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CASE STUDY IN A WIRE DRAWING: PROPOSAL TO REDUCE THE LOSS OF GREATER REPRESENTATIVITY

Regilaine Alvarenga de Barros
regilainealvarenga@yahoo.com.br
Centro Universitário Metodista Izabela Hendrix, Belo Horizonte, Minas Gerais, Brazil

Francielly Sâmara Teixeira
francielly.fs@gmail.com
Centro Universitário Metodista Izabela Hendrix, Belo Horizonte, Minas Gerais, Brazil

Tiago Silveira Gontijo
tiago.gontijo@izabelahendrix.edu.br
Centro Universitário Metodista Izabela Hendrix, Belo Horizonte, Minas Gerais, Brazil

ABSTRACT

This article deals with a case study in a wire drawing business located in the metropolitan area of Belo Horizonte, which sought to verify the losses existing during the production process and in the finished product stock, which can cause rework and losses. The objective of this article was to propose an action plan with a view to reducing the loss of greater representativeness for the company. Through the research form, all the deformities that influence the quality of the product developed by the company were listed. For the determination of the loss of greater representativity, we used the Pareto diagram, which orders the occurrences in a decreasing way. In order to identify the causes that lead to the loss of greater representativeness, we used the cause and effect diagram. In order to propose preventive solutions for the problem under study, the action plan based on the 5W1H model was used. Specifically, preventive measures were proposed to reduce the oxidation of the drawn bars, since the results obtained by the research pointed to oxidation as the loss of greater representativity for the company.

Keywords: Losses; Wire drawing; Quality tools.

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1. INTRODUCTION

Steel is used in several economic sectors, such as civil construction, the automobile industry, energy, agriculture, household utilities and so on. In this way, the relevance of academic research on the subject, both at national (Costa, 2015) and international level (Guo et al., 2013), can be perceived, since steel is today the most recyclable product and the most recycled in the world. Cars, refrigerators, stoves, cans, bars and wires become scraps, which feed the furnaces of the mills, producing again steel of the same quality (Instituto Aço Brasil, 2016).

In any industrial segment, when a product is produced that does not meet the quality specifications, that is, that presents a defect, in addition to the waste of material used for manufacturing, several other resources are wasted. The labor required for production, time spent and the use of storage space are resources that are directly related to waste and that increase the costs of products when they are reworked.

According to Marques et Mello (2013), "it is not interesting for any organization, especially regarding costs, nor that there is incidence of reworking, nor of losses in the productive process". The same authors affirm that identifying the facts that cause rework and losses is of paramount importance to organizations, since through identification it is possible to minimize the occurrence of losses and to reach higher efficiency standards.

In view of the above, in order to reduce the waste situation in which the studied company is located, the present study aimed to propose an action plan, based on the 5W1H model, with a view to reducing the loss of greater representativeness for the company. Specifically, the loss of greater representativeness for the company was evidenced through the Pareto diagram and the causes contributing to this loss were determined through the cause and effect digrama.

In addition to this introduction that contextualizes the subject, justification and research objective, this article was organized from the following sections: Theoretical reference, which presents the conceptual references correlated to the tools for quality control; Methodology, informing how the research was developed; Results and discussions, in which the results obtained are demonstrated and analyzed; and, finally, the Conclusion, with the general analysis of the study.

2. THEORETICAL REFERENCE

2.1 Tools for quality control

Seleme et Stadler (2010) state that the term quality is a descendant of the Latin qualitate, and designates the link between companies and the market, where consumer satisfaction is the reason for the existence and survival of organizations.

Lucinda (2010) states that the more the characteristics of a given product or service meet certain requirements, the more quality the product will have. In this way, organizations must meet the needs with products and services expected by customers and the market. Alvarez (2010) points out that in product design, regardless of the size of the processes, these should be monitored, supervised and controlled so that a product is within the specifications.

In this context, Seleme et Stadler (2010) emphasize that the tools for quality control are essential for planning and prevention, since they anticipate the problems, analyzing them before they occur.

Based on the foundation that the quality tools are planning and prevention resources, many works have been developed in this area. It should be noted, however, that there is a lag in this type of approach in the steel sector, more precisely in the wire drawing business. Therefore, the importance of the subject under study.

Chart 1 shows some studies carried out using quality tools for different types of approaches. It is noticed a predominance of works that deal with project management, process improvement, product performance, prevention and loss reduction, since the aforementioned tools contribute decisively to the processes of planning, execution and control of engineering projects (Falconi, 2004).

