QUALITY ASSURANCE ON CRITICAL AND SAFETY ITEMS IN SCREWDRIVING PROCESSES

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Abstract

Quality management can be defined as a set of practices and philosophies aimed at ensuring that products or services meet predefined standards of excellence, seeking continuous process improvement and full customer satisfaction. In line with quality assurance, the aim of this research was to identify and describe the benefits of using quality tools in quality assurance. In the research, improvements were made to the equipment calibration and preventive maintenance processes, resulting in greater precision, operational efficiency and environmental benefits. Based on the case study carried out, it was possible to verify that the adoption of a more robust and detailed methodology in the joint tightening control process resulted in a significant improvement in the precision and efficiency of the production process.

Keywords: Quality management, Calibration, Tightening Machine, Safety.

1. INTRODUCTION

Quality Management has become a fundamental pillar for optimizing production processes, especially in highly complex and demanding sectors such as the automotive industry. The central focus of this approach is on continuous improvement, with the aim of ensuring product compliance with strict standards, increasing process efficiency and, consequently, meeting and exceeding customer expectations (JUMA et al., 2023; MENEZES; ESCRIG-TENA; BOU-LLUSAR, 2022; SHI; LI; TIAN, 2021). In today's automotive industry, characterized by growing competitiveness and the need to innovate amid increasingly demanding safety, sustainability and performance standards, quality tools have taken on a strategic role. They not only prevent and correct faults, but also optimize every stage of production, from planning to final delivery, contributing to strengthening the value chain and the sustainability of operations (ALI; JOHL, 2024; JEGATHEESAN, 2024; TONJANG; THAWESAENGSKULTHAI, 2024).

Quality Management can be defined as a set of practices and philosophies aimed at ensuring that products or services meet predefined standards of excellence, seeking the continuous improvement of processes and full customer satisfaction (ALI; JOHL, 2024; JUMA et al., 2023; POP; TITU; POP, 2023). It encompasses the application of systematic methodologies and specific tools, such as statistical process control, internal and external audits, and the implementation of continuous improvement cycles to ensure that production processes are robust, efficient and capable of delivering consistent results. Based on principles such as customer orientation, effective leadership, a process approach, continuous improvement, data-based decision-making and relationship management, Quality Management aims not only to comply with standards and regulations, but also to seek innovation and constant improvement (REIS et al., 2021; SIN; JUSOH; MARDANI, 2021; SULTHONUDDIN; HERDIANSYAH, 2021). The following question arises from this context: what benefits does quality management bring to the screw tightening production process in stages classified as critical and safety items? To answer this question, the aim of this research is to identify and describe the quality assurance benefits provided using quality tools.

2. THEORETICAL BACKGROUND

Quality is a concept that takes on different meanings depending on the context in which it is applied. Generally, it relates to the degree to which a product conforms to established requirements in order to meet customer requirements (GOMES et al., 2022; PIRES; ALPERSTEDT, 2022; ULUSKAN; KARŞI, 2023). It can also refer to characteristics such as durability, reliability and efficiency. But it can also be understood as a continuous process of improvement that involves the entire organization. Thus, it can be considered an organizational culture that aims to improve all processes. It is a key factor in an organization's competitiveness and success (ENACHE et al., 2023; MITTAL et al., 2023; SALES et al., 2022).

Quality Management (QM) is a management approach distinguished by principles that guide the way an organization learns, implements its strategies, develops and distributes its resources, and establishes routines and processes. When applied systematically, this approach can lead an organization to achieve superior performance (ACHIBAT et al., 2023; JIRASUKPRASERT et al., 2014; MITTAL et al., 2023). The QM has benefits that address economic profit and objectives beyond capital, such as the effectiveness of the production process, organizational management, the efficient use of inputs and the reduction of negative impacts on the environment. These actions are carried out by reducing material waste, reusing materials and using energy efficiently (ABBAS, 2020; DIOUF; BOIRAL, 2017).

