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THE IMPACT OF THE TECHNOLOGY IMPROVEMENTS IN STATISTICAL PROCESS CONTROL (SPC) IN INDUSTRIES

تأثير التحسينات التكنولوجية بالتحكم في العمليات الإحصائية في الصناعات

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CHAPTER – 1

INTRODUCTION

Every organization has different tools to maintain and to ensure the level of quality is retained in all products or services. Different engineers and Researches had contributed towards quality. Statistical Process Control (SPC) is an approach to process control that has been widely used in any industrial or non-industrial fields. SPC is based on so called Shewhart's conception of the process variability. This conception distinguishes variability caused by obviously effected common causes (process is considered to be statistically stable) from variability caused by abnormal assignable causes (process is considered not to be statistically stable).

The main goals of SPC is an identification of abnormal variability caused by assignable causes with the aim to

1. Make the process stable.
2. Minimize the process variability.
3. Improve the process performance.

The main function is “to reduce variation in an output characteristic by signaling the change of an undefined process input”. Effective application of SPC is such complex application which leads to the reduction of the process variation, i.e. to the process improvement. Meeting this goal is proportional to the level of allowing for groups of these factors during the SPC implementation and application and to the rate of integrating SPC into the overall business system of an organization.

Quality Management ensures that an organization, product or service is consistent. It has 4 main components

1. Quality planning.
2. Quality assurance.
3. Quality Control.
4. Quality Improvement.

Quality assurance and control of process as well as products to achieve more consistent quality. What a customer wants and is willing to pay for it determines quality. It is written or unwritten commitment to a known or an unknown customer/consumer in the market. Thus quality as fitness for intended use.

The next forward was promoted by several people including

F.W.Taylor, a mechanical engineer to improve industrial efficiency. He also called as **“Father of Scientific Management”**. He was one of the intellectual leaders of the efficiency movement and part of his approach laid a foundation for quality management.

Walter A. Shewhart made a major step in the evolution towards quality management by creating a method for quality control for production, using statistical methods, first proposed in 1924.

Edward Deming later applied statistical process control methods in the **United States during World War II**, thereby successfully improving quality in the manufacture of munitions and other strategically important products. He is probably known for his management philosophy establishing quality, productivity and competitive position. He has developed 14 principles to improve the level of quality in all industries. Customer Satisfaction is the backbone of quality management. The influence of quality thinking has spread to non-traditional applications outside of walls. Extending into service sectors such as sales, marketing and customer service.

1.1.2 QUALITY ELEMENTS

- Quality Objectives
- Quality Manual
- Organizational Structure and responsibilities
- Data Management
- Processes including purchasing
- Product quality leading to customer satisfaction
- Continuous improvement including corrective and preventive action.
- Quality Instrument
- Document Control

1.1.3 PRINCIPLES

The International Standard for Quality Management (ISO 9000:2015) adopts a number of management principles that can be used by top management to guide their organizations towards improved performance.

1.2 NEED FOR THE STUDY

- At the beginning inspection based quality control was used for checking the final product/service quality. However, inspection –based quality control was unreliable, inefficient, costly and time –consuming. Moreover, inspection based quality control is reactive in the sense that defective items or products will be made before they are found and thus will incur scrapping or reworking costs.
- It is time-consuming process and adds no value in terms of continuous improvement. In order to tackle this problem, a preventive measure must be used in the operation stage in order to ensure that desirable product quality can be achieved. Companies must strive for continuous improvement in quality, efficiency and cost reduction.
- An approach based on Statistical Process Control (SPC) is used to monitor, control, analyze and improve process performance by systematically eliminating special causes of variation in processes. The SPC process is implemented to move a company from detection based to prevention based quality controls. By monitoring the performance of a process in real time the operator can detect trends or changes in the process before they result in non –conforming product and scrap.

1.3 OBJECTIVE

1.3.1 PRIMARY OBJECTIVE

- To study on the impact of the technology improvements in statistical process control (SPC) for quality upgradation in industries.
- To study the impact of the technology improvements SPC as a powerful management method to improve quality and elimination of waste.

1.3.2 SECONDARY OBJECTIVE

- To detect variations in the process so that it can be controlled. To improve in quality and productivity process variation.
- To demonstrate all the advantages associated with its use as a method for improving quality and reducing waste.
- To achieve increase in quality level and to reduce the cost by continuous monitoring and improvement in the process.

CHAPTER 2

REVIEW OF LITERATURE

There are complex and numerous factors affecting the SPC implementation. These factors are prerequisites for the creation of an environment favorable for the SPC use. The CSF condition failure may lead to issues associated with the implementation, maintenance and continuity of the program (**Antony et al., 2000; Lim et al., 2014; Rohani et al., 2010; Woodall & Montgomery, 1999**).

