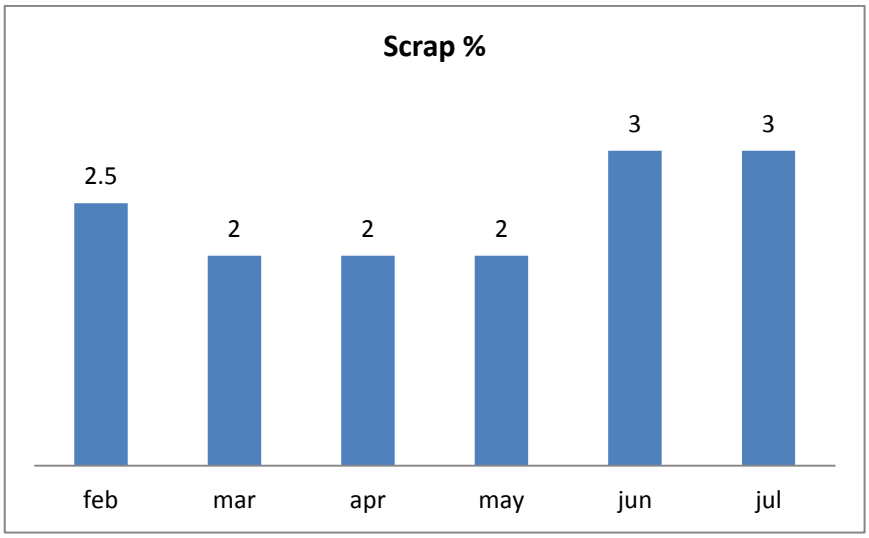

Figure 9 – Monthly Scrap Percentage

Currently it seems that scrap is under control and remained somewhat constant over the 5.5 month period. Improvements here can be evaluated but it may not provide a substantial benefit. The cost of scrap equates to lost revenue of R345 000 year to date, which is only 0.2% of revenue. Due to this the effect on profit are not substantial enough to justify investment on reduction at present.

5.8 WIP inventory

During the TAF exercise it was discovered that WIP inventory as well as stock is not controlled thus presenting an opportunity to have the discussions with suppliers to reduce inventory in order to improve the financial position.

This project has resulted in the production team taking a holistic view at where money is tied up as a result of WIP inventory. It was discovered that most of the panel internal frames on the shop floor is paid for and not all are kept as consignment stock as communicated earlier. Frames also utilises floor space which should be freed up to improve mobility in working areas thus being conducive to workflow activities. The quantity of frames utilised per month is

exactly equal to the quantity of panels produced with an estimated value of R1.8 million per month. Currently the value of frames kept on site is close to R4 million.

It was discovered that a total of 850 tons of PU raw material are currently tied up between on-site storage, warehousing and outstanding orders ex Europe. As mentioned earlier, the monthly raw material usage is currently 100 tons per month equating to R3.5 million whilst almost R30 million in cash is currently tied up.

5.9 Cutting



Figure 10- Bottleneck at Cutting Machine

Some panel designs limits it to be manufactured using cross bar frames (cross steel bar in the centre). This results in PU material shrinking more and ends up being below the required dimension in width. These panels are then manufactured slightly oversize to compensate for shrinkage and cut to size using a cutting machine. Panels sometimes tend to pile up in front of the cutting machine which is a bottleneck on its own which restricts workflow of certain orders. Adding an additional cutting machine will require a R500 000 investment with depreciation charges not affecting profit at all.

5.10 Packaging & Transport

Completed orders are transported to the neighbouring facility where it is packed in cardboard boxes, palletized and labelled. Thereafter it is transported to the transport department, invoiced and shipped by road. Export orders tend to pile up at the packaging department due to the amount of paperwork required prior to shipping.

The packaging department packs in the region of 60 000 panels per month, but the output from the machines per month is approximately 52 000. This means that not all orders which are packed get invoiced in that month. The difference of 8000 falls into the WIP category.

Multotec does not solely produce screen panels and most times it forms part of a purchase order which includes products from various business units thus delaying delivery of panels. Whilst it is understood that some local customers do not accept part deliveries on orders consisting of multiple products, some actually do accept delivery in parts. Orders awaiting completion of other products with longer lead times gets stored in the despatch area, and although it is invoiced, if the parts are delivered after the monthly invoicing cut-off time for a certain customer, payment is delayed for products already manufactured, thus negatively affecting cash flow.

