Quality improvement: reduction of defective parts in the stamping department of an automotive company

Mejora de la calidad: reducción de piezas defectuosas en el departamento de estampado de una empresa automotriz

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Abstract

Complying with the quality that customers require is an essential part of an organization, whether they are internal or external customers. This investigation was carried out in the Stamping and Body Departments of an assembled car company, these have performance indicators that impact both, one of them is *Body Bining to Stamping*, which represent the incidents in R / 1000 of defective parts released by Stamping found in Bodywork. During the analysis of the report, an increase in the indicator from 30.43 R/1000 to 44.14 R/1000 was noted, limiting the flow of parts of the manufacturing process, influencing productivity and the use of resources to repair parts with defects. Therefore, the objective is to reduce the number of defective parts of the *Body Bining to Stamping* indicator to increase the quality of the parts in the department studied. The procedure to be followed was DMAIC methodology, using the following activities: define the project to be attended, measure the process, analyze the causes of origin, improve the process, control the improved process and document the problem-solving process. The results that obtained show a decrease in the amount of defective parts of DPMO sending to the internal customer in approximately 65%. The goal of the Closures indicator was to send 28 R/1000 monthly incidents and managed to send 15.39 R/1000.

DMAIC, Continuous improvement, Quality

Resumen

Cumplir con la calidad que requieren los clientes es parte esencial en una organización, sean estos clientes internos o externos. Esta investigación se realizó en los Departamentos de Estampado y Carrocería de una empresa ensambladora de autos, estos tienen indicadores de desempeño que impactan a ambos, uno de ellos es *Body Bining a Estampado*, que representa las incidencias en R/1000 de piezas defectuosas liberadas por Estampado encontradas en Carroceria. Durante el análisis del reporte se notó un incremento del indicador de 30.43 R/1000 a 44.14 R/1000 limitando el flujo de piezas del proceso de fabricación, influyendo en la productividad y uso de recursos para la reparación de piezas con defectos. Por lo tanto, se plantea el objetivo de reducir la cantidad de defectos por millón de oporntunidades (DPMO´s) enviados a Carroceria. para incrementar la calidad de las piezas en el departamento estudiado. El procedimiento que se siguió fue la medotología DMAIC, utilizando las siguientes actividades: definir el proyecto a atender, medir el proceso, analizar las causas de origen, mejorar el proceso, controlar el proceso mejorado y documentar el proceso de solución de problemas. Los resultados que se obtuvieron muestran una disminución de la cantidad de DPMO´s de piezas defectuosas enviadas al cliente interno en aproximadamente un 65%. La meta del indicador *Body Bining a Estampado* era enviar 28 R/1000 incidencias mensuales y logró enviar 15.39 R/1000.

DMAIC, Mejora continua, Calidad

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Introduction

At present, the top management of every organization is concerned with the implementation of plans or procedures to improve the quality in each of its processes. This allows them to increase the competitiveness of their organization at national and international level, therefore and for some years, quality has become one of the most important strategies for all those organizations that are engaged in the production of goods or services, in order to remain competitive in the market.

According to Cubillos and Rozo (2009), the importance of quality for the competitiveness of companies is undeniable; The role of quality within organizations, its impact on the market, the progressive increase in the interest of the academic community, the changes it has undergone in its principles and practices, the organization of experts in the field, are indicators of its Advance. The quality approach has evolved both chronologically and conceptually until it reaches quality management, considering it as a multidimensional construct. So that the evolution and development of the various approaches has generated substantial changes in the profiles of the skills required by quality specialists and given the global nature of the management models, all members of the organization have a duty to Identify, control and improve quality levels under your responsibility.

Excellence in quality is a quality that any product must have to guarantee performance in terms of operation and durability. All companies seek to improve their competitiveness and seek that their products meet the demands of society. However, due to inadequate situations in their production, they are not able to establish quality control methods, since not all of them carry out a continuous improvement process to comply with norms and standards established by consumer needs.

According to Navarra (2010), improvement methods are of paramount importance for companies today, every company wishes to evaluate and improve the capacity of its processes. It also states that continuous improvement is much more than a method; It is a process-oriented way of thinking. It is a management philosophy whose protagonists are the employees themselves, those who best know the process and, therefore, can provide interesting improvement measures.

According to the above, all organizations must use continuous improvement to increase their productivity and competitiveness. For Lloyd's Register México, process improvement, waste reduction and product quality improvement lead to cost reduction to improve the final results (Lloyd's Register, 2018).

According to the Ministry of Economy (2017), the automotive industry is one of the most dynamic and competitive in Mexico and has established itself as an important player in the sector globally. Here vehicles that are sold throughout the world are produced, auto parts that are successfully integrated into the global industry value chains and niches are strengthened as the premium vehicle segment.

