Transdisciplinary Engineering Methods for Social Innovation of Industry 4.0
M. Peruzzini et al. (Eds.)

doi:10.3233/978-1-61499-898-3-993

Key Inefficiencies and Improvement Opportunities in the Textile Sector: A Case Study

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Abstract. The textile sector in Portugal has a relevant economic and social importance. In this sector, dyeing and finishing are a significant part of the value chain of a textile product and the majority of companies are SMEs, lacking specialized human resources. Most of these companies have human and technological resources necessary for a smooth operation, however, they may lack management resources that allow efficient performance of the dyeing/finishing processes. The objective of this work is to highlight the organizational inefficiencies of a SME in a dyeing and finishing textile company, in Portugal, identifying their wastes, and improvement opportunities, highlighting the barriers and obstacles to the adoption of quality management and lean manufacturing principles. This paper presents the diagnosis of the performance of an SME in the textile sector, in Portugal. Through a case study, identifies key inefficiencies and wastes, documents the dyeing and finishing process, and detects problems using Quality and Lean tools. These inefficiencies can be translated by productivity losses or an increase of operational costs making the company less competitive. To overcome these problems and to improve production process performance, improvement suggestions were developed.

Keywords. Dyeing and Finishing Process, Lean Manufacturing, Organizational problems, Quality Improvement, Wastes.

Introduction

The textile and garment industry (TGI) is one of the most important industries for Portuguese economy, accounting for around 10% of total Portuguese exports and 20% of manufacturing employment. Despite the challenges and difficulties that this sector has experienced in the last decades, caused by the liberalization and globalization of markets [1], which has brought down protectionist barriers and exposed companies to global competition, TGI in Portugal has in recent years been gaining relevance at national and European level. Additionally to these challenges and difficulties, the TGI is strongly influenced by seasons, trends and changes in fashion and climate, having to meet the constant changes in demand in a short period of time. Many of these companies did not resist this new marking context and others had to adopt new management paradigms and undertake deep restructuring processes.

In the TGI restructuring that has been taking place all over the world, competitive capacities such as innovation, design, and speed of response emerge as the main factors

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of profitability [2]. Other factors such as efficiency and effectiveness of processes and quality of products/services have been shown to be equally important for the competitiveness of this sector. In textile sector, dyeing and finishing are a significant part of the value chain of a textile product and the majority of companies in Portugal are SMEs, lacking specialized human resources that allow efficient performance of the dyeing/finishing processes, and an environment favorable to innovation and to productivity and competitiveness improvement of the ever-changing industry. Indeed, these SME are currently facing high pressure to perform in terms of operating efficiency and quality. There is a need to improve the performance of these companies, even if they are small in size, have few resources or have low quality maturity levels [3, 4].

Innovative production concepts, as well as high performance technologies are needed to improve cost and time factors in order to keep up with international competition. Thus, the main objective of this work is to highlight the organizational inefficiencies of a SME in a dyeing and finishing textile company, in Portugal, identifying their wastes, and improvement opportunities, highlighting the barriers and obstacles to the adoption of quality management and lean manufacturing principles.

The paper is further organized as follows: Lean manufacturing principles and practices in SME, and barriers to JIT production are described briefly in literature review section. Research methodology is described in methodology section. The following section aims at a brief description of the case study company, a diagnosis of the current situation of the company is made and improvement proposals are presented. Finally, the main conclusions and barriers to implementation proposals are exposed.

1. Literature review

An organization can be viewed as a system, interconnecting all its functional areas to optimize them and achieve competitive advantage [5]. Organizational performance assessment should be based on the philosophy of continuous improvement, not only measuring current processes performance. Thus, the need to evaluate companies' performance with regard to their products and processes emerges so that indicators analysis could provide suggestions for improvement opportunities. It also allows identifying what works and what does not, knowing the causes and conditions that justify this non-functioning [6].