Considering the importance of the use of quality tools for the diagnosis and maintenance of quality by means of the prevention of failures or losses in processes, for the purposes of this article we used the Pareto diagram, the cause and effect diagram and the action plan with 5W1H, which are listed below.

2.1.1 Pareto and Ishikawa diagram

Seleme *et* Stadler (2010) show that the Pareto diagram allows us to identify and classify the most important problems that must be corrected first, allowing greater efforts to solve them and allowing the organization to

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Chart 1. Application of quality tools in different approaches

Variables	Approach	Authors
Project management	**It presents, through bibliographic review and observations, the main quality tools and demonstrates the effectiveness of its applications for a more efficient project management.**	**Galiazi et Santos (2015).**
Productive processes	**Quality tools were used to identify production problems, relating their causes and suggesting solutions that contribute to the improvement of the quality of the production process and the product.**	**Vasconcelos et al. (2009).**
Loss Prevention	**Based on the principles of continuous improvement, quality tools were used in an attempt to eliminate losses and increase the efficiency of the production system in a wood drying company.**	**Piechnicki (2014).**
Product performance	**Quality tools have been used to reduce time in solving product performance problems and to find the root cause with a fast and effective process.**	**Reno (2015).**
Loss reduction	**Quality tools have been used to identify and solve major problems in production in order to control or eliminate the potential causes of problems in a sausage manufacturing company.**	**Maiczuk et Andrade Júnior (2013).**
Loss control	**Identification of problems with the use of quality tools, and consequently avoid and reduce process losses.**	**Carvalho et al. (2015).**

Source: The authors themselves

use its resources properly to improve process and product quality.

For Slack et al. (2009), the Pareto diagram is a fundamental tool for prioritizing the problems to be corrected, since it separates the most important actions from the least important ones.

Braz (2013) states that the cause and effect (Ishikawa) diagram is a tool used to present the relationship between a particular outcome of a process (which is an effect) and the various factors (causes) that may influence that outcome. Its structure consists in ordering the initial causes for its final effects. The diagram lists the most likely causes that contribute to an effect and these causes are divided into categories as described below:

- Method - procedures, ways to perform each job;
- Labor - the knowledge and skills necessary for the good performance of people;
- Materials - type of materials and availability for use in the process;
- Machine - conditions and capacity of facilities and physical resources;
- Environment - conditions of factors related to the business environment;
- Measurement - referring to measurements.

2.1.2 5W1H

According to Seleme et Stadler (2010), the 5W1H tool translates the use of questions (written in English) starting with the letters W and H: What, what, where, when, why, and how. These questions aim to generate answers for the clarification of the problem to be solved. By using the questions, it does not mean that there will be guidance for an accurate indication of failures, but rather an explanation for a more accurate check.

3. METHODOLOGY

The research universe was composed of all materials blocked by the quality area, from March 1, 2016 to June 30, 2016, due to some non-compliance. These materials included drawn bars, wire machine (raw material with diameter between 4mm and 40mm) and long bars (raw material with a diameter between 40mm and 80mm).

The sample consisted only of anomalies arising from failures during the production process and nonconformities derived from the storage conditions of the finished product. Nonconformities in the raw materials were not considered in the sample, since these nonconformities are not inserted in the production process.

To carry out the research, a data collection form was applied to be filled out by quality professionals, when they blocked drawn bars or raw materials. Blocking consists of the identification, by means of a warning label, of non-conforming materials. This procedure is performed

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by quality contributors in order to avoid unintentional use of the material or even delivery to customers.

The search form was composed of three fields for completion. The first field for block date information; the second, to fill the reason; and the latter for the insertion of the amount in kilo (kg) of the blocked material.

The data obtained in the research form were transcribed into a spreadsheet for treatment. Then, the defined sample was selected for the construction of the Pareto diagram, through which it was detected which loss, among the occurrences in the production process and in the stock of finished products, is more expressive. With this information, the cause and effect diagram was developed to determine the conditioning factors for the occurrence of loss of greater representativity. Before the identification of the causes, an action plan was elaborated to clarify the problem to be solved through the model 5W1H.

4. RESULTS AND DISCUSSION

For a better visualization of the studied case, the process of drawn bars manufacturing is shown in Figure 1 in a synthesized form.

