PROCEEDINGS FOR SOLVING NON-CONFORMITIES OF CAR WIRING SYSTEMS

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Rezumat. *În lucrare sunt prezentate proceduri pentru soluționarea neconformităților identificate la sistemele de cablare auto. Sunt stabilite cauzele rădăcină care conduc la apariția neconformităților în diferite posturi de lucru din fluxul de producție și se evidențiază procesul de proiectare și de utilizare a unui sistem Poka-Yoke necesar pentru îmbunătățirea operației de asamblare a agrafelor la produsul "Cablaj Planșă de Bord HJD". De asemenea, acest sistem asigură scăderea riscului de apariție a pieselor neconforme și a efortului operatorului în efectuarea operației menționate. Sistemul Poka-Yoke se adaugă celorlalte mijloace de control al calității utilizate în companie. Pentru îmbunătățirea permanentă a eficienței organizației, a calității produsului și a procesului este necesar să se lucreze într-o abordare structurată, cu o mentalitate adecvată.*

Abstract. *The paper presents some proceedings for solving non-conformities identified in car wiring systems. The root causes that lead to non-conformities in different workstations in the production flow are established and the process of designing and using a Poka-Yoke system needed to improve the assembly activities of the clips of the product "HJD Dashboard Wiring Systems" is highlighted. This system also ensures that the risk of non-conforming parts and the operator's effort in carrying out the activities is reduced. The Poka-Yoke system is in addition to the other means of quality control used in the company. In order to continuously improve the efficiency of the organization, the quality of the product and the process it is necessary to work in a structured approach, with a proper mentality.*

Keywords: non-conformities, wiring system, proceedings, Poka-Yoke, method 5 Why?

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1. Introduction

Car wiring systems are made of sets of wires that connect the car's components used for electrical and electronic functions. They ensure the supply of electricity, data and the control of the control pulse between the various electrical and electronic equipment to ensure all the electrical connections of the car.

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The paper presents some proceedings for solving non-conformities identified in car wiring systems [1-3]. The root causes that lead to the appearance of non-conformities in the production flow are specified, by analyzing the way of carrying out the activities within the workstations in which non-conformities products were manufactured. The case study was conducted within the Quality department from Leoni Wiring Systems. Emphasis was placed on the methodology for dealing with complaints received from the customer, but also on the quality methods and tools used for such analyzes [4].

Following the complaints received from the customer (Dacia Renault), the following activities were carried out to achieve the objectives:

- the cause-effect diagram was made in order to resolve the complaint received from the customer and to improve the quality of the product and the process [5];
- method *5 Why*? [6] has been applied in order to resolve the non-conformities claimed by the customer, but also to prevent the occurrence of other defective parts;
- the Poka-Yoke system [7, 8] was designed and implemented for the clips assembly device for the product “HJD Dashboard Wiring Systems” to prevent the recurrence of the “Missing Clip” defect and to reduce the operator's effort in performing the mentioned operation.

The paper also presents the improvements implemented by the Leoni company, in order to exclude any risk of a defect.

2. Procedure for handling complaints

The product “HJD Dashboard Wiring Systems” has several components in its structure: connectors, wires, terminals, tubes, clips, channel. Clips and channel are elements that help to secure the wiring systems on the car. These components are made by various companies, received and assembled within the company Leoni Wiring Systems. Therefore, it is important to have procedures for checking the quality of all parts received from suppliers and also procedures for checking the finished product [1].

Complaints from Leoni Wiring Systems customers are officially received in a computer system called GQE (Incoming Quality Management) where they are centralized and tracked daily. The validation of a complaint takes place only after it has been proved that the defect notified by the customer is caused by the supplier and not by other factors (improper storage of the product by the customer, non-compliant transport due to non-compliance with the supplier’s specifications) [9].

Fig. 1 shows a capture from the GQE system. It is noted that in addition to receiving complaints (Declaration of non-conformity of quality) this system also ensures the follow-up of the resolution of the causes of non-conformity (process 8D) and the economic data related to the activities carried out.