Performance measurement refers to the quantification of the action. However, [7] emphasize the difficulty that managers may have in choosing performance measures, so they suggest a design of a measurement system. The use of information technologies can promote a dynamic system of performance measurement in the search for continuous improvement [8]. To promote this approach of finding problems, its causes and solutions it is necessary that employees create habits or routines of continuous improvement, becoming an usual task embedded in other "regular" functions. This can contribute to discover new and different ideas [9].

An organization can be viewed as a self-regulating control system where data is collected, analyzed and compared to a performance standard allowing sources of customer dissatisfaction to be reduced or eliminated [10]. Quality control, applied to both the process and the product, is supported by the principles of Total Quality Management (TQM) - a philosophy driven by continuous improvement.

Continuous improvement concept approximates productivity and quality perspectives and was a key agent in the success of Japanese production [11]. In this way, activities must be aligned to produce significant effects on results, as well as involving employees to improve knowledge management [12]. TQM uses multiple tools associated with the control and evaluation of processes from which the so-called basic quality tools stand out. In addition to these tools, it is worth noting the growing assertion of Lean practices in various industry sectors.

The frequent use of Quality and Lean tools contributes to efficiently improve companies' performance [13]. Dynamic work routines and standard operations, frequently improved and updated in search of a lean organization can result in waste reduction and reduction of non-value-added activities [14].

Lean manufacturing involves a variety of principles and techniques, whose objective is to eliminate waste and non-value-added activities at every production or service process in order to bring the most value to the customer. The idea of waste elimination is to review all areas in organization, determine where the non-value added work is and reduce or eliminate it. Waste is all that does not contribute directly to add value to the product, from the perspective of the customer, having been identified by [15] and explained that waste is sometimes hard to see, but can be classified by: overproduction, waiting, transportation, over processing, inventory, movement and defective products. For the identification/elimination of these wastes, Lean proposes several practices, techniques and tools, which can be presented as follows:

- *Quality methods and Tools*: Jidoka, Poka-yoke, Lean Six-sigma, Basic quality tools (Pareto Chart, Fish Born Diagram, Histogram, Control charts, Scatter Diagram, …)
- *Improvement methods:* PDCA, Kaizen, VSM (Value Stream Mapping)
- *Just in time:* Kanban, SMED (Single Minute Exchange of Die)
- *Visual management:* 5S, TPM, Andons
- *Standard Work*: Work sequence, Takt time, Cycle time, Job element sheets.

Lean manufacturing is a strategy that does not require a large investment in automation or information technology, nor requires employees with advanced analytical training, and can be implemented in both large and small companies. Lean manufacturing techniques can be the primary methods for improvement [16, 17].

Despite the proven benefits of Lean manufacturing for many companies around the world, difficulties and barriers to implementation are also known [17, 18] point out that of the two pillars of the Lean (JIT and Jidoka), JIT is the one that faces many challenges or barriers even though it offers benefits such reduction in inventory holding cost, reduction in space requirement and lead time reduction. Krafcik [19] draws attention to the inherent risks of Lean management policies, which must be managed with discipline and skill, and that these risks can be neutralized through the training of work teams, projects to obtain quality products and a network of high-performance suppliers. Resistance to change by both management and shop floor workers was most often cited as a barrier to implementing Lean.

An informal survey of practitioners of Lean manufacturing revealed that changes to the production environment have only a 30% success rate, and 70 % of lean implementations experience decay and return to the original way of doing business [20]. In a study carried out in SME, in Iran, identifies the main barriers in the implementation of Lean manufacturing principles in Iranian SMEs [21]. As a result, the main barriers were classified into four categories namely: lack of top management support, financial capability, lack of employee’s skill, and expertise and organizational culture. Jadhav *et al*. [18] provide the details of JIT/Lean Barriers falling in related manufacturing practice areas for a High-Performance Manufacturing company.

