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THE IMPORTANCE OF RELIABILITY ENGINEERING PRODUCTION SYSTEMS

THE IMPORTANCE OF RELIABILITY ENGINEERING IN PRODUCTION SYSTEMS

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Abstract -- This paper aims to show the importance of the relationship between quality, reliability and reliability engineering in systems within manufacturing companies, service companies and higher education centers in Mexico. Some elements of the Normativity are included, specifically ISO 9001:2015 and IATF 16949 and the use of the basic concepts of reliability. Classic automotive systems and the reliability of a higher education system are analyzed.

Keywords: Reliability, Quality Engineering, ISO 9001:2015, Agile Methodology, Product Design.

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INTRODUCTION

The common definition of a system is a set of elements related to each other to achieve a common objective. Under this simple definition, it is of paramount importance to define the system, its components and, of course, its objectives. It is also important to define what can be considered the system's failure(s).

Quality is defined in different overlapping ways such as: meeting customer expectations, suitability for Juran usage, and quality is the loss imparted to society since the product is shipped from Taguchi. The quality of products, services and systems in general will be to meet the expectations of functionality and reliability.

Reliability Engineering is defined as the discipline of ensuring that a product (or service) will be reliable when it operates in the specified manner [1], i.e. the function of reliability engineering is to avoid failures, i.e. the probability that a device will work without failure for a preset period of time, under normal operating conditions [2].

Reliability is the probability that a device will operate without failure for a preset period of time under normal operating conditions [2][15].

[12] defines reliability in a colloquial way as the property that something works when we want to use it.

The analysis of the reliability of products and systems in general, using analysis and measurement techniques, as well as appropriate models, has become increasingly important. The main objective of reliability engineering is to reduce product and system failures, thus increasing warranty times and improving the competitiveness of companies.

Currently, manufacturing industries and their Quality Assurance and Quality Control departments focus their efforts towards continuous improvement of their products and services, i.e., improving the ability to meet customer requirements, mainly from the dimensional point of view. However, the criteria used are that the parts produced only comply with being within the specification limits, even though there are

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quality indicators such as process capability indices, which should be rigorously calculated and monitored.

DEVELOPMENT

Reliability measurement techniques provide a common discipline that can be used to make projections of reliable systems throughout the life of the product [3].

Pacheco [4] mentions that reliability is the perceived ability of a product or service to provide long periods of failure-free performance during use. He further adds that, qualitatively, reliability is related to the that, qualitatively, reliability is related to the success or failure of performance, and the lack of reliability reduces the value or usefulness of a product or service.

A study in which the perception of country brand (what is made in Mexico is well done) was investigated; that is, how reliable and sought after its products are by foreign consumers. Germany has the first place and a rating of 100; on the other hand, Mexico has 37 [5]. It also mentions that according to the Country Brand Index, Mexico has the third best brand country in Latin America. It is necessary to take into account the nationality ; biasbasically, he says that the attitudes, perceptions and habits of purchase of the consumer change according to the country of origin a good. It also adds that some Mexican products are bought more than others, such as beer, tequila, tomatoes, strawberries and basically beverages and food if it says made in Mexico it will most likely be bought. It is also mentioned that Mexico is still seen as a third world country, which causes little acceptance of more complex products.

Quality has become one of the most important decision factors of the consumer is the good selection of products and services. Thus, improving the quality understood from the customers' desires is a key factor to achieve business success [11].

It is here, where quality engineering must broaden criteria for control with a greater vision towards product reliability, so that all those involved in the processes focus their efforts towards reliability engineering.

Reliability in Manufacturing Companies The competitiveness of companies in the market is directly related to the reliability of their products, which, in turn, is strongly related to the quality of their processes. The growth of the company in terms of market area depends on quality and reliability.

Therefore, companies should direct their efforts towards the design of products with higher reliability, expanding the knowledge of design, quality, production and maintenance engineers, among others, towards quality and reliability engineering. Even companies that are not responsible for design should have extensive knowledge of reliability engineering, and be able to perform Burn-In tests and even accelerated life tests for the main stresses to which their products will be subjected in the field.