In addition, economic sustainability is closely related to quality. Organizations that invest in quality generally manage to meet or even exceed customer expectations, which drives consumption and, consequently, increases revenue. This cycle creates a balanced system, allowing for savings in certain areas while maintaining overall stability (GHASEMI et al., 2021; KUMAR et al., 2020; LIM et al., 2022). The relevance of Quality Management in the automotive industry is widely recognized due to the high complexity of production processes and the demand for strict standards of product safety, reliability and performance. In the automotive sector, quality is fundamental not only for customer satisfaction, but also for compliance with international regulatory standards, such as ISO/TS 16949, which establishes specific requirements for the production of vehicles and automotive components (ABBAS, 2020; BOZOLA, 2020; DIOUF; BOIRAL, 2017).

3. METHOD

This research is classified as applied and exploratory, with a qualitative approach. The technical procedures adopted were bibliometric research and content analysis, respectively (Table 1) (KOTHARI; GARG, 2019). To approach this case study, exploratory research was chosen in order to understand the context, analyze and become more familiar with the problems identified in the company, making them more explicit (YIN, 2017).

To begin the activities, a literature review was carried out on the subjects in question, consulting books and national journals. The aim was to develop a theoretical basis for the study. Visits were then made to the company to gather information for the case study. These visits analyzed the tools used in the company and their effectiveness in solving problems that occur in production and throughout its process, as well as checking whether they are being implemented properly.

Table 1 – Research classification

Nature	Objective	Approach	Research procedures
Basic	Exploratory	Quantitative	Experiment
Applied	Descriptive	Qualitative	Prisma
	Explanatory	Combined	Bibliometric Study
	Normative		Modeling
			Maturity matrix
			Case study
			Simulation

Source: Adapted from Cronin and George (2023), Kothari e Garg (2019) and Reis *et al*. (2021).

A case study was carried out at a multinational automotive company in the south of the state of Rio de Janeiro. In this organization's process, vehicles are joined together by permanent fixings, such as welding, rivets and so on. There are also movable fasteners in this process, such as screws. This process controls the tightening of critical and safety items such as steering wheels, airbag systems, seat belts, steering rods and wheels and functional stops. To guarantee that these items have been properly attached to the surface they were designed for, their torque must be controlled.

This control comes from the equipment that performs this tightening, which are control panels that work in conjunction with an electronic screwdriver. These devices have micro-torques, which can vary from 0.1 to 1 Nm and torques from 1 to 1000 Nm, with an accuracy of 5%. To obtain the required level of quality from the equipment, a number of procedures are carried out, such as scheduled preventive maintenance work, which involves completely dismantling the equipment, checking the general condition of the bearings, gear sets and planetary gears, changing the grease and checking the electronic system assemblies, such as the welds and micro-control boards.

These processes are controlled by computerized systems that comply with internal and external standards and audits. Preventive maintenance is carried out annually and, after this, the equipment is calibrated in accordance with the procedure described. In the old calibration procedure, 5 tightenings were taken, the parameters collected and analyzed; after the study described, it was found that increasing the sample to 25 tightenings would result in greater precision in the tests and data obtained.

The fact of moving from a sample of 5 tightenings to a sample of 25 is due to the fact of obtaining a higher quality in the results of the calibration of the equipment according to the process. This sample of 25 presses is based on a statistical standard, but no statistical rule is being used, only the number 25 in the sample. With this change, it is possible to manage the control and scheduling of preventive measures, increasing the frequency of maintenance on the equipment used in the production process. The study was divided into 4 groups: 1) short-term capacity analysis, preliminary investigation of process capacity; 2) preliminary investigation of long-term process capacity; 3) short-term capacity analysis; and 4) analysis of quality capacity metrics for manufacturing facilities and processes.

