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Performance indicators in the sustainable management of the company Metalyzinc

Desempeño de indicadores en la gestión sostenible de la empresa Metalyzinc

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Abstract

The research has been developed according to the result of the experimental study of the anti-corrosion protection service of the company Metalyzinc, in the period September 2020 - April 2021, where it is proposed that the performance of the indicators favors the competitiveness of the industrial service of the company of the COBOS Group founded in 1989, therefore, how is the sustainable impact by the management of the indicators in the service of the anti-corrosion protection system?; question that has allowed the content analysis of the reference framework of the context of the study, the knowledge of the operating process that involves the types of variables of the Galvanizinc System service, with the purpose of examining the impact of management, and the evaluation of the performance of the process with the support of diagnosis, application of statistical tools, innovation methodology and use of operational diagrams, contributing to the strengthening of strategic planning, the development of proposals for improvement and sustainable management.

Indicators, Galvanized, Management

Resumen

La investigación se ha desarrollado conforme al resultado del estudio experimental del servicio de protección anticorrosiva de la empresa Metalyzinc, en el periodo de Septiembre 2020 – Abril 2021, donde se plantea que el desempeño de los indicadores favorece la competitividad del servicio industrial de la empresa del Grupo COBOS fundada en 1989, por lo tanto, ¿Cómo es el impacto sostenible por la gestión de los indicadores en el servicio del sistema de protección anticorrosiva?; interrogante que ha permitido el análisis de contenido del marco referencial del contexto del estudio, el conocimiento del proceso operativo que involucra los tipos de variables del servicio Sistema Galvanizinc, con el propósito de examinar el impacto de la gestión, y la evaluación del desempeño del proceso con el apoyo de diagnóstico, aplicación de herramientas estadísticas, metodología de innovación y uso de diagramas de operaciones, contribuyendo en el fortalecimiento de la planeación estratégica, el desarrollo de propuestas de mejora y de la gestión sostenible.

Indicadores, Galvanizado, Gestión

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Introduction

The company is in search of a quality improvement that allows the control of the service parameters, which is equivalent to generate products or services according to the standards established by the regulations or clients, which is the reason why in the last ten years quality has acquired transcendence in all levels of society (Verdoy et al., 2006).

The hot-dip galvanizing service is an advanced industry, dedicated to the protection against corrosion of iron and steel parts by immersing them in a crucible with molten zinc. As a result of the immersion, coatings are obtained that provide the parts with effective and long-lasting protection. These coatings have a much better adhesion than paints because they are alloyed with the base steel.

The control of indicators has become one of the key issues in organizations, since waste and losses caused by rejects, rework and returns can be very high, affecting the profitability of the business.

However, statistical control tools have evolved in the industries, but the use of statistical techniques is very low, often being considered very difficult, unnecessary and with high costs (Miró, 2005).

By means of statistical analysis and process design in particular, it is possible to reduce the number of critical variables. Since the application of statistical process control is governed by the concept of continuous improvement, the results obtained must be evaluated from time to time in order to, in a given case, re-evaluate from the lower and upper limits to the definition of KPI (Key Performance Indicator).

In the organization there are KPIs according to the areas within it, highlighting their use in areas such as logistics, quality, purchasing, sales, production.

The main objectives of the performance indicators are to measure the level of service, make a diagnosis of the situation, reporting its status, generating an environment of motivation to the teams responsible for meeting the objectives reflected in the KPI and, in general, to evaluate the progress constantly, that is why, the interest of promoting its importance within the business environment, and to promote the importance of this topic to engineering students, teachers and related professionals and also to companies that do not know the use of a KPI, which implies the characteristics, its use and impact on the performance of the organization through a methodology that can duplicate the effectiveness in innovation processes, also, that allows sustainable integration, stability, improvement and reduction of variability.

Planning and measurement are essential for a company to succeed. Carefully evaluating strategies and their results allows correcting mistakes, detecting new opportunities, anticipating consumer behavior and making better decisions. In order to carry out this continuous evaluation process, it is necessary to start from the key performance indicators, where the respective performance of the indicators favors the competitiveness of the industrial service, and the sustainable impact by the management of the indicators on the service of the corrosion protection system.

