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STATISTICAL PROCESS CONTROL – DOCUMENTATION, RECORDS AND ANALYSIS OF DATA

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Abstract
This paper is in continuation with "Statistical Process Control – Effective tool of quality control" published paper in the same issue. An integrated approach of documentation, records and analysis of data is adopted in this work. It is already recognized that statistical process control can result in high efficiency, stable accuracy, short set-up time, eliminate waste, reduce rejections and low cost. But the real performance of a system is rooted in a powerful ability of the system to ''replace'' or exceed that which is done traditionally. It is apparent that almost all the literature is focused on principles and theoretic aspects of quality control. This puts a question of the practical value of research. There is a clear demand of studying and listing documents used in industry. The present research work satisfies this demand by deploying the real industrial practice into an overall manufacturing process to obtain best solution for process control and quality control. Entire study is prepared at Orbit Bearings India Private Limited, a leading manufacturing company of taper and cylindrical roller bearings for automotive & industrial application based at Rajkot, Mechanical & Automobile Engineering hub of India & world. Control plan, Production Part Approval Process and 4M Boards are discussed.

Keywords: Statistics, Statistical Control, Statistical Process Control (SPC), Control plan, Production Part Approval Process, 4M Boards

I. Introduction

Statistical Process Control is made up of three words. Statistics, Statistical Control and 3. Statistical Process Control.

1. Statistics: A value calculated from or based upon sample data (e.g., a subgroup average or range) used to make inferences about the process that the produced the output from which the sample comes.
2. Statistical Control: The condition describing a process from which all special causes of variation have been eliminated and only common causes remain.
3. Statistical Process Control (SPC): The use of Statistical techniques such as control chart to analysis a process or its output so as to take appropriate actions to achieve and maintain a state of statistical control and to improve the process capability.

II. Literature

Quality of the product or service can be determined by the process employed to develop a method plays a crucial role. Every organization should develop a standard, organized procedure for best quality. Statistical Process Control is the best tool to develop better quality products, to control & improve the process, to identify the reasons for quality problems and reduce variability in product output, in making delivery, in maintenance, in equipment use etc. [1]

H. G. Wells has mentioned the goals of SPC as collection of data, finding out variations, analyzing through brainstorming, finding out the causes and effects, continuous improvement [2]. Dr. Kaoru Ishikawa first introduced and mentioned benefits of these quality control techniques to the workers in Japan in 1968.

The concepts, need, steps, use and advantages of the seven basic quality control tools - pareto diagram, process flow chart, cause and effect diagram, check sheet, histogram, scatter diagram and control chart were illuminated by A. Mystica & J. Mary Suganthi Bai [3].

Studying the statistical process control tool in manufacturing systems with the broad aim of upgrading them to improve on quality and cost effectiveness was focused by Ignatio Madanhire & Charles Mbohwa [4].

The basic techniques of multivariate statistical process control (MSPC) under the dimensionality criteria, such as Multiway Principal Component Analysis, Multiway Partial Squares, Structuration à Trois Indices de la Statistique, Tucker3, Parallel Factors, Multiway Independent Component Analysis, Multiset Canonical Correlation Analysis, Slow Features Analysis, and Parallel Coordinates were highlighted by Miriom Ramos et al. [5].

The objective of research work presented by Laura Nabero Horácio et al. is to analyze and raise the problems reported by various sectors of the company in the manufacture of rollers and foam blocks. Factors such as problems related to quality, variation in size and quality of the equipment were observed, using the tools CEP (statistical process control) and control charts [6].

Sarah Isniah and Humiras Hardi Purba reviewed the 2016-2020 research papers that consistently apply the SPC method and have been published [7]. Published and relevant literature meta-analyses to provide some evidence of the effect of the existence of the implementation of the SPC method with several classifications were reviewed, which includes the growth of research publications in the manufacturing sector and other sectors. The results of research literature that have been published from 2015 - 2020 is this research is useful as a basis for developing knowledge, gaps in views, providing evidence of effects, and if done well, has the capacity to be applied as further research ideas. Elimination of waste as reduce defect and increasing quality and improving process can be achieved through SPC. As the SPC method implements must be carried out continuously, high process commitment is required for subjective application of the SPC method.

