IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN:2278-487X, p-ISSN: 2319-7668. Volume 26, Issue 4. Ser. 9 (April. 2024), PP 21-30
www.iosrjournals.org

Production Planning In The Metalworking Industry For Enhancing Production Processes

Weliton Pessoa Santos[1], Breno Eustáquio Da Silva[2] , Ana Paula Cota Moreira[3], Luzia Nunes Dos Santos[4] , Bráulio Frances Barcelos[5] , Marco Túlio Domingues Costa[6] , Mayara Roberta De Castro[7] , Rúbia Magalhães Fraga Zocal[8] , Wagner Cavalare De Souza[9]

[1]*(Faculdade Doctum De João Monlevade, Brazil)*
[2]*(Faculdade Doctum De João Monlevade, Brazil)*
[3]*(Faculdade Doctum De João Monlevade, Brazil)*
[4]*(Faculdade Doctum De João Monlevade, Brazil)*
[5]*(Faculdade Doctum De João Monlevade, Brazil)*
[6]*(Universidade Federal De Ouro Preto, Brazil)*
[7]*(Universidade Do Estado De Minas Gerais, Brazil)*
[8]*(Universidade Fumec, Brazil)*
[9]*(Universidade Do Estado De Minas Gerais, Brazil)*

Abstract:
Background*: Investigate failures/gaps in production planning; research, among various management models, the one that best fits as a response to the production planning needs of the researched organization, and finally propose changes to address deviations through the PDCA methodology*.
Materials and Methods*: Applied research, with a qualitative approach, bibliographic and documentary research that provided the study on production planning in the metalworking industry, as well as understanding the peculiarities involved in jobbing production with the application of PDCA and 5W2H tools*.
Results*:The mapping of the production process allowed us to identify some flaws such as difficulty in visualizing the lead-time of orders, slow and costly processes, wear in the replanning process, and low efficiency in production control. Corrections were proposed for all these flaws.*
Conclusion: *The research was supported by concepts of Total Quality Management (TQM) systems, considering their methods and tools. Therefore, with the correction of the identified flaws, greater gains in productivity, reduction of variable costs, and faster delivery of products are expected. The use of the PDCA cycle management tool allowed suggesting corrective actions for the identified flaws, starting from the better utilization of the existing ERP in the company, with the addition of hardware and software that can enhance process automation.*

Key Word*: Total Quality Management; PDCA; 5W2H; Production Planning*

Date of Submission: 18-04-2024 Date of Acceptance: 28-04-2024

I. Introduction

This investigation focuses on the field of Production Management, with special attention to the role played by Production Planning (PP) in reducing losses, waste, and costs, as well as increasing efficiency and productivity in organizations. The research focused on studying the production planning of a medium-sized company in the metalworking sector in João Monlevade, Minas Gerais, Brazil.

According to Chiavenato (2014), companies are born with the purpose of producing something (goods or services). In addition to satisfying the needs of society (consumers) and the market, companies seek to add value to their products or services. Initially, the enterprise generates wealth through its production processes; then, through profit or return on investment (Chiavenato, 2014).

When it comes to the process of transforming inputs into finished products, in industrial companies, the productive activity is called production. Thus, production management, in the field of administration, uses physical and material resources of the company to carry out production or operations that lead to the transformation of raw materials into final products.

One of the areas that constitute production management is the Production Planning and Control (PPC) sector, whose function is to plan and control production according to demand, considering the company's production capacity (Chiavenato, 2014).

In this study, the focus was on addressing the production planning stage, which ultimately works with an information system for managing the integration of the company's productive resources. Essentially, production planning (PP) determines what will be produced, when; evaluates the availability of inputs, and manages the efficiency of the production process to ensure alignment with demand. This means that PP coordinates and integrates equipment, people, inputs, materials, and production processes in a systematic, harmonious, and integrated manner (Gislon, 2012).

Gislon (2012) highlights that the concept of planning encompasses two important aspects in administration: effectiveness and efficiency. Effectiveness relates to the action of producing the desired effect correctly, while efficiency corresponds to doing it in the right way (Gislon, 2012). On the other hand, the same author warns that the lack of planning can bring harm to the company: loss of sales due to inefficiency, high costs, underutilization of labor, high inventories, inadequate production levels (Gislon, 2012).

This study aimed to contribute to the identification of failures/gaps in the production planning of a metalworking industry, research among various management models, the one that best fits as a response to the production planning needs of this organization, and finally propose changes that can address the deviations. Thus, the problem-question that guided the research is as follows: How can the production planning of a metalworking industry be improved, based on the contribution of management models that fit its reality?