The sections of the article have been developed by blocks with the purpose of optimizing by demonstrating an option of impacting sustainability in the management of the indicators of the corrosion protection system, where, in the development part, listed in three parts, the topics are described in section one, the corrosion protection service, and in section two, the experimental work, where the methodology consisting of application of statistical tools is described in the section of general methodology of the study and innovation. Subsequently, the results, acknowledgements, conclusions of the research and its references are indicated.

Figure 1 Facade of Metalyzinc, S.A. de C.V. facilities
Source: COBOS Group Marketing

Corrosion protection service

The Galvanizing process in the plant starts when we coat with Iron, Steel with Zinc or with alloys made of Zinc-Iron by immersing the part in molten Zinc, thus forming a long lasting protective layer with resistance in almost all natural environments.

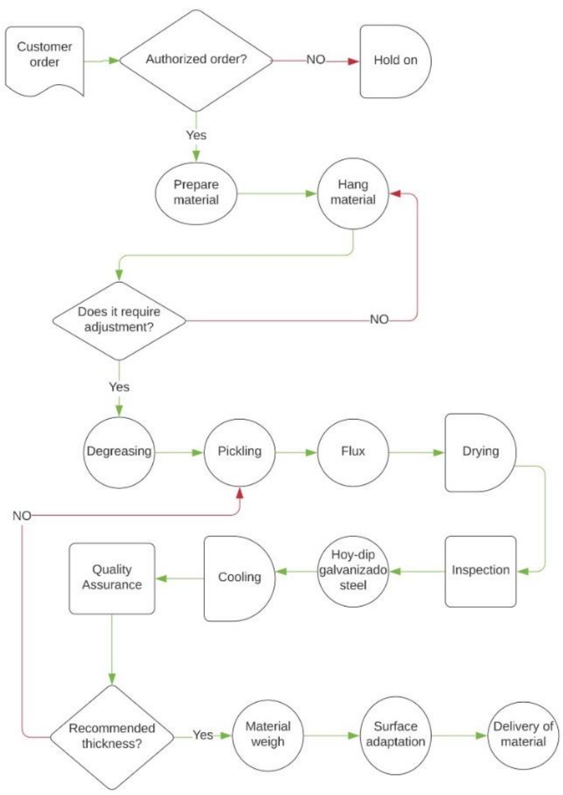


Figure 2 Flow chart of the operational process
Source: Thesis by Martínez Peña, Mª. Guadalupe

This diagram in figure 2, consists of the description of the following steps:

- At material reception, the conditions and weight of the material are inspected, as well as the initial service conditions are established.

- The process of hanging parts to be galvanized allows the parts to be sorted and clamped in relation to their weight and shape, also, the inclination and the object holder are determined so that the hot Zinc can flow properly.

- In the saline solution, the material is purified by eliminating grease or oil impregnated since its manufacture. It is very useful to eliminate organic contaminants such as grease, oil and dirt that adhere to the metal surface.

- In the rinsing stage, it avoids carrying impurities to the next stage of the process.

- With respect to the acid solution at room temperature, it allows the removal of rust and calamine, which are the most common surface contaminants.

- With the second rinsing stage, it prevents acid residues from passing to the next stages of the process.

- In the salt bath process, it favors the impregnation of the molten zinc on the steel surface.

Figure 3 Steel in salt bath
Source: Ruiz, E. (2016) Practical guide for hot dip galvanizing. Retrieved from https://www.idu.gov.co/web/content/7423/guia_galvanizado_24nov14+(1).pdf

- In the hot air-drying option, the parts are transferred to a hot air drying pit before immersion in the molten zinc bath.

- Being the heart of the process, the galvanizing area, the parts are immersed in a bath of molten zinc, at temperatures between 440ºC and 460ºC, this temperature will depend on the type of material structure to be protected.

- And, as a stage prior to delivery or storage as an accepted product, the thicknesses are sampled and appearance is checked to comply with the standard requested by the customer, when necessary, it is taken to the finishing area to remove burrs, sharp drops and surface adhesions of ashes or salt residues, to later perform a final inspection.

