FINAL YEAR REPORT OF THE WORK DONE ON THE MINOR RESEARCH PROJECT

UGC Reference No. : **MRP(S)-0195/12-13/KLCA027/UGC-SWRO**

Title of Research Project**: 'An Application of Acceptance Sampling Techniques in manufacturing forging products'.**

INTRODUCTION:

The world economy has undergone rapid changes during the past two decades with the advent of global competition to an extent that almost every company (large or small) is touched by it in some ways. As creativity and innovation are necessary for bringing forth the change required to obtain competitive advantage, quality is the most effective factor a company or organization can use in the battle for customer/clients. To be competitive, the customers must be satisfied and to satisfy thecustomers, we must focus on quality. Quality control provides the philosophy and driving force for designing quality in order to delight the customers by focusing on best value of a company's products and services. The basic goal of quality control is to ensure that the products, services or processes provided meet specific requirements and are dependable, satisfactory, affordable and physically sound (Hotelling, 1947).

Quality control is made up of those activities and techniques used to achieve and maintain a high standard of quality in a transformation process at reduced cost. They may include systematic inspection of inputs and outputs at various stages in their transformation to ensure that acceptable tolerances are not being exceeded. They may also involve a statistical analysis of data produced by the sampling (particularly in line production), benchmarking, continuous improvement (CI) and supplier partnering. In this case, in traditional organizations, management has to balance the cost incurred against the customers' goodwill. Quality control is also concerned with finding and eliminating the causes of quality problems.

However, Andrew J. Marlow (2006) views quality as integral part of all products including services. It is an important consumer decision criterion in selecting among competitive products. Deming (1986) saw quality as aiming at the needs of customers (present and futures). Robert Kotler (1994) view a product's quality as the ability to perform its functions. It includes the product's overall durability, reliability, precision, ease of operation and repairs and other valued attributes. Although,some of these attributes can be measured objectively from marketing point of view, but quality should be measured in terms of buyer's perception. Sullivan (1986) showed evidence on this issue when he defined seven stages

of quality in Japan in order of increasing level of quality to include: product oriented, process oriented, system oriented, humanistic, society, cost oriented and quality function deployment (QFD). Juran defined quality as fitness for purpose. While Crosby (1979) saw quality primarily as conformance to requirement.

Broh (1982) defined quality as the degree of excellence at an acceptable price and control of variability at an acceptable cost. However, quality improvement has become the key factor for the success and growth of any business organization. Investment on quality improvement gives rich returns. Japan is the best example. There are many different ways in which quality can be approached, so one might wonder which one is the best for technical documentation. Since quality is a necessary prerequisite for any company operating in today's highly competitive business environment, it is therefore, implied that as quality varies from one company to another, it also dependent on their mission, policy and other elements that guide the company in the realization of its corporate goals. It is therefore, a common knowledge that in the manufacturing sector, quality is everything.

Essentially, quality control involves the examination of a product, service or process for certain minimum levels of quality. The goal of quality team is to identify products that do not meet the company's specified standards of quality (Woodall, *et al.,* 2004). If a problem is identified, the job of a quality control team or professional may involve stopping production temporarily depending on the particular service or product as well as the type of problem identified, production or implementation may not cease entirely. Usually, it is not just the job of the quality control team or professional to correct quality issues, typically, other individuals are involved in the process of discovering the cause of quality issues and fixing them. Once such problems are overcome, the product, service or process continues production or implementation as usual.

In the manufacturing environment, quality improves reliability, increases productivity and customer satisfaction. Quality in manufacturing requires the practice of quality control.