For its part, TIBA Mexico, states that the automotive market has become one of the most dynamic and competitive, being able to position itself as the 7th largest producer and 4th exporter of vehicles globally, contributing more than 3% of the National Gross Domestic Product and 18 % of manufacturing GDP. As for Foreign Direct Investment, the sector captures 20%. The auto parts industry maintains a sustained growth trend in the country since in the last five years, it has reached record figures both in production (82,000 million dollars annually) and in exports (65,000 million dollars annually). Currently, the country has become the sixth largest producer in the world, and the expectation is that in the coming years it will advance several positions (TIBA Mexico, 2017).

The company under study is dedicated to the stamping and assembly of cars. Its main objective is to provide high response capacity to the constant variations of the environment and adopt a new corporate philosophy that leads to business excellence and enriches the culture. It currently has five departments: Stamping, Body, Paint, Final Assembly and Administrative Offices. These are strategically distributed together with the material flow to optimize the use of the resources you need. The stamping department is divided into four lines, the process is similar between them and they are dedicated to the manufacture of panels or pieces of aluminum and steel sheet to be sub-assembled with the rest of the components of a car.

ISSN-On line: 2524-2040

Once the entire process has been carried out in each of the four production lines, the parts that are leaving are inspected to verify whether they are suitable for the market or not, following strict quality standards already established by the organization according to the specifications of the customers and safety regulations; the pieces that are accepted are placed in containers to be transported to the warehouses of the plant, to later be acquired by internal and external customers. Those that are rejected are classified into two types: those that can be repaired and those that are wasteful; those that can be repaired are placed in containers to be transported to the plant's metal finishing workshop (Metal Finish), and those that are waste are stored in the scrap baskets to be transported to an external customer who gives them a second use.

Within the stamping department there are performance indicators that help the organization to have a current situation against a desired situation, these are constantly compared and monitored to find opportunities for improvement and carry out projects that help minimize the gap between these values. Because the stamping process is not always executed in a similar way, it has to do with operational, physical and cultural factors, there are gaps between the ideal and the real. The following table shows the indicators that measure the performance of the object under study according to the standards and norms.

Indicator	Description	Real value	Desired value	Difference	Failure
1.Dimensional Capability PP	Measure the accuracy and capacity of the long-term stamping process.	100%	100%	0%	It is within the desired value
2.Dimensional Capability PPK	It measures the accuracy and capacity of the long-term stamping process.	99%	98%	1%	It is within the desired value
3. FTT: First Time Trough	Measure the percentage of NOK pieces within the total pieces produced in the turn.	91.8%	97%	5.2%	The desired value is not achieved. There are multiple reasons why the pieces come out with defects, whether operational, physical or cultural.
4. Metal Finish Inventories	Measure the NOK quantity of parts that are sent for repair on the shift.	1803 piezas/ turno	<1000 piezas/ turno	803 piezas/ turno	
5. Body Bining to Stamping (R / 1000): total incidents / 1000 pieces	It measures the leakage of reported NOK parts that were sent for subassembly.	60 R's / envío	30 R's / envío	30 R's / envío	The desired value is not achieved. The method of inspecting parts when leaving the line is not working properly.

Table 1 List of performance indicators of the stamping department
Source: Organization under study, 2017

It is observed that three of the five relevant indicators for the object under study show a difference between the real and the ideal, presenting symptoms such as:

- Variation in the processes.
- Breach of dimensional standards.
- Objectives out of control.
- Quality alerts sent by customers.
- Engineering changes in the designs.
- Rework in defective parts.
- Malfunction of the inspection process at the end of the line.
- Lack of culture and commitment in operational staff.

Problem Statement

In the Stamping and Body Departments of a car assembly company, they have performance indicators that impact both, one of them is Closures, which represents the leakage of defective parts that were sent from Stamping to Body. During the analysis of the report the following problem was noted:

The Body Bining to Stamping indicator has had an increase in a month from 30.43 R / 1000 to 44.14 R / 1000 limiting the flow of parts of the manufacturing process, influencing the use of resources for the repair of parts with defects and productivity the line.

Objective

Reduce the number of defective parts of the Body Binding to Stamping indicator to increase the quality of the parts in the production line four of the department studied.

Theoretical foundation

Dr. W. Edwards Deming in the thirties taught quality control courses and realizes that teaching statistics only to the manufacturing area of the organization would not solve their problems. After World War II he was invited to Japan to help encumbrar the nation and that is where Deming preaches the importance of management leadership, client-supplier association and continuous improvement in product and process development (Evans and Lindsay, 2014).