This protection is stronger than steel itself and is capable of protecting small bare areas (by means of galvanic protection) and is extremely economical. For small parts, on the other hand, we apply centrifugation after immersion. We also perform the process of galvanizing only on the outside, to power radiators, coils and other parts.

The hot-dip galvanizing layer is formed by Zn-Fe alloys, which is made with the Zinc and Iron bath of the parts. The thickness and appearance of this protective layer depend on multiple factors, some of which are specific to the part itself and others to the bath.

Hot dip galvanizing (Galvanizinc System) is one of the best options for corrosion protection of iron and steel.

Figure 4 Galvanized parts over molten zinc
Source: Metalyzinc Quality

The barrier protection occurs because a thin layer of zinc oxides is created on the zinc surface, due to the fact that carbon dioxide CO_2 from the atmosphere reacts with the zinc resulting in zinc carbonate $ZnCO_3$ which is insoluble in water and prevents the formation of corrosion products. Through a process of diffusion saturation of the steel surface with zinc, as a rule, in the range of 300-550ºC in a suitable medium.

Experimental work

Collection of information

The selection of the service was made in conjunction with the company's quality manager, considering the impact on delivery time due to rework or reprocessing. Considering the process of immersion of parts in molten zinc. The information for the year 2020 was recorded, specifically for the type of structural material, in order to have sufficient data for the analysis. This analysis was developed in the period from December 2020 to February 2021. The critical variable is the time of immersion in molten zinc, which has the following classification of defects found during the analysis period, which depends on the quality of chemical cleaning.

Category	Type of defect	
Zinc-related	Zinc lumps	Zinc splashes
Appearance	Welding spatter	Ungalvanized surfaces
Superficial	Blisters (air bubbles)	Clogged threads

Table 1 Defect category
Source: Metalyzinc Quality Area

As can be seen, the different types of defects that were studied were mainly six, where, when grouped together, they are concentrated in only three categories, related to zinc, appearance and surface.

And, according to the type of performance indicator, they were analyzed with a financial, customer, process, learning and growth perspective, as part of the good practices of the balanced scorecard.

With reference to the use of the indicator, they were determined by their duration, quality and effectiveness.

General methodology of the study

The steps developed in the research were through the following items in conjunction with the innovation methodology subsequently characterized:

- Diagnosis of the company: Knowledge of the process, identification of areas of opportunity and key indicators.

- Information gathering: Search for records of operations, selection and analysis through statistical tools (Pareto Chart, Statistical Process Control CEP, Bayes Theorem).

- Development of the indicators model according to the opportunities and weaknesses determined in the production line.

- Implementation through the follow-up of the operations with the support of a flow chart generated by guided tours, interviews and observation logs.

- Analysis of the results with statistics, incorporated in each area of the production line, reaching great importance in the process, being an essential tool for decision making through data summary, sampling plan, control, design and research.

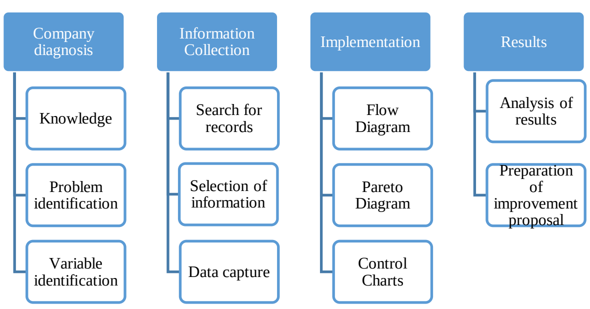


Figure 5 Methodology scheme
Source: Thesis of Martínez Peña, Mª. Guadalupe

It highlights, Statistical Process Control, is a statistical approach to help operators, supervisors and managers manage quality and eliminate the causes of variability in the process (Berthe and Gidey 2016).

Innovation methodology

The experimental study applied the steps of the Forth Innovation methodology, proposed by consultant Patricia Galiana in 2017, created by Gijs van Wulfen, is a methodology dedicated to doubling the effectiveness in customer-focused innovation processes that helps develop and improve products, services and business models. Forth helps to improve processes through innovation improvements that work effectively through three of the most useful trends of our time: design thinking, creativity and business reality.