The research aimed to promote improvements in the production planning activity of a metalworking company in the city of João Monlevade, MG. To achieve this, the investigation was based on the following specific objectives: (a) to map the flow of production processes, from order arrival to the end of product production; (b) to examine the procedures related to the production planning task to verify the existence of possible failures or gaps; (c) to investigate how management methods and tools can be efficiently applied in the production planning process to mitigate the identified failures; (d) to propose new procedures to address the existing failures/gaps in the investigated procedures, in order to achieve higher levels of productivity and cost reduction.

The research is justified by the fact that production planning, due to its characteristics (reducing losses, rework, waste, and costs), can contribute to the company by reviewing its production planning procedures to identify failures and proposing new procedures to mitigate deviations. Thus, it is expected that the company will gain competitiveness by reducing costs and improving its productivity levels.

Methodologically, the research is classified as exploratory regarding objectives; regarding procedures, a case study was adopted, aiming to deeply understand the how and why of a particular situation, as well as being an investigation that included a single organization; data collection occurred through documentary research and structured and unstructured interviews with managers and employees; finally, the data were analyzed using a qualitative approach.

II. Theoretical framework

Organizations share a common goal: to offer products or services that generate profit, provide utility, and meet market expectations, thereby gaining positive recognition. They often operate in highly competitive environments and strive for product/service differentiation, innovation, quality, and continuous improvement in their production processes (Santos, 2017).

The adoption of Total Quality Management (TQM) systems constitutes an important means of introducing quality procedures into organizations, as these systems can address complex production process issues in a straightforward managerial manner (Santos, 2017). The fact that Total Quality methods and tools are based on lean production principles (without waste), continuous process improvement, and the pursuit of the simplest, most replicable solution makes them highly relevant for enhancing the production planning process of the investigated industry.

Total Quality Management (TQM) Programs and Methods

Geopolitical and macroeconomic changes, particularly those following World War II, especially from the 1970s and 1980s onwards, exponentially intensified competition in the international market (Miyake, 1993). Oakland (1994, cited in Mainardes, Lourenço & Tontini, 2010) asserts that the growth in consumption and market demand compelled companies to handle quality matters more carefully. This led to the emergence of key concepts and methods in the field of quality (Avelino, 2005). In modern times, quality is centered on customer needs, as emphasized by Mendonça (2011), who states that quality is not solely achieved through technology but also through people, requiring their commitment to excellence in work.

As the concept of quality evolved, there was an understanding of the need for quality management at all stages of the product life cycle, leading to the emergence of various quality management techniques for product improvement (quality in required attributes) and waste reduction.

Nunes, Serrano, Belusso, and Paula (2018) assert that Total Quality brings advantages to the organization's type of operation, including cost reduction, error reduction, less wasted time on corrections and rework, and increased product reliability (Nunes et al., 2018).

To achieve these goals, TQM standardizes production processes, with standardization understood as the identification and treatment of non-conformities. This involves the development of formalized routines for activities performed in a work unit (Nunes et al., 2018). Thus, the use of TQM methods and tools is essential for standardization compliance. The following are descriptions of some of these instruments, considered essential for investigating the production processes of the industry chosen for research.

a) PDCA

The PDCA Cycle is a widely applicable management tool used in organizations to manage internal processes to ensure the achievement of defined goals, based on the use of information generated in the process as a guiding factor for decision-making (Mariani, 2005). PDCA stands for Plan-Do-Check-Act and is a four-stage method for implementing and executing changes. It is a tool for continuous process improvement. The use of PDCA is envisaged for cases where there is a need to implement changes in entrenched procedures detrimental to production process planning.

b) Action Plan - 5W2H

The 5W2H method involves using questions (originally formulated in English) to generate answers that clarify the problem to be solved; organize ideas in problem-solving; allow for the division of a process into stages to identify flaws hindering its proper completion. The 5W2H methodology can also be used to create an Action Plan to achieve goals and pursue continuous improvement (Silva & Silva, 2017). Figure 1 explains the meaning of each step.

Table no1: Action Plan – 5W2H.

5W2H QUESTIONS	DEFINITIONS
What:	Describes the actions to be taken. Records the current situation and the desired outcome.
Why:	Indicates the possible causes of non-conformities or the advantages the company may gain by investing in a particular project.
Where:	Considers the overall context of the strategic planning being developed and its scope.
When:	Establishes the timeframe for completion. It's important to focus not only on the final result but also on all stages.
Who:	Assigning responsibilities is essential to the action plan, defining the people who will coordinate and execute the plan.
How:	Specifies the procedures and methods to be adopted, as well as establishing evaluation and quality criteria.
How Much:	The final step of the 5W2H application is to estimate the costs that the proposed solutions will have for the company. This helps assess the feasibility of each idea presented.

