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ScienceDirect

Procedia Computer Science 219 (2023) 889–896

Procedia Computer Science

www.elsevier.com/locate/procedia

CENTERIS – International Conference on ENTERprise Information Systems / ProjMAN – International Conference on Project MANagement / HCist – International Conference on Health and Social Care Information Systems and Technologies 2022

Development of tools to support the production planning in a textile company

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Abstract

Technologies are constantly evolving and so with advances in industry 4.0, its intelligent technologies with production planning and control (PPC) give rise to a smart PPC. Nowadays, one of the fundamental systems in a company is the ERP, since it allows the integration of various information from the different areas belonging to an organization, which allows access to data in real time, among other things. Through a work carried out in a textile company, it was noticeable the need to develop a tool to support its installed ERP system and the respective data control. Thus, it is noted that PPC systems, which include the integration of all areas of a company, must be adapted to its environment, work method and characteristics. With the application of this tool, it was possible to perceive an increase in efficiency and speed in obtaining the desired results, being that it is still under development and could evolve even more.

Keywords: Production planning and control; industry 4.0; ERP system; smart technologies; support tool; textile

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Peer-review under responsibility of the scientific committee of the CENTERIS – International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies 2022
10.1016/j.procs.2023.01.364

1. Introduction

Production Planning and Control (PPC) is a very complicated task for each one of the production stages. In addition, the textile area, with its characteristics, transforms the planning into something even more complex, as it includes different types of fibers, raw materials, chemicals, various operations, methods, and a variety of final products. All these factors, combined with customer requirements for short delivery times, product quality and fulfillment of orders, contribute to complicate the planning process [1].

PPC is extremely important for a good performance of the production system. This consists in defining which products to carry out, when, and the quantities needed, and can also make the necessary corrections, if there are significant deviations from what was planned to what was produced [2]. The PPC plays the role of coordinator, plans orders, program the operations and controls the various factors of production [3,4].

The most common PPC systems are slow, static, difficult to proceed any changes and do not provide up-to-date information in real time about production operations. With the advances that have been emerging in technology and with industry 4.0, it is intended that they help improve PPC, making it more efficient. Smart PPC is the integration of emerging industry 4.0 technologies and resources with PPC processes to improve the performance of production systems, enabling real time decision making based on continuous data from multiple sources [5,6].

2. Information systems

2.1. Industry 4.0

Industry 4.0 stimulates the evolution of autonomous production systems with the utilization of various technologies, it shows the integration of traditional manufacturing systems with new IT (Information Technology) systems [7]. It should be carried out by the aggregation of a set of emerging technologies, such as Cyber-Physical Systems (CPS), Internet of Things (IoT), radio frequency identification (RFID), big data, artificial intelligence, smart sensors, cloud computing, new network technologies (5G), 3D printing, additive manufacturing, among others [8,9].

With vertical, horizontal, and end-to-end integration, industry 4.0 is expected to change manufacturing industries and increase their productivity by up to 55%, and their profit by up to 15% [8].

This new era has brought many advantages to companies, providing greater productivity, flexibility, responsiveness, and environmental performance. Besides that, they reduce setup times, increase process dynamics and system reconfiguration, which in turn can manage to reduce costs and waste, increase the reliability of production systems and yield quality, and contribute to the improvement of sustainability and the efficiency of operations. Data from various technological equipment can be accessed and analyzed to upgrade the sustainability of production operations, contributing/collaborating to the reduction of energy consumption and the use of raw materials, emissions, and a consequent reduction of environmental impact throughout the product life cycle [10–12].

Innovations coming from industry 4.0, can create new opportunities for PPC and as this is one of the main functions of the production system, it can be affected by new smart tools and change. Some production management functions, including PPC, can be modified using digital technologies, turning these into more integrated and automated functions [13,14].

2.2. ERP

With the elapsing of time, there has been a great global development, and, to face the market demand and its competition, companies must keep up with the technological evolution. To this end, they recognize the importance of implementing an integrated information system.

Enterprise Resource Planning (ERP) is a system used regularly for the integration and automation of existing processes in an organization, to increase efficiency and profits, using only a single database. This system collects data from all functions of a company, providing the entire company with information with a broader perspective, real time data and relevant information, to be able to carry out a good management of the organization [15].