5.11 Effect on Financials

The new budget for 2019 was used to investigate the effect on profit on the scenarios discussed above.

It was determined that the most substantial increase in operating profit in the current operating scenario would be to revert to continuous 24 hour production inclusive of weekends and holidays. The increase in operating profit will be 16% with the introduction of an additional shift.

Introduction of a new machine increases revenue by 10% due to the additional throughput to be realised and the depreciation effect only decreases operating profit by 1%. This will result in the 2019 profit budget being achieved. Reduction

in time spent on meetings by keeping it outside of production time or keeping it on time delivers no real financial benefit as a reduction in downtime strategy.

An additional cutting machine in the packaging area can assist the flow of finished product to shipping when throughput increases. The depreciation charges are negligible.

6. Recommendations

Tool changes: The recommendation is to perform tool change activities emulating a formula 1 vehicle making a pit stop. All resources such as manpower, hand tools, lifting equipment should all be optimised in order to spend the least possible time performing a tool change.

A tool change can consist of a number of activities depending on the type of change. The different types should be grouped together and a time study should be conducted to exactly establish the quickest time it should take to perform each change by optimising all activities involved.

First it needs to be established which tools and resources are required to perform each type of tool change in the fastest possible time. Once this is done the necessary resources need to be obtained and the reduction in downtime must be related to the gain in profit.

Even though this project will not deliver the best impact on profit if 50% of the time lost is gained, It still presents an opportunity to improve the financial position and is therefore identified for further research to be conducted.

Keeping meetings outside production time: If meetings are held outside of production time, a total of 1100 panels can be reduced from monthly WIP thus having no substantial increase in the panel production rate.

Keeping meetings on time allocated: If meetings are held to the time allocated as per company rules, Multotec should save approximately 11 hours per month which equates to a total of 1100 panels. Multotec would then have produced an additional 6480 panels over the 5.5 month period. This is not a

substantial impact on reducing the monthly WIP, and should therefore not be considered. The effect on operating profit is a mere 1% increase.

Machine breakdowns: When a machine breaks down as a result of a minor mechanical or electrical fault, an on-site artisan fixes the problem. There is no record kept to determine the repetitiveness of minor problems. Multotec should record these issues, build a database and try to make sense of the data with the aim to implement preventative maintenance activities.

Major breakdowns can be prevented by building interlocks into IM machines. In other words, should the temperature of the PU when introduced into the heater not be as per the set-point, the screw injector will not start. This could have prevented the failure which resulted in a machine being out of production for almost a full month.

Multotec will introduce a SCADA software system to control machine operation and performance in the near future which will be the next level of a TAF exercise. This system will be the foundation for future automation of the production process, but will only be used for machine monitoring initially. Even though this initiative was not born as a result of this study, it should be used to further improve production performance related to the Theory of Constraints methodology.

Raw material stock reduction: It was discovered that minority of the internal steel frames are kept as consignment stock. Multotec will liaise with the frame supplier to introduce on-site storage of frames weekly in use. As a result of this only frames used will be billed on a monthly basis instead of Multotec buying it in bulk and keeping stock thus reducing WIP inventory.

Approximately 500 tons of PU raw material is currently in stock between on and off-site storage whilst 350 tons are currently on order to be supplied ex-Europe. This is an overstock scenario taking into consideration that the monthly raw material usage is 100 tons. It is recommended that Multotec liaise with the raw material supplier to set-up an on-site warehouse where raw material will be issued as per monthly usage. This will result in a reduction in storage costs and improve cash flow.

The raw material stock situation indicates that R36.75 Million has been spent on PU raw materials year to date whilst this value should have been R19.25 million due to the quantity of material used monthly over the 5.5 month period which is approximately 100 tons per month at an average price of R35/kg. This indicates that a cash flow injection of R17.5 Million could have been realised if Multotec only paid for raw material used on a monthly basis. Currently another 350 tons are on order which will result in an additional cash outflow of R12.25 million. Multotec must reconsider the way in which raw material stock is being purchased for a substantial amount of cash is tied up due to the stock level and purchasing frequency. Ownership of on-site stock must be transferred relative to the quantity required on a monthly basis.

Bottleneck in packaging: There is only one cutting machine to cut panels to size which is manufactured oversize. There are always pallets of panels stacked In front of the machine informing me that an increase in throughput from the machines will worsen this situation. Panels are being cut and re-stacked resulting in double handling. Multotec must purchase another cutting machine prior to embarking on an increase in panel throughput. The investment in another cutting machine is approximately R500 000 and the depreciation will have no effect on operating profit. When machine throughput is increased this will become a necessity to improve workflow.