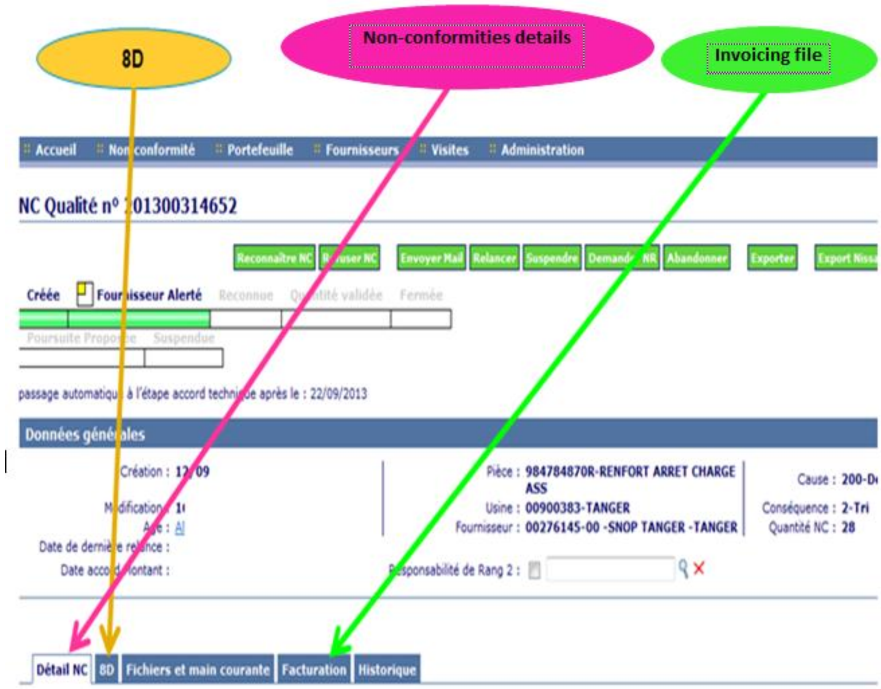


Fig. 1. Complaint opened in GQE

In order for the analysis of complaints to be effective it is necessary to know all the information about the claimed defect, namely:

- traceability of the product, in order to find out the date when it was manufactured, the shift on which it was made, the batch to which it belongs, the person responsible for the occurrence of the defect, in order to establish and restrict the dispersion field of suspected non-conform products;
- the effect on the customer, in order to be able to establish the corrective and preventive action plan;
- the impact of the defect on the finished product in order to carry out the retouching.

Each complaint opened in the GQE system by the customer has a number of points. Based on them, the supplier's score is calculated for the non-conformities recognized by him. The score represents the measure of the non-quality of the suppliers and is calculated as a weighted mathematical function, the relation (1), which takes into account the severity of the incidents, their consequence and recurrence, the number of non-conform parts.

$$\text{Non-quality points} = \text{Severity} + \text{Consequence} + \\ + (0.2 \times \text{number of non-conform parts}) \quad (1)$$

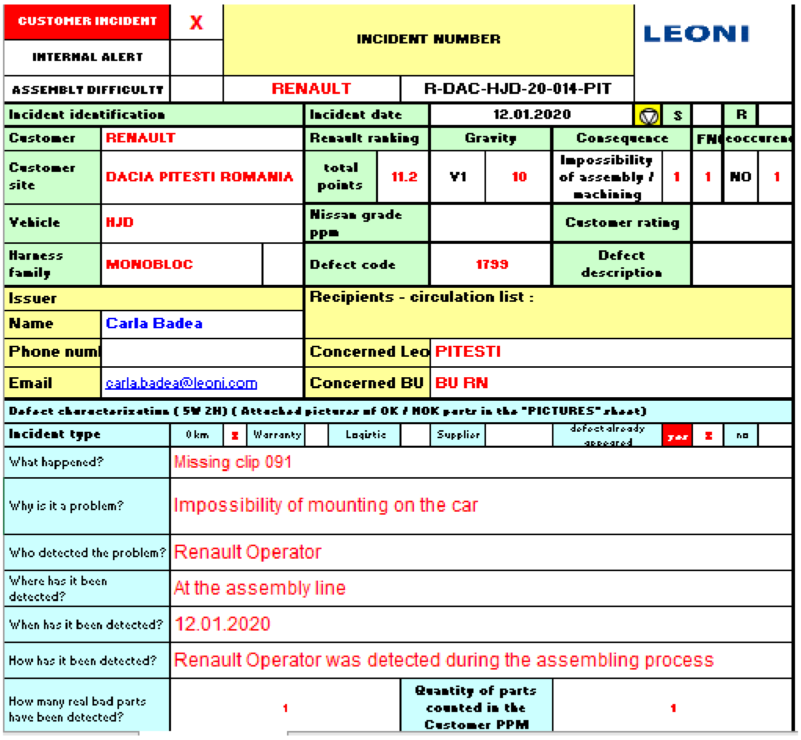
All these data are mentioned in the GQE statements of the clients. Table 1 shows the rating coefficients for each severity indicator (grouped on three levels, colored separately) and the type of the consequence.

