

Analysis of the production planning process using the Current Reality Tree

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Abstract The production program process and control is often not performed as proposed, so it is necessary to identify the gaps and to act consistently and effectively in the root cause of the problems. This paper seeks to implement the Current Reality Tree, one of the tools of the Theory of Constraints Thinking Process, to identify and relate the undesirable effects faced by the studied company and that lead to lack of adherence of the production scheduling, such as stock count errors, lack of visibility of packaging, programming includes parts which tools are under maintenance, among others. The instruments of data collection used in this research were interviews and participant observations. The results show that there are three main undesirable effects that cause the others: inadequate use of indicators, lack of information sharing and lack of a stock control information system, and solutions are proposed to mitigate the existence of these problems.

Keywords: Production program process, Theory of Constraints Thinking, Current Reality Tree, production scheduling.

1 Introduction

Inefficiency is no longer accepted by the customer, as there are more product options on the market. The efficient functioning of Production Planning and Control (PP&C) is essential for the success of any productive organization, considering that it is possible to obtain significant gains in time and efficiency through a reliable programming and an adequate sequencing of production (Bezerra, 2014). In the same way, production control has an equally important function, as it is not enough to have an aligned planning if it is not fulfilled according to your specifications. The purpose of production control is to inspect, verify and correct possible deviations and ensure that activities are carried out according to plan (Peinado and Graeml, 2018).

The main activities associated with the PCP concern: (i) forecasting demand; (ii) development of an aggregate production plan; (iii) medium-term capacity planning; (iv) breakdown of the production plan; (v) production scheduling in the short term in terms of final items (Master Production Program - MPP); (vi)

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production control through rules; (vii) issuance / release control of production and purchase orders; (viii) inventory control; (ix) scheduling / sequencing of operations (Godinho Filho and Fernandes, 2010).

Additionally, due to the unpredictability of the planning result and to ensure customer service, several companies choose to maintain inventories to compensate for the differences between what was planned and what was done. While inventories are costly and retain a considerable amount of capital, they also provide a guarantee for unexpected situations (Chen *et al.*, 2016). However, Production Planning and Control (PP&C) process rarely works as expected due to forecast errors, delivery lead time variations, machine breakdown, absenteeism and inventory control errors (Chen *et al.*, 2016). Thus, it is essential to diagnose the internal environment of the organization, so that changes and interventions are carried out effectively (Bushe and Marshak, 2009).

Thus, it is essential to diagnose the internal environment of the organization, so that changes and interventions are carried out effectively (Bushe and Marshak, 2009). Organizational problems related to manufacturing strategy can be analyzed with the help of the Thinking Process presented in the Theory of Constraints. The Thinking Process is a set of cause-and-effect tools that are designed to identify problems, analyze them and propose solutions for different situations (Goldratt and Cox, 2016). The Current Reality Tree (CRT) is one of these tools and it is used for the systematic identification of the main problems of a given context (Cox III and Schleier, 2010). The problems faced by the company under study are related to the production team does not follow the production scheduling, as well as failures in inventory, packaging and tools control. Thus, the objective of the present work is to analyze the production programming and control process using the CRT, in order to identify the root problems that cause the emergence of other undesirable effects (UEs) and propose solutions based on the literature.

2 Literature review

2.1 Production Planning and Control (PP&C)

The main words in all headings (even run-in headings) begin with a capital letter. Articles, conjunctions In recent years, technical and system changes have occurred in the manufacturing industry and the demands placed on companies by the market are also constantly changing. The PP&C is being asked to respond effectively to these internal and external changes, providing a faster response and better control of resources and delivery performance (Bonney, 2000). The PP&C involves a chain of decisions that aims to define what, how much and when to produce, buy or deliver, as well as what to produce, where and how (Bezerra, 2014)(Godinho Filho and Fernandes, 2010).

The PP&C has the responsibility to establish the operational plan for the administration of production and to manage the activities of productive operations, so that customer demand is satisfied and that production occurs uninterruptedly, without failures or errors. The PP&C is charged with monitoring and carrying out corrective actions so that the specifications related to the organizations' products and services are met (Slack, Chambers and Johnston, 2009). Thus, the PP&C is responsible for the coordination and use of productive resources in order to meet better the established planning (Chen *et al.*, 2016).

The responsibility of the Production Planning and Control (PP&C) is to plan and control the procurement of inputs, the manufacturing process and all tasks related to these activities (Gaither and Frazier, 2002). The four functions of PP&C are demand management, material requirements planning, capacity planning, and scheduling and task sequencing (Mula *et al.*, 2006). However, there is a gap between the PP&C theory and practice (Bonney, 2000). Planning and control difficulties arise when there is an incompatibility in one or more parts of the system. Thus, an obstacle faced by the PP&C concerns the planning of raw material inventory (Chen *et al.*, 2016).