The bar drawing process starts with the supply of the raw material roll (machine thread) in the process, through a turntable (unwinder). While it is unwound, the machine wire passes through the pre-straightener, suffering deformation and becoming rectilinear. In the next step, the machine wire passes through the pickling process, in which it is hit by spherical steel shot to obtain a good cleaning of the surface in order to avoid excessive marks.

After being pickled, the machine thread is introduced into the die where the drawing takes place, which is the reduction of the section of the material through its traction. Subsequently, the material undergoes inspection and is cut according to the length specified by the customer. The drawing bar is then polished to improve its finish, packed and shipped to the storage area to await shipment to the customer. When it is detected at the inspection stage, non-compliance with the pre-established quality requirements, the drawn bars are cut, packed and sent to the storage area, where they await the opinion of the professionals of the quality sector regarding the need for rework or scrap.

By means of the data collection, a total of losses in the studied company of 273,955 kg was detected, according to the data presented in Table 1.

Table 1. Results of losses found

Reason for loss	Quantity (kg)	Representation (%)	Accumulated representation (%)
Oxidation	143.090	52,23	52,23
Warping in process	26.050	9,51	61,74
Mechanical defect	25.306	9,24	70,98
Length	24.274	8,86	79,84
Defective raw material	18.156	6,63	86,47
Gauge	9.527	3,48	89,94
Helical Brands	6.695	2,44	92,39
Mixture	6.202	2,26	94,65
Pickling stains	5.245	1,91	96,57
In stock	4.211	1,54	98,10
Motion Defect	2.655	0,97	99,07
Scratches	2.544	0,93	100
Total	273.955	100	

Source: The authors themselves

Considering that the monthly production of the company varies around 10,000 monthly tons, it was observed that the total losses represented 0.68% of the production, analyzing the same interval of 4 months, referring to the period of data collection.

The results showed that more than 50% of the losses are attributed to only one cause, which is oxidation, and the remaining percentage is distributed to another 11 causes. The characteristics of the Pareto analysis were also verified through the data obtained, since 80% of the losses belong to a small number of causes and 20% are associated with a larger quantity, confirming that the quality problems are divided into “few vital” and “many trivial”. According to Braz (2013), the vital few include problems that, despite being few, have a very large impact, and the trivial many are those that represent a great number of problems, but do not cause significant impacts to the company.

The results indicated that the losses after the production process are more expressive, followed by the losses during the drawing process and, finally, due to the nonconformities in the raw material, as shown in Table 2.