Its name comes from an acronym taken from the first letter of each of the steps that must be followed to develop this methodology. Thus, the nickname FORTH comes from:

- Full steam ahead.

- Observe&Learn (observe and learn).

- Raise Ideas (generate ideas).

- Test Ideas.

- Homecoming.

With this, the FORTH methodology aims to sort out the chaotic state of innovation and foster a culture for innovation in a 20-week expedition.

The results of this innovation expedition are 3-5 mini new business cases for innovative ideas, which are in line with the reality of the organization (Galiana, Patricia; Van Wulfen, Gijs. 2017).

And, with statistical thinking in the methodology, it has contributed at the three levels of the organization, involving the strategic, managerial, and operational area. (See figure 6):

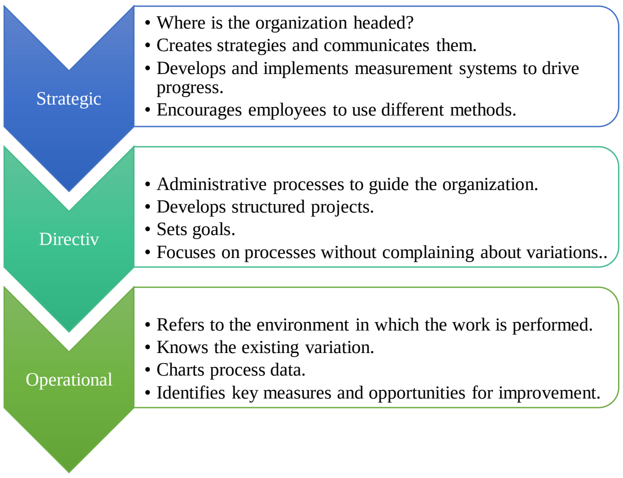


Figure 6 Diagram of statistical thinking
Source: Gutiérrez and De la Vara (2009)

Results

The operational indicators were aligned with the strategic objectives considering the context, the level, the data, their interpretation and the generation of the action plan. Therefore, the indicator has been considered to influence by being specific, measurable, achievable, real and just in time. And the following scheme simplifies the steps for the design of a KPI used for the galvanizing production line.

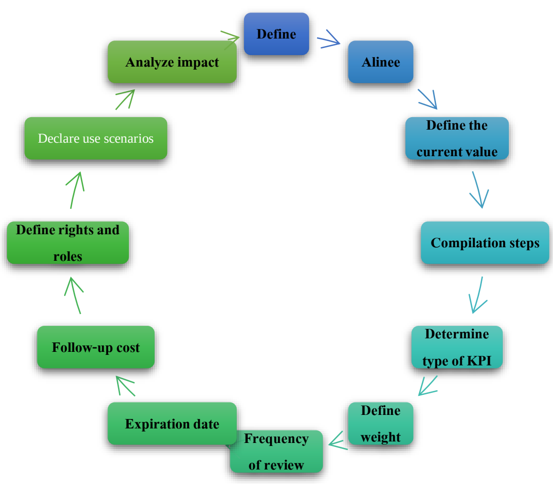


Figure 7 KPI Template: 12 steps to achieve a perfect KPI
Source: BSC Designer.

Hereby, the steps of the KPI template, applied in the research, are described:

1. The name of the indicator is defined, avoiding combining the objective, time scope and units of measurement.

2. The indicator is aligned with a strategic objective, where it does not imply doing a little better than what was previously done.

3. The current value is defined through questions, from the reference point and the objective, which implies reaching or staying within the tolerance level.

4. The information is collected by identifying the data recorded through the network (connected) or manually.

5. The classification of performance indicators related to success factors or results (achievement of the goal) is performed.

6. The weighting weight (percentage value) is defined with respect to its impact and relevance.

7. The updating periods are defined to avoid the excess of performance metrics and high measurement costs.

8. Establish dates of evaluation or expiration of the indicator for changes in tolerance or focus in the business strategy.

