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QUALITY ASSURANCE DURING STEERING COLUMN ASSEMBLY PROCESS

Abstract: Each manufacturing process is accompanied by a great deal of problems often leading to non-conformity occurrence. Due to the accent of final customers on supplying organizations in terms of price reduction it is crucial to ensure the cost reduction, continuous quality of product and process improvement which cannot be achieved without appropriate quality tools deployment. The article deals with practical application of quality tools in serial manufacturing process of steering columns assembly in order to attain efficient equilibrium of quality-cost-delivery imperative.

Key words: Quality tools, Quality Assurance, Steering Columns

11.1. Introduction

Based on requirements of particular industrial standards like (JIS, Toyota, PSA, RSA, VDA, ANFIA, AIAG etc.) and of course the ISO 9001:2015 and ISO/TS 16949:2009 standards the organization shall continuously improve the effectiveness of the quality management system via the usage of the quality policy, quality objectives, audit results, dataanalysis, corrective and preventive actions, and management review. The organization needs to demonstrate its ability to consistently provide product that meets customer and applicable statutory and regulatory requirements. Furthermore, aims to enhance customer satisfaction via the effective application of system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements (ISO/TS 16949: 2009). Asserting the customer requirements in terms of criteria for product ac-

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ceptance the organization shall establish and develop a mighty tool for process and product quality assurance at system, subsystem, component and/or material level of that is well known as Control Plan. The Control Plan itself should list the controls used for the manufacturing process control, including methods for monitoring the special characteristics, including customer required information and initiate the specific reaction plan in case the process becomes unstable or not statistically capable. This means a set of procedures describing the effective actions in the case of non-conformity or problem occurrence. The product conformity can be generally assured in four stages that are: the quality of product and process design and development, quality of manufacturing process, quality monitoring system, and procedures for prevention and curative actions. The scope of preventive and curative procedures covers three areas of actions which can be the suppliers, manufacturing process, and customers (DIAN M. 2011). The Control plan is ought to be reviewed and updated when any change occurs affecting product, manufacturing process, measurement, logistics, maintenance, supply sources or FMEA(ISO/TS 16949:2009). The article is focused on quality assurance of manufacturing assembly process and quality tools present deployment with proposal of some improvement in order to improve the effectiveness of quality assurance process and product quality at the same time.

11.2. The steering column quality requirements and manufacturing assembly process

The steering column is a safety device intended to ensure the transmission of the circular motion of the steering wheel to control the steering mechanism. It provides more positioning of the steering wheel in the cockpit. This position must be adjustable in height and depth. The steering column provides anti-theft feature enabling to block the steering wheel shaft. It must absorb the transmission length variations due to false round without creating stress on the steering mechanism and its own components. The steering column must have a sealing function to the sounds

of lifts transmitted by air. Finally, the steering column participates in compliance with regulations related to impact and inviolability. There has long been spread out a huge effort to reduce the risk of injury in a form of various design developments with steering columns. Accident studies have shown that rigid steering column represents a danger to the driver. Present safety steering columns are able to absorb impact energy due to a couple of deformation zones. The quality itself is not only one characteristic but a set of characteristics. The fundamental dilemma is for what parameters we must submit the guarantee? Should that be for all the product parameters or purposely chosen ones? Monitoring all parameters would increase the cost so, the selection of only the important ones is the right choice. These important parameters can be divided into two specific groups firstly into measurable critical parameters and secondly into critical defects (attributes) and connected to term essential characteristics (CSE) or critical to customer (CTQ) characteristics (DIAN M. 2011). In order to choose the appropriate parameters it is necessary to consider parameters that must comply with law (regulatory), norms and standards and parameters that are the most important for the customer mainly fitting parameters (key parameters). Some of the customers underline such parameters in own specifications using specific marks.