The term sampling inspection plan, is used when the quality of product is evaluated by inspecting samples rather than by total inspects, which required cost and time .Acceptance Sampling is one of the major component of the field of Statistical Quality Control. It is primarily used for the inspection of incoming or outgoing samples. Acceptance sampling is classified into acceptance sampling plans by attributes and by variables. Acceptance sampling by attributes consists of different types of sampling plans, viz., single sampling plan, double sampling plan, multiple sampling plan, sequential sampling plan, continuous sampling plan, chain sampling plan and skip-lot sampling plan. The single sampling plan (SSP) by attributes is a commonly used and simple procedure. A single sampling plan is given by two parameters, the sample size n and the acceptance number c, which are to be determined based on the given requirements. Such

determination of the parameters, in general, is termed as “designing of single sampling plans by attributes”.

Acceptance sampling is used for quality assurance and in recent years, it has become typical to work with suppliers to improve the process performance. Acceptance sampling is one of its techniques. Acceptance sampling consists of quality assurance schemes designed to test whether the quality of batches of products or services conform to requirements, based on inspecting only a sample from each batch.

This project relates to a case study which describes the application of acceptance sampling in testing of forged product. This study analyses, the effectiveness in the application of acceptance sampling in manufacturing forging products. Acceptance sampling which is one of the major part of the statistical quality control tools help whether to accept or reject work based on their acceptance criteria.

OBJECTIVES OF THE STUDY

1. To design a customized variable sampling plan to overcome various implementation issues like high holding time for batch-wise testing, passing of forging product and high difference between actual and reported values.
2. To improve the products quality and ensure continuous customer satisfaction.
3. To maximize quality at minimum cost.
4. To test the quality of batches of items, especially when a large number of items must be processed in a short time.

METHODOLOGY

Acceptance sampling technique is applied, as a practical tool for quality assurance to decide whether the lot is to be accepted or rejected. This study analyses, the effectiveness in the application of acceptance sampling in manufacturing forging products. The study is based on case study methodology. Process and measurement variations are considered to design the sampling plan.

SIGNIFICANCE OF THE STUDY

This study is intended to compare acceptance sampling plans with 100% inspection, as the acceptance sampling plan has the following advantages;

1. More Economical, owing to fewer inspections.
2. Less handling of units during inspection.
3. Fewer inspection, thereby simplifying recruiting training and supervising.
4. Upgrading the inspection job from monotonous piece- by – piece decisions to lot- by- lot decision.
5. Applicable to destructive testing.
6. Rejection of entire lots rather than the return of defectives, there by providing stronger motivation for improvement of quality.
7. No extra holding time is required for customized sampling plan

8. Other benefits of sampling like less manpower, power and handling damages are accomplished.

YEAR-WISE PLAN OF WORK DONE:

FIRST YEAR:

Data Collection, Literature survey and Collection of Research Papers from various sources. From the case study, it was found that the company has clear vision of their strengths, weaknesses, opportunities and threat analysis.

SECOND YEAR:

Application of Sampling techniques to the data.

PRODUCT LIFE CYCLE BASED ON QUALITY CRITERION

Fulfillment of customer's requirements is closely with delivering them the products of the highest quality. In order to preserve and increase quality level of products, the producers should take measure this quality, control it and try to improve it. Such activities should take place on every stage of existence of the product and technology; from the moment of market researches and projecting, and until its removal market. The correct quality control, which makes it possible to create satisfying products for customers, has take into account many factors. These factors were shown schematically on figure 1. The synergetic influence of presented factors shapes the final level of product quality. However this influence is not equal on every stage of product life cycle. Depending on considered phase of product life cycle or technology life cycle the different

factors have dominant impact on quality, and this function of company changes in process of product quality forming. The organization can take leading function in this process, as it has during designing, production and delivery of products to customer or it can play only helping function realized on stages of use, exploitation and of the removal product.

