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A novel computer application for scrap reporting and data management in the manufacturing of components for the automotive industry

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Abstract

The automotive industry is constantly growing with the continuous creation of new technologies in the components industry, also requiring a greater quality control during their manufacturing process. The scrap data management is fundamental to being able to have a sense of where the main production problems are and when to act on them in order to improve processes and reduce scrap costs, getting continuous improvement. In this work, a computer application was created and implemented to manage the information regarding scrap data reporting. Current procedures for reporting and processing scrap data followed a very complex set of steps that made much of the reported information inconsistent and in some cases not even correctly reported, leading eventually to a dataset whose reliability was affected. To address these problems, a computer application for scrap reporting and data management was then created which integrated all existing procedures into one application and standardized all reporting and data processing procedures. In this way, it was possible to optimize scrap reporting and data analysis processes, improving reliability by 76% and, combined with all of this, reduce the time and associated costs related to scrap data treatment procedures by about 75%.

Keywords: Quality, Scrap, Scrap report, Computer application, Automotive industry, Time saving in reporting.

1. Introduction

The automotive industry is increasingly demanding high production rates, accompanied by a high level of accuracy, ensuring high standards of customer satisfaction and competitive pricing. Productivity, quality and flexibility remain the main pillars of the automotive industry, the first two being important points in the past, as well as at the present, and the third varying over time as customer requirements and needs are constantly changing, bringing new paradigms to the automotive industry [1].

According to a study performed by the Automotive Industry Action Group (AIAG) group, a set of 22 Original Equipment Manufacturers (OEMs) and automotive suppliers have traced those they consider to be the most critical issues in the automotive industry and that cause greater impact in the final quality, which are: problem solving, customer specific requirements, quality management system, product development, lack of experience, supplier management, change management, core tools, warranties and metrics. To address these issues, some key points have been identified to address them and improve the quality of organizations, such as collaborating on the change creation, talent selection and knowledge dissemination, implementation of standardized requirements, effort in sharing the organization and data analysis to identify root causes of problems [2].

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In selling products or services there are three fundamental parameters that determine the success of these sales, namely, the price, quality and logistics associated with them. The success and survival of an organization is thus due to its ability to respond to customer needs and meet their expectations as well as the requirements imposed by them [3]. Quality can be defined in many ways, according to various authors. Ensuring that quality of an organization's products and services is critical to its success and its distinction from competitors in the same industry [4,5]. In order to improve the production system results, a number of techniques, methods or tools may be used to increase production capacity, volume of products produced and its quality [6]. Since TQM (Total Quality Management) is an approach to Quality management, according to the literature, the elements of TQM can be grouped into two dimensions: management system (leadership, planning, human resources, etc.) and the technical system (TQM tools and techniques) [7,8]. The fundamental tools and the first to be developed were the seven quality tools, being used in any quality improvement system and contributing to the increase of the organizational level, performance and respective quality of results [7,9]. Considering the specific characteristics and challenges of the automotive sector, the industry relies on ISO (International Organization for Standardization) 9001 and ISO TS (ISO Technical Specifications) 16949 to ensure quality management standards able to ensure customer satisfaction while preventing defects and reducing variation in waste throughout the supply chain [10].

There are several methods and tools that can be used to maintain a good level of quality, and to assist in continuous development and improvement in a company [11]. The combined use of the seven quality tools and other continuous improvement methods, such as Plan Do Check Act (PDCA) cycle, five whys method and lean methodologies, among others, have been proven to have high contributions in problem solving and production process optimization [12–14].

One way to evaluate organizational performance is through its Key Performance Indicators (KPIs), with the Parts Per Million (PPM) indicator being a defect indicator used to assess the organization's Sigma level [15,16]. For the analysis of this indicator, it is essential that the collected data must be reliable and standardized, thus allowing to compare objectives and outline new goals [17]. To follow this indicator, the problem solving tool, A3, based on the PDCA methodology, becomes essential in monitoring, analyzing, sharing ideas and supporting identified improvement decisions [18–20].