The modern steering column is composed approximately out of 35 components from different suppliers from around the Europe. The whole number of special customer characteristics is 47 security (S), 12 regulatory (R), and 107 key characteristics (fig. 11.1.). The manufacturing assembly process consists of ten machines besides the shaft assembly process (figure 11.2.).

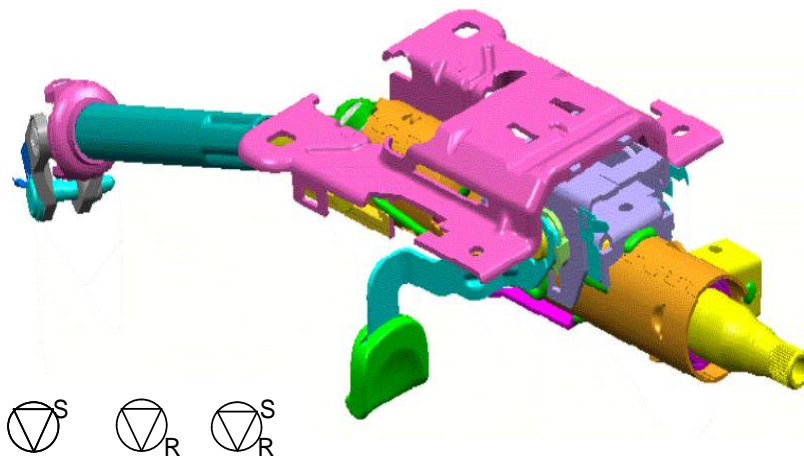


Fig. 11.1. Steering Column composition and special characteristics marks

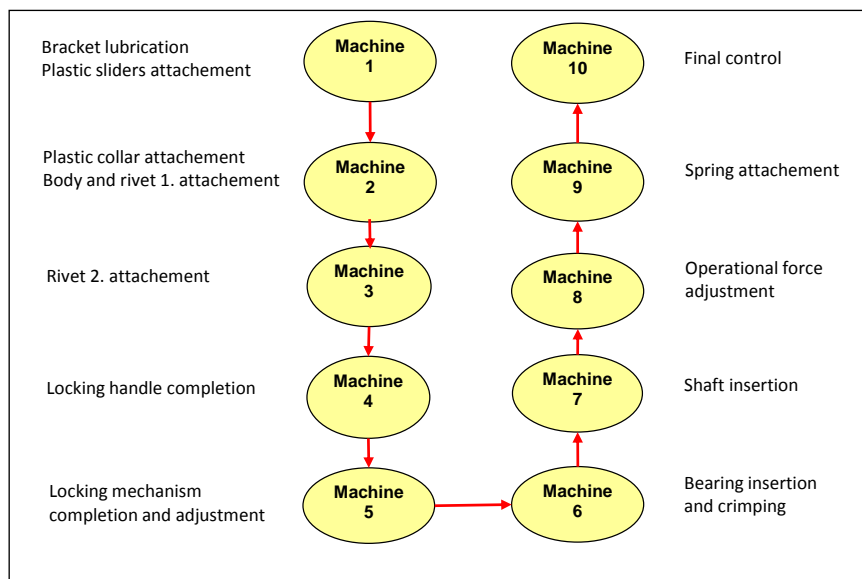


Fig. 11.2. Steering Column assembly process

11.3. Quality assurance tools deployment

There has been generally known four significant stages for product quality assurance which are the product and process design and development, pre-serial stage of production, serial production, and service operation. The first three mentioned stages provide so called inherent quality whereas the last provides the service or operational quality connected to term reliability. A regular manufacturing company usually deals with supply product quality and own manufactured quality that both are determined by product and process design, and development stages. Within process of product the APQP (Advanced Product Quality Planning) methodology and PPAP (Production Part Approval Process) are used in order to guarantee customer satisfaction during preparation process and the serial production afterwards. The contemporary quality philosophy is that the quality must be manufactured and not controlled up. Two of the crucial outputs having significant influence on product quality are a relevant control plan describing the set of controls throughout the manufacturing process including supply parts and final control, and the FMEA (Failure Mode & Effect Analysis). Mutual control plan and FMEA optimization with feedback from claim management, NG markets, and cost saving activities can bring increasing quality assurance level in manufacturing process, inspection control reduction, and cost saving. The inspection