2. Methodology

This study was carried out in an SME textile dyeing and finishing in Portugal, within the scope of a curricular internship of the master's degree in Engineering and Industrial Management. One of the authors of this work was in the company full time for 9 months to carry out an in-depth diagnosis of the dyeing and finishing processes in order to achieve an understanding of the organization's opportunities and operational challenges. In that period, the researcher had access to a large set of company data (relating to customers, suppliers, operating times, technical restrictions, procedures and operating routines ...), freedom of movement on the shop floor, and opportunity to attend work meetings of the company. Frequent brainstormings with employees directly or indirectly involved in the process were useful for understanding the process, identifying wastes and opportunities for improvement, and defining improvement measures/actions to implement.

3. Case study

3.1. Company Characterization

The company associated with this study is considered an SME and belongs to the textile sector (Figure 1).

Figure 1. Value-adding chain of a textile product.

The company has about 100 employees and works 24 hours a day, 5 days a week, producing dyed and finished knitwear for the garment industry. Most of the employees are males (83%), and about 60% are between 30 and 50 years of age. The level of schooling is low, 45% of people have the 9th grade or less, and only 6% have a bachelor's degree. The production unit is composed of two production sections: dyeing and finishing. Jersey, rib, interlock and American and Italian plush are the most dyed and finished knit types in this company.

3.2. Dyeing and finishing process

The production process takes place in four functional areas: reception and preparation of the raw material (knitting), dyeing, finishing, and quality control. Figure 2 shows the flowchart of the production process in more detail.

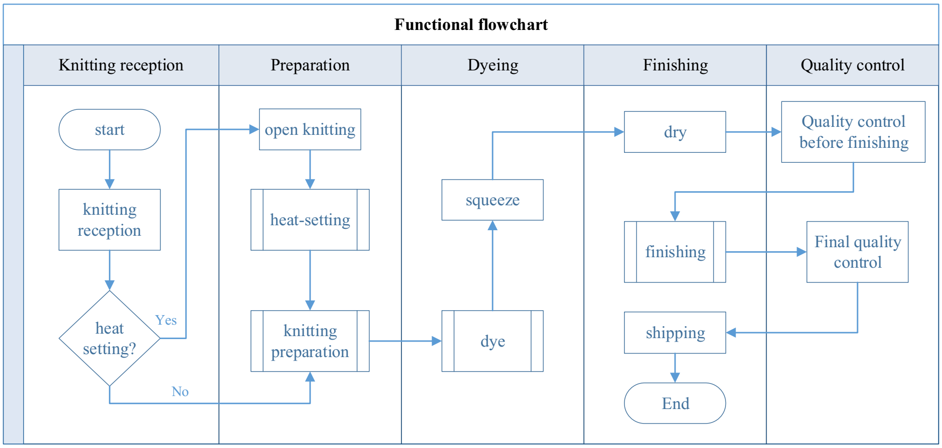

Figure 2. Dyeing and finishing production process.

The information flow of the company related to the management of the production process is supported by a computer system that is complemented by others throughout the entire production process of the company. This Integrated Management System for the Dyeing and Textile Finishing Industry aims to interconnect the different departments and functional areas, allowing different functionalities, namely, the management of customer orders, company Service Orders (SO), chemicals, quality control tests, etc. There are other software programs used to creation shipping guides and transport guides, etc., for the complete control of the work done in the laboratory. Other existing programs manage the flow of information of the Accounting Department, assist in receiving the raw material, weighing it and recording other relevant information.

The dyeing and finishing process is subordinated to the proper functioning of the equipment, which requires high levels of reliability and availability. So, machines need regular maintenance of various components and parts, depending on the period and frequency of use, action time, process specific requirements or a combination of these to perform at the highest level.

3.3. Diagnosis of the current situation

This diagnosis is related to the identification and quantification of wastes related to the machines and equipment used in the production process, with the procedures, and with the collaborators, to be able to recognize improvement opportunities. For this purpose, data related to management functions and technical functions were analyzed, namely: customer complaints/returns data, performance of the dyeing finishing process, color nonconformity, and ink solidity to washing. In this diagnosis, quality and Lean tools were used, which proved to be useful.