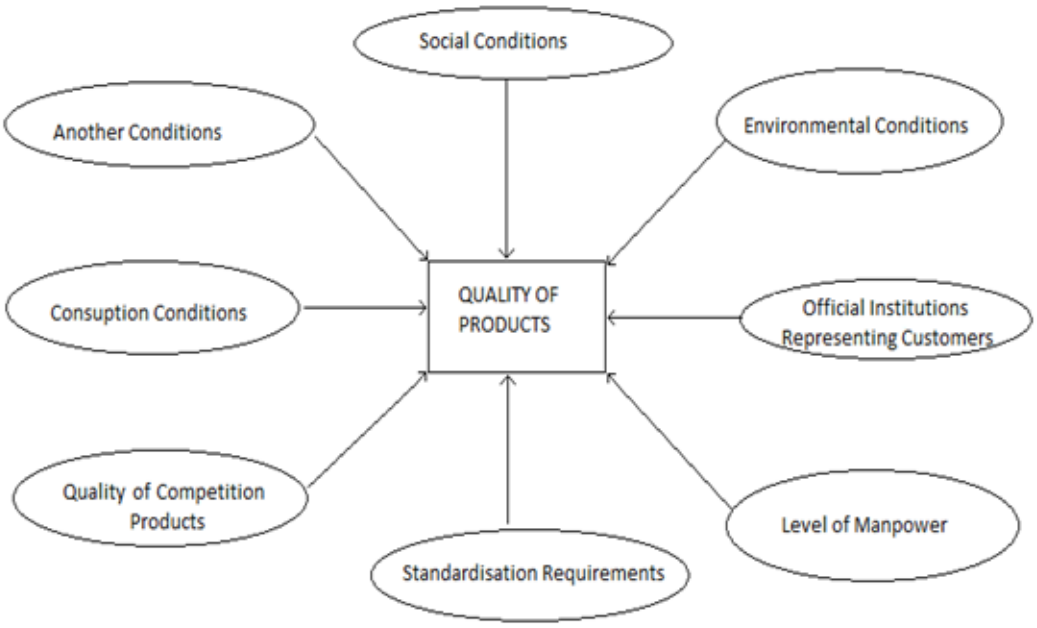


Fig-1: The factors forming quality products requirements

The quality management system in organization should control the quality of every phase of product life cycle. These phases can include: market research and product development, process research, planning, and development, purchasing, production, packaging and storage, marketing, sales, distribution, and delivery, product installation, service, and support, product disposal or recycling. However not all of mentioned activities take place in every company. It depends on area of activity and complexity of offered services.

FORGING PRODUCT MANUFACTURING

Forging refines the structure of metals by smashing up large grain formations and closing the cavities that are present. It also improves the mechanical properties thereby helping to withstand dynamic forces as well as static loads available.

Forging refers to the process of plastically deforming metals or alloys to a specific shape with a compressive forge exerted by some external agency like hammer, press roles or by an upsetting machine of some kind. The portion of work in which the forging is done is termed as "forge'. The work is mainly performed by means of heavy hammers, forging machines and presses. Forging processes are among the most important manufacturing techniques since forged are used in small tools, rail- road equipments and aviation industries.

The metals and alloys are classified into Good Forge (GF), Somewhat Difficult Forge (SD) and Difficult Forge (D).

- Aluminium alloys (GF)
- Magnesium Alloys (GF)
- Copper Alloys (GF)
- Carbon Steel Alloys (GF)
- Martensite Stainless Steels (SD)
- Nickel Alloys (SD)
- Titanium Alloys (D)

MANUFACTURING OF COMPANY A:

Company A, is a subsidiary of Steel industry. Company A cater to a wide range of Industries in Defense, Automobile, Heavy engineering, Aero Space Research, Railways, Earthmoving Equipments.

Main production Machinery comprise of 10 Ton and 6 Ton closed of 7500 Metric Tons of Carbon and Alloy Steel, non- ferrous, Special metals viz. Titanium and Nickel Based alloys, stainless Steel etc. The supporting machinery consists of Billet Shearing machines, 1000 Ton and 6500 Ton trimming presses, Electric and oil fired furnaces for heat treatment and billet heating, shot blasting machines etc. There is a modern heat treatment plant equipped with number of furnaces both LDO fired and electrically heated and a charging machine which takes care of loading and unloading of heat treatment charges.