Five dimensions of benefits were identified: operational, managerial benefits, strategic, IT infrastructure and organizational. However, the direct benefits are the simplification of operations and agility in the decision-making process [15,16].

In general, the implementation of an ERP system is very complex, lengthy, and expensive process which requires a continuous change in the organization and consumes a lot of resources, once it must deal with a very unpredictable environment, expanding markets and increasing customer requirements. The main phases of the ERP implementation process are planning, implementation, stabilization and upgrading [16].

The selection of ERP set is a crucial step, as your choice must meet the needs and requirements of each company. If the decision is based on an inappropriate set for the company, which does not conform to its characteristics, the implementation of the system may be subject to high customizations [17], so, it is essential, during the selection phase, to rigorously analyze the current processes, before combining the company's requirements with the characteristics and functionalities of the potential system [18].

2.3. Smart Production Planning and Control

PPC allows defining what, when and how much to produce, buying and delivering to the customer, so that the organization adapts its production performance to customer needs [19].

The production systems, in addition to being a support in decision making, are also a source of task automation. These new investments in technologies provide the opportunity to create a smart PPC, which allows for dynamic, integrated production planning and control with real time data [20,21].

A company's PPC has the function of coordinating and using the company's available resources. Ensuring that there are always the resources or materials that are needed to produce your products, with the view to satisfy customer demand. In the day-to-day work, it is essential to make decisions, some of which are at the planning level, and others at the level of production control [20].

The development of industry 4.0 came to provide a connection between resources, services, and people in real time [22]. PPC includes several systems (integration of various information) such as MRP (Material Requirements Planning), MRPII, ERP, MES (Manufacturing Execution Systems), APS (Advanced Planning and Scheduling). Thus, smart PPC results from the meeting of industry 4.0 resources and technologies with PPC [20].

The smart PPC mainly comprises four essential elements: real time data management, dynamic production planning and replanning, autonomous production control and a continuous learning [22,23].

Real time data management consists of tracking, collecting, analyzing and protecting data from external sources (for example, customers and suppliers, etc.) and internal sources (such as, changes in stock, events on the shop floor, among others) in real time, which is essential to provide an adaptable and responsible planning, programming and execution system [23]. To constantly analyze the current situation, it is essential that these data are concise, allowing to obtain the necessary information at the necessary moment. Having access to real time updates, data facilitates workers' decision making in the preparation and execution of the PPC, as well as in its dynamic replanning (if it is necessary) [24].

In a market more and more uncertain and competitive, it is necessary to know how to deal with sudden changes in the work environment and in customer requirements. The smart PPC permits that a company has the ability to respond quickly to certain unexpected changes that may happen before and/or during the production process, in order to prevent errors. It is necessary to have good dynamic programming and reprogramming ability to automatically deal with these adversities. Dynamic planning can be efficient, provide a reduction in labor costs, increase the speed and responsiveness of production, and improve product quality control [20,22,23].

Production control translates into certifying that the plan and schedule defined for production are, in fact, well executed. With autonomous control, it is intended to improve the performance of production systems.

Advanced technologies can be used to support control systems in solving problems in real time, getting greater flexibility, robustness, and reliability, which makes it possible to expand the application of autonomous production control. Despite the strong evolution and the bet on technologies, some human intervention is always necessary, because many decisions in PPC must be taken by specialists and based on their experience. As technology is constantly developing, the human being, to be able to follow this progress, must have access to continuous learning that enables the growth of "digital thinking", to make smarter, faster, and more accurate decisions [20,25].

There are some variables that can impact the need for smart PPC. The variables are divided into 3 categories: products, market, and process (Table 1).

Table 1. Variables with impact on smart PPC [6,20].

Category	Variables			
Product	Product complexity	Product variety	Product life cycle	Product volume variability
Market	Delivery lead time	Delivery lead time variability	Demand variability	Inventory management
Process	Process lead time	Process flexibility	Process complexity	Supply variability

3. Support tool for a computer system

To achieve greater efficiency in production and aiming to optimize the planning process, the opportunity to develop a tool to complement the PPC system emerged, and this tool was developed based on information from a textile company located in the north of Portugal.