According to Gutiérrez and de la Vara (2013), a fundamental requirement of customers is that the products are of quality so that customers are satisfied. ISO (2015) defines quality as the degree to which a set of inherent characteristics of an object meets the requirements. In order for companies to comply with quality, they must be aware that if all areas and activities are improved, costs are reduced because there are fewer reprocesses, failures and delays. This implies that if the use of resources is improved, therefore it will increase productivity, therefore it is more competitive in the market. The challenge is to seek continuous improvement.

According to the rational basis of the quality management principle, established in ISO 9000: 2015, improvement is essential for an organization to maintain current levels of performance, react to changes in its internal and external conditions and create new opportunities. Continuous improvement is then established as a recurring activity to improve the performance of activities, processes, products, services, systems or organizations. Quality improvement is proposed as part of quality management aimed at increasing the capacity to meet quality requirements (ISO, 2015).

Ensuring that all the productive, administrative and service activities of an organization are planned, executed, controlled and, in the same way, improved with an orientation towards the needs of the consumer, both internally and externally, allows to develop what Deming called quality control to the whole width of the company (Cantú, 2011).

This same author states that the task of the leaders of the organization lies in bringing the company to the current level of performance, which it must have in order to grow and remain in the future, therefore, the processes must improve at the pace that the environment of competition mark. Total quality is a strategy that must be carried out as part of the company's operation and recommends using the Deming cycle: Plan, Do, Verify and Act (PHVA).

This same cycle applies to process improvement. The ISO 9001: 2015 standard establishes that the PHVA continuous improvement cycle can be applied to all processes and to the quality management system as a whole. It also states that the organization must improve processes and the quality management system (ISO, 2015).

Evans and Lindsay (2014) propose methodologies for process improvement, among some are: the Deming cycle, Creative problem solving, Custom improvement methodology and DMAIC. Escalante (2013), presents the phases and steps of the Six Sigma methodology based on the PHVA cycle:

1. To plan
a. Define the problem / select the project
b. Define and describe the process
2. Do
a. Evaluate measurement systems
b. Determine the significant variables
c. Evaluate process capacity
d. Optimize and strengthen the process
3. check
a. Validate the improvement
4. Act
a. Control and follow up the process
b. Continuously improve

This same author raises the DMAIC medotology (Defines, Measures, Analyzes, Improves and Controls) relating the previous activities:

1. Define
a. Define the problem / select the project
2. To size
a. Define and describe the process
b. Evaluate measurement systems
3. Analyze
a. Determine the significant variables
b. Evaluate the stability and capacity of the process
4. To get better

ISSN-On line: 2524-2040

a. Optimize and strengthen the process
b. Validate the improvement
5. Control
a. Control and follow up the process
b. Continuously improve

Methodology to be developed

The procedure that was followed was using DMAIC medotology and adapting it to the activities carried out by the organization, it is shown below:

Define the project to attend

In this stage, the critical output variables (CTQ's) of the indicator to be improved and the scope of the project were defined. To carry out these activities, a process flow diagram and a process diagram were mainly made, which helped to understand their operation, the "Walk the Process" was also performed, which means "Walk the Process", this in order to observe the process under study and meet everyone involved. The scope was defined in conjunction with the decision maker, in order to have clearly defined that it is desired to improve.

Measure the process

In this stage a measurement of the current performance of the process was performed to quantify the problem and characterize the critical output variables identified above, an analysis of the measurement system that is currently used in the process was also performed. Through a study of repeatability and reproducibility. These activities were carried out in conjunction with the process owners, in this case the production line supervisors and technical operators of the line, in order to numerically identify the difference between the real and the ideal.

Analyze the causes of origin

The sources of variation were identified, the causes of origin and the relationship between the causes were determined. To carry out these activities, a meeting was held with the decision maker or project supervisor and the process owners. Together, a brainstorm was created that allowed each of them to be organized and classify those that are directly affecting the problem identified.

To organize the ideas mentioned above, the cause and effect diagram (Ishikawa) was used, where the causes were classified by their different sources within the process, which could be: Material, Method, Labor, Machine, Measurement and Environment. Finally, the elements that make up each of the causes or which factor of that cause can be improved were also analyzed.

Improve the process

In this phase the effects of the identified critical variables were reduced, jointly reducing waste, improving the quality of the process. In addition, the improvement implemented was validated, obtaining the capacity of the process and analyzing the indicators involved. To carry out these activities, the factors or elements that can be improved must be taken as input. In this stage one or more factor of each cause are taken to be improved. At this stage, tools such as 5W + 1H, Histograms, were used to help improve the process under study.