Merge packaging with production: Panels are manufactured, stacked on pallets and transported using a trolley to the packaging area next door which is a mere 30 metres away. These two facilities should be merged so that panels are manufactured, cut and packed at the machines. The wall between these two buildings should be broken down and the current packaging area should be a collection area only. In this manner, when panels come off the machines, they are so to say ready to be transported. Labelling of boxes can occur pro-actively when a specific order nears completion. The financial benefit of this initiative is related to the recommendations to increase throughput, for an increase in finished goods from the machines will result in an increase in WIP if follow up activities are not geared to cope with additional volumes. Reducing WIP is a

direct increase in revenue which increases operating profit by more or less the same margin.

Invoicing and transport: In most cases a customer purchase order forms part of products from other business units with different lead times. It should be investigated which customers do accept partial deliveries so that panels can be delivered irrespective of other goods on the same purchase order. This will create improved flow of goods from manufacturing to delivery thus preventing goods to be stacked up in the dispatch area. However, partial deliveries might result in delayed payments, so it should be considered for customers to place separate orders for panels. This can present a market constraint, but engaging with customers during the quoting phase can probably address this issue.

When throughput increases beyond the extent of available transport, deliveries should be outsourced as a start. Thereafter it can be established what the investment in transport should be to cope with the increase in throughput and delivery frequency with the aim to increase profit.

Reshaping MDW: Multotec already has a system in place called MDW. This looks at the performance of a workstation in terms of speed, cost, quality and people. This system can be reshaped to create alignment between prior and follow-up activities in the production process to change the focus from local optimums to optimising the entire value chain. This will create synergy between units of the value chain; however the vision, mission and goals of teams must be coherent to achieve a common objective. Currently production, packaging, transport and sales have their own vision, mission and objectives resulting in local optimums as per TOC. It is recommended for all metrics related to speed in follow up departments to be aligned to ensure the increased throughput spends the least amount of time possible on the shop floor, for the faster goods move through the value chain and get invoiced, the more realistic the effect on profit will be.

TOC Project execution: The results obtained after analysis of TAF must be shared with the board of directors and a cross-functional team must be put together consisting of individuals from each business unit including finance to

execute this project with the aim to increase throughput, reduce WIP and subsequently increase profit. Each activity which is optimised should have a positive impact on the financials and if not, it should not be embarked on. The aim of this project must solely be to shift all bottlenecks present in the manufacturing process eventually to the marketplace resulting in an increase in the salesforce to sell the additional products manufactured.

Change management practices: From the TAF data over the 5.5 months, it can clearly be seen that this new measurement resulted in an increase in time spent on meetings, however there was an improvement in the panel production rate.

It is therefore important to involve the production personnel in the decision making process prior to just implementing new measurement systems and new ways of work. Senior management must therefore strive to evaluate unintended consequences prior to embarking on projects involving the workforce. Change in the workplace must as far possible not contradict the values of the people involved, otherwise the project will lack sustainability for people will not buy in for the long term.

Globalisation: A continuous 24 hour shift cycle should be considered if Multotec want to become a global player in the screening media business. The additional 16% which could be realised in throughput delivers a 16% increase in revenue and an 11% increase in operating profit. It is believed that the local South African market will not allow this monopolistic strategy for Multotec already owns 70%, therefore the additional throughput should be absorbed elsewhere for example, the Americas and Africa. The screening market size in North and South America together equals $545 million with Central and Northern Africa constituting $300 million in revenue. This equates to additional revenue of R2.5 billion from the Americas if 70% of the market could be captured, but Multotec is not geared to enter this market using current infrastructure.

Based on the South African business model, a similar size of the sales force can only generate 5% of the revenue of the North American screening market.

This indicates that a substantial investment in the sales force is required in Tema USA to penetrate the North American screening market. Tema predominantly focus on the stone and quarry markets therefore it should be considered to establish a mining division within Tema USA operated by Multotec. Further studies should be conducted to determine whether supply from SA or China will be feasible for aggressive entry in the North American mining market versus site establishment.

Multotec should therefore start the discussions with the shareholders to partner with sister companies with the aim to penetrate the global mining markets starting with North America to supply the additional throughput which could be realised. Once this market is captured and on the growth path, investment in local production and supply can be evaluated.