The PPM indicator and the defects data are the main issues to be worked with this study, by collecting and analyzing the data of defective parts produced in the injection module of a company which manufactures Bowden cables, cushions and suspension mats for the automotive industry. Using quality tools, such as Ishikawa's diagrams and flowcharts to define current processes related to the processing of scrap data, combined with brainstorming and five whys methodologies, in the problem identification and subsequent idea generation phase [21,22], a computer application has been created through this work, to allow integrated management of all reporting and scrap data processing This can reduce time and associated costs, as well as increase the reliability of the data and the accuracy of the PPM indicator.

This work is divided into 5 section, being this Introduction the first one. In section 2 are described the methods used to identify and solve the problem. Section 3 describes the tool, Section 4 describes the implementation and results and Section 5 draws the Conclusions.

2. Methods

The handling of scrap / defect data is an important point in an organization, allowing to monitor periodically which projects produce the largest volume of scrap and to follow up the most critical, in order to eliminate potential causes for the occurrence of this scrap and the various types of existing defects. By calculating the PPM indicator and using A3 tool, these defects are tracked, and improvement measures taken to eliminate them. Reliability of scrap / defect data reported throughout the period is therefore essential.

The current defect reporting and handling processes are based on a lengthy, confusing and error-prone set of procedures that often culminate in the absence of reported data, affecting the credibility of the analyzes derived from the same data and the PPM indicator. The processes are based on three key points:

- Creation of scrap report sheets for each finished good (FG) product reference, with defect designations and reporting codes, to record all defects that occur during production;
- Reporting of defects, in the Enterprise Resource Planning (ERP) system called Business Planning and Control System (BPCS), through their reporting codes, which occur during production;
- Data processing at the end of each period to calculate the PPM indicator and to elaborate the A3 tool to follow the main defects by workstation or project.

Associated with the three processes mentioned above, the main problems arising from them were identified, generating a cycle of events translated by Fig. 1.

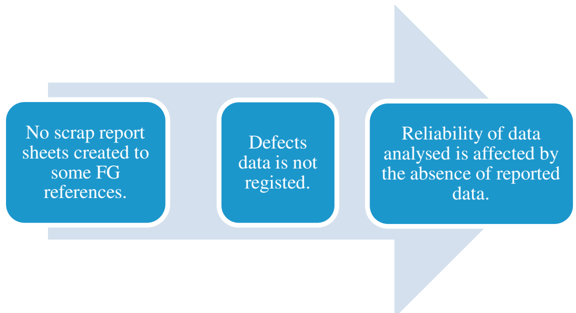

Fig. 1- Problems cycle related to scrap/defects data.

All the defect data management is handled in BPCS, from creating reporting codes to report and export them. The final data treatment and analysis is done using MS Excel®. Below are the three processes referenced above and the main problems identified in each one.

2.1. Creation of defects report sheet

Each FG reference must have a report sheet associated with the possible defects that may occur during the production process. The process of creating a sheet and its readiness to report defects in a BPCS system has a set of steps. Using a database where the various types of defects, materials and their codes are stored, the entire scrap report sheet is created completely manually using MS Excel®.

In the production module where this work was performed, the number of defects and their codes per sheet can be up to 27. Since each code not only records the defect associated with the FG reference, but it also removes material and associated costs from the ERP system, there is a need to have a code for each defect. Fig. 2 shows an excerpt from a scrap reporting sheet with the defects in the respective workstations on the left and the reporting codes on the right.