At the end of the investigation into the production planning problems of the company under study, an Action Plan based on 5W2H was developed for the implementation of the new solutions found.

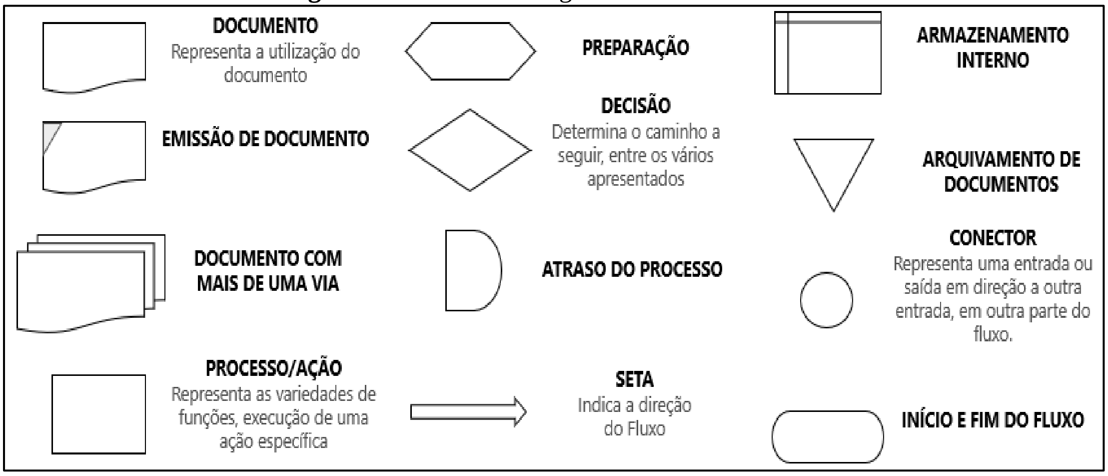
Total Quality Management Tools

Total Quality Management (TQM) tools are used to measure and analyze company processes, aiming to determine resolutions directed towards identified problems; the goal is to establish preventive actions capable of providing quality to the organization's activities. In this study, the Flowchart Diagram tool is highlighted, used for mapping the production process of the company under study.

Flowchart Diagram - The workflow of the process describes the sequence of execution of the various activities that comprise it, indicating the activity or possible activities for execution after the completion of each of its stages. Complexity increases as there are blocks of activities executed in parallel, which generates a dependency relationship between the outcome of these activities and the decision on the path to be followed for the continuation of the process workflow. The most employed technique to meet this need for process management is the workflow diagram.

Through geometric figures and other similar elements, a flowchart, when well elaborated, can simplify the flow of information. In Figure 2, presented in Portuguese, it is possible to visualize the geometric figures and their use in the elaboration of a flowchart according Azevedo (2016):

Figure no2: Geometric figures used in flowcharts.



Production Planning (PP)

Originally, production planning is part of the Production Planning and Control System (PCP), which aims to monitor and control production performance in relation to what was planned, correcting any deviations that may arise during operations (Chiavenato, 2014). All administrative processes begin with a planning stage, where objectives and actions to be executed in advance are thought out and established. Planning requires decisions to be made based on factual information and data.

Manufacturing organizations need to plan their production activities, which are complex because they involve thinking in the long, medium, and short term. Production planning occurs at the operational level and specifies the daily production of products. This planning includes projecting material needs; the production process itself, with the preparation of daily production plans; allocation of loads on assembly lines; among other factors (Peinado & Graeml, 2009).

Supporting Activities to the PP System

Production planning is smart to avoid problems such as team and machine downtime, which cannot afford to wait for data or materials. In this sense, it is essential to apply good information management in the company. Due to this factor, production planning is fed with various sources of data, such as operation bulletins provided by industrial engineering; specific labor for each process is defined with the Human Resources area; supplies are scheduled with the purchasing department; the company's production plan and the quantity of finished products are defined with the sales area, etc. It is thus perceived that production planning operates in an integrated manner with other areas of the organization to achieve its purposes (Chiavenato, 2014).

Strategic Production Planning

In the case of strategic production planning, it should aim to maximize production operations and minimize decision-making risks. Thus, the focus of planning is centered on the strategy of developing a production plan that relates the various decision areas of the production system in order to position the company more adequately in the market and, consequently, increase its competitive advantages (Barreto et al., 2017).

III. Material And Methods

This investigation, in terms of nature, is an applied research because it aimed to generate knowledge for practical application on production planning, diagnosis, and organizational self-analysis through PDCA and proposition of action plans to mitigate failures and deviations in production management. Regarding objectives, it was an exploratory research, as it focused on the discovery of ideas and thoughts, relied on observation to better understand the research object. Exploratory research analyzes how things come together and interact.