III. Control Plan

3.1 Purpose

- Control the product characteristics and the associated process variables to ensure capability and stability of the product over time.
- Manufacture of quality product according to customer requirements (Specification & Satisfaction).
- Used for minimizing process and product variation.
- Product parameters can be obtained.

3.2 Control Plan includes information such as:

1. Control plan no.
2. Part number
3. Date (Original & Revised)
4. Type of control plan
5. Part/Process no
6. Process name
7. Machine, Device, Jig, Tools for manufacturing
8. Characteristics (Product & Process)
9. Special Characteristics
10. Product & Process specification/ Tolerance
11. Evaluation/ Measurement Technique
12. Sample Size & frequency
13. Responsibility
14. Control Method
15. Reaction Plan.

3.2.1 Control Plan no.:
Enter the control plan document number used for tracking.
3.2.2 Part number:
Enter the number of the system, subsystem or component being controlled.
3.2.3 Date (Orig. & Rev.):
Enter the date when the original control plan was compiled.
Enter the date of the latest control plan.
3.2.4 Types of Control Plan:
1. Prototype:
A description of the dimensional measurement, material and performance tests during prototype build.
2. Pre-Launch:
A description of the dimensional measurement, material and performance tests recorded after prototype and before normal production.
3. Production:
A comprehensive documentation of product/process characteristics, process control, and test and measurement system recorded during normal production.
3.2.5 Part/Process no:
This item number is usually referenced from the Process Flow Chart. If multiple part numbers exist (assembly), list the individual part numbers and their process accordingly.
3.2.6 Process name:
All steps in the manufacturing of a system, subsystem, or component are described in a Process Flow Chart. Identify the process /operation name from Process Flow Chart that best describes the activity being addressed.
3.2.7 Machine, Device, Jig, Tools for Manufacturing.
For each operation that is described identify the processing equipment.
3.2.8 Characteristics:
1) Product:
Product characteristics are the features or properties of a part. (e.g. Size, Taper, Ovality, Squareness, Roundness)
2) Process:
Process characteristics are the process variables (M/c operating parameters Wheel Head RPM & Work Head RPM)
3.2.9 Special Characteristics:
Special Characteristics are unique symbols to identify important characteristics such as those that affect customer safety, compliance with regulation, function and fit. ➢ Outer ring OD, Inner ring Bore, Roller OD, Cage bore
3.2.10 Product & Process specification/ Tolerance:
Specifications/tolerance are dimensions of product which are require during manufacturing and assembly.
3.2.11 Evaluation/ Measurement Technique:
This column identifies the measurement system being used.
This could include gages, fixtures, tools, and/or test equipment required to measure the part/process/manufacturing equipment.
LC - Least Count (0.001 mm) least count is the smallest measurement that can be taken by an instrument accurately.
3.2.12 Sample Size & freq.:
This column identifies sample size and frequency of product checked during manufacturing process.
F.P.A. — First Piece Approved
3.2.13 Responsibility:
This column identifies responsible person for the sample inspection

3.2.14 Control Method:

This column identifies a written summary of the specification/ Tolerance for process and product parameter by responsible person.

3.2.15 Reaction Plan

The reaction plan specifies the corrective actions necessary to avoid producing N.C. products or operating out of control.

3.3 Production Part Approval Process

3.3.1 Introduction

Production part approval process is used in the automotive supply chain for establishing confidence in component suppliers and their production processes, by means of demonstrating that all customer engineering design record and specification requirements are properly understood by the supplier and that the process has the potential to produce product consistently meeting these requirements during an actual production run at the quoted production rate.