Inventories are essential elements in meeting anticipated demands and are directly related to the competitiveness of organizations as they allow, among other aspects, organizations to practice economies of scale in obtaining inputs. Inventories can be defined as "accumulations of material resources between specific stages of the transformation process" (Corrêa, 2006). Inventories act as regulators of business flow.

Due to differences in the speeds with which goods are received and used, the stock acts as a buffer (Martins and Alt, 2006). Inventories offer benefits to the related production system with regard to the level of customer service and indirect cost reduction, as they enable production not to suffer from fluctuations in demand, ensuring product availability (Ballou, 2007). Inventory management is related to the company's strategic positioning, aiming to make the best use of resources and enhance the organization's results (Rufino, 2009).

Inventory divergences are usually caused by control failures, whether at entry, exit or in handling and storage tasks, and the more automated the inventory control, the greater the chances of avoiding errors (Ayres, 2009). The lack of information sharing, the obstacles to information processing and the application of different platform technologies throughout the company are often considered the main reasons for the malfunction of inventory management systems. Consequently, the adoption of information systems is closely related to inventory management practices and it is for this reason that the contribution of management information architecture to achieve internal and external objectives needs to be explicitly addressed in the definition of the inventory management concept (Ayres, 2009).

2.1 Theory of Constraints and the Thinking Process

Poor information sharing, barriers to information processing, and the application of the different platform technologies across the enterprise are often considered to be the main reasons for inventory management systems to bad function (Ayres, 2009). In this way, Theory of Constraints (TOC) highlights the relevance of constraint management in a system to achieve its goals (Cox III and Schleier, 2010). The constraint limits a system to achieving superior performance with respect to their goal (Goldratt and Cox, 2016). The essence of TOC is to identify the constraint as the weakest link in the chain and eliminate it. TOC can be described as a management method aimed at continuous improvement, seeking to optimize operations and reduce production flows (Goldratt, 2010). In other words, TOC seeks to improve production by recognizing the resources that limit the production system as a whole (Verma, 1997).

The TOC can be defined by the 5 focusing steps: (i) identify the constraint; (ii) exploit the restriction; (iii) subordinate to the restriction; (iv) raise the restriction; (v) identify new constraint (Cox III and Schleier, 2010). It is assumed that by identifying a constraint and working to improve it, another part of the process will become the new constraint and thus, the system is always fed back in search of continuous improvement (Cox III and Spencer, 2009).

Two types of restrictions can be classified: physical, which refer to material resources (machines) and non-physical, created by daily procedures and practices of strategic business management (Wanderley, Cogan and da Silva, 2010). The management of restrictions refers to the planning, control of product production and has evolved into the Thinking Processes, applicable to any type of organization and non-physical problems of a strategic nature (López and Grasel, 2016). The TP is defined as a set of tools that assist in the decision making process through the construction of logical schemes, allowing an improvement in the system visualization (Cox III and Schleier, 2010). This process is based on three questions: "what to change?", "Why change?" and "how to change?" (Carmo, Machado and Cogan, 2015).

The Thinking Process analyzes a system or situation that causes a main problem, developing a solution and determining how to implement it (Scheinkopf, 1999). It is operated through five trees, used individually or together. The Current Reality Tree (CRT) is one of these tools and consists of a diagram through which cause and effect connections are made in order to interconnect symptoms presented in the system, making it possible to find the constraint (Cox III and Schleier, 2010). CRT starts from two basic assumptions: The first is that a perceived problem is an undesirable effect (UE). The second is that the identification of a few elements is responsible for most of the UEs should be sought. Undesirable effects arise due to a root problem (Goldratt and Cox, 2016). CRT is structured top-down, starting from effects to causes, but should be interpreted in the opposite direction, bottom-top, using the IF-THEN relationship. One or more UEs may cause another effect or two effects that occur simultaneously cause a third effect. In this case an ellipse is used to relate to them (Gupta and Boyd, 2008). The construction of the CRT must follow these steps: (i) list the main undesirable effects (UEs) identified in the situation; (ii) test the clarity of each UE; (iii) look

for causal relationships between UEs; (iv) determine what is a cause and what is an effect; (v) continue the connections between the UEs considering the IF-THEN logic until all connections are completed; and, after expanding the tree, (vi) reviewing the work, correcting any inconsistencies (Cox III and Spencer, 2009). The application of CRT clearly demonstrates impacts and represents a starting point for continuous improvement work (da Silva and Sellitto, 2010).