Referência: 121 912 777

	Defeito	Código Defeito			
	Arranque / SETUP		1.ºT	2.ºT	3.ºT
p	Coxim - Peças Arranque	Q 912 2 PF 54 777			
	Injecção Plástico				
s	Subc.Arame - arame mal conformado (12334977)	Q 912 1 AR1 52 777			
s	Subc.Arame - arame mal conformado (12334978)	Q 912 1 AR2 52 777			
s	Subc.Arame - arame oxidado (12334977)	Q 912 1 AR1 53 777			
s	Subc.Arame - arame oxidado (12334978)	Q 912 1 AR2 53 777			
s	Subc.Arame - Arame Partido / Amassado (12334977)	Q 912 1 AR1 81 777			
s	Subc.Arame - Arame Partido / Amassado (12334978)	Q 912 1 AR2 81 777			
p	Coxim - Erro de Impulsos	Q 912 1 PF 80 777			
p	Coxim- Falha injecção (RECUSADA PELA MAQUINA)	Q 912 1 PF 27 777			
p	Coxim - PEÇAS AFINAÇÃO	Q 912 1 PF 59 777			

Fig. 2. Scrap report sheet format.

Once the sheet layout has been created, all report codes must be validated in BPCS in order to be ready to be reported. This was identified as being a bottleneck of the entire process. For an average number of 21 codes per scrap sheet, it takes about 3 hours to encode a complete sheet. This process involves the Quality and Logistics departments where in the latter one, only one person is responsible for coding, delaying the entire sheet readiness process. The flowchart of Fig. 3 represents the steps of this procedure.

Associated with the time required to validate each scrap sheet, another problem arises where, if the sheets are not validated, all defective material reporting is done using the components references, presented in BOM (Bill of Materials) of FG reference, subtracting them from the system. These reports only remove material from the BPCS system so that there is no false inventory, but no defects are recorded which will not be accounted for in the PPM indicator study or A3 tool. This means that data analyzed monthly loses reliability since they may not reproduce what is happening exactly in the productive environment.

2.2. Scrap Report

In the scrap reporting phase throughout each shift, all defects are reported using scrap report sheets, if any, or BOM if none exist. If there is scrap sheet, the quantities of each defect are recorded during the shift and, at the end of the shift, are introduced in the BPCS system, in the reporting menu, where the defects will be recorded, and their materials and costs will be discounted. This procedure is a bit cyclical since for each code it must be completed the cycle of Fig. 4 to report each single defect. Fig. 5 presents the main differences between reports with and without scrap codes.

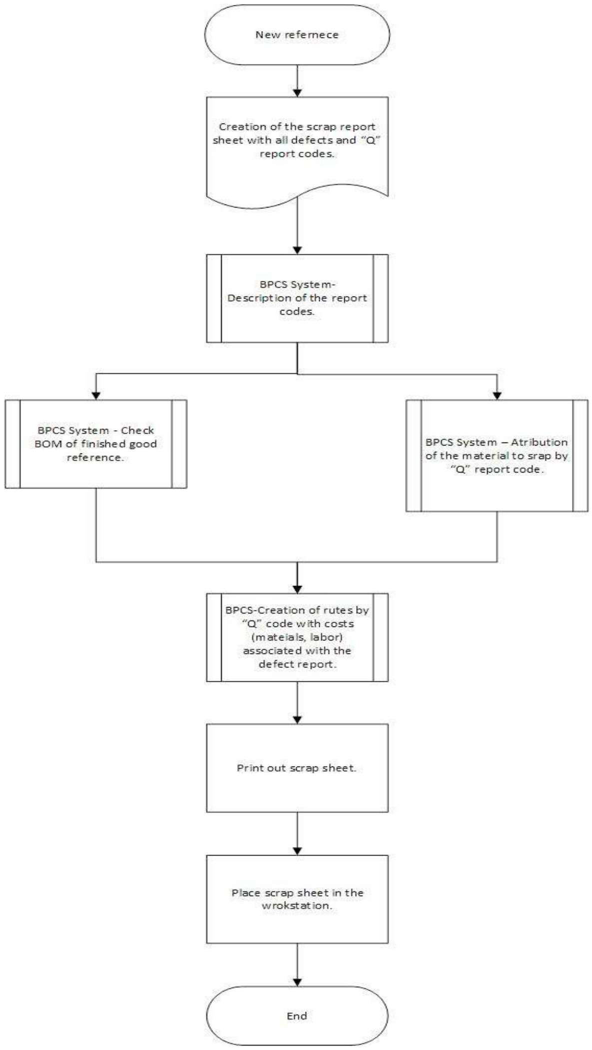

Fig. 3. Creation and validation of scrap report sheets.