The PPAP process is designed to demonstrate that the component supplier has developed their design and production process to meet the client's requirements, minimizing the risk of failure by effective use of APQP. Requests for part approval must therefore be supported in official PPAP format and with documented results when needed.

3.3.2 Purpose

The purpose of any Production Part Approval Process (PPAP) is to confirm that Suppliers have properly understood all the design and specification requirements for the components they supply, and that the supplier's process has the capability to consistently deliver products that comply with those requirements.

The result of this process is a series of documents gathered in one specific location (a binder or electronically) called the "PPAP Package". The PPAP package is a series of documents which need a formal approval by the supplier and customer. The form that summarizes this package is called PSW (Part Submission Warrant). The approval of the PSW indicates that the supplier responsible person (usually the Quality Engineer) has reviewed this package and that the customer has not identified any issues that would prevent its approbation.

Suppliers are required to obtain PPAP approval from the vehicle manufacturers whenever a new or modified component is introduced to production, or the manufacturing process is changed. Obtaining approval requires the supplier to provide sample parts and documentary evidence showing that:

The client's requirements have been understood.

The product supplied meets those requirements.

The process (including sub suppliers) is capable of producing conforming product.

The production control plan and quality management system will prevent nonconforming product reaching the client or compromising the safety and reliability of finished vehicles.

3.3.3 Elements of PPAP

3.3.1 Design Records

A printed copy of the drawing needs to be provided. If the customer is responsible for designing, this is a copy of customer drawing that is sent together with the Purchase Order (PO). If supplier is responsible for designing this is a released drawing in supplier's release system.

3.3.2 Authorized Engineering Change Documents

A document that shows the detailed description of the change. Usually this document is called "Engineering Change Notice", but it may be covered by the customer PO or any other engineering authorization.

3.3.3 Engineering Approval

This approval is usually the Engineering trial with production parts performed at the customer plant. A "temporary deviation" usually is required to send parts to customer before PPAP. Customer may require other "Engineering Approvals"

3.3.4 DFMEA

A copy of the Design Failure Mode and Effect Analysis (DFMEA), reviewed and signed-off by supplier and customer. If customer is design responsible, usually customer may not share this document with the supplier. However, the list of all critical or high impact product characteristics should be shared with the supplier, so they can be addressed on the PFMEA and Control Plan.

3.3.5 Process Flow Diagram

A copy of the process flow, indicating all steps and sequence in the fabrication process, including incoming components.

3.3.6 PFMEA

A copy of the Process Failure Mode and Effect Analysis (PFMEA), reviewed and signed-off by supplier and customer. The PFMEA follows the Process Flow steps, and indicate "what could go wrong" during the fabrication and assembly of each component.

3.3.7 Control Plan

A copy of the Control Plan, reviewed and signed-off by supplier and customer. The Control Plan follows the PFMEA steps, and provides more details on how the "potential issues" are checked in the incoming quality, assembly process or during inspections of finished products.

3.3.8 Measurement System Analysis Studies (MSA)

MSA usually contains the Gage R&R for the critical or high impact characteristics, and a confirmation that gauges used to measure these characteristics are calibrated.

3.3.9 Dimensional Results

A list of every dimension noted on the ballooned drawing. This list shows the product characteristic, specification, the measurement results and the assessment showing if this dimension is "ok" or "not ok". Usually, a minimum of 6 pieces is reported per product/process combination.

3.3.10 Records of Material / Performance Tests

A summary of every test performed on the part. This summary is usually on a form of DVP&R (Design Verification Plan and Report), which lists each individual test, when it was performed, the specification, results and the assessment pass/fail. If there is an Engineering Specification, usually it is noted on the print. The DVP&R shall be reviewed and signed off by both customer and supplier engineering groups. The quality engineer will look for a customer signature on this document.

In addition, this section lists all material certifications (steel, plastics, plating, etc.), as specified on the print. The material certification shall show compliance to the specific call on the print.