Table 1. Complaint rating coefficients

Severity indicator	*Severity score*	*Consequence*	*Consequence score*
K1	50	Factory blockage	50
K2	20	Retouched out of flow	20
V1+	20	Flow rupture	10
K3	10	Retouch parts in flow	1
V1/A	10	Impossibility of assembly	1
B	5	Difficulty in assembly	1
C	1	Retouched without impact in the factory	1

Non-quality supplier points are a standard tool for:

- measuring the non-conformity of the quality of the parts made by each supplier;
- classification of suppliers according to the degree of penalty.


CUSTOMER INCIDENT: X
INTERNAL ALERT
ASSEMBLY DIFFICULTY
INCIDENT NUMBER: RENAULT R-DAC-HJD-20-014-PIT

Incident identification	
Incident date	12.01.2020
S	
R	
Customer	RENAULT
Customer site	DACIA PITESTI ROMANIA
Vehicle	HJD
Harness family	MONOBLOC
Renault ranking: total points	11.2
Gravity	V1 / 10
Consequence	Impossibility of assembly / machining / 1
FN	1
occurrenc	NO / 1
Nissan grade ppm	
Customer rating	
Defect code	1799
Defect description	
Issuer	
Name	Carla Badea
Phone num	
Email	carla.badea@leoni.com
Recipients - circulation list :	
Concerned Leo	PITESTI
Concerned BU	BU RN
Defect characterization (5W 2H) (Attached pictures of OK / NOK parts in the "PICTURES" sheet)	
Incident type	0 km: x; Warranty; Logistic; Supplier; defect already appeared: yes x, no
What happened?	Missing clip 091
Why is it a problem?	Impossibility of mounting on the car
Who detected the problem?	Renault Operator
Where has it been detected?	At the assembly line
When has it been detected?	12.01.2020
How has it been detected?	Renault Operator was detected during the assembling process
How many real bad parts have been detected?	1
Quantity of parts counted in the Customer PPM	1

Fig. 2. Internal complaint specific to Leoni Wiring Systems company

As soon as the complaint has been opened in the GQE customer system, the quality engineer gathers all the information from this system and translates it into an internal complaint format (Fig. 2), which is distributed to the company's management and the action plan will be opened later. The form in Fig. 2 contains the following information [10]:

- the number of the customer' complaint and the date of its receipt;
- the customer and the claimed product;
- the number of points assigned to this complaint;
- characteristics of the defect: what ?, why ?, who ?, where ?, when ?, how was the defect detected?

The complaint "Missing clip" was received for the product "HJD Dashboard Wiring Systems". The clip (Fig. 3) is needed to assemble the wiring system on the dashboard of the car.

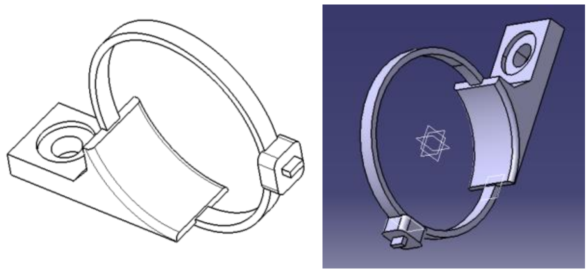


Fig. 3. 3D drawing for the piece "clip"

This complaint was rated with a V1/A gravity indicator that reserves 10 points, the consequences being the impossibility of mounting which causes 1 point, and the number of non-conform parts is 1 wiring system.