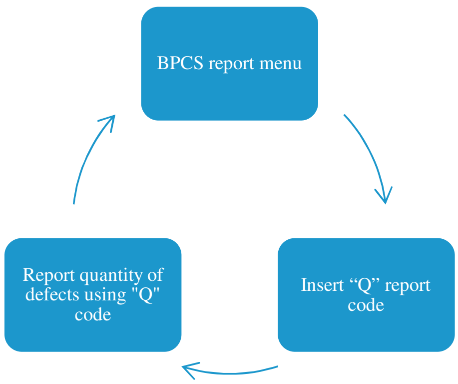

Fig. 4. Report cycle of each "Q" report code.

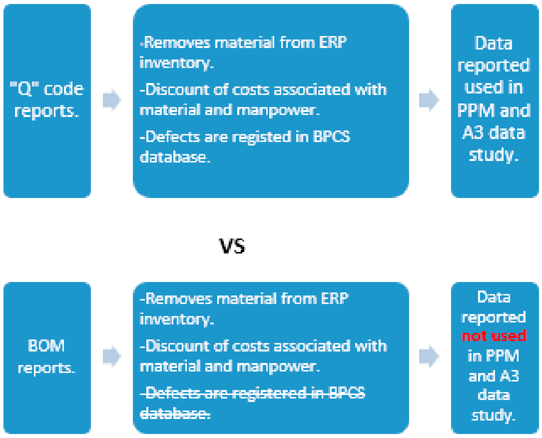

Fig.5. Difference between "Q" code and BOM reports.

2.3. Data treatment

The last process is the treatment of reported data through scrap codes, throughout the month, by exporting them from the BPCS system to an MS Excel® file. This data will undergo a set of steps, since in the creation of the names of the defects, and because this is a manual process, there is no defined naming standard. Thus, different FG references with the same type of defects may have a different nomenclature in BPCS. Thus, when organizing data in MS Excel® into pivot tables and grouping by defect types, different separators will be created for the same defect type. To eliminate this problem, the defects data must be renamed, standardized and only then grouped. Fig. 6 presents a real example of some codes that report the same type of defect in different FG references, but the designations attributed in BPCS are different.

Reference	Validação
Q9122PF20400	3 COXIM - DIAMNETRO GANCHOS
Q9122PF20575	2 COXIM DIAMETROS GANCHOS
Q30452PF20001	3 COXIM - DIAMETRO GANCHOS
Q30452PF20003	3 COXIM - DIAMETRO GANCHOS
Q9112PF20900	3 COXIM -DIAMETRO GANCHOS NOK
Q9112PF20901	3 COXIM - DIAMETRO GANCHOS NOK
Q9122PF20030	3 COXIM - DIAMETRO DE GANCHOS
Q9122PF20065	3 COXIM- DIAMETRO DE GANCHOS
Q9122PF20254	3 COXIM - DIAMETRO GANCHOS NOK
Q9122PF20738	3 COXIM DIAMETRO GANCHOS
Q9112PF20998	3 COXIM - DIAMETRO GANCHOS NOK
Q20452PF20001	3 COXIM - DIAMETRO GANCHOS
Q9122PF20637	3 COXIM DIAMETRO GANCHOS
Q9122PF20769	3 COXIM - DIAMETRO GANCHOS
Q9122PF20636	3 COXIM DIAMETRO GANCHOS
Q9122PF20401	3 COXIM - DIAMNETRO GANCHOS
Q21452PF20002	3 COXIM - DIAMETRO GANCHOS NOK
Q9122PF20642	3 COXIM - DIÃ‚METRO DE GANCHOS
Q9122PF20643	3 COXIM - DIÃ‚METRO DE GANCHOS
Q9122PF20777	3 COXIM DIAMETRO GANCHOS
Q9122PF20645	3 COXIM DIAMETRO GANCHOS
Q30452PF20134	3 COXIM DIAMETRO GANCHOS
Q9122PF20635	3 COXIM-DIAMETRO GANCHOS
Q9122PF20061	3 COXIM DIÃ‚METRO GANCHOS
Q9122PF20770	2 COXIM - DIAMETRO GANCHOS