3.3.11 Initial Sample Inspection Report

The report for material samples which is initially inspected before prototype made

3.3.12 Initial Process Studies

Usually, this section shows all Statistical Process Control charts affecting the most critical characteristics. The intent is to demonstrate that critical processes have stable variability and that is running near the intended nominal value.

3.3.13 Qualified Laboratory Documentation

Copy of all laboratory certifications (e.g. A2LA, TS) of the laboratories that performed the tests reported on section 10.

3.3.14 Appearance Approval Report

A copy of the AAI (Appearance Approval Inspection) form signed by the customer. This is applicable for components affecting appearance only.

3.3.15 Sample Production Parts

A sample from the same lot of initial production run. The PPAP package usually shows a picture of the sample and where it is kept (customer or supplier).

3.3.16 Master Sample

A sample signed off by customer and supplier that usually is used to train operators on subjective inspections such as visual or for noise.

3.3.17 Checking Aids

When there are special tools for checking parts, this section shows a picture of the tool and calibration records, including dimensional report of the tool.

3.3.18 Customer-Specific Requirements

Each customer may have specific requirements to be included on the PPAP package. It is a good practice to ask the customer for PPAP expectations before even quoting for a job. North America auto makers OEM (Original Equipment Manufacturer) requirements are listed on the IATF website.

3.3.19 Part Submission Warrants (PSW)

This is the form that summarizes the whole PPAP package. This form shows the reason for submission (design change, annual revalidation, etc.) and the level of documents submitted to the customer. There is a section that asks for "results meeting all drawing and specification requirements: yes/no" refers to the whole package. If there are any deviations the supplier should note on the warrant or inform that PPAP cannot be submitted.

3.3.20 PPAP Submission Levels

PPAP requirements are typically distinguished by level as follows:

1. Level 1 - Part Submission Warrant (PSW) only submitted to the customer.
2. Level 2 - PSW with product samples and limited supporting data.
3. Level 3 - PSW with product samples and complete supporting data.
4. Level 4 - PSW and other requirements as defined by the customer.
5. Level 5 - PSW with product samples and complete Template

3.4 Benefits

The benefits of PPAP report are as follows:

- Forces formal part conformance and approval
- Ensures formal quality planning
- Helps to maintain design integrity
- Identifies issues early for resolution
- Reduces warranty charges and prevents costs because of poor quality
- Assists with managing supplier changes
- Prevents use of unapproved and nonconforming parts
- Identifies suppliers that need more development
- Improves the overall quality of the product & customer satisfaction

3.4 Boards

3.4.1 4M BOARD

4M board consist Men, Machine, Method, Material.

Men is related, when the operator change their shift, then show changes in men column.

When machine is replaced or changed, then make changes in machine area.

Whenever the methods are changed, then show the changes of their location.

Material is related, when changes is in raw material then make place to show the changes.

Basically, 4M changeover represent the changes in Men, Machine, Method, Material

3.4.2 PQCDSM-BOARD

P - productivity - To achieve planned production

Q - quality - To improve product & process quality

C - cost - To reduce cost

D - delivery - To meet delivery targets

S - safety - To maintain safety

M - moral - To improve moral

IV. Conclusion

The present volume of this article gives an insight to learner, how to document, record and analyze data. Steps to be followed are visit entire plant, study about different processes and products in plant, study statistical process control for different components and their characteristics, fill up the reports

and maintain the documentation records, plan for the different machines, also made yearly planning. Then prepare documents of control plan, which have all process and parameter for the components. Maintain the distribution sheet for control plan, Prepare PPAP (production part approval process), which contain all information related to components and their specification, measurements, characteristics, lab testing reports and many more documents combined in one file. This exercise is helpful in performing 5S audit also. Entire paper being prepared at Orbit Bearing India Private Limited; this paper sets the classical example of research in practical environment.

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