Research Methods Used: For the development of this research, bibliographic research was conducted, which provided the study on production planning in the metalworking industry, as well as understanding the peculiarities involved in jobbing production; in addition to the PDCA cycle management tools and the 5W2H methodology. This investigation was also characterized as a case study because an "in loco" analysis was carried out in the researched company, an opportunity to explore real facts of its daily functionality, observe and investigate the decisions about production planning, as well as how to manage jobbing production. In the terms presented here, the case study methodology was applied as an investigation circumscribed to an industrial unit, aiming to understand in depth the production planning applied to the metalworking sector, the challenges, and the contributions arising from the transposition of theory to business practice.

Data Collection Procedures and Instruments: To proceed with data collection, 5 (five) "in loco" visits were made to the sectors directly involved with production planning, with various objectives: to learn about the nature of the business; get to know the production facilities; interview sector managers; seek data for company characterization; collect data related to the planning procedures used. These visits provided freedom to conduct interviews in a cooperative tone with the informants, who were participatory throughout the process. It can be said that exploratory interviews and observations were promoted during the initial visits, as, according to Gerhardt and Silveira (2009, p. 50), they "allow the researcher to become aware of aspects of the issue that their own experience and readings could not highlight."

In terms of instruments for data collection, some scripts were used, designed not to leave behind any relevant aspect for analysis, but dialogical exchange prevailed, where the researcher and the informants discussed the subjects that were the focus of interest on each visit.

Treatment and Analysis of Collected Data: According to a qualitative approach to the data, the treatment applied followed an initial categorization into three divisions: (a) data related to company characterization; (b) data related to production planning, and (c) data derived from the application of PDCA.

For Gerhardt and Silveira (2009, p. 31), qualitative research "is concerned (...) with aspects of reality that cannot be quantified, focusing on understanding and explaining the dynamics of social relationships," which were replaced here by organizational relationships. The interest of this investigation is to provide a metalworking industry with management tools capable of improving its productivity, reducing or eliminating gaps/failures in production planning, from a modern and effective managerial perspective.

Thus, the initially categorized data, in the data analysis, mix, complement, and highlight information that would not otherwise shed light on the study object.

Company Characterization: The research field company belongs to the Metalworking sector, founded in 1994, located in the city of João Monlevade, MG. It is a family business that started its activities in the small boiler sector. Over the years, the organization has developed and expanded its field of activity in other areas, encompassing other activities in its production processes.

Today, the company operates in segments such as technology, mining, steelmaking, and the automotive industry. Additionally, it develops solutions in the manufacture of parts and equipment. It offers engineering services, machining, manufacturing, assembly, and industrial maintenance services to the market. All organization processes are certified by NBR ISO 9001, through a Quality Management system responsible for maintaining the required standard.

The maturity of the business brought important clients to its portfolio, such as VALE; Companhia Siderúrgica Nacional (CSN); Usiminas Siderúrgicas do Brasil, and ArcelorMittal. With its development history, the company has increasingly consolidated its presence in the Médio Piracicaba region.

Regarding management, in the medium-sized company, decision-making is carried out by the founding director who acts as a decision-maker from the strategic level to the production sector. The organization is fully integrated by the Protheus software from Totvs, responsible for supporting all existing sectors in it. Regarding the production process adopted by the organization, the company produces by jobbing (order) or according to pre-developed engineering projects. Thus, everything starts with the Budgeting sector, which works incessantly performing price calculations for several quotations received from customers every day. After one of these budgets is approved, a sales order is received, which acts as a trigger for the start of the entire production process, which will result in the final product(s) contemplated.

Regarding products, in the production method used by the company (jobbing), there is no standard product to be manufactured, however, some types and general formats of products are very common and have a higher frequency of orders, such as: conveyor belt drums, pulleys, wheel sets, trucks, structures, axles, pinions, and bearings.

IV. Result

In this section, the analyses of the data regarding the description of the production process executed by the researched company are presented, aiming to better understand the involved sectors and the challenges faced. From this broad perspective, the map of the production process was analyzed to identify flaws in the production process planning stage. Next, the identified flaws are presented along with an analysis of the consequences for planning and production processes. As a result of the previous procedures, suggestions for improving production planning are presented, based on the use of the PDCA management tool. Finally, the views of production planning managers and operators on the role of production planning within the researched organization are also presented.

Description of the Production Process Executed in the Researched Company

The company operates with a pull production process, producing on a jobbing basis or according to pre-developed engineering projects. Everything starts in the Budgeting department, which continuously performs price calculations for various quotations received daily from customers. After one of these quotations is approved, a sales order is received, which serves as a trigger for the start of the entire process that will result in the final product(s) being delivered.