Reliability engineering is oriented to product failure. The main problem is to predict the failure in use of the devices and the time in which it will occur. The information obtained will be used to improve designs, maintenance and replacement and establish warranty periods [8].

The vast majority of manufacturing companies in Mexico, mainly, as mentioned above, are not responsible for the design, so there is no great concern that the product meets customer requirements, i.e., the design goals.

What is regularly done is to implement quality control at the exit of the processes that could well be functional of the pass-fail type.

Reliability analysis should start from the establishment of design goals, i.e., at the stage of planning product functions according to customer requirements.

The establishment of the design goals clearly determines what is a device failure. The next step is to establish the methods for predicting failures and their time of occurrence.

ISO 9001:2015 and IATF 16949 (Quality Systems) both include the AIAG documents, created in the QS 9000 standard, being:

- APQP (Advanced Quality Planning Process), FMEA (Failure Mode and Effect Analysis in Product and Process),
- SPC (Statistical Process Control),
- MSA (Measurement System Analysis) and
- PPAP (Production Part Approval Process).

The APQP document considers the following steps:
I. Program/Concept Approval, II. Product Design and Development, III. Process Design and Development, IV. Product and Process Validation, and V. Feedback, evaluation and corrective action.

In the product design stage, prototypes should be developed and tested according to the defined failures and stresses to which they will be subjected. In the design of the tests it should be taken into account that each different type of stress will cause different failure modes. At this stage, the operating conditions of the devices should be established.

The next stage, process design, is of great importance for the reliability of the devices. The proper functioning of the equipment, its preventive maintenance programs guarantee the output quality, and, , the reliability of the devices in the field.

Quality is the quantity by which it satisfies user requirements. Product quality is partly a function of design and conformance to design specifications during manufacture. Reliability is related to how long the product continues to perform according to design goals. Therefore, reliability can be viewed as the operational performance quality of the product over time, and as such extends quality into the time domain [2][7].

In these concepts, the normative elements (ISO 9001:2015 and IATF 16949, should lead us to think doing things differently; following, first of all, the guidelines given in the documents, for example, DFMEA, analyzing the failure modes of the design components and adding them as of primary importance to the process design, this in order not to cause them to fail at the time of manufacturing them.

The PFMEA is a document to analyze the different failure modes that could potentially occur in the process and the effects on a predefined customer, the causes and the controls to prevent the occurrence of the cause.

All controls established in the PFMEA should appear in the control plan, as defined, without making any changes and performing the established measurements and tests.

Element 9 of ISO 9001:2015 [6], Performance Evaluation, states in point 9.1 that:
The organization must determine:

a) What elements need to be monitored and measured.
b) Monitoring, measurement, analysis and evaluation methods, as appropriate, to ensure valid results.
c) When monitoring and measurement should be performed.
d) When the results of monitoring and measurement should be analyzed and evaluated.

However, most organizations do not establish in their performance indicators and control plans how to relate quality in the process and its relation to system failure in the field of application.

Quality and reliability go hand in hand. An item may pass a quality measurement or test in the process, but if the assembly or processing was at the limit, the product may not survive the guaranteed time.

Determining product design characteristics and processing characteristics should always be done in a systematic way, which can be achieved by using properly designed experiments [9][10].

Reliability Engineering provides us with the theoretical and practical tools through which we can determine the failure probabilities of the systems and their components, in such a way that improvements can be established, thus achieving customer expectations [13].

After performing quality tests, reliability , degradation tests or Burn.in tests should be performed on many manufactured products, with three main objectives: first, to avoid

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The second is to correct faults and improve design issues in the plant, and the third is to avoid loss of prestige and gain in competitiveness.

Figure 1. Diagram P.
Source: Own elaboration.