Using the above data, the total number of non-quality points is calculated using the formula (1):

$$\text{Non-quality points} = 10 + 1 + (0.2 \times 1) = 11.2 \qquad (2)$$

The complaint was rated with 11.2 points, which means that it is classified as the average level of gravity (in Table 1, orange color).

3. Case study

The assembly process of the product "HJD Dashboard Wiring Systems" is performed on an assembly line composed of 14 workstations and 2 stations outside the assembly line. The 14 workstations are intended for splicing operations (covering the branches of the wiring with insulating tape), inserting wires in connectors, inserting tubes of different temperature classes, wiring forming and closing stations, clips table, electrical control stand, final control and conditioning.

The clips table is the workstation where the wiring system is dimensionally checked and the clips are assembled on it. Also in this workstation, 100 % of each wiring system produced is checked, and in order to validate the operation, a label is issued, which is glued on the branch of the wiring system.

Within the company, several analyzes were performed that followed the following indicators:

- number of external defects (established based on the number of complaints received from the customer); is calculated in PPM (parts per million) [11];
- number of internal defects (established based on internal analyzes of the company / supplier);
- external sorting costs (for each complaint received from the customer, the sorting of the stock to the customer and to the supplier is organized).

PPM is the main indicator of quality, it is monitored daily by recording the daily amount of wiring systems produced and the defects recorded.

The PPM is calculated according to relation (3):

$$PPM = \frac{number\ of\ defective\ parts}{number\ of\ parts\ produced} \times 1000000 \tag{3}$$

January was chosen for the case study, as most of the complaints were registered this month. ”HJD Dashboard Wiring Systems” complaint is in the top 3, being in the first position in terms of number of complaints. Fig. 3 shows the number PPM of the external defects registered in January 2020.

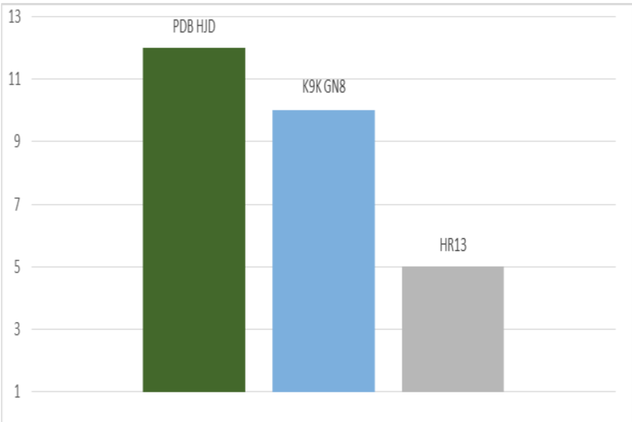


Fig. 3. Number of external defects registered in January 2020

Fig. 4 shows the number and type of internal defects registered in January 2020.

In January it is observed that the highest costs for sorting the parts of different products are recorded for the product ”HJD Dashboard Wiring Systems” (Fig. 5).