9. A budget is determined for monitoring the indicator, identifying the types of costs.

10. The privileges of the organization's personnel are determined, which implies the level of visualization of the behavior, collection or consultation of results of the indicator of a certain process or work area.

11. The reasons for assigning the indicator and the way of using the data in reports, follow-up or self-monitoring are established.

12. The results or performance of the indicator are analyzed through statistical tools suitable to the understanding of the organization, involving the description of operational and administrative changes.

Subsequently, the following table, as part of the study of a given period and type of material, shows the ordered frequencies of the classification by type of defect in the hot dip galvanizing process as part of one of the indicators identified in the study.

Immersion	Defect Appearance	Defect Surface	Thickness defect
419	4	12	9
241	2	17	12
326	0	11	8
260	0	9	7
474	0	5	5
242	1	7	2
278	1	5	4
436	2	7	5
381	3	2	1
536	4	5	2
380	2	2	2
412	7	1	4

Table 2 Frequency of immersion and category of defects.
Source: Metalyzinc 2020 Quality Area.

The analysis of the data in table 2 allowed determining key indicators for productivity, safety and quality with the support of IBM SPSS Statistics Software, analyzing the variety of correlation to determine a standard control or improvement of the service or operation in the next orders that influences the immersion time and delivery time scheduling.

It is indicated as a sample of the analysis of the study, three tables with their respective graph with reference to the proportion of statistical control defects where the sample size (immersions) is variable and application of the Pareto diagram:

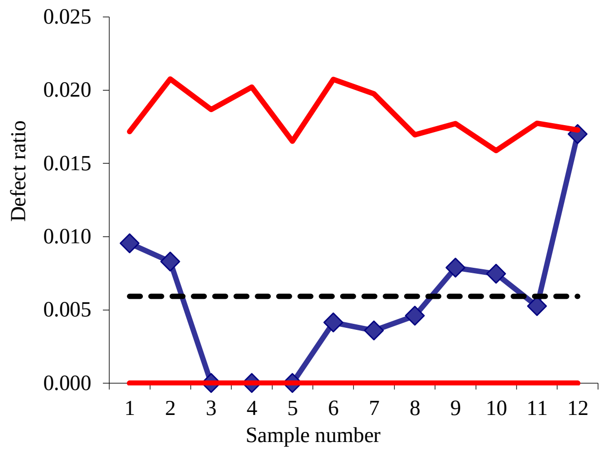
Input: Sigma limit = 3

Output: $\bar{p} = 4385 / 26 = 0.006$

Defect Appearance

Sample	Sample size	Number of defects	Proportion Defects	p	Upper Limit	Lower limit
1	419	4	0.010	0.006	0.01718	0.000
2	241	2	0.008	0.006	0.02077	0.000
3	326	0	0.000	0.006	0.01869	0.000
4	260	0	0.000	0.006	0.02021	0.000
5	474	0	0.000	0.006	0.01651	0.000
6	242	1	0.004	0.006	0.02073	0.000
7	278	1	0.004	0.006	0.01974	0.000
8	436	2	0.005	0.006	0.01696	0.000
9	381	3	0.008	0.006	0.01773	0.000
10	536	4	0.007	0.006	0.01588	0.000
11	380	2	0.005	0.006	0.01774	0.000
12	412	7	0.017	0.006	0.01728	0.000
Total (Di)	4385	26				

Table 3 Calculation of appearance defect ratio
Source: Own elaboration



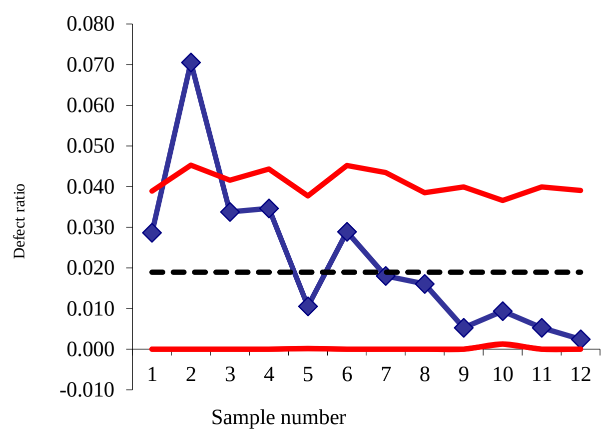
Graphic 1 Number of sample with respect to the proportion of appearance defects
Source: Own elaboration