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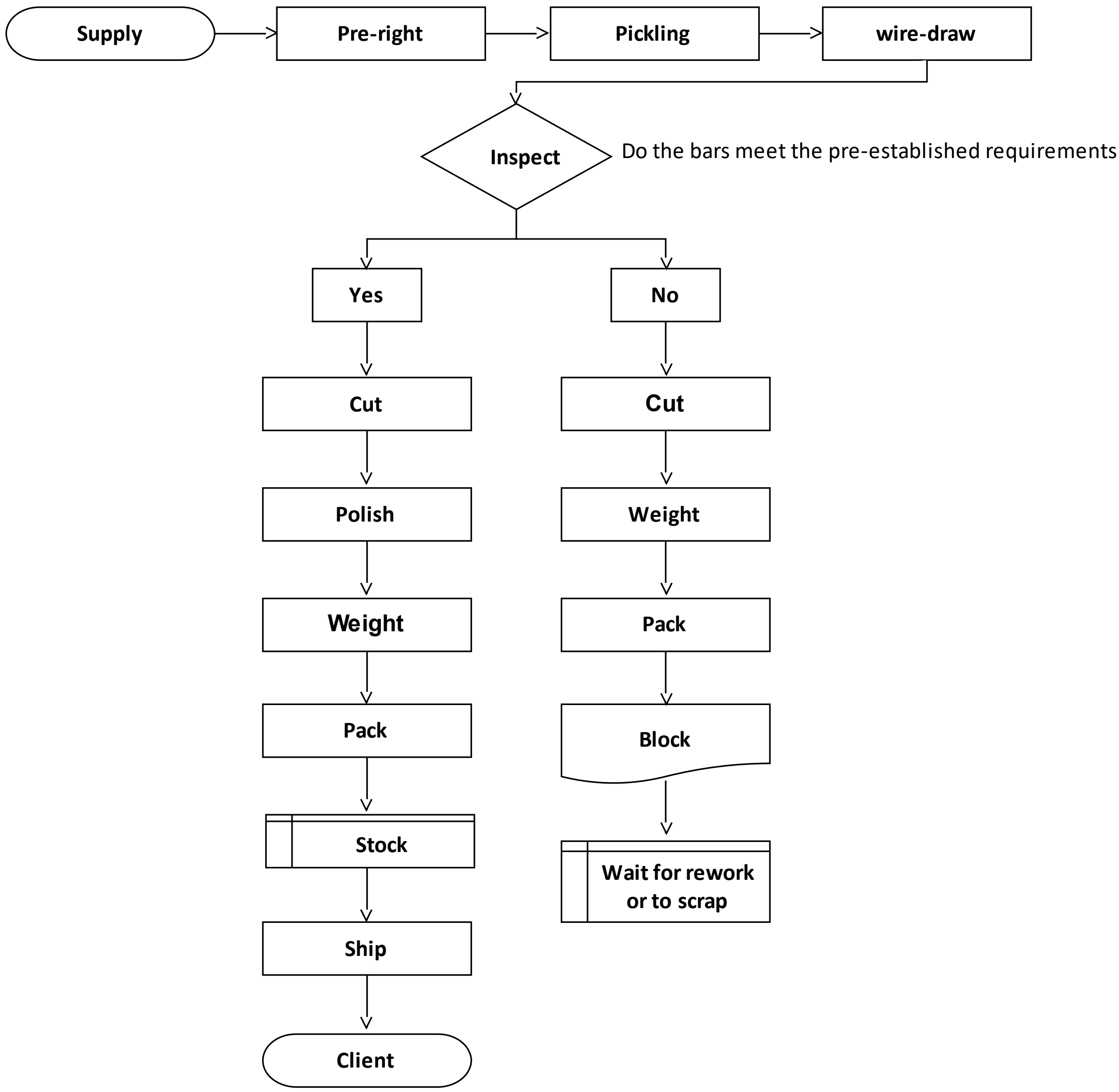

Figure 1. Flow diagram of the drawing bar process

Source: The authors themselves

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Table 2. Discrimination of losses

Lossess after the process	
Reason for loss	Quantity (kg)
Oxidation	143.090
Warping in process	4.211
Motion Defect	2.655
Subtotal	149.956
Losses during the process	
Reason for loss	**Quantity (kg)**
Warping in process	26.050
Mechanical defect	25.306
Length	24.274
Gauge	9.527
Helical Brands	6.695
Mixture	6.202
Pickling stains	5.245
Scratches	2.544
Subtotal	105.843
Loss of raw material	
Reason for loss	**Quantity (kg)**
Defective raw material	18.156
Total	273.955

Source: The authors themselves

Considering that the sample defined for study comprises only the anomalies arising from failures during the production process and nonconformities derived from the conditions of storage of the finished product; the anomalies from the raw material were excluded. Suppressing these nonconformities, a total of 255,799 kg of drawn bars with abnormalities was considered. In this way, the contribution, in percentage, of each cause in relation to the total amount of losses was calculated again. The new calculations showed that the loss of greater representativeness for the company studied in the analyzed period is oxidation, representing approximately 56% of the total losses.

By the construction of the Pareto diagram, denoted in Figure 2, the representativeness of the oxidation to the waste situation in which the target company of the study is found became notorious.

From the evidence that oxidation is the loss that has determined the greatest damage to the company studied, it was analyzed which causes contribute to the occurrence of this phenomenon. With the application of the cause and effect diagram, it was possible to structure and organize the main causes that lead to the oxidation of materials, as shown in Figure 3.

After the causes were studied, it was studied in detail the contribution of each of them to the oxidation of the bars. Starting with the raw material, it was studied that the use of steel with low carbon content can favor the corrosive process in the bars, because, under the action of atmospheric agents or chemical agents, steels with these characteristics tend to return more quickly to its primitive state. Another inherent aspect is the quality of the protective oil in the final drawing step: the better its properties, the more effective the corrosion protection of the steel.

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Another aspect raised was the way the finished product is packed. At the request of customers, some drawn bars are packed with polypropylene tape that inhibits the contact of the bars with the environment; however, much of the material produced by the company is not involved with this type of tape. The water vapor present in a variable quantity in the air and the dust that agglutinates with the steam of water have corrosive action on the steels, and are configured as a harmful factor that causes oxidation.