TESTING AND INSPECTION FACILITIES

Surface conditioning is done by shot blasting / grinding and final inspection is carried out once again to ensure quality requirements. Stage-wise inspection non- conformities are taken care through timely corrective and preventive action. The company has set up a system of total quality control consisting of an array with state- of -art specialty equipments where their products go through a series of rigorous tests, destructive test including tensile, jominy and impact testing, wet analysis, carbon- Sulphur determination, metallographic and non- destructive tests using Spectrometer, Microscope, Ultrasonic flaw detection, Magnaflux crack detection, Die Penetrant etc, tests that ensures quality. Setting and control of quality standards at all stages right from the receipt of raw material to the finished product through quality plan makes them deliver superior quality forging with close dimensional tolerances and metallurgical properties.

In this project, the product items 518 bull Gear and Connecting Rod with Cap are considered.

First consider **the product item 518 bull Gear**:

ACCEPTANCE SAMPLING PLAN FOR 518 BULL GEAR

Here the product item 518 bull gear inspected and a decision should be made whether to accept or reject lot.A detailed sampling plans are developed based on their acceptance criteria.The calculation of one of the acceptance sampling plan is shown below in table 1 and operating characteristics curves for the sampling plan are shown in figure 2.

N = Total number of items in a lot.

n= Total number of items actually tested from lot.

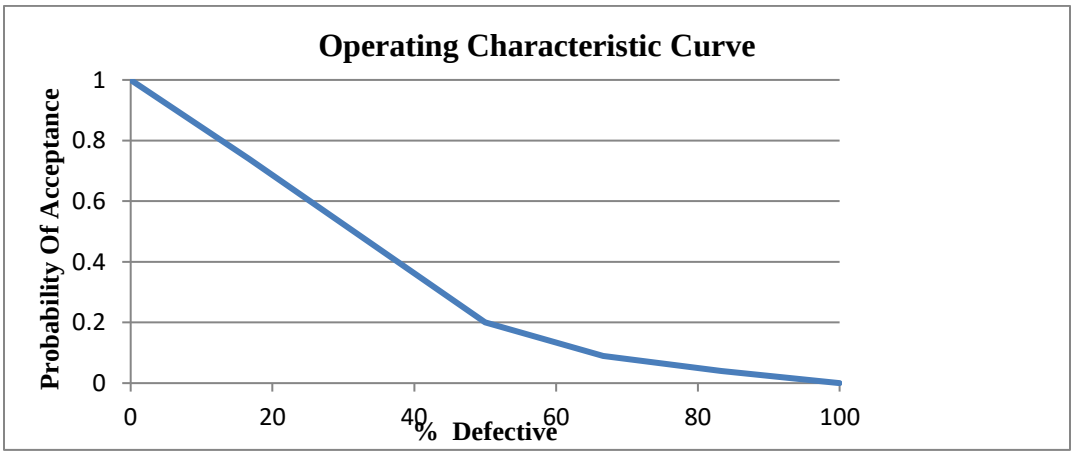
c = Acceptance number

x = number of defectives in tested items.

Probability of acceptance calculated from the Poisson Probability.

Table 1: Calculation of Acceptance Plan

N	n	c	No. of defectives	% Defectives	Probability of Acceptance
300	6	1	0	0	1
300	6	1	1	16.67	0.74
300	6	1	3	50.00	0.20
300	6	1	4	66.67	0.09
300	6	1	5	83.33	0.04



Therefore by using acceptance sampling the engineer or quality controller can make a decision whether completed work should be accepted or rejected. If these tools are used in the manufacturing of forging products, then there will be strong procedure to monitor the quality of work and also this will be helpful to the manufacturer and engineer to maintain the quality of work and this will avoid future rework and cost related to it.