in manufacturing process is generally realized by means of visual control, automatic control including Poka-Yoke, using SPC (Statistical Process Control), statistical acceptance (AQL), random control, control of first three and last three pieces, and finally a control of the first manufactured piece. All the mentioned types of inspection can be found across the industry in various combinations. Based on mutual comparison of quality guarantee, costs, philosophy, and control ability the best choice to be used is unambiguously the SPC and statistical acceptance (AQL). Moreover, with their usage the final and incoming inspection can be rapidly

reduced even eliminated. A shortage of SPC and statistical acceptance is the fact that they are only able to monitor achieved quality level. They cannot be used in the case that the organization is unable to manufacture quality which is the moment when problems with reaching required levels of C_p , C_{pk} , and AQL appear. On the other hand 100% control must be used when the organization is unable to manufacture quality. This control has been performed either as visual or automatic and can catch nonconformity whilst reducing their level unfortunately its efficiency is not really 100%. The reason is that the efficiency of 100% control is influenced by two factors the attention of performer which after a period of 45 minutes rapidly decreases and measurement device error including the automatic one causing that manufactured piece even at the verge of tolerance is rejected even though it is conform and vice versa. It is owing to the fact that the results, „vibrate“ and the device in each performed measurement will display different value even with the same measured piece. Inspection of first manufactured piece is frequently used control in nowadays industry. When measuring first piece the information obtained reflects hardly mean value of variability without determining a range of variability. Based on own experience the most prevailing model of manufacturing process control in industry is the inspection of the first manufactured piece accompanied with some number of Poka-Yoke, and extensive final control as well.

CONTROL TYPE	QUALITY GUARANTEE	COSTS	NOTE	PHILOSOPHY
100% control by an operator	Nobody knows, what the real status is, but probably bad.	100% + nonconformities and claims	Able to find nonconformities, reduce level of nonconformity	Controlled up quality
100% automatic control	Nobody knows, what the real status is, but probably good.	100% + nonconformities and claims and purchase costs	Able to find nonconformities, reduce level of nonconformity	Controlled up quality
Control of the first piece	None	Costs of one piece	Obsolete control of machinery set up	Camouflaged quality
Random Control	None	Tens of pieces	Necessary control of operator	Camouflaged quality

Fig. 11.3. A set of the most common controls in quality assurance process

The steering column quality assurance is depicted in a Control plan, the fundamental quality assurance document. It is composed out of four basic parts. The synoptic map describing the process flow of incoming parts entering to manufacturing process with defined measurable and aspect parameters, the same for process parameters in production including final control, list of Poka Yoke, and finally an instruction in case of nonconformity occurrence. A system for measurable and aspect determination is precisely mentioned in (DIAN M. 2012). The quality assurance tools deployment is depicted in figure 11.4.