Fig. 6. Difference between designations in the same type of defects.

3. Development of the digital application for scrap data treatment

In the attempt to eliminate problems related to scrap coding and reporting and handling of defect data, a computer application has been developed to:

- Automate the creation of scrap sheets;
- Reduce the difficulty of scrap reporting;
- Increase the number of defects recorded and thus increase the reliability of the PPM indicator and the data analyzed in A3 tool.

To expose the problem and set the goals for the computer application, several brainstorming sessions were held in different phases, which are going to be described. This is a quality powerful tool which needs to be used to solve complex problems involving a team. Thus, the team which developed the brainstorming sessions was constituted of seven people: Quality manager, Production manager, Logistics manager, and four Team leaders.

3.1. Brainstorm

The brainstorming sessions were divided into three stages (A, B and C), trying to find out solutions in a structured way. The different stages are described below.

A. Identification of existing objectives and associated problems)

- How to simplify processes for scrap sheet creation, scrap reporting and scrap data processing;
    - o Association of defects with their codes (very manual process);
    - o The process of entering scrap reporting codes in BPCS is very complex and time consuming;
    - o BPCS scrap reporting process is too cyclic;
    - o Data processing to standardize defect nomenclature and post association of that data to the A3 defects tool is quite complex;
- Release extra work from the Logistics and Quality departments by simplifying processes related to scrap data;
- Increase data reliability in calculating monthly PPMs and analyzing A3 defects tool;
    - o BOM reports do not count for study of defects.

The difficulty in creating the codes generates the big problem translated in the graph of Fig. 7.

Fig. 7. Consequences related to main bottleneck of the process.

In order to better understand the origin of this problem, the Five Whys tool was used to reach its root cause, as shown in Fig. 8.

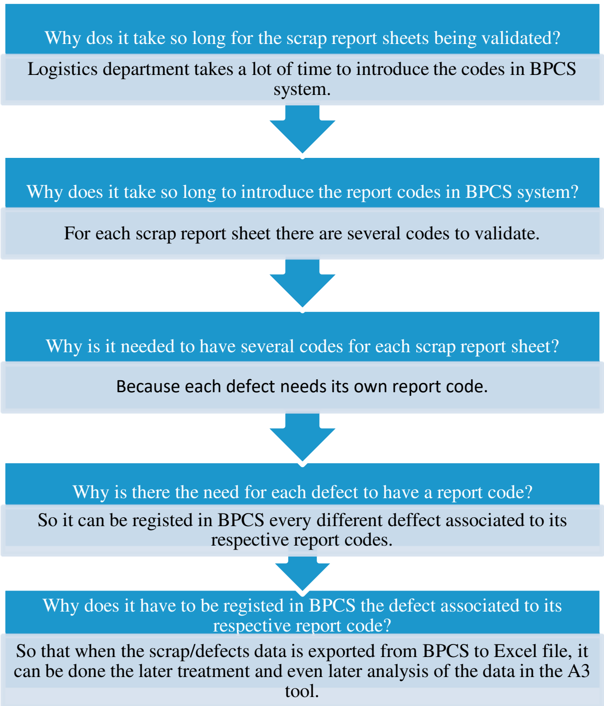

Fig. 8. Five Why´s methodology to reach the root cause for the delay in scrap sheet validation.

Since the process of creating a single code is very complex and time consuming, increasing the number of codes per sheet, increases the time required for them to be validated.