After receiving the sales order, the Sales department forwards all received documentation, including drawings and scopes of supply, to the Production Planning and Control (PPC) department, which will be responsible for performing all project/jobbing engineering. In this department, the order undergoes three types of treatment, namely: materials engineering, production planning, and operations engineering.

Materials engineering is initially responsible for analyzing all industrial drawings sent, scope of supply, general documentation sent by the customer in the order, and verifying the conformity of the information contained therein. After this procedure, a list of all materials and items needed for the manufacture of the requested product(s) is generated, generating purchase orders for commercial items and cutting plans for sheets and bars contained in stock. If necessary, the employees in this materials engineering stage are also able to develop sketches/drawings to assist or complement the manufacturing process.

On the other hand, operations engineering's function is to analyze all the drawing(s) contained in the order and develop the entire operations sequence that must be followed to produce the final product(s). This stage also includes printing the manufacturing drawing(s), releasing production orders (POs), and necessary documents for the production sector supervisor.

The production planning stage's main function is to sequence all orders contained in the backlog on production resources, aiming to produce in line with delivery deadlines agreed with the customer. Therefore, it is also responsible for capacity analysis, factory utilization, and making decisions such as outsourcing and hiring more production force when necessary.

After the treatment in the PPC department is completed, the order is released, along with the necessary documentation for order fabrication, destined for the Production department. In this department, the production stages are carried out in the sequence of operations determined by the PPC. However, this manufacturing process does not start immediately after the documents are released by the PPC because the raw materials to be worked on are not stock materials, as there is no standard product in this type of production.

The Purchasing department receives the requests and places purchase orders, selecting registered suppliers with the best conditions of price, quality, and supply lead time. After placing the purchase order, the logistics department is responsible for transportation and monitoring until the arrival of the raw material at the factory, at which point the Production department begins the operations, step by step.

Before the start of the production process, the Shipping department is responsible for receiving the materials or raw materials from the orders, performing dimensional and quality controls at this stage, as well as certifying their conformity. After releasing the materials to the stock, the production process begins.

The Machining department is composed of machine operators, a maintainer, and a production supervisor, whose function is to release the POs and oversee the entire production sector, addressing doubts and assisting in possible problems. The maintainer verifies which POs will enter production and on which machines, is responsible for distributing the raw materials appropriately, enabling the start of productive operations. This sector is responsible for producing the product(s) through roughing operations, shaping the part(s) according to the drawing(s) and information contained in the POs.

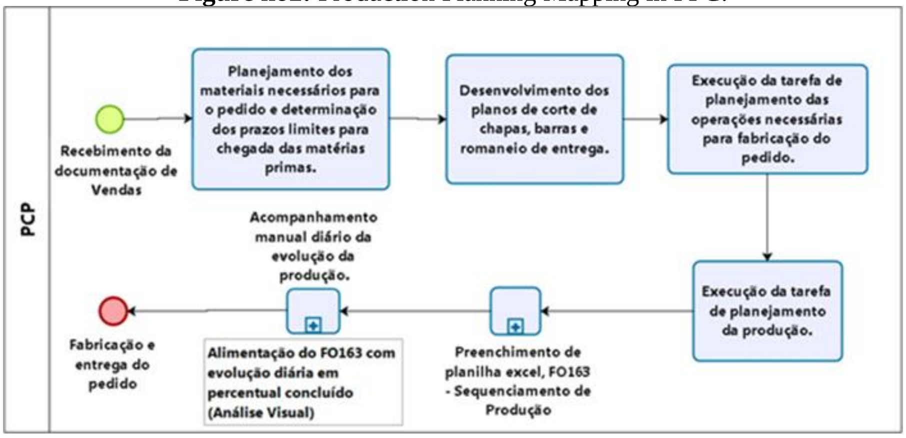
The Quality department consists of a quality inspector who is responsible for general product controls such as dimensional checks according to drawings and PO information, visual inspections, finish checks, and mechanical assembly conformity. This department also performs intermediate checks on the parts after the completion of each production stage.

Finally, the Painting department has an employee tasked with painting the non-machined parts of the pieces with the color and thickness indicated in the POs. After painting, the parts undergo a final check, are invoiced, and released for shipping, where they are properly packaged and prepared for transportation to customers.

Mapping of the Production Process of the Research Company

Based on the description of the production process adopted by the researched company, it is possible to present how production planning occurs, starting with the presentation of the Flowchart with the developed stages. The survey was conducted by following the work performed by the responsible professional, that is, the production planner, in order to understand how the process behaves in practice. The Figure 2 presents, in Portuguese, the mapping of the production planning process employed, as can be observed:"

Figure no2: Production Planning Mapping in PPC.