A screen panel install base survey is currently conducted on the Africa screening market to determine the extent of current and future business to be realised for mining projects are on the increase especially in East, West and Central Africa. This exercise is strongly recommended for North America as well.

7. Conclusion

In the past, Multotec would invest in throughput relative to market demand. In 2010 the first rubber injection moulded machine was procured. At that stage it was not known what the cost structure would be should the rubber injection moulded business expand. Multotec now has 5 rubber injection moulded machines and in order to better understand the business unit, it was decided to conduct a TAF study to determine the exact cost structures in terms of labour hours for the dynamics are different to that of PU injection moulding.

It was decided to conduct an in depth study of the time utilised in the IM PU factory with the aim to streamline the business through increasing throughput and improve the financial position of the business unit. The TAF study has created and opportunity to zoom in on activities in the production process by identifying bottlenecks and exploit them, but before it could be exploited a study

was conducted to determine how much of the time allocated to production is actually being utilised to produce products.

In the current scenario where Multotec screen panel business wish to grow by 10% year on year, it is now fair to state that energy should not be spent on reducing downtime, but rather a focus on investing in capacity. Investment in machines seems pleasing and will immediately contribute to throughput. The effect on profit will be in the region of 10% due to an additional revenue contribution of R25 million. The increase in depreciation is negligible and the output level will be sufficient to achieve 2019 budget.

Meetings, tool changes and machine breakdowns were identified as the 3 major components negatively affecting the increase in production throughput. Keeping meetings on time will not result in a substantial increase in throughput, and holding meetings outside of the time allocated for production for 2018 will also not result in the monthly budget to be achieved utilising the same production hours of the previous year. However, when the production target is increased come 2019, only extended working hours or the addition of a new machine can result in budget to be achieved.

The TAF study has indicated that tool changes contributes substantially to a loss in production time and subsequent throughput. Workflow activities and floor space is not conducive to improve the speed of these activities and the optimal time it should take for each change has not established. Floor space is currently being freed up to improve workflow. A project to establish the resources to optimise each tool change is currently underway but it must be noted that even if the current downtime as a result of tool changes is halved, the effect on profit will only be 3%. Therefore a study needs to be conducted to establish if it is worth investing in increasing tool change speed.

Machine breakdowns should be prevented through conducting preventative maintenance practices. A database should be constructed to identify the common problems resulting in downtime and plans must be put in place to prevent unplanned stoppages as a result of electrical and mechanical issues. A SCADA system is currently being investigated and sequence start-up models

will be built into the machines control philosophy to prevent major breakdowns on machines.

It was communicated that internal steel frames are kept on site as consignment stock. This was found to be untrue and discussions with suppliers will be conducted to reduce WIP inventory so that only the amount of frames required in a particular work week is delivered to site and these are paid for monthly. The same should be carried out for the PU raw material supply.

Multotec is embarking to become predominantly focused on global markets as from the year 2020, and to do this it is required to increase local production substantially due to the magnitude of these markets. Foreign investment in local mining projects has decreased over the past few years which are mainly due to weak currency, commodity prices and political instability. Multotec is not well positioned to compete in the global markets at present as a result of the infrastructure required to actively participate.

There are a number of business units within the group of companies who will benefit from a similar TAF study and this report should be the reference point going forward. The information obtained has indicated that control of non-production activities does not always generate the required results in terms of the financial impact not being substantial as established in this study.

The packaging and production facility must be merged to enable goods to be trimmed, cut and packed as they come off the machine. Currently when product defects are picked up during packaging, a tool change must be done to complete the manufacturing of the defected unit to complete the order. This loss in time as a result of a tooling change is not recorded. When inspection during packaging takes place at the machine during production, the unit can be re-run without a tool change being required. The current packaging area must only be used as a collection bay once the merger is complete.

Once smooth workflow has been achieved on the production and packaging shop floor, the bottleneck will shift to the transport department. Multotec should engage with customers and convince them to place orders for panels separately due to the attractive lead time. In this manner, panels can be invoiced and

delivered immediately without being delayed by other longer lead time items. This will in itself reduce WIP.

In order to create synergy between business units in the value chain it is required that each unit is in sync in order to achieve a common goal. MDW currently presents an opportunity to create synergy in the value chain by making sure performance measurements are not in isolation as in the current case due to local optimums. It is therefore preferred for business units to be positioned in line to achieve a common goal.