3 Methods and procedures

The present research uses a qualitative approach applying the Thinking Process of TOC. The following steps were stipulated for the development of the work: (1) understanding of the process and survey of UEs; (2) CRT construction and root problem analysis and (3) solution proposition (Goldratt and Cox, 2016).

The first stage concerns the investigation, being possible to understand the production control plan, identify its operation and its limitations. Participant observations and interviews were conducted with employees from PP&C department and production leadership. With greater clarity and understanding of the process, it was possible to survey the UEs faced. The next step refers to making a diagnosis of the current situation, associating problems in the process and creating a cause-effect relationship, thus forming fragments of the tree. These fragments were later concatenated, taking into account deeper causes that could connect them. The CRT was then built, identifying the root causes that make the most contributions in terms of UEs. Afterward, a discussion was held with the company's employees to validate the CRT. Additional observations were identified and the CRT was adapted. Finally, in the last stage, a discussion about the root causes was considered, analyzing possible solutions based on the literature and considering the impacts and difficulties of application.

4 Experimental/numerical setting

The studied company is a multinational company specialized in the manufacture and assembly of automobiles and has three assembly plants in Brazil. The site currently manufactures two vehicle models, featuring 16 different versions, sold in the Brazilian market and some of them exported to Latin American. The production volume is 66 cars per hour and the factory operates three production shifts, employing around 3,000 direct and 2,000 indirect employees. The study was carried out at the company's stamping department, where all external vehicle panels are produced. The panel manufacturing process begins with the receipt of coils. The coil is transferred by crane to Blanking Line, a machine that transforms the coils into metal sheets already in the dimensions of the panel to be stamped. There are 35 different models of parts produced. Each part requires a different tool and the speed of this machine varies from 20 to 55 strokes per minute, according to the specifications of each tool. The sheets produced are deposited on pallets which are placed in the intermediate stock and subsequently sent to one of the 3 automated stamping lines. The presses feature 4 stamping operations until the panel is finished: draw, cut, hole and flanging. In total, 45 different panel designs are produced and there is a stock of stamped panels equivalent to approximately 2.4 days of production at the work. The stamping department currently faces some shortcomings with regard to production scheduling and control, inventory management, packaging and tool control. All these factors lead to non-compliance with the production schedule.

5 Results and Discussion

A brainstorming was performed between the production team and the programmer to identify the undesirable effects (UEs) that led to non-compliance with production scheduling. Based on the surveyed UEs, it was possible to classify which ones had cause-effect relationships and connect them in order to

create CRT filaments. Other UEs perceived during CRT structuring were included. After some attempts and investigations about the real causes of each effect, the CRT (Fig. 1) was constructed and validated with the production team and the programmer. According to the CRT, it is understood that there are three UEs that lead to the others: (i) improper use of indicators, (ii) lack of information sharing and (iii) lack of an inventory management information system.

The UE “improper use of indicators” is related to the variation in production speed of the parts produced at Blanking Line, which generates different volumes depending on the production of each part. However, a stroke per production hour target is set and this target is fixed. Thus, often the production team will not even produce the size batch of low production speed parts, if they are not in critical stock, instead prioritizing high speed production parts to increase volume. In order to have a correct analysis of the production performance, it is necessary that the goals are established according to the peculiarity of each piece. By designing the goal in accordance with the strokes per minute that each piece can perform, we can truly see which pieces need attention to act objectively on improvement actions.

The “lack of information sharing” UE is related to pallets where the finished metal sheets are stored and the tools that shape the sheets. Due to the size of the sheets produced, there are different pallet sizes, that could be found available for use or not (for example, under maintenance). As each counting information is controlled by different people, it is possible that the shift schedule will include several parts that use large pallets because they are low on stock, while having many large pallets under maintenance. In addition, there are communication failures between the programmer and the tooling team. Often the part programmed to be manufactured on shift has the tool under maintenance, but this has not been communicated to the programmer. Thus, the production team will not be able to produce the part and will change programming. This situation could be remedied by unifying information already available. The company already uses a Business Intelligence (BI) tool in some departments. Thus, the proposed solution for better control and information sharing is the use of BI software to unify the information.

Due to the “lack of an inventory management information system”, inventory management is performed manually. This process takes about 50 minutes, which means the production team starts the shift producing what the previous shift already left on machine. Because the production team needs to know as soon as possible the next part to prepare for the setup, a parallel inventory count is made by the production team to see which parts are low on stock. The company is advised to implement or develop a system that monitors inventory inputs and outputs, from the receipt of coils to the output of stamped press panels, enabling the materials traceability. This system makes it possible to establish the lot size and safety stock of each part in the system and to schedule alerts when the stock is close to the re-fulfillment point.