B. Ideas Improvement

- Creation of a computer tool dedicated exclusively to scrap defect data that allows:
  - Manage the various types of defect codes and materials in the application through a maestro menu;
  - Defect management by category/group;
  - Manage defects and assign them their codes automatically;
  - Automatic creation of scrap sheets;
  - Decrease interactions with BPCS in the creation of scrap reporting codes;
    - Application stores reported defects so they will not be needed to be specified in BPCS;
    - Code entry in BPCS, only to remove material and associated costs;
      - Group defect codes by materials and costs to report;
    - Allow scrap reporting in a simple way using the application;
  - Store all scrap/defect reports in the application database;
  - Manage the data reported in the application;
    - Direct export of organized data to A3 tool without intermediate treatments.

The above ideas aim to automate the scrap code creation system, standardize defect nomenclature, facilitate the scrap defect reporting system and ultimately increase the reliability of reported data. Once the ideas are defined, the next step is the implementation plan.

C. Sequence of steps for implementation plan

1. Program application according to the ideas previously established for the plastic over-injection module due to its importance in scrap data and greater ease of initial implementation;
   a. Import from the BPCS into the application all module references and work centers;
2. Creation of a maestro menu to manage all types of encoding parameters;
3. Optimization of scrap sheet layout;
4. Creation of a maestro menu to manage defects and assign the respective code parameters;
5. Creation of a maestro menu to associate the defects with the respective category to which they belong;
6. Creation of a maestro menu to create scrap report sheets by FG product reference, automatically, seeking information from the menus of points two, four and five;
   a. If different defects to be reported have the same materials scrap value and their associated costs, within the same FG product reference, only one of them will be coded in the BPCS, and this code will be used to report all the others;
      i. Substantial work on code entry in BPCS is freed up;
      ii. Relieves the BPCS database;
      iii. BPCS only removes material from the system and there is no interest in saving the types of defects;
      iv. Defect data is all managed and stored in the application;
   b. Option to preview final scrap sheet shape;
7. Creation of a menu to report defects during production;
   a. Production operators select the FG reference and the defect list is automatically generated;
      i. There is only needed to enter the defect quantities to be reported;
   b. Option to print scrap sheets generated automatically;
8. Creating of a menu to consult reported scrap data, allowing to export this data to an external source (Ex: A3 tool for defect tracking file).

Fig. 9 summarizes and distinguishes existing interactions with those intended after the implementation of the scrap application.

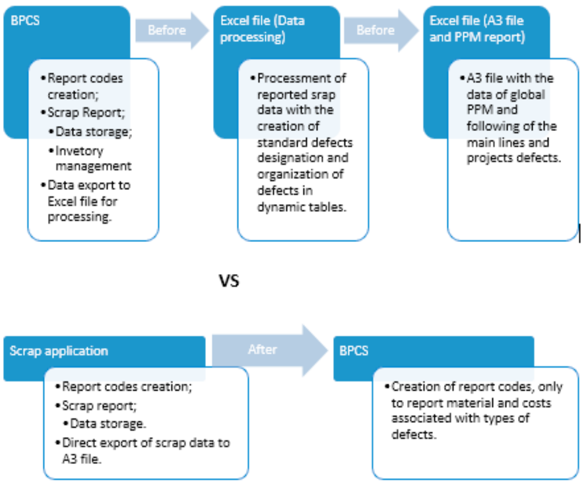

Fig. 9. Interaction differences before and after Scrap application implementation.

Thus, the application is intended to automate all existing processes, as it is impossible to achieve this in the BPCS, which becomes only responsible for removing material from inventory and reporting costs associated with the defects. After this, begun the implementation of the application and demonstration of the results obtained.

4. Scrap application implementation

The management of the application is limited only to those who are responsible for its maintenance and operation and is done through the company's Intranet. Those responsible for scrap reporting, team leaders and supervisors, also have access, but only to the scrap sheet reporting and consultation area.