Figure 1. (P Diagram) shows a systems approach for the analysis the independent or controllable variables (Xi) and the non-controllable variables (Zj) that influence the response or dependent variables (Yk). These variables should be subject to analysis, both at the Product Design and Development stage (Point 8.3 of ISO 9001:2015), and at the Process Design and control stage (Point 8.1, ISO 9001:2015).

Correct and consistent adherence to the guidelines established in the Advanced Quality Planning Process (APQP) should ensure that design goals, quality goals and reliability goals are met.

The congruence of the documents shall be established according to the following sequence:

1. Plan of the part
2. Design Failure Mode and Effect Analysis (DFMEA)
3. Characteristics matrix
4. Process Flow Diagram
5. Process Failure Mode and Effect Analysis (PFMEA)
6. Control Plan

The use of customer requirements analysis tools such as QFD and the Kano method would be very useful for the establishment of design goals and product and process assurance plans.

The evaluation of the measurement systems, both from the aspect of suitability for measurement, resolution and quality of the device must be carried out with the required regularity, i.e. its calibration (MSA).

Reliability in general systems

As mentioned before, the best known definition of a system is a set of elements interrelated to each to achieve an objective. In an automobile there are several systems, such as, for example, the braking system, the cooling system, the ignition system, lubrication system, etc. Each and every one of the aforementioned systems is made up of elements that are interrelated to fulfill specific functions such as braking, cooling, ignition and lubrication.

The design of the system according to customer requirements, manufacturability and assembly and maintainability are the starting activities that should be thoroughly analyzed.

The automotive industry manufactures complete brake systems of different types such as disc and drum brakes.

The braking system is the one that allows the car to down or come to a complete stop while in motion.

It involves a transformation process, where the mechanical energy of the movement is converted into heat energy generated by friction when the brake pedal is applied.

The quality and reliability of the system will depend on the quality and reliability of each of its components. The quality in each of the operations of the process will guarantee the fulfillment of the customer's requirement: effective braking for a predefined period of time, and the predefined maintenance within the instructions for use of the system.

Maintainability is defined as the probability that a failed system or component can be repaired or restored to a specified condition within a specified period of time when maintenance is carried out according to prescribed procedures [2]. Maintenance is defined as the set of actions aimed at

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to preserve or restore a system and/or equipment to its normal operating state to fulfill a given service under economically favorable conditions [14].

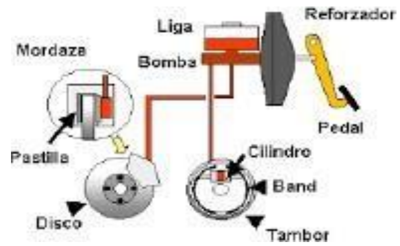

Figure 2. Conventional brake system (Source: Multiservicio Automotriz 3H).
Source: Own elaboration.

The Lubrication System is manufactured in automotive industry plants. The function of the lubrication system is to prevent parts from wearing through friction in the engine.

The elements of the system are:

1. The oil pan, commonly known as the sump, which is where the oil is stored,
2. the oil pump, which is responsible for moving the oil from the crankshaft,
3. the pressure regulating valve which is responsible for opening and closing to keep the pressure at a stable level and
4. the oil filter that separates and retains the solid elements that the oil may contain (see Figure 3).

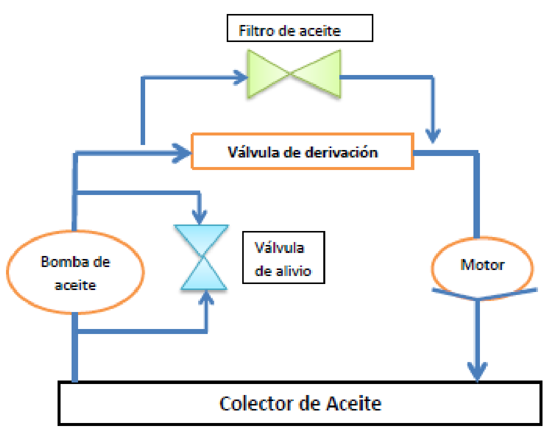

Figure 3. Lubrication system. Source: Own elaboration.