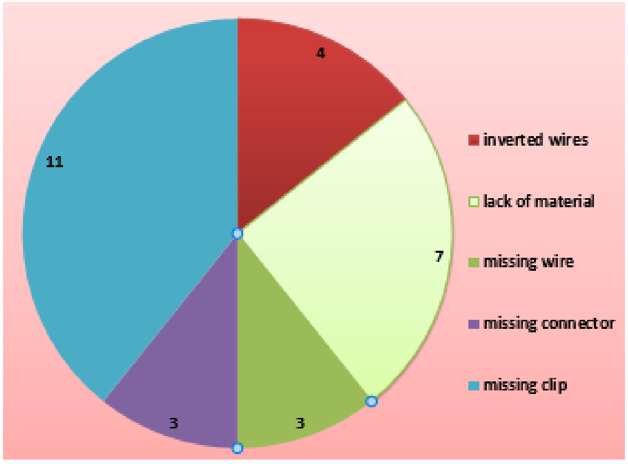


Fig. 4. Number and type of internal defects registered in January 2020

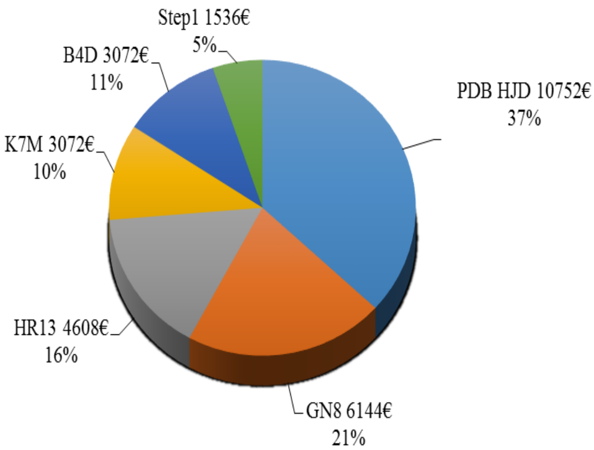


Fig. 5. Sorting cost for different products recorded in January 2020

Fig. 6 shows the non-conform product "HJD Dashboard Wiring Systems" claimed by the customer, due to the "Missing clip" part, compared to a conform product, which respects the position and presence of the clip.

Fig. 6. Non-conform product requested by the customer (right) compared to a conform product (left)

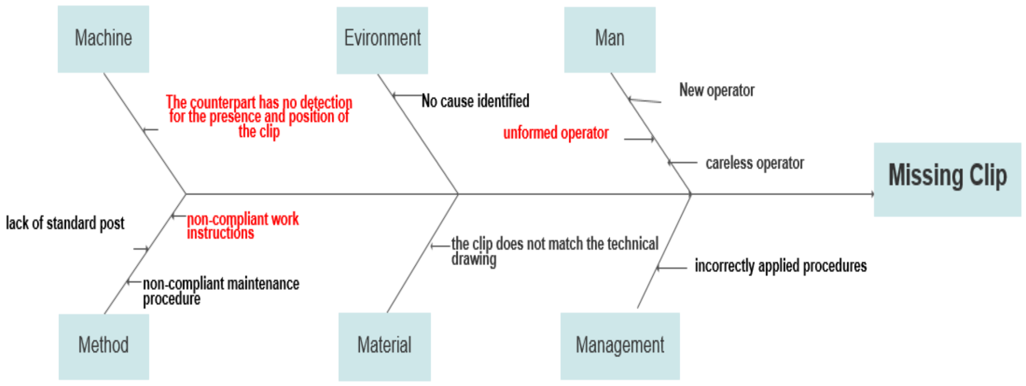


Fig. 7. Cause-effect diagram for “Missing clip” defect detection

In order to identify the causes that led to the non-detection and occurrence of the “Missing clip” defect, the cause-effect diagram was made (Fig. 7) [12]. All the factors that could lead to the non-detection of this type of defect were taken into account:

- machine – the workstation where the defect could have been detected; it is at the clips table, where the clip is assembled; the defect was not detected because the counterpart is undetected, there was no Poka-Yoke system;
- man – the operator of this workstation was trained, but after the analysis it was identified that he does not follow the work instructions;
- method – the working instruction and the job standard have been checked, and they are clear and well done, with all the necessary information;
- material – no direct cause was found because the clip matches the execution pattern;
- environment – the workstations are well lit, no direct cause for non-detection of this type of defect;
- management – the proceedings are analyzed if they are complete / incomplete, if they are applied correctly / incorrectly.

Starting from the two direct causes found with the help of the cause-effect diagram, the method *5 Why*? is applied to identify the root cause for non-detection and “Missing clip” defect occurence (Table 2).

Following the analysis, using the cause-effect diagram and method *5 Why*?, two root causes were identified for non-detection and occurrence of this type of defect:

- the counterpart is designed without detection, thus allowing the operator not to insert the clip at the time of cutting and thus influencing the lack of the clip;
- the clamp’ cutting is done manually, with a gun that is set to a force of 150 N; Fig. 8 shows the gun and the manual cutting performed by the operator at the clips table.

Table 2. Method *5 Why*?