Control the improved process

In this phase, the standardization of the process was sought through the improvements already made, creating feasible strategies for the entire production system. To carry out these activities, the process control charts were used to monitor that they are working properly, as well as a strategic process control plan that helps anyone involved to maintain the improvement for a long period of time. weather. To carry out this plan, the owners of the process and the project supervisor were involved, given their knowledge of the process, waiting for strategies that really help control it.

Document the troubleshooting process

At this stage the documentation of the entire process that was carried out to solve the problem was carried out, so that it serves as a guide to similar processes within the organization.

Results

Define the project to attend

In the stamping department of the Stamping and Assembly Plant, there are quality indicators for both the department itself, and for internal and external customers that are part of the flow of the manufactured material.

ISSN-On line: 2524-2040

In the present study it was decided to work with the indicator of the Department of Bodyworks (Body Shop-Closures), see figure 1.

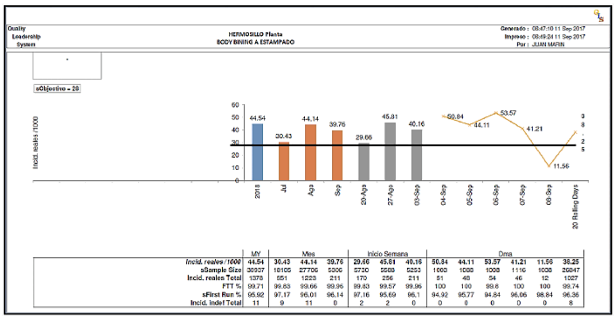


Figure 1 Indicator of Incidents in R / 1000 of Body Binding to Stamping for Stamping
Source: Stamping Department, 2017

The behavior of the Body Bining to Stamping quality indicator of the Closures area is measured in real incidents (released defective parts found in Bodywork) between the production size of that period of time (month, week, day, etc.) and finally It multiplies by a thousand. During the month of August 2017, there was an increase in this indicator, from 30.43 r / 1000 to 44.14 r / 1000, so the decision was made to work on it. The goal of the stamping department is to have only 28 r / 1000 per month. From this decision, an in-depth analysis of the indicator emerges, taking as much data as possible to classify and prioritize the incidents found, and to have a specific definition of the project. The classification tables of the collected data are shown below:

Default		Incidents		
		Total Aug	Total Sep	Total
1	Notch	449	124	**573**
2	Deformed surface	275	5	**280**
3	Dented out	100	53	**153**
4	Bad repair	59	33	**92**
5	Bruised blow	16	35	**51**
6	Dented inside	14	2	**16**
7	Contaminated	6	1	**7**
8	Die mark	5	1	6
		924	**254**	

Table 2 Classification of actual incidents found by default

Area	Total incidents	R / 1000
EOL (END OF LINE)	590	28.19
MF (METAL FINISH)	334	15.96
Sample rate	20932.41537	

Table 3 Classification of real incidents found by area in the month of August 2017

Default	Incidents	DPMOs
Notch	449	5362.4963
Deformed surface	275	3284.37969
Dented out	100	1194.31989
Bad repair	59	704.648734
Bruised blow	16	191.091182
Dented inside	14	167.204784
Contaminated	6	71.6591933
Die mark	5	59.7159944

Table 4 Conversion of actual incidents found by defects in the month of August 2017 to DPMO's

Area	Total incidents	DPMOs
EOL	585	6986.77135
MF/Criterio	334	3989.02843
Total	919	10975.7998

Table 5 Conversion of actual incidents found by area in August 2017 to DPMO’s

From the data shown above, it was possible to specify that most of the defective parts sent to the internal customer (Body) were found with “notch” type defects. To graphically understand the data shown, the Pareto diagrams of the incidents found in August 2017 are presented below:

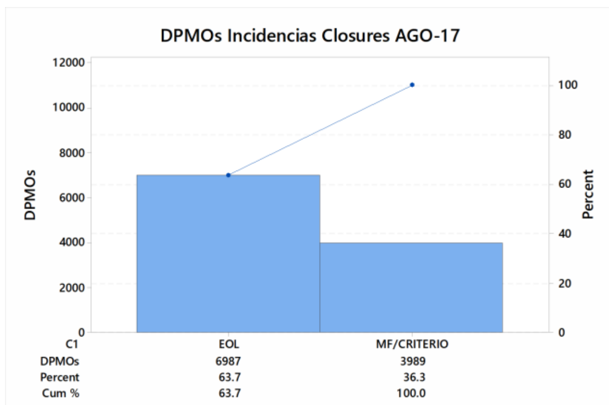


Figure 2 DPMO’s Pareto Diagram by Area

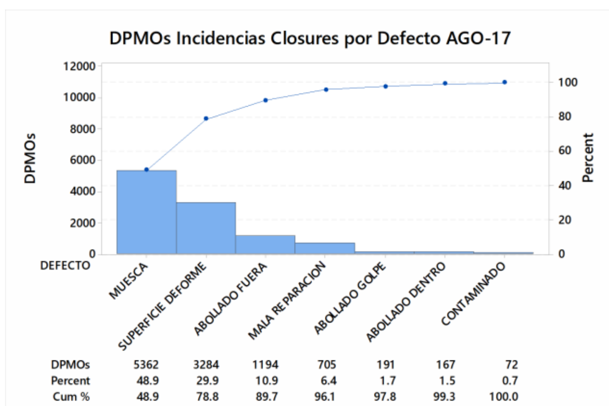


Figure 3 DPMO’s Pareto Diagram by default

ISSN-On line: 2524-2040

June 2019 Vol.3 No.4 1-11

The diagrams presented above show that 80-20 of the defective parts sent to bodies have defects such as notches and deformed surfaces, in addition, it can be seen that the largest number of defective parts sent come from the end of the line (EOL), which It implies that these pieces were released by the technical staff here as "OK" when in fact they should be considered "NOK" pieces.

Measure the process

To measure the process a capacity study was carried out, the steps to perform it were the following:

1. Make an agreement with the Process Audit team in turn for collaboration with the study.
2. Select the sample of parts to be inspected.
3. Perform the inspection of the parts together with the FPA in a total of 100%.
4. Document the results.

The process that was measured is that which is carried out at the end of the production line, where the parts being manufactured are inspected, which are not 100% inspected due to the cycle time of the production line. A format was first designed to help collect the data necessary for the study, which is shown below:

CAPACIDAD DEL PROCESO DE INSPECCION - MUESTREO DE PIEZAS						
OPERADOR: TURNO: FECHA DE PRODUCCION:						
# DE PIEZA	# DE DEFECTOS	TIPO DE DEFECTO	CUADRANTE	EXISTE INSPECCION DE MALLA	CUADRANTE	COMENTARIOS
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
n...						

Figure 4 Data collection format for studying the capacity of the inspection process

Afterwards, containers of "OK" pieces were taken randomly and were already released to be sent to customers. The selected pieces were inspected in their entirety to verify that they did not present any type of defect. The data collected is shown below in summary form:

Part number	Part	OP1	OP2	OP3	OP4	Average
441	BodySide ORhF	.00	.27	.00	.00	.07
442	BodySide OLhF	.00	.00	.00	.00	.00
443	Hood of	.15	.05	.15	.10	.11
444	FrontFender RLF	.08	.00	.00	.04	.03
451	BodySide OrhL	.06	.00	.06	PEND	.04
452	BodySide OLhL	.00	.00	.00	.00	.00
473	Hoodol	.05	.00	.10	.10	.06
474	Front FRLL	.13	.33	.04	.13	.16

Table 6 Table of results of the inspection process capacity

The quantities shown in the table above refer to the percentage of defective parts found in the container of the parts or parts released as "OK". The green color means that that amount is within standard and the red color means out of standard. However, with this data, a specific report of the capacity of the process could not be generated, so it was decided to summarize the data in the following way:

Shows	Inspected Parts	Defective pieces
1	11	0
2	11	3
3	11	0
4	11	0
5	11	0
6	11	0
7	11	0
8	11	0
9	20	3
10	20	1
11	20	3
12	20	2
13	26	2
14	26	0
15	26	0
16	26	1
17	16	1
18	16	0
19	16	1
20	16	0
21	16	0
22	16	0
23	16	0
24	16	0
25	20	1
26	20	0
27	20	2
28	20	1
29	24	3
30	24	8
31	24	1
32	24	3

Table 7 Summary of data collected to determine process capacity

The last step to obtain the capacity of the inspection process at the end of the line was to enter the data obtained to MINITAB to generate the capacity analysis report, obtaining as a result the following:

ISSN-On line: 2524-2040

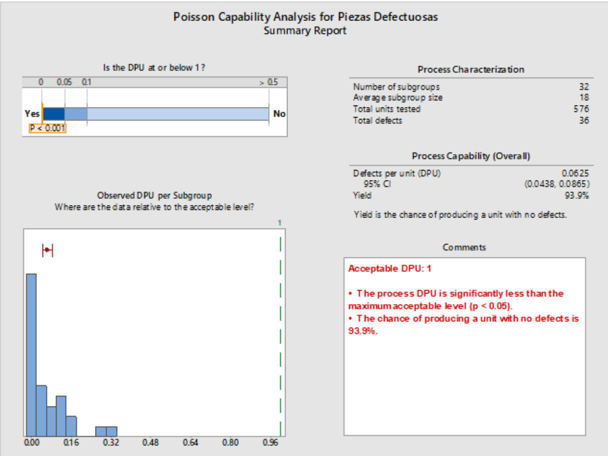


Figure 6 Inspection capacity analysis report
Source: Extracted from Minitab 2017

The report reflects that the inspection capacity of the end of the line is good, since it establishes that the possibility of producing a unit without defects is 93.9%, and that the process of DPU (Defects Per Unit) is significantly lower than the level maximum acceptable (p <0.05).