Educational Systems

An educational system is a structure for the development of the teaching-learning relationship integrated by a set of institutions and agencies that finance, regulate and provide services for the achievement of basic and formal education in accordance with the policies established by the state.

Addressing only the Technological Education System, let us consider the established MISSION which states: "To train professionals in quality technological higher education, capable of contributing to science, technology and research with a creative and innovative approach, through an integrated education based on competencies for the sustainable development of an inclusive, globalized, equitable and humane society".

The Technological Education System has been required to be certified to ISO: 9001:2015 in order to demonstrate its quality. Let's review the 7 principles of Quality Management of the ISO 9001:2015 Standard:

1. Customer Focus: Who is the customer?
2. Leadership: Who exercises it? What type of leadership does he/she exercise?
3. 's commitment: What is the organization's environment?
4. Process approach. Is the teaching-learning relationship really the key process in the system?
5. Evidence-based decision making: Are performance indicators adequately analyzed? Are decisions correctly made based on the results of performance indicators?
6. Continuous improvement: Is there a development program in the programs of each career? Are the requirements of customers and relevant stakeholders verified in order to establish improvement activities?
7. Relationship management: Are liaison activities adequately established and are all relevant stakeholders included in these relationships?

EXPECTED RESULTS

- **Awareness:** Any intention to offer services and/or products should, in the first instance, be done in a systematic and analytical manner. The results of this analysis should generate the awareness of the elements of the system to be included, as well as the objectives to be achieved. The following points will be the result of this awareness.

• **Improved customer focus**: It is expected that the main objective set in implementing a Quality System should be to meet all customer requirements. Each and every element of the system should be involved and committed to achieving quality whatever the nature of the system.

• **Increased market reach**: true compliance with established standards provides assurance to potential customers. The growth of the market area is generated due to the image projected by the fact that an organization offers quality goods and services, evidenced by real and convincing data, according to the performance indicators established in the system.

• **Improve the organization's processes**: Traditionally, the approach to auditing system performance was to review documents that "proved" their functionality. Companies producing goods and services will focus their efforts on reviewing the performance of each and every process, analyzing their expected results, and then preparing documents. This will necessarily lead to improvement in general.

• **Competitiveness:** Any system, be it a product or a service, will be competitive if we are realistic and analyze the strengths and weaknesses of our system, as well as its strengths and weaknesses, thus establishing new objectives in search of improvement.

CONCLUSIONS

Within the documented quality systems (ISO 9001:2015, IATF 16949, ISO 14001, ISO 50001, etc.)
there are multiple subsystems such as: production system, maintenance system, measurement system, contracting system, etc.
The manufacturing industry in Ciudad Juarez, Chihuahua, produces a wide range of products, from white goods, automotive sensors, automotive headliners, seat belts and airbags, brake pads, discs, aeronautical products, motorcycles and recreational vehicles, etc.
The vast majority of the aforementioned products are, in turn, components of other subsystems, such as the braking system, the injection system, the fuel injection system, etc., but they are also components of other subsystems.

fuel, etc., with strictly established quality and reliability goals.

Achieving the design, quality and reliability goals depends entirely on the implementation and maintenance of the management systems mentioned above. Those in charge of the implementation of the management system must take exhaustive care in the sequence (and congruence) of each of the stages. These stages could be:

- Product or service design (meet customer requirements)
- Design of quality and reliability goals
- Bill of Materials (Supplier Selection)
- Inventory system management,
- Process design (Equipment layout for production)
- Selection of equipment according to customer requirements in relation to quality and delivery volumes.
- Maintenance and release of production equipment.
- Selection and maintenance of measurement systems.
- Selection and hiring of personnel.
- Selection of transportation and distribution.
- Customs administration.
- Control of key indicators.
- Risk Management.

In each of the aforementioned activities (stages), the personnel must have the required knowledge to carry out the different activities required to adequately develop their function and fulfill the assigned responsibility,

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