The first noteworthy aspect is that production resource planning is done manually, order by order, with only the delivery date and programmed hours quantity as sequencing parameters/criteria.

The planning process is quite mechanical, requiring manual input by the planner. This process involves visiting the production area several times a day, visually assessing the progress of each operation, monitoring the status of orders in production, and manually updating the form.

For actual production planning, an Excel spreadsheet named FO-163 is used, where orders are manually allocated one by one. To sequence each order, the planner must have the operation route for each sales order and establish a priority based on it. This priority is calculated using the critical index, where a lower index indicates higher priority. After determining the priority, the planner manually allocates the order to the cells representing the machines where the product will be processed, with lower priority orders above and higher priority orders below.

For monitoring the progress of operations at each production resource, the planner, with the supervisor's assistance, is also responsible for updating the spreadsheet. They must visit the production area every two hours to visually analyze production progress (percentage). Thus, in addition to manually planning all orders on the factory floor, which is a cumbersome process, the planner also has to perform production control functions. This consumes a lot of the professional's time. Consequently, the process is not very functional and does not produce the expected results for the company, as delays in product delivery, high costs, poor traceability, and little production system control were observed.

V. Discussion

Observing the workflow of the production planning process and visualizing it through the flowchart allowed for the identification of several significant flaws arising from the use of the FO-163 spreadsheet. The identified flaws are as follows: (a) difficulty in visualizing the lead time of orders; (b) cumbersome manual allocation process; (c) exhaustive replanning process; (d) low efficiency in production control; (e) limited visibility of allocated orders; and (f) lack of system occupancy analysis. The following is a descriptive exposition of these flaws.

Difficulty in Visualizing Order Lead Times

The planner can visualize the lead time of individual orders in the FO-163 spreadsheet by comparing the end date/time with the start date of the first production operation. However, as the influx of orders increases, the tool does not provide the necessary traceability for the planner to track the progress of each order's operations.

One possible solution would be for the planner to record the lead time of each order in another document, allowing for visualization of the planning for all processes in the pipeline. However, due to the complexity of the production method studied, it is known that replanning is a daily routine in the company. Therefore, when faced with the need for replanning, this solution becomes unfeasible, as it would require recalculation of all product lead times and manual reallocation of all operations of the resources involved, which would be a very time-consuming and costly process.

Cumbersome Manual Allocation Process

The production planning for a sales order requires, after establishing its priority index, the planner to allocate each operation individually to the respective production resources, meaning entries must be made in the corresponding column of the spreadsheet. This process is time-consuming, as it requires inspecting each column, examining the position of the allocated operation, among other tasks.

This can be operationalized in production centers that deal with few orders associated with few operations. However, in the researched company, as the number of orders to be allocated grows, the difficulty increases progressively, leading to a reduction in planner productivity and an increase in planning process costs.

Exhaustive Replanning Process

In the jobbing production method, there is a wide range of products that can be produced using the available factory resources. Since there is no standard product, the engineering department in PPC necessarily needs to develop an operation route for each fulfilled sales order. Thus, the manufacturing process is more susceptible to errors and issues, resulting in frequent replanning and rework.

Low Efficiency in Production Control

Regarding production control, the FO-163 electronic spreadsheet is inefficient because it consumes a lot of the production planner's time, who must collect visual data on the progress of each ongoing operation throughout the day. Consequently, there is a reduction in productivity in the actual production planning task, leading to increased costs for the company.

Limited Visibility of Allocated Orders

Having good visibility of sales orders in the factory is essential for capacity analysis, system occupancy level, and decision-making on outsourcing operations. Thus, for the investigated company, the FO-163 tool is limited because it only displays two operations in the viewing window for each resource, making it difficult to conduct a comprehensive analysis of the entire planning.

Lack of System Occupancy Analysis

The analysis of system occupancy with allocated orders is one of the most important functions of the production planning routine for several reasons: (a) it provides technical criteria for the planner to make decisions such as production shift duplication, order outsourcing, workforce hiring, among others; (b) it provides arguments to the Sales department regarding possible refusal of orders with unfeasible deadlines; (c) it allows the Budget department to explore better prices, generating greater results for the company. When the system's capacity is better evaluated, the deadline fulfillment level improves, even with demand peaks; thus, system occupancy analysis ends up playing a strategic role.

Through the FO-163, this analysis is unfeasible, and thus, it is not performed by the production planner. To perform it, the professional would need to individually sum the scheduled time for each operation in each production resource, which would be a time-consuming and unproductive process, especially with many orders in the pipeline.

As clarified, the FO-163 tool does not meet the organization's strategic objectives, necessitating the formulation of a new planning process.