4.1. Scrap Application functioning

The application runs on the company's Intranet interface and features four management menus, called "Maestros", and two additional menus, one for reporting and one for analyzing and exporting reported data, as shown in Fig. 10.

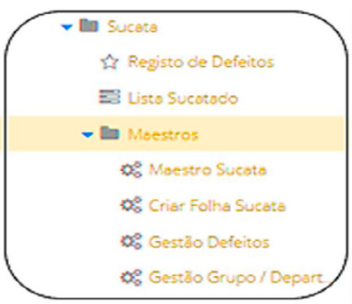

Fig. 10. Scrap application menus.

This gives the following application menus:

- Defect Log ("Registo de Defeitos"): a menu used by team leaders to report scrap at the end of each shift instantly and easily;
- Scrap List ("Lista Sucatado"): allows to analyze everything that was reported as scrap (scrap history), and export the data stored in the application database;
- Masters ("Maestros"): menu reserved for the management of the entire application;
  - Scrap Master ("Maestro Sucata"): it manages all types of materials, types of defects, number of jobs, types of lines, among others;
  - Create Scrap Sheet ("Criar folha sucata"): allows automatic creation of scrap sheets and their management by reference of final product;
  - Defect Management ("Gestão defeitos"): allows the coding of the types of defects and their distribution through the production lines;
  - Group/Department Management ("Gestão grupo/Departamento"): allows the management of the different work centers.

To understand the chaining and sequence of operation of the menus, the following flow chart is shown in Fig. 11.

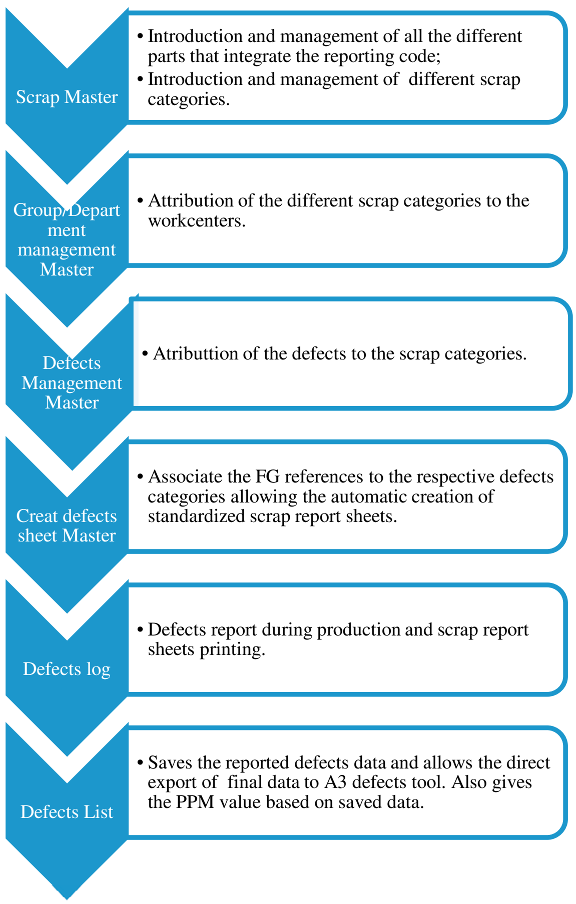

Fig. 11. Scrap application menus working sequence.

The fact that all defect management is now done in the application has eliminated the need to create a BPCS scrap reporting code for each defect. Since BPCS is now only responsible for discounting material and recording costs for reported defects, a code by group of material types and associated costs can be created only. All defect differentiation is recorded and handled in the application.

The need for code creation in BPCS continues, but much less so that all defect sets with the same material and cost reporting have the same code in BPCS. Fig. 12 presents as an example this differentiation in BPCS code creation.