Consider the **product item Connecting Rod with Cap and** its weight measure are considered. The assumption underlined is that the end test value is same at any point of the sample forging product. Acceptability of this assumption is mostly depends upon variation of the parameter along with weight measure of the forged product or in statistical terms process variation for the parameters and GRR (Gauge Repeatability and Reproducibility) performance of the measuring instruments. Variation is controlled to a minimum level so as to avoid any parameter going out of specification limit at any point of the tested sample. As forging product

testing generates numerical data, for quality assurance of the parameters, variable sampling plan is most appropriate.

CUSTOMIZATION OF SAMPLING PLAN

A sampling plan customized to high volume forging product quality testing has been designed to overcome the hurdles with conventional variable sampling plan. Two variations– process and measurement are considered to design such sampling plan.

PROCESS VARIATION

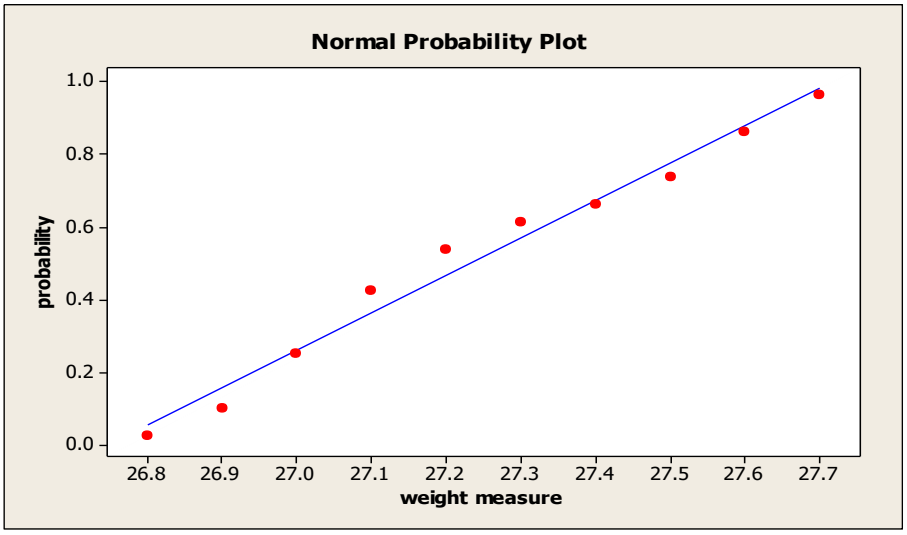
Measurement of weight and hardness parameters of the forging product CONNECTING ROD WITH CAP is destructive in nature. Here top or bottom measured values are assumed to be same at any point of the product. Graphical methods are also useful when one is selecting probability distribution to describe a population. Probability Plotting is a graphical method for determining whether sample data conform to a hypothesized distribution based on a subjective visual examination of the data. The measurements of the sample are analyzed for the normality using "Normal Probability Plot". If the measurements of sample appear as straight line on normal probability plot,then the mean of the sample is used for assigning values for the spools of entire batch. An example is given below for weight measure to the forged product CONNECTING ROD WITH CAP.

Table 2 shows base data of Weight measure for the forged product .CONNECTING ROD WITH CAP. Fig.2 shows result of normality test of base data. In assessing the "closeness" of the points to the straight line, imagine a "fat pencil" lying along the line. If all the points are covered by this imaginary pencil, then a normal distribution adequately describes the data. Since the points in Figure1 would pass the "fat pencil" test, one can conclude that the normal distribution is an appropriate model. The measurements of sample appear as straight line on normal probability plot. Therefore the mean of the sample is used for assigning the values for the spools of the entire batch.