Suggestions for Mitigating Identified Flaws in the Company's Production Planning

Considering the results obtained in identifying the flaws in the production planning process adopted by the company, it is necessary to present procedural alternatives that can mitigate the deviations and contribute to achieving the organization's goals and objectives. The Production Planning, certainly, has important contributions to make in this regard. The results of the analyses combined with the principles of the PDCA cycle allowed the elaboration of some corrective actions to mitigate the observed flaws in the company's production planning.

The table 2 presents the proposal, which has already been evaluated by the company's managers, approved, and is in the implementation phase.

Table no2: Corrective Actions for PP, according to PDCA.

Problem	Measures	Check	Corrective Action to be Implemented
Difficulty in visualizing lead-time of orders	Sequencing operations on resources simply and dynamically.	Found that the need for replanning makes the use of the FO-163 spreadsheet unfeasible for lead-time recalculations.	Develop a function in Tekla that provides all orders in the pipeline, along with their start date and estimated end date, based on the total programmed time of their operations.

Cumbersome manual allocation process	Use of hardware to directly feed the ERP system, to provide real-time information on the progress of planned operations in production.	Found that allocating each operation to the proper production resources is laborious and costly.	Program, in conjunction with the IT department, hardware to directly feed the ERP system, providing real-time information on the progress of planned operations in production.
Exhaustive replanning process	Evaluation of the need for replanning or rework due to non-conformities, or adjustment to meet delivery deadlines.	Found that in jobbing production, the manufacturing process is prone to errors and the FO-163 does not assist in replanning.	Develop the 'Production Sequencing' function in Tekla, allowing for simple and objective replanning/sequencing of each resource in the factory.
Low efficiency in production control	Automation of information on sequenced operations in the production sector and presentation of data on task progress compared to the plan.	Found limitation of the FO-163 spreadsheet because it requires visual data collection on the progress of each operation.	Provide GERTEC pointing keyboards in production that allow for the start and end of each task to be recorded, as well as real-time analysis by PPC of the times executed.
Limited visibility of allocated orders	Development of a screen allowing visualization of allocated operations and the total number of hours programmed on a given resource.	Found another limitation of the FO-163 spreadsheet because it does not allow good visibility of the company's sales orders.	Develop a screen/function that allows all allocated operations and orders and the total number of hours scheduled on a given resource to be displayed.
Lack of system occupancy analysis	Development of a screen allowing visualization of allocated operations.	Found that the FO-163 spreadsheet is unfeasible for providing data for analysis of system occupancy in production.	Develop the "Factory Load" function, a screen that allows all allocated operations and the total number of hours programmed on a given resource to be viewed.

VI. Conclusion

Throughout this study, it was possible to describe how the jobbing production process occurs, which involves non-standardized products, often resulting in re-planning and rework due to necessary adjustments to meet customer requirements.

The mapping of the production process allowed us to understand and identify the main flaws that impact both PP and production control in the researched company. Six flaws resulting from the use of the FO-163 electronic spreadsheet were identified, which, due to its limitations, cause: difficulty in visualizing the lead time of allocated orders; the need for some procedures involving visual data verification on the shop floor, making the process slow and costly; wear in the replanning process; low efficiency in production control; little visibility of allocated orders; and the absence of analysis of the production system's occupancy, which also negatively impacts other sectors of the company.

In turn, the use of the PDCA management tool allowed us to suggest corrective actions for these flaws, by better utilizing the existing ERP in the company, with the addition of hardware and software that can enhance the automation of processes related to production planning - previously manual, slow, and costly - bringing agility, data integration, and information reliability. For this, the participation of the IT department is necessary to develop programs that meet the needs of planning and controlling the jobbing production process adopted by the company.

As future results, greater productivity gains, reduction of variable costs, and faster product delivery are expected, aiming for customer satisfaction. The expectation is that the company will progress in terms of quality and reliability of supply to its customers, thus achieving its organizational strategic objectives.

The limitation of the study concerns the results found, which, reflecting only the context of the studied company, cannot be generalized.

For future work, it is recommended that the company, through the existing production control system, further analyze the productivity data of machining operations.

Authors' Note: The Portuguese version of this article was presented during the X International Symposium on Management, Projects, Innovation, and Sustainability (SINGEP) in São Paulo (SP), held by Universidade 9 de Julho (Uninove) in 2022. The text underwent updates, received new editing, and was translated into English with the help of Artificial Intelligence.

References

[1]. Avelino, A. (2005). Qualidade No Processo De Produção: Um Modelo De Gestão Para Garantir A Qualidade De Acabamento Das Carrocerias Em Chapa Na Linha De Produção. Dissertação De Mestrado. Escola Politécnica, Universidade De São Paulo, São Paulo, Brasil. Disponível: Https://Repositorio.Usp.Br/Item/001494214.