To continue with the measurement of the process of the present project, a repeatability and reproducibility study of the measurement system used was carried out, which in this case are the line operators since they are the ones that carry out the inspection of the parts, because the system is measured by attributes with the philosophy of "accepted or rejected". The procedure to carry out the study was similar to the previous one, in this case only one container of parts was taken, and it was inspected by all the operators involved, in the container there were "OK" pieces and unidentified "NOK" pieces. operators had to observe each of the pieces and based on their criteria and experience in the process decide whether that piece was accepted or rejected. The collected data is shown below:

Unit	Operador 1		Operador 2		Operador 3		Operador 4		Operador 5		Operador 6		Expert Decision
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	
1	Accept	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Reject	Accept
2	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject
3	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject
4	Accept	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Reject	Accept
5	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Accept
6	Reject	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject
7	Accept	Reject	Accept	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
8	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Reject	Reject	Reject
9	Accept	Reject	Accept	Reject	Accept	Accept	Reject	Reject	Accept	Reject	Accept	Accept	Accept
10	Accept	Reject	Accept	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Accept	Accept
11	Accept	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Reject	Accept	Accept
12	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject
13	Accept	Reject	Accept	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Accept
14	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Reject
15	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Accept
16	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject
17	Accept	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Reject	Accept
18	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept	Reject
19	Accept	Reject	Reject	Reject	Accept	Reject	Accept	Reject	Reject	Reject	Accept	Reject	Accept
20	Reject	Reject	Reject	Reject	Accept	Accept	Accept	Reject	Reject	Reject	Reject	Reject	Accept
21	Accept	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Reject	Reject	Accept	Accept	Accept
22	Accept	Reject	Reject	Reject	Accept	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Accept
23	Reject	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Reject	Accept	Accept	Reject	Accept
24	Reject	Reject	Reject	Reject	Accept	Reject	Accept	Reject	Reject	Reject	Accept	Reject	Accept
25	Reject	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Accept	Reject	Accept
26	Reject	Reject	Reject	Reject	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
27	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Reject	Accept
28	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Reject	Accept
29	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept	Reject	Accept
30	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Accept	Reject	Accept	Accept	Accept
31	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Accept	Reject	Accept
32	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Accept	Reject	Accept	Accept	Accept
33	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
34	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
35	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Accept
36	Reject	Reject	Reject	Reject	Accept	Accept	Reject	Reject	Reject	Reject	Reject	Reject	Accept
37	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
38	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
39	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept
40	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Accept

Figure 7 Data collected for the R&R Study

In addition to the inspection made by the operators, a "master" inspection was carried out and was done by the audit team. Taking into account your decision as an expert since the procedure for conducting an R&R study by attributes so proposes. The next step was to enter the data obtained to MINITAB to generate the report of the R&R study, obtaining as a result the following:

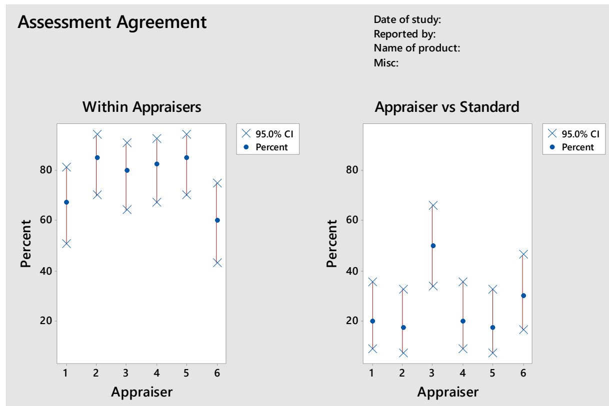


Figure 8 R&R study report by attributes
Source: Extracted from Minitab 2017

The report of the repeatability and reproducibility study reflects that the percentage of agreement between the operators is acceptable since the majority presented from 60% to 85%, however the measurement system is affected because the opinion of the operators against the defined standard It is not the same, and this is reflected in the second graph of the report where it is observed that the percentage of agreement is between 10% and 40%, so corrective actions must be taken to improve the measurement system and improve together the indicator of defective parts released to the internal customer.