Due to the emergence of the 4th Industrial revolution and the drive towards automation and the internet of things, Fisher (1997) states that introducing the latest technological advancements to decrease operational expenditure will be irrelevant if poor interdepartmental relations and industry practices exist. The current approach and reccomendations to increase throughput, decrease inventory and operational costs with the current resources presents the perfect opportunity for Multotec to build strong interdepartmental relations and to adopt best industry practices due to TOC involving the entire supply chain. Once all constraints have been elevated and the associated profit is realised, introduction of technology can be considered and evaluated for it will stand a better chance of being accepted by the workforce.

During on-going discussions with key personnel in the organisation, different views were shared. It now seems that even though individuals had ideas as to where the opportunities might be present for improvements in the business unit, these suggestions were not supported by facts or data. Discussions with the board will now be substantiated with reliable data for deeper investigations to be carried out for the opportunities are now more relevant. Even though not all recommendations made may seem viable in the short term, there are definitely immediate actions which can be taken to change behaviour for exponential shifts in growth for the future. Other business units within the organisation will be able to develop a similar framework to improve performance.

When the new TAF measurement was implemented there was an increase in time spent on meetings. This does indicate that the workforce was consulted

and ideas were shared thus involving the workforce in the project. If there was a concept which they could not understand, the measurement was adapted in way that would suite them. This clearly indicates that any strategy should be in line with the beliefs and values of a team in order to facilitate execution. Communication skills are therefore integral during team discussions which require effective listening and understanding of their needs for they know the operation the best on a physical level.

Change to a 24 hour continuous operation will require more than just discussions. It will require rules of engagement for negotiations to satisfy the fundamental human needs of all stakeholders involved. The workforce will need to understand the importance of their role within the organisation whilst their needs of understanding, security and well-being must be satisfied. Furthermore the workforce will need to be compensated at fair value and at the same time the organisation will have to invest in their health and well-being. This will increase output with the current infrastructure to over 10%.

Joint ventures with sister companies operating in global markets must be established which will require shareholder approval if Multotec want to pursue the global screening market for substantial investment is required. Purchasing a new machine and changing the operating hours to a 24 hour cycle can only assist in achieving budget for the next 3 years. Thereafter Multotec will have to continuously buy a new machine in order to make budget, but the South African market is almost at its threshold. Global market penetration should start immediately if Multotec want to grow as a company post the next 3 years.

A screen panel installed base survey is currently underway for East and West Africa. It is recommended that the same be done for North America as a start. This will give Multotec a good idea as to the strategy to be pursued for penetrating the global market. Once customers have been won and relationships are established, local infrastructure investment can be developed at the same growth rate. Currently the market in East Asia is being targeted using established local infrastructure but the rest of the world can also be targeted simultaneously.

Through embarking on this project the following was established after discussions were held with key stakeholders across departments and by conducting the TAF study:

1. In the current set-up it is believed by others that the machines are not the bottleneck, but the facility is not exploited to increase throughput, thus making them the bottleneck. When the production facility is exploited to increase throughput, all following activities will become bottlenecks. It is therefore important to involve packaging, transport and sales in the discussions prior to embarking on increasing throughput.

2. Through asking the right questions, it was determined that a substantial amount of funds are being tied up on raw materials. This is having a substantial influence on the stock turnover and cash flow. By reducing inventory Multotec can improve their cash position.

3. Senior management always complain about the time production personnel spend conducting meetings. What they do not know is that lost production time as a result of meetings has very little effect on production throughput and operating profit. The addition of new machines delivers the biggest impact on throughput and the associated financial benefit, but it requires investment.

4. Implementation of a Drum-Buffer-Rope system is required for the management of raw materials. This will improve the cash flow position substantially with an increase of over R25 million to be realised in immediate terms. Suppliers need to be consulted immediately to negotiate on site storage and supply only what is required on a monthly basis.

This study concludes that Multotec's injection moulding polyurethane facility will require substantial investment on an annual basis post 3 years in order to achieve budget in terms of revenue. Although investing in one machine does not affect profit in the present, continuous future investments will diminish returns. Multotec should therefore shift focus from local to international footprint and business growth. The strategy that Multotec is pursuing to become a predominantly global supplier post 2020 is a focus in the right direction.

Multotec Manufacturing has a number of business units and product lines namely; injection moulding PU, hand casting PU, rubber injection moulding and wedge wire screens. A similar study needs to be conducted in each business unit to establish the current capacity versus the revenue targets in the next few years. And in line with this, recommendations need to be made as to the best way forward with the main focus on improving the bottom line.

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