Table 2: Base data of Weight measure (D)

Observations	Weight Measure(D)	Observations	Weight Measure(D)
1	27.4	21	27.6
2	27.5	22	27.0
3	27.7	23	27.2
4	27.6	24	27.0
5	27.6	25	27.1
6	27.6	26	26.9
7	27.3	27	27.1
8	27.5	28	27.1
9	27.0	29	26.8
10	26.9	30	26.8
11	27.0	31	26.9
12	27.1	32	27.3
13	27.5	33	26.9
14	27.0	34	27.7
15	27.1	35	27.5
16	27.0	36	27.6
17	27.3	37	27.5
18	27.0	38	27.2
19	27.1	39	27.2
20	27.0	40	27.7

Figure 3: Normal Probability Plot of base data



Average = 27.233, Standard Deviation = 0.28137, N = 40

MEASUREMENT VARIATION (GAUGE PERFORMANCE CURVE)

Gauge performance curves are determined for each parameter and measurement system from gauge repeatability and reproducibility (GRR) study. GRR study is carried with five samples covering entire specification range, three operators, and three readings per sample per operator.

Figure 4: Gage Performance curve for Weight Measure

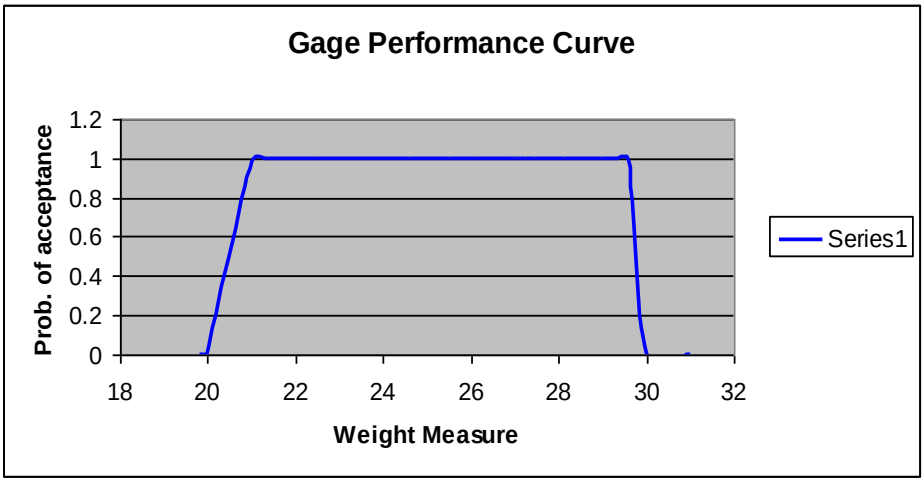


Fig.4 is Gauge Performance curve of Weight measure having upper and lower specification limit 20 D and 30D respectively. The 99% zone for the measuring system is 20.4 to 29.6 D. It means that if the actual measurement of Weight parameter is between 20.4 and 29.6 then probability of making correct decision 99% of time. The frequency of measurement system analysis is normally six month until and unless there is breakdown or major maintenance work.

BENEFITS

Benefits accrued by introducing customized sampling plan for high volume production of forged product are:

- No extra holding time is required for customized sampling plan.
- Insignificant difference between reported and actual values for un-tested samples.
- As measurement variation is considered during designing of sampling plan, there is much less possibility of passing failed forging because of sampling particularly for the batches where population is close to the extreme limit of specification range.
- With variable sampling plan, 70-80% less samples are required to test and one set of weight measure testing instrument can do testing same volume of production for which four sets of instruments would be required when 100% testing in place.
- Other benefits of sampling like less manpower, power, and handling damages are accomplished.

ISSUES IN QUALITY CONTROL IMPLEMENTATION

The important issues in quality control implementation are motivating factors, challenges and future trends in QC implementation.

MOTIVATING FACTORS IN QC IMPLEMENTATION

The implementation of quality control in company A is reported in this study. As shown in the case study, the reasons for the implementation might come from the company itself, the parent company, or from customer. On the current world market, both manufacturers and consumers require guarantees for the quality of products and services. One of the ways to ensure that the required quality is obtained at appropriate cost and time is by applying quality control in the

organisation. The aim of these companies is the same i.e. to produce high quality and reliable products, meet customer expectation, fulfill ISO condition and compete in the market.