Input: Sigma limit = 3
Output: $\bar{p} = 4385 / 83 = 0.019$

Superficial defect

Sample	Sample size	Number of defects	Proportion Defects	p	Upper Limit	Lower limit
1	419	12	0.029	0.019	0.03890	0.000
2	241	17	0.071	0.019	0.04526	0.000
3	326	11	0.034	0.019	0.04157	0.000
4	260	9	0.035	0.019	0.04428	0.000
5	474	5	0.011	0.019	0.03771	0.000
6	242	7	0.029	0.019	0.04521	0.000
7	278	5	0.018	0.019	0.04345	0.000
8	436	7	0.016	0.019	0.03851	0.000
9	381	2	0.005	0.019	0.03987	0.000
10	536	5	0.009	0.019	0.03659	0.001
11	380	2	0.005	0.019	0.03990	0.000
12	412	1	0.002	0.019	0.03907	0.000
Total (Di)	4385	83				

Table 4 Calculation of surface defect ratio
Source: Own elaboration



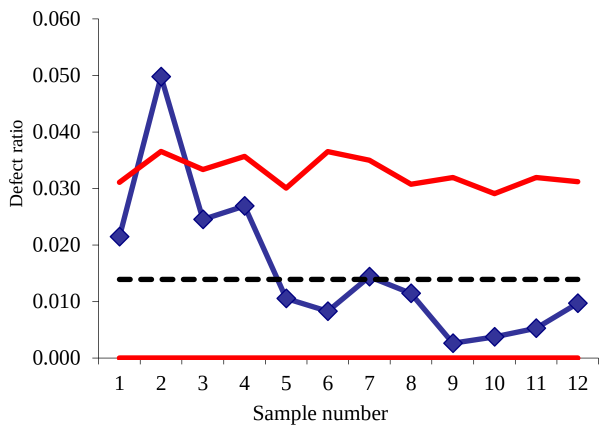
Graphic 2 Number of samples with respect to the proportion of surface defects
Source: Own elaboration

Input: Sigma limit = 3
Output: $\bar{p} = 4385 / 61 = 0.014$

Thickness defect

Sample	Sample size	Number of defects	Proportion Defects	p	Upper Limit	Lower limit
1	419	9	0.021	0.014	0.03108	0.000
2	241	12	0.050	0.014	0.03654	0.000
3	326	8	0.025	0.014	0.03337	0.000
4	260	7	0.027	0.014	0.03570	0.000
5	474	5	0.011	0.014	0.03005	0.000
6	242	2	0.008	0.014	0.03650	0.000
7	278	4	0.014	0.014	0.03498	0.000
8	436	5	0.011	0.014	0.03074	0.000
9	381	1	0.003	0.014	0.03191	0.000
10	536	2	0.004	0.014	0.02909	0.000
11	380	2	0.005	0.014	0.03194	0.000
12	412	4	0.010	0.014	0.03122	0.000
Total (Di)	4385	61				

Table 5 Calculation of defect ratio by thickness
Source: Own elaboration



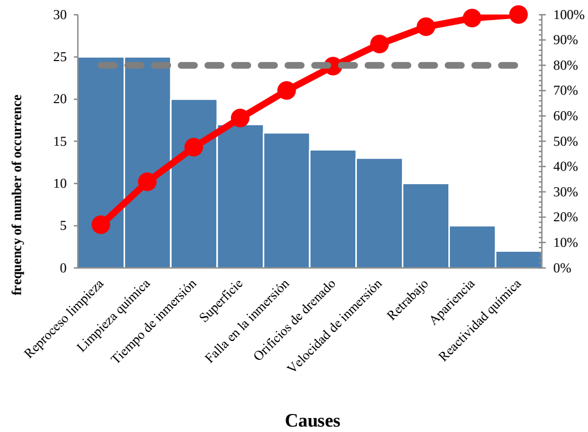
Graphic 3 Number of sample with respect to defect to thickness ratio
Source: Own elaboration

With reference to the detection of the main defects, they were analyzed by the frequency indicated in the Pareto diagram.