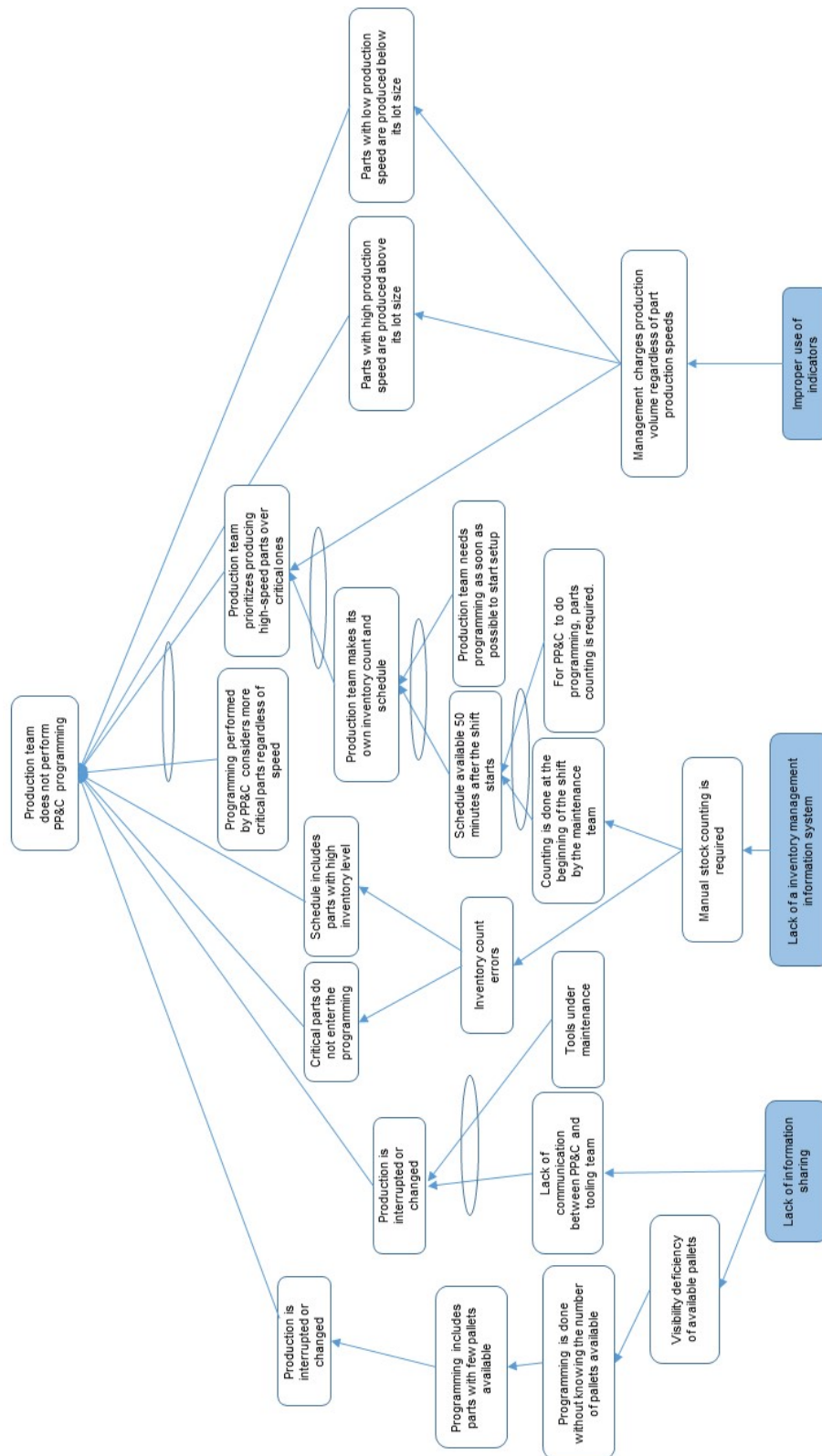


Fig. 1 Current Reality Tree (CRT).

6 Results and Discussion

The present work used the Current Reality Tree to analyze the problems faced by the company under study regarding the non-compliance of the production schedule by the production team and to propose solutions. Through CRT it was possible to list the undesirable effects and it was observed that the improper use of indicators, the lack of a stock control system and the lack of information sharing are the three root problems that cause the other dysfunctions. To remedy the unfavorable situations found some solutions have been proposed, like revision of production targets per hour, considering the production capacity of each part and not an average of hits per minute. This change is necessary for the production team to comply with the production schedule and not just to produce in high-speed to reach the inadequately established production volume. Also, the developing of the stock management system is essential to make the process more efficient. Finally, we suggested the use of a BI software for information sharing. This way the parties involved in the process have visibility of what is going on, besides facilitating the control and analysis of the data

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