Analyze the causes of origin

In this phase a brainstorm was carried out in conjunction with the decision maker (project manager) to understand the operational, physical and cultural factors that affect or benefit the process under study. The cause-effect diagram (Ishikawa) shown below was used to sort the ideas:

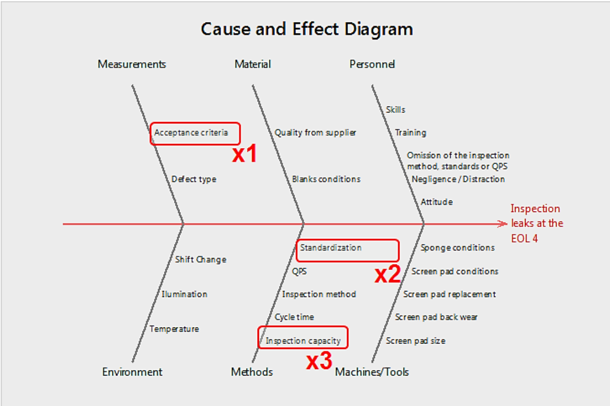


Figure 9 Diagram cause effect
Source: Extracted from Minitab 2017

After organizing all the causes in the diagram shown above, three of them were chosen as "potential causes" that directly affect the problem, which are ordered from major to minor importance below:

1. Acceptance requirements.
2. Standardization of the method.
3. Inspection capacity.

Improve the process

To improve the process under study, the components mentioned above in each of the potential causes were taken as a reference; Below is a table with each of them and evidence of corrective action to improve:

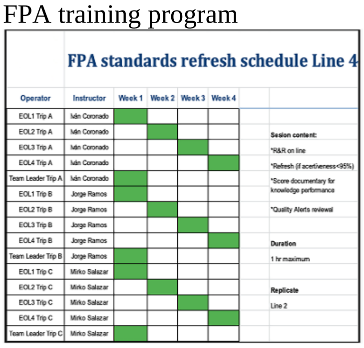
<table>
<tr><th>Potential Cause Component</th><th>Evidence of corrective action to improve</th></tr>
<tr><td>1. Improve the acceptance criteria through the implementation of a training / training program for the FPA of both work stations (stamping and closures department).</td><td>FPA training program

<table>
<tr><th colspan="6">FPA standards refresh schedule Line 4</th><th></th></tr>
<tr><th>Operator</th><th>Instructor</th><th>Week 1</th><th>Week 2</th><th>Week 3</th><th>Week 4</th><th></th></tr>
<tr><td>EOL1 Trip A</td><td>Iván Coronado</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>EOL2 Trip A</td><td>Iván Coronado</td><td></td><td></td><td></td><td></td><td>Sesion content:</td></tr>
<tr><td>EOL3 Trip A</td><td>Iván Coronado</td><td></td><td></td><td></td><td></td><td>*R&R on line</td></tr>
<tr><td>EOL4 Trip A</td><td>Iván Coronado</td><td></td><td></td><td></td><td></td><td>*Refresh (if acertiveness<95%)</td></tr>
<tr><td>Team Leader Trip A</td><td>Iván Coronado</td><td></td><td></td><td></td><td></td><td>*Score documentary for knowledge performance</td></tr>
<tr><td>EOL1 Trip B</td><td>Jorge Ramos</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>EOL2 Trip B</td><td>Jorge Ramos</td><td></td><td></td><td></td><td></td><td>*Quality Alerts reviewal</td></tr>
<tr><td>EOL3 Trip B</td><td>Jorge Ramos</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>EOL4 Trip B</td><td>Jorge Ramos</td><td></td><td></td><td></td><td></td><td>Duration</td></tr>
<tr><td>Team Leader Trip B</td><td>Jorge Ramos</td><td></td><td></td><td></td><td></td><td>1 hr maximum</td></tr>
<tr><td>EOL1 Trip C</td><td>Mirko Salazar</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>EOL2 Trip C</td><td>Mirko Salazar</td><td></td><td></td><td></td><td></td><td>Replicate</td></tr>
<tr><td>EOL3 Trip C</td><td>Mirko Salazar</td><td></td><td></td><td></td><td></td><td>Line 2</td></tr>
<tr><td>EOL4 Trip C</td><td>Mirko Salazar</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Team Leader Trip C</td><td>Mirko Salazar</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>2. Improve the standardization of the method through a change in the QPS's of both workstations (stamping and closures department).</td><td>To better visualize the QPS's of both stations it is recommended to see Annex 1. QPS's BEFORE-AFTER the work stations involved.</td></tr>
</table>

Table 8 Corrective actions for the process under study

In summary, the corrective actions mentioned above reflected an improvement in the performance indicator under study, obtaining the following result:

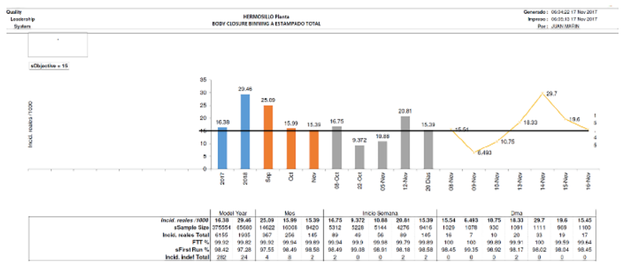


Figure 10 Incident Indicator in R / 1000 of Closures for Stamping (after)
Source: Department of Stamping and Removing of Minitab 2017

In contrast to Figure 1, the significant improvement that reduced the amount of R / 1000 or DPMO's of defective parts sent to the internal customer by 65.33% can be observed. The objective of the Printing department is achieved, which is to send an amount of 28 R / 1000 per month, decreasing this amount from 44.14 R / 1000 to 15.39 R / 1000 for the month of November 2017.

Control the improved process

To control the process under study, a stability report was made in the 2017 Minitab software:

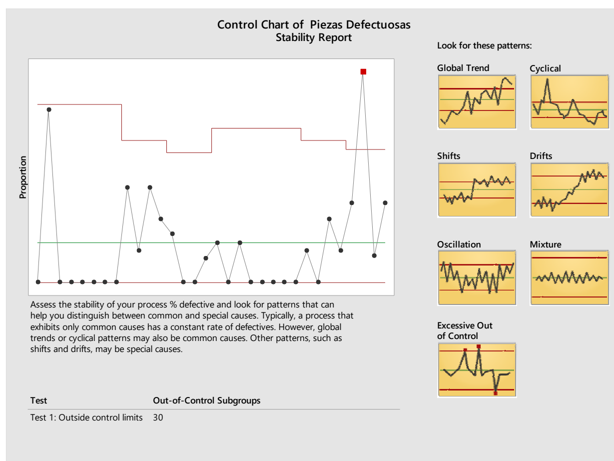


Figure 11 Stability report of the line 4 inspection process
Source: Extracted from Minitab 2017

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In the report it can be observed that the process is stable, however it shows fluctuations or variation, so care must be taken so that it does not get out of control. To reduce the possibility of getting out of control, it was decided to implement a daily monitoring plan, which was added to the TDM (Time and Data Management) of each supervisor and each production leader in turn, so that a procedure is complied with adequate monitoring and continuous improvement achieved; Below is the updated TDM:

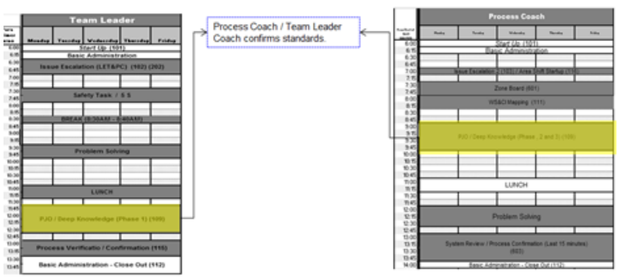

Figure 12 TDM Supervisor and Production Leader updated

Document the troubleshooting process

To carry out the documentation of the problem-solving process through the DMAIC methodology, a presentation was made in Microsoft Power Point with the steps and evidence of each of the phases of this methodology, using the standard format of the organization under study. Below is the cover of this presentation as evidence that was made and published in the database of the same.

Figure 13 6-panel presentation cover

Conclusions

The development of statistical methodologies helps any organization to know, analyze and improve its products and processes. Continuous improvement is a process that aims to increase compliance with the requirements of the products, services and processes of an organization. The evolution that the quality management approach has undergone has allowed us to visualize that all the members of the organization have the duty to identify, control and improve the quality levels of the activities and their results that are under their responsibility.

It can be established that continuous improvement is a management philosophy whose protagonists are the employees themselves since the successful implementation of continuous improvement in any organization requires as a starting point to create a culture of improvement. This is achieved by raising awareness among all the personnel involved and making them part of the team so that they feel responsible for any significant changes that the process presents.

If workers receive constant training or training, they help operators to feel owners of the processes and gain interest in improving. The part that was improved was within the inspection process: it was standardized, moving from several methods used to just one inspection method where all participants received the corresponding training.

In the present study, a beneficial result was obtained for the department, since it was possible to reduce the amount of defective parts that the immediate client receives, having an impact of 65.33% reduction on the amount of total DPMOs during the months of August to November of the year in which it was made. It is important to mention that the procedure carried out is reapplicable for any similar process of the organization in any department, since the improvements that were made are of a general nature and can easily be made.

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