Cause	Frequency
Drainage orifices	14
Appearance	5
Chemical reactivity	2
Failure to dive	16
Reworking	10
Reprocess cleaning	25
Immersion time	20
Immersion speed	13
Chemical cleaning	25
Surface	17

Table 6 Frequencies of defect causes
Source: Own elaboration

The causes shown in Table 6 and represented in Pareto Chart 4 are the result of holding work meetings applying brainstorming, prioritizing the causes with their respective analysis through the Ishikawa diagram with respect to the times of the stages of the forth innovation methodology.



Graphic 4 Pareto diagram of defect causes
Source: Own elaboration

Finally, Bayes' Theorem was applied to the operations by type of defects and their respective cause, and the following example is presented as evidence of the experimental work:

In the Hot Dip Galvanizing production line. It is assumed that the probability of presence of defect in the zinc coating on the steel structural surface (sill and angles of ¾" thickness). After the chemical cleaning process and its immersion in the molten zinc bath at 450 degrees Celsius is 2.5%.

Also, it is assumed that, given that a batch of 20 pieces has low coating thickness, the probability of inspection sampling yielding an acceptance result is 95%. In addition, it is assumed that a lot of 20 parts has no defects, upon inspection of the parts, the probability of being rejected by the quality inspector is 8%.

A random lot selected from a customer with a structural roof construction job, selected from the population of customer material received and inspected, generates a rejected coating result. What is the probability that the lot is effectively rejected by the quality area?

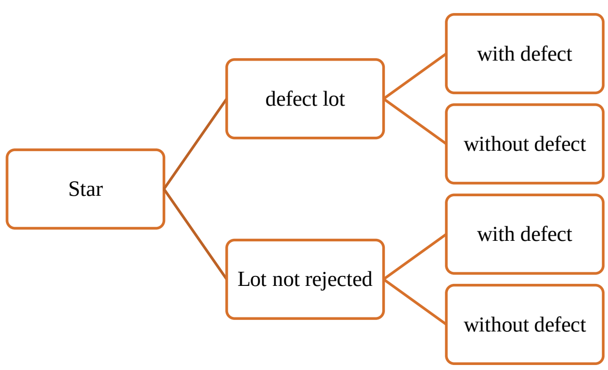


Figure 8 Tree diagram of application of Bayes' Theorem
Source: Own elaboration

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P (presence of defect in coating / lot with defect) =

A = Event: Defective lot

B = Event: Batch rejected

P(A) = 0.025

P(B) = 0.02375 + 0.078 = 0.10175

P(B/A) = 0.95

P(A/B) = (0.025 * 0.95) / 0.10175 = 0.2334 = approximately 23.34 %.

Data that have allowed the training and evaluation of the results in the meetings with the personnel for the establishment of indicators.

Thanks

The management and support of Metalyzinc company personnel through its internal resources, the members of the Academic Body UV-CA-470 Innovation in Management Systems, as well as the participation of the students María Guadalupe Martínez Peña (ZS16001478) and Milca Deyli Hernández Morán (ZS16001471) for their contribution to the development of the project.

Conclusions

A KPI, also known as a key performance indicator or key performance indicator, is a measure of the performance level of a process. The value of the indicator is directly related to a previously set target and is expressed in percentage values. A KPI is designed to show how progress is in a particular process or product, making it a reliable performance indicator.

The analysis of the data with SPSS software has allowed visualizing the generation of combination of variables with respect to regression, Pearson correlation, Curvilinear estimation, and their respective scatter plots, contributing in the improvement of the parameters and their adequate relationship of the variables of the hot dip galvanized production line with molten zinc in structural type parts.

The importance of monitoring and combining different variables is identified as a sample of the options to analyze through the software that allows the quality personnel to establish improvement proposals in the formats for recording the performance of the process and to consider the critical variables as the data is analyzed.