5 Why?	*Occurance*	*Non-detection*
Root Cause	non-compliance with work instructions	the counterpart is not a Poka-Yoke device
Why?	the defect occurs when the operator does not follow the work instructions	when checking the part according to the work instructions, it is not possible to detect the defect
Why?	the operator goes through certain stages of the corresponding work process	the counterpart does not have a detection pin for the presence of the clip
Why?	do not insert the clip into the counterpart when cutting the clamp	the clip can be moved to the next workstation without being inserted into the counterpart at the time of cutting
Why?	the operator is in a hurry to perform the operations from the workstation	the counterpart is without clamp presence detection
Why?	the operator does not keep up with the cadence of the working band	the counterpart is not a Poka-Yoke device and it is with manual cutting
ROOT CAUSE	improperly performed operations, degraded working mode	it is the absence of detection, it is not required to insert the clamp into the device at the time of manual cutting by the operator

Fig. 8. Tightening and cutting gun for clamp

The first action taken to eliminate this type of defect was the development and installation of a Poka-Yoke device. Fig. 9 shows the 3D drawing of the device.

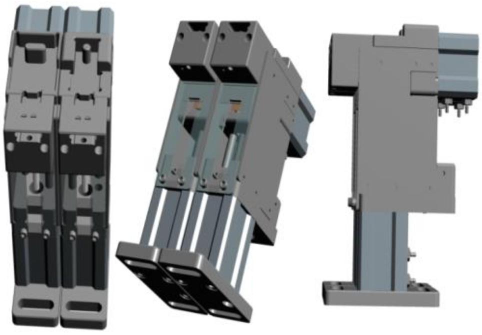


Fig. 9. 3D drawing of the device Poka-Yoke

The second action implemented to prevent this defect “Missing clip” is the obligation of the operator in the final control station to check 100 % the presence of the clip, according to the quality flash. Fig. 10 shows the quality flash proceeding.

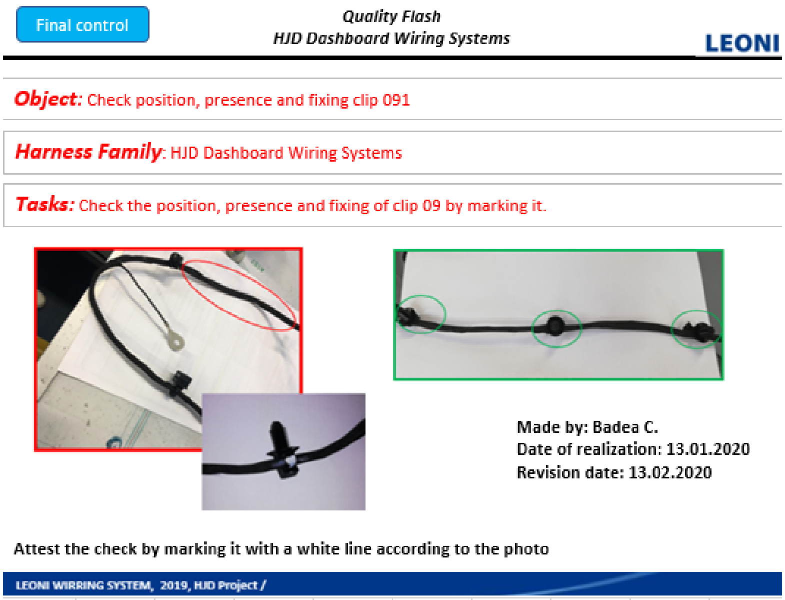


Fig. 10. Quality flash proceeding

After implementing the improvement methods, the Poka-Yoke device and the quality flash proceeding, the quality indicators “number of defects” and “sorting cost” were analyzed, noting that the process has improved. These methods were applied in February, the first full month of improvement being March.

The attestation of the fact that improvements have been made is observed in Fig. 11 - 14 where the evolution of several indicators is presented.