Defect	Report reference (old scenario)	Report reference (new scenario)	Material and costs to discount in BPCS
Defect 1	"Q" Reference1	"Q" Reference1	Material and costs 1
Defect 2	"Q" Reference2		
Defect 3	"Q" Reference3		
Defect 4	"Q" Reference4		
Defect 5	"Q" Reference5		
Defect 6	"Q" Reference6		
Defect 7	"Q" Reference7	Q Reference2	Material and costs 1
Defect 8	"Q" Reference8	Q Reference3	Material and costs 2
Defect 9	"Q" Reference9	Q Reference4	Material and costs 3
Defect 10	"Q" Reference10	Q Reference5	Material and costs 4

Fig. 12. Difference in "Q" codes creation in BPCS system before and after scrap application.

This allows the main bottleneck of the report sheet validation process to be eliminated. By reducing the number of codes to be created, the whole process is accelerated allowing reporting sheets to be available much faster and increasing the reliability of reported data. Thus, the implementation of the Scrap Application implementation brought very positive results, as described below.

4.2. Results

For the reference with the highest number of defects of the production module where the application was implemented, the results obtained can be seen in Table 1, for the sheet validation times, before and after the application implementation.

Table 1 - Time improvement in validation of the FG reference with higher number of defects.

Before scrap application	After scrap application
Reference with most scrap report codes = 27 codes	Reference with most defects report codes = 5 codes
Coding time in BPCS system for the reference with most scrap report codes ≈ 4,5 hours (240 minutes)	Coding time in BPCS system for the reference with most scrap report codes ≈ 0,74 hours (45 minutes)

With 31 different FG references and considering an average number of 21 defects per FG reference, the hypothetical scenario of Table 2 was created to show the difference in coding and validation of all scrap reporting sheets before and after application implementation.

Table 2 - Hypothetic scenario for time improvement in codification of all FG references of the productive module.

Before scrap application	After scrap application	Difference
Number of codes to validate in BPCS system: 21*31 = 651 codes	Number of codes to validate in BPCS system (worst scenario of 5 codes for each reference): 5*31 = 155 codes	-76%
Coding time for one single code in BPCS system ≈ 0,15 hours		
Coding time for all codes in BPCS system: 651*0,15 ≈ 98 hours	Coding time for all codes in BPCS system: 155*0,15 ≈ 24 hours	-76%

Approximately 76%-time reduction in validation of all reporting sheets is achieved. Associated with time, there is also a great decrease in validation cost per scrap reporting sheet. Table 3 shows the estimated gains for an average scenario of 21 defects per FG reference.

Table 3 - Gain in validation/codification of a scrap report sheet.

Before scrap application	After scrap application	Gain
Time spent for each scrap report sheet = 3 h	Time spent for each scrap report sheet = 0,74 h	----
Operator cost responsible for coding in BPCS system = 8 €/hour		----
Cost per sheet validation = 24 €	Cost per sheet validation = 5,92 €	18 €/sheet (75%)

For a coding scenario of 10 sheets per month, there are obtained savings of 180 €/month and 2160 €/year. As the application will be extended to other production modules, it is estimated that this gain will increase sharply. In addition to the gains previously shown, the following was achieved with the implementation of the application:

- Streamline and automate the creation of scrap report sheets;
  - Report increase by scrap code;
  - Greater reliability of scrap data;
- Simplify the scrap reporting process;
- Allow direct analysis and export of all defect data saved in the application;
- Integrated management of all scrap data related operations in a single application.

5. Conclusions

Effective data management is critical. Scrap is one of the main problems in the industry and it is crucial that all of this is properly reported, and all data is clear and reliable. Thus, its analysis becomes simpler and it is easier to identify where the main problems are in order to be able to act on them, reducing the likelihood that they will happen again later, minimizing the production costs of the various products, thus making the company more competitive. In identifying the problems that exist in a given set of procedures, the combination of quality tools and continuous improvement methodologies becomes essential to find the critical points and to act on them, trying always to achieve zero defects.

Thus, the main contribution brought by this work was the creation and implementation of an application which can be used for all products of the organization, and can be exported to other industrial sectors, clearly improving the scrap data management.

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