[2]. Azevedo, I. C. G. (2016, Setembro). Fluxograma Como Ferramenta De Mapeamento De Processo No Controle De Qualidade De Uma Indústria De Confecção. Apresentado No Xii Congresso Nacional De Excelência Em Gestão. Rio De Janeiro, Brasil. Disponível Em: Https://Www.Inovarse.Org/Sites/Default/Files/T16_M_024.Pdf.

[3]. Barreto, P. F. M., Bristot, V. M., & Guimarães, L. P. Filho (2017) Importância De Um Sistema De Planejamento E Controle Da Produção Em Uma Indústria De Tintas. In: Revista De Iniciação Científica. Criciúma, Rs, V. 15, N. 2, P. 16-33. Disponível: Http://Periodicos.Unesc.Net/Iniciacaocientifica/Article/Download.

[4]. Chiavenato, I. (2014). Gestão Da Produção: Uma Abordagem Introdutória. 3. Ed. São Paulo: Manole.

[5]. Gerhardt, T. E., & Silveira, D. T. (2009). Métodos De Pesquisa. Porto Alegre: Ed. Ufrgs. E-Book. Disponível: Https://Lume.Ufrgs.Br/Handle/10183/52806.

[6]. Gislon, L. (2012). Planejamento E Controle Da Produção: Gestão De Demanda E Estoques. Monografia. Universidade Tecnológica Federal Do Paraná, Ponta Grossa, Paraná, Brasil. Disponível: Http://Repositorio.Roca.Utfpr.Edu.Br/Jspui/Bitstream/1/1442/3/Pg_Cegipm_Vii_2012_14.Pdf.

[7]. Mainardes, W.E, Lourenço, L, & Tontini, G. (2010, Maio-Agosto). Percepções Dos Conceitos De Qualidade E Gestão Pela Qualidade Total: Estudo De Caso Na Universidade. Revista Eletrônica De Gestão Organizacional, Lisboa, V.8, F.2, P.279-297. Disponível: Https://Www.Researchgate.Net/Publication/235341591_Percepcoes_Dos_Conceitos_De_Qualidade_E_Gestao_Pela_Qualidade_Total_Estudo_De_Caso_Na_Universidade

[8]. Mariani, C. A.(2005) Método Pdca E Ferramentas Da Qualidade No Gerenciamento De Processos Industriais: Um Estudo De Caso.In: Innovation And Management Review, V. 2, N. 2, P. 110-126. Disponível: Http://Www.Spell.Org.Br/Documentos/Ver/26326/Metodo-Pdca-E-Ferramentas-Da-Qualidade-No-Geren

[9]. Mendonça, M. (2011). Qualidade Total. [Apostila]. Universidade Federal Do Amapá: Unifap. Disponível: Https://Www2.Unifap.Br/Mariomendonca/Files/2011/05/Qualidade-Total11.Pdf.

[10]. Miyake, D.I. (1993). Programas De Melhoria Da Produtividade E Qualidade: Um Estudo Comparativo Dos Modelos "Just-In-Time" (Jit), "Total Quality Control" (Tqc) E "Total Productive Maintenance" (Tpm). Dissertação De Mestrado - Escola Politécnica, Universidade De São Paulo, São Paulo, Brasil. Disponível: Https://Www.Teses.Usp.Br/Teses/Disponiveis/3/3136/Tde-11072017-100205/Publico/Darioikuomiyake_D.Pdf.

[11]. Nunes, J. L. T., Serrano, S., Belusso, M., & Paula, R. (2018). Melhoria Do Processo Produtivo Por Meio De Otimização De Processo De Envase. Anais – Engenharia De Produção, V. 2, N.1. Disponível: Https://Uceff.Edu.Br/Anais/Index.Php/Engprod/Article/View/202.

[12]. Peinado, J., & Graeml, A. R. (2007). Administração Da Produção: Operações Industriais E De Serviços. Curitiba: Unicen

[13]. Santos, P. F. (2017). Estudo Da Gestão Da Qualidade Total E Sua Influência Na Produtividade Industrial. Trabalho De Conclusão De Curso. Universidade Tecnológica Federal Do Paraná, Ponta Grossa, Paraná, Brasil. Disponível: Http://Repositorio.Roca.Utfpr.Edu.Br/Jspui/Bitstream/1/7891/1/Pg_Ceep_2016_1_17.Pdf.

[14]. Silva, R. A., & Silva, O. R. (2017). Qualidade, Padronização E Certificação. Curitiba (Pr): Ed. Intersaberes. Disponível: Https://Www.Sebraeatende.Com.Br/System/Files/Conheca_As_Principais_Ferramentas_De_Gestao.Pdf.