3.1. Planning process

The company analyzed presents a vertical production and has a long and complex production process. This type of organization has more flexible processes, providing shorter lead times, optimization of processes and production costs. With this, it can have greater visibility regarding the supply of raw materials, chemicals, etc., leading to the obtention of an added value in the products.

In this situation, the production process of the company has its origins in spinning, passing to the dyeing, twisting, weaving and, finally, finishing obtaining the final product, which is the tissue. This is the process which the product goes through, undergoing through changes and in which value is added.

The planning process is carried out in ~~reverse~~ make-to-order. It all starts with the receipt of a customer's order, where the material, color and quantity required are specified, as well as the delivery date. The delivery date is based on the available occupation of each area, and the production needs for each area are generated from the database. This information is placed in the company's ERP system, which, in this case, is SAP, and the system itself provides the dates, quantities and generates the necessary production orders for each area to satisfy the customer's order. The date informed to the client triggers dates for each of the company's production areas, dates that consider pre-defined assumptions in SAP, such as setup time, machine speed, efficiency, percentage of non-quality, among others. About quantities, these are obtained through the BOM (Bill of Materials) supplied in the system for each one of the produced materials.

3.2. Problems and the solution

The company distinguishes 2 types of production with different lead times. While the production of yarn dye takes between 6 to 8 weeks to fulfill the order, piece dye production takes around 4 to 6 weeks to fulfill the entire order. The organization has some key customers who are considered more important due to the volume of invoicing, these same clients are the ones requiring very tight delivery dates. To comply with these delivery dates, a production order starts to be planned in the SAP system, yet it can't be used the planning dates given by the planning tool as those dates will not be according with the requested one's by the customer. In these cases, it would be necessary that the planning of these orders is carried out manually, getting the start and end dates of production in each area, and the necessary quantities of materials per day, to be able to match the desired order production and its required delivery dates. In addition, being a manual activity, this information is communicated via email or phone call, by which can there be a loss of information in some of the parties, and decision-making is carried out with greater difficulty.

To solve this situation, one of the first ideas would be to change the dates, however, the final date defined with the client, and the dates that appear in the system automatically, cannot be adjusted, they are fixed. In turn, it was found that this planning method is not ideal, and therefore it would be necessary to create a tool linked to the ERP (SAP), so that this entire planning process becomes almost automatic. This will facilitate the planning, making it faster, and all the information will be available, so that all parts of the production process can easily access and follow.

3.3. Tool description

An explanation of the tool will be carried out using a diagram (Fig. 1) where it is explicit what information is needed for the tool to work and what data it returns.