However, the specific variables evaluated according to the analysis samples have been as follows:

- Clogged threads.
- Blisters.
- Zinc splashes.
- Dips.
- Delivery delays.

These variables were obtained from the following causes:

- Drainage holes.
- Appearance.
- Chemical reactivity.
- Immersion failure.
- Rework.
- Reprocess cleaning.
- Immersion time.
- Immersion speed.

Also, the optimization of the management model was determined with the determination of three categories of production performance which are:

1. Duration time in rework,
2. Delays in deliveries by type of material, and 3.
3. Zinc coating thickness quality according to material type or specification.

These indicators are part of the management model, and three are highlighted as defects out of five by management authorization in the results section.

The innovation methodology was the axis that moved the technical and statistical part, optimizing the types of duration of each stage of the study, where, currently, innovation management is being developed in accordance with the ISO 56000 family of standards in Metalyzinc's strategic management system.

Based on the results of the application of the statistical tools, five questions were asked as part of the contextual study:

a) Why is innovation important to Metalyzinc?

b) Does innovation in anti-corrosion systems make business sense?

c) What are the main challenges Metalyzinc faces in developing new products or services?

d) Is Metalyzinc adopting an innovation model in its strategic planning?

e) What changes do you envision in innovating the management system or organizational structure?

It is key to develop a statistical analysis project with an axis-type guide, as proposed by the Forth Innovation methodology, which guarantees the impact of the study on the sustainable development of operations with relevant performance indicators that are consistent with strategic planning.

The combination of innovation with statistical analysis has fostered a diversity of options to address the optimization or improvement of the areas of opportunity of hot dip galvanizing operations, being the gateway to the development of Big Data analytics topics.

As expectations and challenges of the research, are new challenges to develop a sustainable organization that contributes to the objectives of sustainable development by transforming the organization according to the good practices of the sustainable goals proposed by the United Nations in the final document, entitled "transforming our world: the 2030 Agenda for sustainable development", strengthening the context of Metalyzinc, and its impact on stakeholders by promoting a culture of corrosion protection in a framework of law and cooperation of the human resource.

Maintaining synergies alliance of COBOS Group, and its effectiveness in the application of anticorrosive systems, as well as, the integral management system with the use of process innovation tools, performance analysis, and opportunity for consolidation in the growth of the industrial sector of the anticorrosive protection service through training and participation in the promotion of the anticorrosive protection culture through associations and institutions. Developing a strategy to promote the culture of corrosion protection and to offer protection services for new products such as hydro-pneumatic water tanks, gas tanks, boats, and in the construction and energy sectors.

There is a tendency of the personnel to achieve the strategic goals for decision making contributing in the consolidation of the challenges with the development of three processes in the management system according to the scheme shown in figure 9. Scheme of processes of the management system that involves the areas of Purchasing, Warehouse, Sales, Marketing, Quality, Human Resources, Training, Production, Maintenance, Management, Direction, Technical Support, Transportation.

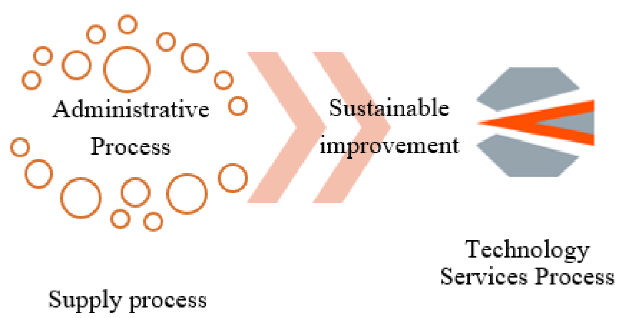

Figure 9 Process schematic diagram
Source: Own elaboration 2020

An organizational structure with solid perspectives in general; however, in relation to each job position, job descriptions can cause confusion at times of audit, a competency-based development approach is essential.

And the type of management leadership that has consolidated the organization in its first 30 years of operation has been developed with situational and transformational strategies forging the delegation of activities and trust of skills for the achievement of objectives and with the establishment of KPI performance indicators as the basis for sustainable structural development.

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