The study of customer complaints/returns is a good starting point for evaluating the quality of a company's products or services. Thus, a special highlight was given in this study to the returns registered in the company in the period 2013-215. Using performance indicators (PIs), the process performance was evaluated, thus allowing opportunities for improvement to be identified. To identify all activities in the value chain of the product that add value and do not add value to the customer, from the receipt of the raw-material until delivery to the customer, a Value Stream Mapping

(VSM) was developed. It is a simple way to observe the flow of information and materials to later create a future perspective of a better performance of the production process. The VSM allowed us to identify aspects such as value-added ratio, cycle time and Work-In-Process (WIP) [22]. Since the dyeing and finishing process is performed by batch, Work-In-Process (WIP) is tended to be high. Bad planning, reworking and machines shutdown by failure contribute to high WIP in this sector.

3.3.1. Returns

Regarding the analysis of returns in the period from 2013 to 2015, their weight was analyzed, as shown in Figure 3a. Thus, the trend of return per year tends to increase, attracting the attention of top management to this fact. With regard to returns per ton shipped (Figure 3b), the same tendency is apparent, meaning that the weight of the returns from customers on the quantity shipped has increased - a behavior that may continue in the coming years, according to the trend line. For this reason, it is important to study this problem.

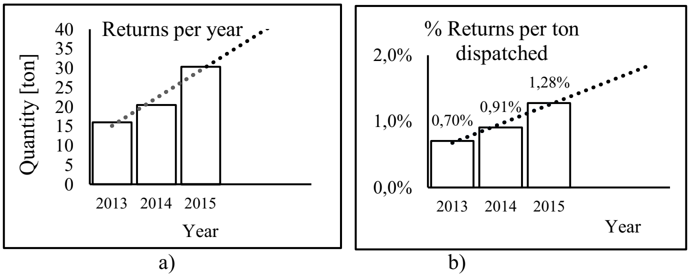

Figure 3. Costumer returns: a) returns per year; b) returns per ton dispatched.

A more detailed analysis of returns/complaints allowed identify the nonconformities that motivated them. In Figure 4, a Pareto chart is presented with the main motives evoked by customers for returns.

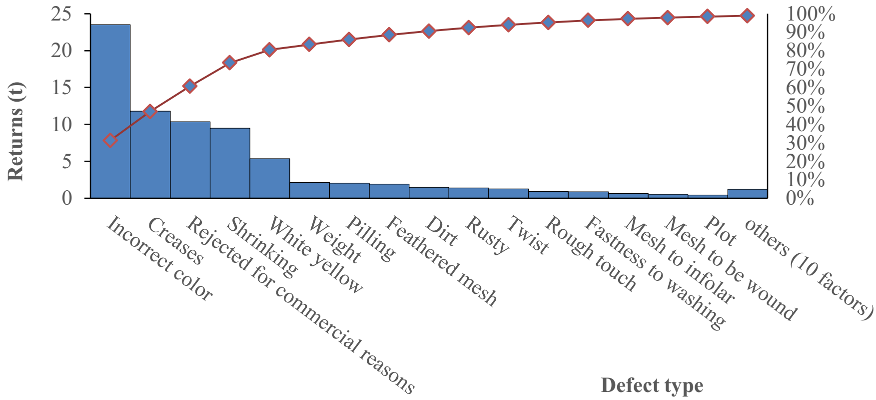

Figure 4. Returns by defect type in the period 2013-2015.

The most notable nonconformity is the incorrect color, with around 31% of total returns. The five most frequent defects (of a total of 38 defect types identified in the company) explain about 80% of the returns, corresponding to about 60 tons of returned product during the three years.