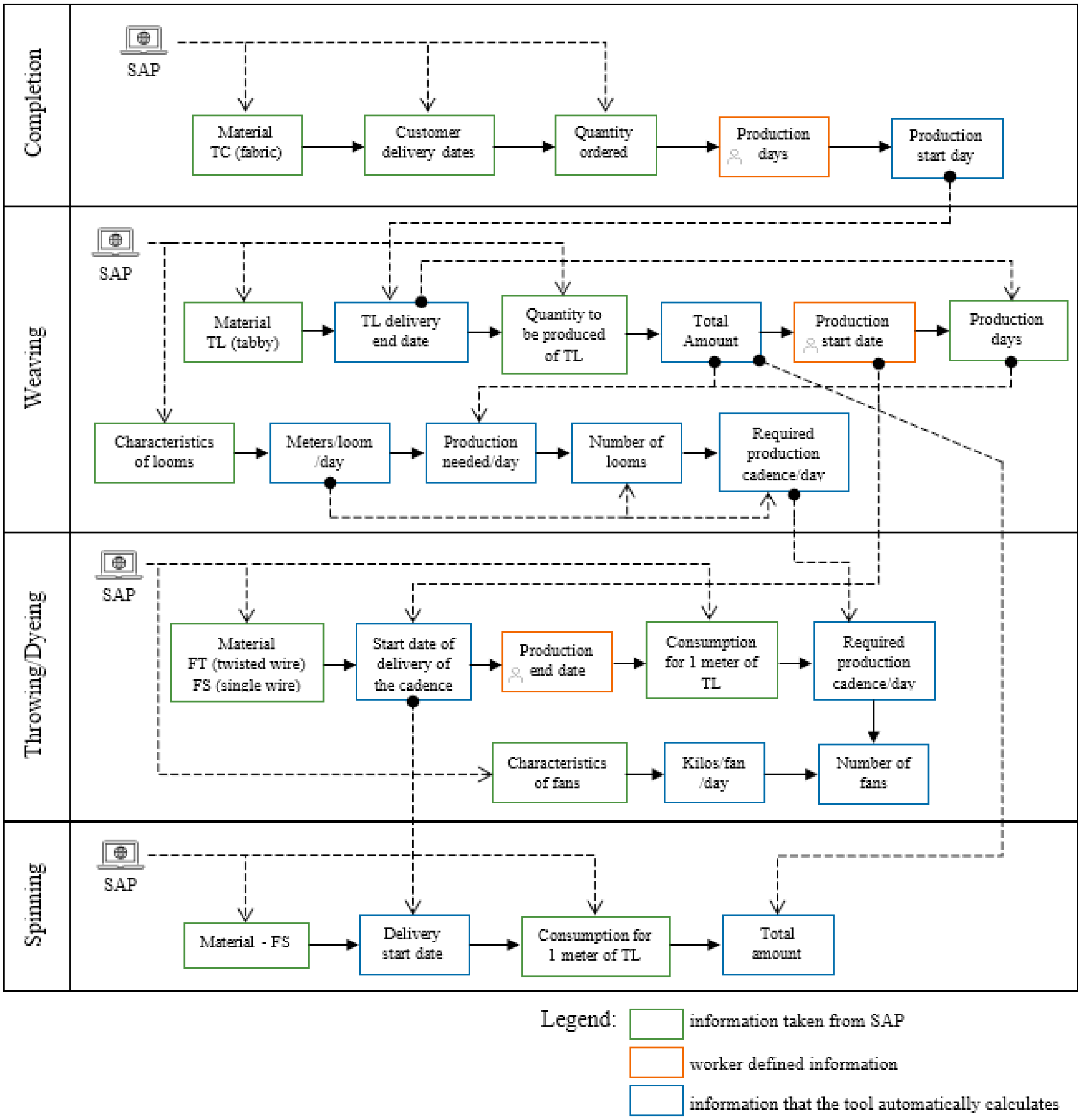

Fig. 1. Tool process diagram.

In the tool there are subdivisions according to the production areas, to obtain concrete data corresponding to each one of them. In this form of planning, different means are used to get the data so that the tool works correctly. One of the ways is through the responsible worker who must put certain necessary information in the tool, on the other hand, the tool provides data automatically based on information already present in the system. The data, in turn, can also be obtained through SAP, however, as this tool is not yet automatically connected to this system, it is necessary for the worker to go to SAP to collect this data and insert it into the tool.

Within the data collected in SAP and later placed in the tool are the final product (TC), the materials that make it up (TL, FT, FS), the quantities to be consumed, the delivery dates to the customer, the quantity ordered for each date delivery times and the specific characteristics related to the machines where the materials will be produced.

From information that are already in the tool and with the help of math formulas, the tool calculates certain data, such as the production start date on completion, the date by which the weaving has to deliver the entire quantity required for each respective delivery date and the date from which the twisting, dyeing and spinning have to deliver the established production cadence. Other data readily obtained are the total quantity to be produced in the weaving and spinning mill, number of days that the weaving company will have to produce, number of looms and fans needed to produce the entire order, quantity that a loom and a fan produce per day, and the quantity that weaving, twisting and dyeing must produce daily. As an example, starting from the total amount of meters woven in the weaving unit and the number of days they must weave, it is possible to obtain the number of meters that need to be weaved per day.

The responsible worker must enter several data such as, the number of days it takes to carry out the finishing operations, the production start date in the weaving unit and stipulate the production end date in the twisting and dyeing areas. In turn, with this tool it is possible to obtain a lot of information, but what matters most for production planning is the daily quantity to be produced, the production start dates for each production area and the number of looms and fans needed to fulfill with production.