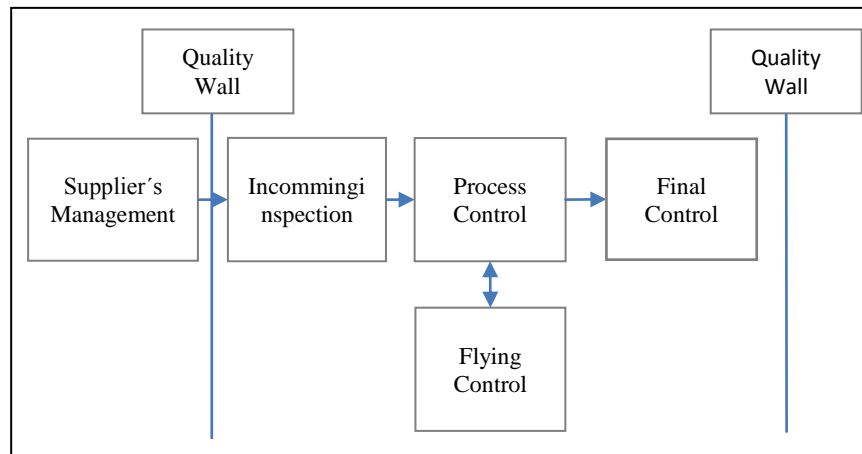


Fig. 11.4. The quality assurance tools deployment

In suppliers management the used tools before an improvement were merely a monthly statistics base on claims occurrence and the action plans following the remedy actions. The frequency of process audits was declared once a year. Prevailing control of supplied batches considered as incoming inspection was declared for 5 pieces for a batch. In the case of non-conformity occurrence the assembly tests were performed whether the parts are suitable for production or not. Due to a high amount of customer claims particularly 26,79% owing to supplier's contribution (DIAN M. 2012a) a monitoring of CSE characteristics via monthly C_p , C_{pk} report was established bringing significant positive effect of claim reduction. Furthermore, there was also influence by Design & Project stages precisely 16,07% among whole amount of customer claims caused by the items that had not been resolved during prototype and pre-serial stages of production. In the case of any quality problem the Quality Wall was lifted up to halt non-conform parts from being introduced into the production. Final tool implemented to supplier quality system was Supplier Rating Audit for selection of new suppliers. The entire set of tools

was about to improve the supplier dependability (KOCOUR P. 2012). The further tool considered for an improvement is ought to be AQL when level of quality of supplied parts reaches the value of C_{pk} equal 1,67 for CSE characteristics. Considering the manufacturing process the prevailing control model was set up as the control of the first piece at beginning of the shift or after machine intervention, 100% control for aspect parameters generally in a form of visual or manual control, further the 100% control using Poka Yoke instruments, and eventually the Final Control. Taking to consideration level of internal non-conformity level, reoccurrence of customer claims, and continuous stress on quality commitments and quality targets as well it was necessary to introduce SPC (Statistical ProcessControl). With SPC implementation for S, R, and Key characteristics, including customer previously claimed problems, the level of customer claims declined about 15%. With SPC introduction into the assembly process the occurrence and quality of machinery adjustments has improved reduces amount of machinery downtimes. The SPC have been managed by an established form of flying control with prompt time of reaction that was in charge of data gathering, analysis, and management of the SPC diagrams. Moreover, when problems occurred it had been in charge of immediate necessary laboratory controls and quality wall management towards the customer. The final control has declined about 50% in terms of control items after SPC introduction. The final control itself was based on visual and manual control and focused on product parameters. Their control had not been implemented into the assembly process during machinery and process design stages and appeared during serial production. The both quality walls were lifted up only in case of emergency. The final activities were focused on 100% Automatic Process Control including Poka-Yoke. The improvement was generally triggered by customer or supplier claims in forms of jigs improvement, new checking device introduction, sensors implementation that of course led into reduction of final control items. Unfortunately, all the above mentioned activities

should have been realized during prototype and pre-serial stages of production preparation process which means during APQP and PPAP processes, including precise FMEA for product and process as well. Having precisely performed and managed these stages and used tools the problems with quality, organization, and high cost would have been significantly reduced.

The synoptic for the assembly process which the control plan is stemming from is introduced in figure 11.5.