Among the problems identified, the difficulty in obtaining the desired color with the first dyeing is highlighted. The reproduction of the recipe in the dyeing section presents a deviation from that which is elaborated in the Colorimetry Laboratory. Thus, the potential root causes of this problem were studied through the elaboration of the Cause-Effect Diagram. The base of its construction was the information coming from the employees of the dyeing shop and the responsible for quality control. With this tool and a close monitoring of the process over several months, the causes of the problem under analysis were identified [22].

3.3.2. Process performance indicators

In general, performance indicators allow process monitoring and therefore support decision-making (operational, tactical or strategic). In this perspective, some performance indicators were developed and calculated that were relevant and adequate for the productive process under study, namely, productivity, efficiency and effectiveness, and value-adding. Given that the core activities of the company are dyeing and finishing, these were analyzed with more detail. The definition of the first two indicators is based on the information collected for two machines: a jet (dyeing) and a *stenter* (finishing). The data collection period was the June 2015. The developed indicators and the numeric results are shown in Table 1.

Table 1. Performance indicators.

	Indicator	Results
Productivity	Dyeing machine (jet)	43,85 kg/hour
Productivity	Finishing machine (*stenter*)	163,96 kg/hour
Efficiency and Effectiveness	Availability	97,23%
	Performance	73,89%
	Quality	94,84%
	OEE	68,14%
Value-adding activities (VAA)	% of time with VAA	58,18%
	% of time without VAA	41,82%

3.3.3. Synthesis of the main wastes identified in the process

Table 2 summarizes the main wastes identified in the dyeing and finishing process of the company under study (according to the Lean classification), as well as the causes listed for each waste.

3.4. . Improvement proposals

To solve the identified problems, plans to reduce or remove the causes and/or mitigate effects were proposed. From a large set of proposals presented in scope of this work [22], the following are some of the most relevant ones.

Defects, Returns and Complaints

To reduce the number of returns by the customer, it is proposed the existence of regular meetings between the most experienced employees in this area to analyze recent defects, returns and complaints, and to understand how they can be mitigated. In addition, the registration of information about defects in a record sheet or computerized form was proposed to enable the treatment of this information and development of preventive actions. The current database only records the “reason for the returns”, but it is ineffective to support problem solving.

Table 2. Waste identified and possible causes.

Wastes		Characterization and Possible Causes
Defect	Incorrect Color	The color of the matches does not coincide with the standard by the client, resulting in corrections or re-dyeing. Causes: Incorrect communication of the lab dip recipe to production; inadequate dyeing bath ratio; poor performance of dyes or Jet itself; mesh from different suppliers; absence of tests on the composition of the mesh when it enters the warehouse.
	Creases	The knitting may show creases in different parts of the process. Causes: abrupt cooling of the bath; friction,
	Shrinkage and weight	There may be a deviation of the dimensional, visual and touch properties of the knitting. Causes: wrong data and information test deficit.
	Rework	The repetition of operations to correct the above-mentioned defects has repercussions on reprocessing.
Trans-port	Trolleys	For each operation, the knitting is placed and transported in trolleys. Causes: big distance between the preparation area and the dyeing area; inadequate factory layout.
Movement	Preparation section	Contacts with the warehouse operators to identify the mesh that appears in their daily plan. Causes: lack of information; poor visual control and space organization.
	Dyeing section	Each operator in the dry cleaning business is responsible for 6 Jets. Causes: stop or break in a Jet; taking samples and transporting them to the place where they are washed and/or soaped; transportation of products from the chemical warehouse to that of Jet, when the dosage is manual; collection of the next dyeing.
	Finishing section	Squeezed knitting trolleys are moved by an operator to the side of the dryer or to the racks. Causes: parameterization of the dryer at the beginning of the drying operation; informal information exchange among operators, documentation; sampling for weight control; cart movement to collect the knitting of the *stenters*.
Over proces-sing	Excessive processing of tasks	High number of corrections and reprocessing of knit sets in dyeing and finishes. Causes: operations performed incorrectly the first time; inadequate working instructions; unnecessary operations for dyeing programs in manual mode.
Waiting	Dyeing section	Knit is waiting in trolleys next to the Jets to be dyed. Causes: departures with more than expected processing time, increasing the waiting time of the following departures; operators await the opinion of the dyer or the shift supervisor on the evaluation of the samples at the end of each procedure.
	Finishing section	Knit waits in trolleys next to the drying machines and the *stenters* to be processed. Causes: operations in the dyeing process and finishes with different cycle times.
High Setup	New dyeing	With each new dyeing, and depending on the color, it is necessary to clean the Jet filters and remove the residues from the previous dyeing.
	New finishing	Operations are necessary when the knit needs other operations before branching the machine has to be adapted for the knit not to be rolled up.
Delay	Customer delivery	Repeating the tasks for their incorrect execution the first time, can mean, in most cases, delays in the delivery of the finished product to the customer.
Stops	Machines	Machines do not produce interrupting the production flow. Causes: Waiting for test results at different stages of the dyeing process; machinery breakdown; problems with the labeling software.
	Operator	Dyeing operator awaits results of the tests and opinion of those responsible