Group 1, checks that if the minimum number of parts required for a preliminary process capability study is not in place, a short-term process capability study can be carried out. This examination is generally used to accept production facilities and machines from the manufacturer and is therefore also called a machine capability examination. In this study, only the influences emanating from the production facilities will have an effect, and the influences of the material, people, method and environment must be kept constant. The result of the short-term capacity test is a preliminary statement about the suitability of the production facility. Normally, 50 production pieces manufactured one after the other are divided into 10 samples of 5 pieces each and recorded in the chronological order in which they were removed, for example, to identify any trends. As the actual working range is often not completely recorded with only 50 pieces manufactured one after the other, the result of a short-term capacity study must be evaluated in the context of the future process. In addition, the 50 measured values are used to evaluate the distribution form.

Group 2, test at least 25 grips, each with at least 4 parts, at regular intervals. Based on a control chart, an assessment is made as to whether the process is within expectations.

Once the process domain under investigation has been confirmed, the process model and distribution form are identified. To enable a meaningful assessment of the expected process capability in the long term, the basic prerequisite for this investigation is that the end conditions of the series have already been implemented and, if possible, all dispersion influences are effective. The procedure for assessing process capability prior to series start-up should also be used to evaluate machines and production facilities.

Group 3, evaluate the quality capacity under real process conditions. Such an investigation should extend over a longer period, appropriate to the process, so that all the factors influencing the variation can show their impact. To guarantee the results of the preliminary phase, a long-term view of the process is absolutely necessary. The procedure is the same as for the preliminary process capability investigation and the control chart for the preliminary phase continues. An observation period of 20 production days should be used as a normal case.

Group 4, to develop a quantitative report on the quality capacity of production facilities (machines) and processes, quality capacity indicators (capacity indices) are determined. When determining quality performance indicators, the boundary conditions under which the process took place must be documented.

4. RESULTS AND DISCUSSIONS

This study showed that when this methodology was applied to the joint tightening process, positive results were obtained for the process. With equipment maintenance being carried out in a more assertive manner, it has brought benefits to the environment in terms of the use of inputs, such as changing the grease in the moving components of the tightening machine's mechanical assemblies. There has been less disposal of productive components, because when a moving component is tightened outside the specified torque limits, it is mandatory to dispose of it.

The decision to increase sampling from 5 to 25 tightening was based on the search for greater precision and reliability in test results, which is essential for guaranteeing the quality and safety of critical components such as steering wheels and airbag systems.

This change, although apparently simple, has brought several operational benefits, not least the reduction in tightening errors, which previously led to components being discarded out of specification. With stricter control, there was a reduction in the waste of parts and inputs, promoting a more sustainable operation, in line with the company's environmental responsibility practices.

Another important point was the positive impact on preventive maintenance, which began to be carried out more assertively, increasing the useful life of the equipment and optimizing the scheduling of interventions. This improvement reduced the need for emergency maintenance, which in turn increased the availability of equipment in the production process.

5. FINAL CONSIDERATIONS

Based on the case study carried out, it was possible to verify that the adoption of a more robust and detailed methodology in the joint tightening control process resulted in a significant improvement in the precision and efficiency of the production process. Expanding the sample from 5 to 25 tightenings enabled more accurate data to be obtained, which contributed to more effective calibration of the equipment used, guaranteeing the quality and safety of critical items.

In addition, the adjustment in preventive maintenance procedures, combined with more rigorous calibration, led to a reduction in the waste of components and inputs, generating environmental and operational benefits, such as a reduction in the disposal of parts and more efficient use of materials, such as grease in mechanical components. The methodology applied showed that by optimizing controls and improving process precision, it is possible to obtain better results in terms of both quality and sustainability. Finally, the study highlights the importance of continuous, long-term analysis, focusing not only on immediate efficiency, but also on the ability to maintain and continuously improve manufacturing processes. As a recommendation for future studies, it is proposed to carry out the process on a larger sample of bolting activities and critical points, and in different production segments, to identify new approaches to quality tools.

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