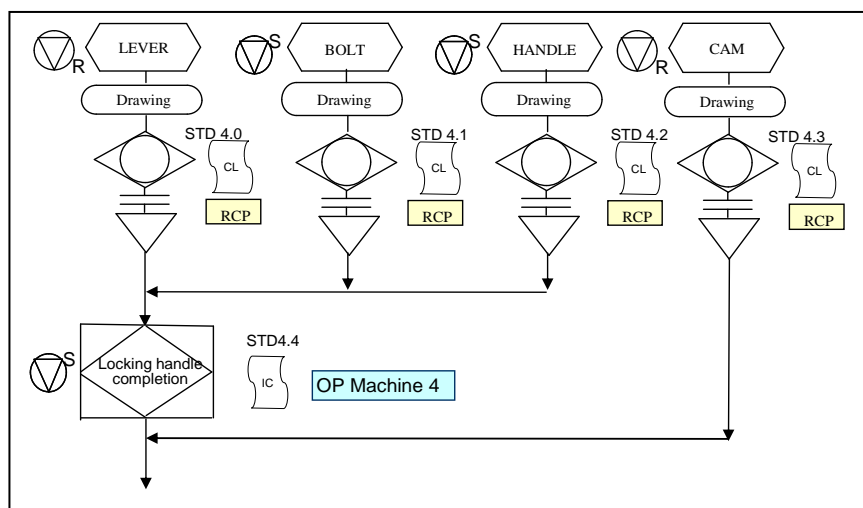


Fig. 8.5. The example of synoptic for reception and process at machine 4

The synoptic map is showing the process assurance from supplier delivered parts with special characteristics to production process assurance. The prescribed control is based on valid part drawing. The part is inspected at Incoming inspection(or Reception)compared with CL (Control list instructions)and then stored in warehouse in FIFO order. Further, based on forecast the parts are introduced into manufacturing process. The process is controlled using IC standards (Instructions of Process Control) and must comply with valid drawings as well. In the standards (STD 4.0 etc.)

there are precisely described parameters that are supposed to be checked and their values accordingly recorded. The standards include the means of control usually with pictures and checking procedures, the aspect and measurable parameters and the range of their acceptable values, the checking frequency and conditions, level of control (operator, foreman, quality inspector), special characteristics (S, R, Key), part and drawing numbers with modification index, the production line and the machine number and should contain the characters of controlled document. Finally, there must be the treatment in the case of non-conformity occurrence and included must be the Automatic control and Poka-Yoke methods of control, (figure 11.6.)as well.

The name of the production company	Manufactured part: Steering Column		Responsible:				S 2 R 1	INSTRUCTION
	System/subsystem: drawing number 43205 index D		Checked by:					OF PROCESS
Operation: Locking handle completion		Date of modification:				CONTROL		
Production unit:	Version: OR: canceled and replaced version							All the non-conform pieces mark with the red color and place into a red box
Prescribed controls:	Means of control and results obtained				N1	N2	N3	
Controls at the machine:								
1. Control of Poka-Yoke and means of Automatic Control	Control of appropriate function based on further instructions		1EH	x	x	N1 (operator) N2 (foreman) N3 (quality inspector) R = recording		
	Visual Control:							
2. Aspect	Piece without marks of damage, corrosion, clean, without marks of grease.		U	x				
	Cam precisely greased Presence of 4 crimpings							
Measurable Control:								
3: Measurable parameters								
Diameter of crimping	Caliper	15,6 max	1EH	x	x			
Height of crimping	Caliper	0,9 ± 0,05	SPC	x	x			

Fig.11.6. The example of process control instructions (machine 4)

11.4. Summary

The presented article stems from requirement for sustainable and continuously improved quality level of manufactured products. Even though the methodologies are used for years as well as the international and industry standards are well known, the present state of quality still

falls between 3,5 to 4 sigma in the best managed companies and calling for an improvement. The coherent quality system, its tools deployment and policy is the essential prerequisite to assure quality targets. The utilization of modern quality tools and their mutual connection with feedback from production and from customer side help to fulfill and improve the set up limits. The control plan for assembly process of steering columns production and its breakdown structure is described in the article accompanied with deployment of quality tools in quality assurance process. Showing the significance, methodology, present problems, and examples how to create an effective control plan, this article contributes to better understanding how to reach strong and sustainable quality level considering the QCD objective.

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