Information Registration

To have reliable and consistent information across all sections, it is suggested that the organization promote workshops to their employees, from the management team to the shop floor operators, about the capabilities of the existing information system so that they can benefit from its functionalities and to make easier data processing.

Performance measurement

It does not bring benefit to have accumulation of data in the software devoid of any treatment, e.g. the calculation of indicators only makes sense if they are useful. To fill a gap in the company, it is necessary to highlight which are the key performance indicators (KPIs) best suited to monitor the production process [23]. This suggests that reaction limits and criteria must be created, allowing process control and comparison of organization's performance with others. Monitoring KPIs favors various aspects of the company, such as enabling employees to know the origin of a failure or a stop of the machines or the productivity and profitability of the machines. This information could provide basis for benchmarking and process improvement.

Layout change

Regarding the layout, a rearrangement was suggested in order to make the flow of materials more intuitive and natural, since in the current situation, the reception area of raw material and preparation are on the opposite side of the next operation (dyeing), leading to waste associated with movements, transport and waiting times.

4. Conclusions

This study proves, corroborating other studies in SMEs, that an SME with little experience in processes, techniques and tools of continuous improvement can, through the use of few resources, identify its wastes and improvement opportunities, based on principles of Quality Management and Lean Manufacturing. However, as the extensive published bibliography reports, the success rate in the implementation of Lean projects is low and the reasons are well characterized.

In this study the main problems related to organizational inefficiencies and wastes of a SME in a dyeing and finishing textile industry in Portugal were addressed, the root causes were identified, and improvement proposals were presented.

In the course of information gathering, it was verified that despite the company goal of satisfying customer needs, offering the final product with quality, there is no evidence of mechanisms and formal dynamics that lead to continuous improvement. This lack of an organizational culture oriented towards continuous improvement was one of the barriers to the implementation of the proposals presented. Other important barriers present in this study were: (i) access to existing information, and poor quality of information; (ii) lack of information sharing and communication among employees and among employees and chiefs; (iii) the resistance to change and the closed organizational culture, from the top to the shop floor (iv); the lack of financial and human resources; and (v) poor planning and layout.

Assuming that the company studied context (management practices, business culture, technical and organizational competencies of employees, commercial relations with clients/suppliers, etc.) is similar for most SMEs of the dyeing and finishing textile sector in Portugal, it can be concluded that the results of this study (on the identification of barriers to the adoption of quality management and lean manufacturing principles) are equally valid for these companies. Finally, the improvement proposals identified could be also applicable, with appropriate adaptations, for these companies.

Acknowledgement

This work has been supported by COMPETE: POCI-01-0145-FEDER-007043 and FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UID/CEC/00319/2013.

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