High storage period also favors the oxidation reactions of the drawn bars, because, over time, the protective oil has its properties reduced, leaving the steel vulnerable to the agents that cause oxidation.

Through the investigation of the causes that induce the occurrence of oxidation, it was possible to identify possible improvements that, if applied, reduce the occurrence of the mentioned loss. Therefore, an action plan was proposed based on the 5W1H model for the suggestion of minimization, as shown in Chart 2.

It was considered that, by inventing all the existing inventory in the company, it is possible to identify the total quantity of materials in good condition and those with nonconformities, since, in some cases, oxidation is only discovered at the time of shipment, when then the bars are blocked by the quality sector. Following the inventory, the need to determine the shelf-life of the protective oil, after application, was identified, considering the present environmental conditions of storage present in the company. It should be noted that this information

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is unknown by the company's employees. Knowing the oil protection period, it is evident the need to adapt the company's safety stock in order to schedule the production orders, so as to avoid the lack of materials for the customers and at the same time not to maintain bars in stock over the oil protection period.

Training with the production and dispatch operators is fundamental to raise awareness and guide them regarding the need to wrap the wood with the specific plastic, because, as already described, the wood can pass moisture from its natural decomposition to the bars and this procedure is not known to everyone. Parallel to the training, a supervision team is included to investigate and request compliance with the procedure.

5. CONCLUSION

The article aimed to propose an action plan to minimize the loss of greater representativity present in the company studied. With the help of quality tools, it was