Among various applied quality control techniques in the companies, Acceptance sampling is the most popular applied techniques.

Acceptance sampling is also applied together with SPC to get better results of process and product improvement. The case study has shown that quality control implementation in Company A relies heavily on acceptance sampling. In company like this one, acceptance sampling plays important roles to decide whether to accept or reject particular lot that contains tremendous amount of products.

The study concludes that the selection of quality control technique in these companies is influenced by three factors. First, ease of use of the technique. A simple but powerful technique will be easily adopted by workers. A more advance technique might require employee knowledge, and might risk employee acceptance to learn new methods. Second, technique that measures product specification fulfillment. Since customer and producer agree with product specification, the selected technique should provide some measurement of specification fulfillment. Third, technique that improves current critical quality and productivity problem. Quality and productivity measures the competitiveness of the company. If company is facing serious problems in these matters, certain quality control techniques will be applied to improve the situation. The application of quality control technique shows similar pattern of usage in the production stage. Many industries report QC application in the post-production stage, meant for finished products.

CHALLENGES AND FUTURE TRENDS IN QC IMPLEMENTATION

The study found that each company has its strengths and weaknesses in applying QC. For example, in Company A, though the applied method seems to be simple, it involves tedious procedure to conduct the inspection test. To overcome the complex measurement problem, Company A might consider using a more efficient technique to conduct the inspection test. Manual approach in conducting quality control could be found in Company A.

CONCLUSION

The study finds that the motivating factors for this company to apply quality control come internally from the management and parent company or externally from customer. SPC and acceptance sampling are used widely by the company.

The selection of quality control technique in this company is influenced by three factors: ease of use of the technique; ability to measure product specification fulfillment; and ability to improve critical quality and productivity problem.

By using acceptance sampling the engineer or quality controller can make a decision whether completed work should be accepted or rejected. If these tools are used in the manufacturing of forging products, then there will be strong procedure to monitor the quality of work and also this will be helpful to the manufacturer and engineer to maintain the quality of work and this will avoid future rework and cost related to it. Effective acceptance sampling involves effective selection and the application of specific rules for lot inspection. The acceptance- sampling plan applied on a lot-by-lot basis becomes an element in the overall approach to maximize quality at minimum cost. Since different sampling plans may be statistically valid at different times during the life of a process, therefore all the sampling plans should be periodically reviewed. From the case study, it was found that the company has clear vision of their strengths, weaknesses, opportunities and threats analysis. A customized variable sampling plan is designed for high volume forging product quality testing to overcome various implementation issues like high holding time for batch-wise testing, passing of forging product and high difference between actual and reported values. The customized sampling is found in good agreement with conventional sampling. The continuous improvement and review of acceptance sampling plan is important to improve the products quality and ensure continuous customer satisfaction.

PAPERS PUBLISHED IN JOURNALS

1. **P.R. DIVYA. (2017):** ***"Application of Acceptance Sampling Techniques in Manufacturing forging products",*** **International Journal of Innovations in Engineering and Technology(IJIET)**, Volume 8, Issue 1- February 2017, pp. 124-128, ISSN: 2319-1058.

PAPER PRESENTATION IN CONFERENCES

1. ***" Analysis of Data on Manufacturing products using Acceptance Sampling Techniques"*** presented in the **National Seminar on Statistical Methods and Applications** sponsored by

Directorate of Collegiate Education, Govt. of kerala, organized by the department of Statistics , Govt. Arts and Science College, Kozhikode during 15-17, December 2016.

PARTICIPATION IN WORKSHOP

Participated in the two day **National Pre-seminar workshop on Big Data Analytics** sponsored by Directorate of Collegiate Education, Govt. of kerala, organized by the department of Statistics , Govt. Arts and Science College, Kozhikode during 13-14, December 2016.

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