In addition, a page was developed, which summarized only the relevant information for each of the areas, coming from the tool, being also a production control tool (Fig. 2). For each of the areas, it is provided the item to be produced, the production start and end dates, or the dates from which they must start delivering the material, as well as the quantities to be produced per day. To control the production, there is a column related to the quantity that was effectively produced, being this value an average in relation to the production days. This value is intended to be provided automatically from a SAP transaction. Subsequently, comparing this effective average value with the stipulated amount per day. Getting to carry out a daily control of production in terms of produced quantity and the number of machines that are working on the respective article.

Legenda:
Valor — Está a produzir a baixo do valor definido
Valor — Está a produzir dentro dos valores definidos
Data — Ainda não ultrapassou a data (não começou)
Data — Já passou a data (já começou ou já acabou)
Data — Dia atual (se for o próprio dia em que se encontra)
Data — Está atrasado (já devia ter iniciado a produção mas não tem nada produzido)

Data atual: 22/05/2022

	Acabamentos	Designação	Tecelagem	Data Inicio Tecel.	Data Fim Tecel.	Quantidade/Dia	Quant./Dia Real (média)	UM	Torcedura		Data Início Entrega	Quantidade/Dia	Quant./Dia Real (média)	UM	Tingimento		Data Início Entrega	Quantidade/dia	Quant./Dia Real (média)	UM	Fiação	Quant. Total	UM
1ª Data				10/05/2022	15/05/2022	2 440	2 261,40	M	FT030200531	TE	09/05/2022	500	502,70	Kg	FS042700126	TE	06/05/2022	500	520,14	Kg	FS042700001	7300	Kg
2ª Data	TC884300233	Pinot	TLD13400062	16/05/2022	22/05/2022	1 627	1 874,57	M	FT053400215	TR		520	495,38	Kg	FS064800073	TR		510	516,78	Kg	FS064800001	7 700	Kg
3ª Data				23/05/2022	29/05/2022	1 898		M															

Fig. 2. Production control example.

3.4. Development method

Before starting to develop this tool, it was essential to know the entire production process, to understand what errors could exist and what was missing, to facilitate planning, making it, in turn, more efficient. The tool has already undergone several modifications since its first structure version, and it may suffer a few more, once, when using it, new situations may emerge in which it will be necessary to adapt it.

Several tests were carried out in which, comparing with the results of manual planning, it was possible to verify that the results of the tool met the intended values and even improvements were verified with the use of this tool (Table 2).

Table 2. Comparison results between manual and used tool planning (test results).

Tests	Time to plan manually (min)	Time to plan with the tool (min)	Reduction (%)
Test 1	55	32	41,8
Test 2	65	40	38,5
Test 3	47	26	44,7

It should be noted that this tool was developed in an Excel file, but the objective is to move it to SAP, so that the PPC is realized from a single system only, and it is standardized all over the production sector. It is important to mention that the company's IT staff validated that there was no restriction in the implementing this tool in SAP, being the next step the effectively carrying out this transaction in the company.

4. Conclusion

The production planning, for the customers' orders which request for a shorter lead time, was treated outside the company's common system, being prepared manually. It became a long time-consuming process, as it was necessary to consult the ERP SAP to obtain the desired data, analyze and consult the other areas to obtain any additional information, and posteriorly still communicate what has been defined to each of the respective areas. This proceeding took about 1 hour to perform, with the developed tool, it was possible to reduce the time spent by approximately 50%. It appears that, with this new tool, the entire process becomes faster, more efficient, reducing the use of resources and time, since it has become an automated process.

In addition, there are also improvements in the communication, whereas, when performing the plan manually, none of the other collaborators had immediate and direct access to information and it would be necessary to transmit the data via email or phone call, taking more time and possible communication failures. With the use of the new tool, all collaborators have direct access to the same information, given that it is transversal to the entire company.

In certain cases, customers may want to extend or change delivery dates or may even occur a delay in the validation of the item by the client, which forces the company to update the plan and replan the order. This tool is so flexible and agile that it makes the replanning process much easier.

In short, this tool provides several significant improvements to the PPC process.

Acknowledgements

Thanks to the company Riopele - Têxteis, SA for the support and which allowed the development of this work.

This work has been supported by the Portuguese Foundation for Science and Technology (FCT) within the R&D Units Project Scope UIDB/00319/2020 (ALGORITMI).

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