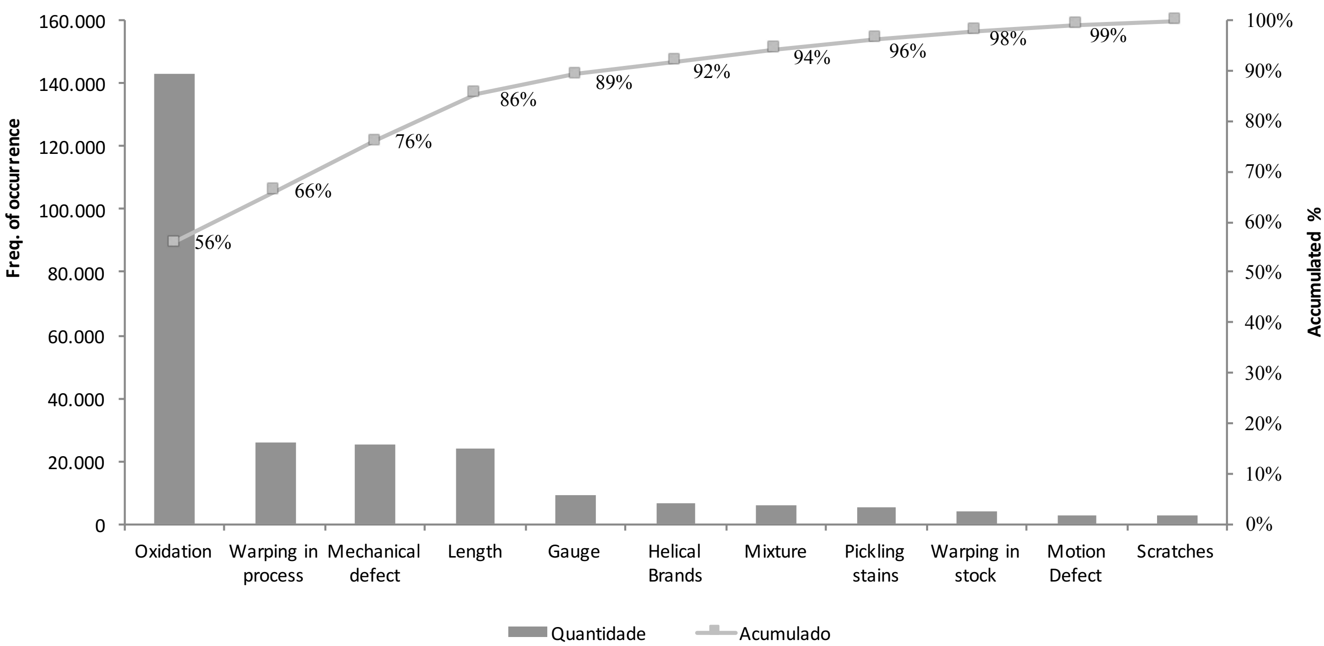

Figure 2. Pareto diagram of the losses
Source: The authors themselves

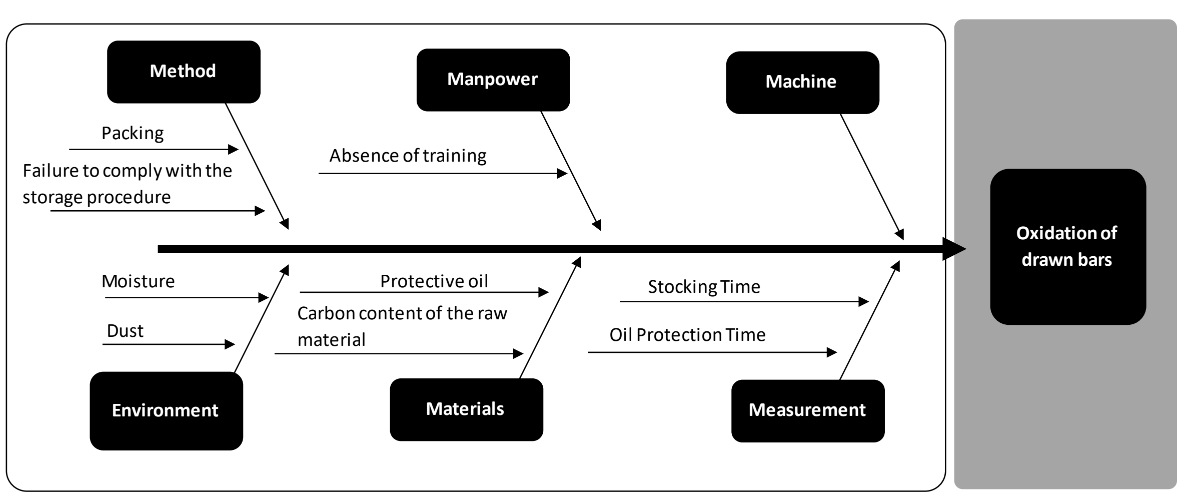

Figure 3. Diagram of cause and effect of the loss of greater representativity
Source: The authors themselves

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possible to identify oxidation as a factor that has caused the company more damage and determination of its contributing causes, which guided the elaboration of the action plan, providing a broader view of the process.

Through the detailed study of the oxidation causes, it was possible to notice that there is not a single indication of the source causing the oxidation of drawn bars, since several factors are influential and these can act together or separately.

With the high competitiveness existing in the world economic scenario, a company must take into account all the factors that compromise its productive efficiency. As verified, the company needs to adjust the quality control in its processes, because a significant number of nonconformities were verified during the operations. A process with a significant amount of losses or rework results in high costs to the company. These costs, once embedded in the final product, make it more expensive, jeopardize the company's relationship with its customers and compromise its economic competitiveness. Therefore, quality control should be conducted in parallel with process control.

For future work, it is suggested a detailed study of the layout of the company's storage area, in order to identify

Chart 2. Action plan - Oxidation minimization of drawn bars

Action	What?	Who?	Why?	Where?	How?
(A)	Inventory and map the stock	Logistics/ Shipping sector	Distinguish conforming materials from nonconformists	Stock	Compile all available materials and their quantities
(B)	Perform critical analysis of oil protection durability	Outsourced company	Check the validity of the oil and its effective protection after being applied to the bars under current storage conditions	Chemical laboratory	By means of quality test
(C)	Reset scheduling of production orders	Logistics Manager	Improve the flow and turnover of the stock, avoiding long storage time and, consequently, reducing the possibility of oxidation of the bars	Planning Management and Production Control	Define better ordering of production orders
(D)	Conduct training with production and dispatch operators	Production or Logistics Supervisor	Alert on the need and importance of the wood coating and the existing relationship with the oxidation of the bars	Company Training Room	Theoretical and illustrative presentation
(E)	Supervise the plastic sheathing in the support woods	Shipping Operators	Make the storage procedure comply in order to minimize the inherent aspects of oxidation	Stock	Insert warning label on bare wood and request adequacy

When? - Weeks

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
■	■																		
■	■	■	■																
				■	■	■	■												
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■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: The authors themselves

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improvements in material movement, enabling the reduction of accumulations and aiming at the minimization of losses. It is also suggested a detailed study of the costs involved in the actions of improvements.

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