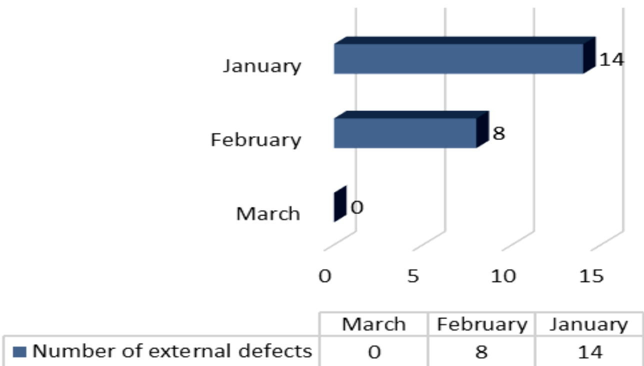


Fig. 11. The evolution of external defects in the three months

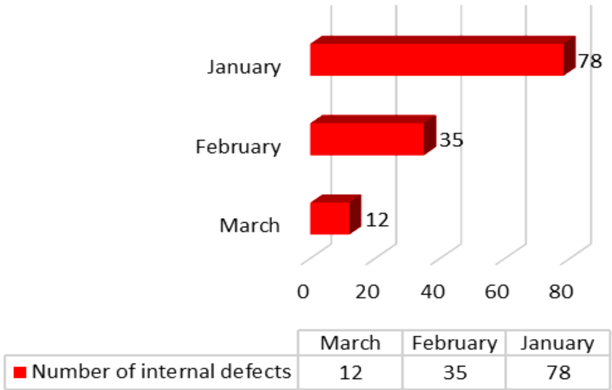


Fig. 12. The evolution of internal defects in the three months

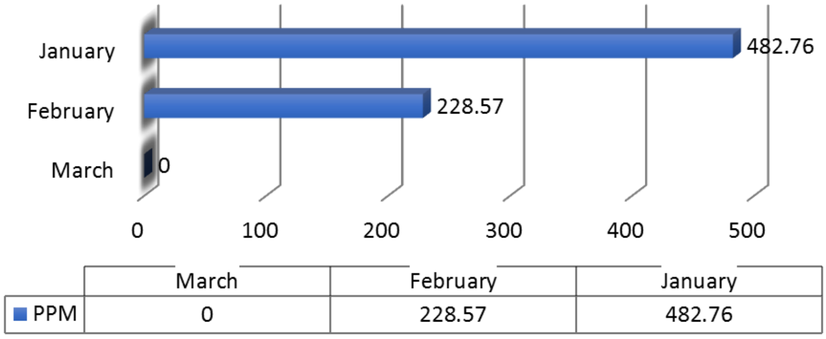


Fig. 13. The evolution of the PPM indicator in the three months

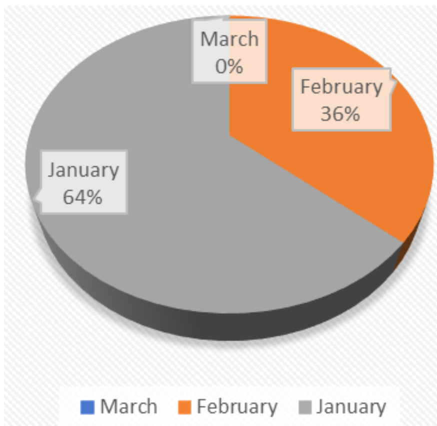


Fig. 14. The evolution of the sorting cost in the three months

The value of the PPM indicator in January is 482, and in March it is zero following the implementation of Poka-Yoke devices and the quality flash proceeding (Fig. 13). After the improvement of the process, the number of defects decreased considerably, which led to a decrease in the cost of sorting.

Conclusions

This paper dealt with a complaint received from the customer. The performance of the complaint handling process can be maximized when it comes to encouraging customers to communicate any suggestions or dissatisfaction with the purchased product, including customer satisfaction questionnaires.

In order to continuously improve the efficiency of the organization, the quality of the product and the processes it is necessary to work in a structured approach, with a proper mentality.

When complaints are handled properly, the result is an improvement in the company's reputation, regardless of the size, location and industry of the company.

In order to remedy the complaint received from the customer, the opportunity to implement a Poka-Yoke device was analyzed. It must be implemented according to the conditions imposed by the company's internal standards: requirements regarding costs, materials, technical characteristics of components and equipment. The proposed solution must first be compared with other possible variants and then implemented.

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