There are two important aspects associated with SPC implementation: the managerial aspect, also called organizational; and the technical or operational aspects (**Does et al., 1997; Mason & Antony, 2000; Egl et al., 2008; Putri & Yusof, 2008; Rohani et al., 2009**)

According to the literature, the construction of an environment focused on an improvement culture is an important aspect for SPC deployment. It is worth focusing on customer satisfaction, on mutual trust among peers and on the improved visibility of problems within the scope of organizations that understand SPC as a necessary technique to keep stable processes (**Grigg & Walls, 2007a**).

Top management support and resources are the basic conditions to create an improvement culture (**Antony & Taner, 2003; Mahanti & Evans, 2012**). Top management commitment is one of the most important factors for a successful SPC implementation (**Mahanti & Evans, 2012; Rungasamy et al., 2002**).

Senior executives should assist initiatives supporting time, financial and human resources

(ANTONY & TANER, 2003; MAHANTI & EVANS, 2012; MASON & ANTONY, 2000).

The senior management support and training initiatives to generate and spread SPC knowledge are related to each other. The SPC should start in the top management level and then be spread to other organizational levels through trainings supported by the senior management **(Grigg & Walls, 2007a).**

Senior management is responsible for making resources available for the training sessions, as well as for encouraging employees to participate in them **(Mahanti & Evans, 2012; Phyanthamilkumaran & Fernando, 2008).** Based on these theoretical statements, the current paper aims to confirm the following research hypothesis.

The Statistical Process Control - SPC is a set of statistical techniques focused on process control, monitoring and analyzing the variation causes in the quality characteristics and/or in the process parameters. Several authors see SPC not only as a collection of techniques, but also as a concept able to define the criteria to interpret variability and their causes **(Antony & Taner, 2003; Burr, 1976; Caulcutt, 1996; Hayes & Romig, 1977; Oakland, 2008; Woodall, 2000).**

The control chart application is based on proper statistical assumption domains and on the correct selection of control charts **(Antony & Taner, 2003; Rungasamy et al., 2002),** which may enable process adjustments, whenever necessary **(Mason & Antony, 2000).**

The use of SPC, specifically of the control chart, is based on statistical methods. It aims at stabilizing the process by identifying and acting on the two types of variation causes. Special causes are few, but identifiable and they have strong effect on variability and product quality. There are many common causes, but they have little effect on process variability **(Montgomery, 2010; Montgomery, 2014; Oakland, 2008; Woodall & Montgomery, 1999).**

A Systematic Literature Review (SLR) was conducted to define the procedures in order to impartially identify, analyze and interpret the available evidences related to a particular topic, research question or phenomenon of interest, which can be replicable and evidence-based to create generalizations **(Biolchini et al., 2007; Brereton et al., 2007; Tranfield et al., 2003).** The following search string was adopted to identify critical factors in the literature: “statistical process control” or “SPC” or “control chart”, and “critical success factors” or “success factors”.

The control charts should be applied to the critical characteristics as functional and safety features of products and processes **(Antony & Taner, 2003)**. Training is responsible for the possibility of properly applying the control charts and the statistical tools, and it regards the correct choice for charts and critical characteristic **(Mahanti & Evans, 2012; Phyanthamilkumaran & Fernando, 2008; Rohani et al., 2010; Mahanti & Evans, 2012)**.

It is consensus among many authors that one of the benefits from SPC is the process variation reduction to achieve the best quality performance of processes/products **(Antony et al., 2000; Antony & Taner, 2003; Grigg & Walls, 2007a; Hoerl & Snee, 2010; Lim et al., 2014; Lim & Antony, 2013)**. However, such demands rapidly identify and act on the special variation causes **(Mason & Antony, 2000)**.

According to **Yamamoto & Bellgran (2013)**, infrastructural investments in the organization regard not only the physical assets, but also organizational procedures and intangible assets such as knowledge, skill, motivation and leadership. The SPC training should present different control chart types and the situations that each chart should be applied, as well as how to identify special causes, to collect and record data in the control chart **(Antony & Taner, 2003; Rohani et al., 2010)**; the presence of these issues concern a quality training. Other important issues associated with quality training are related when the acquired knowledge about SPC is applied after the training session and when there is additional training in SPC application and tools (it features new control chart techniques and recalls the fundamental concepts of conducting the enforcement activities of control charts) **(Mahanti & Evans, 2012)**.

There is the paradigm that using control charts allows process behavior prediction since there is knowledge accumulation and the systematic use of statistical methods to reduce future uncertainties able to cause a paralyzing behavior with time **(Lim & Antony, 2013)**. Other benefits reported in the literature are: significant reduction in the time spent to solve quality issues aiming at reducing scrap, rework and inspection **(Antony et al., 2000; Lim & Antony, 2013; Mason & Antony, 2000)**; fact that leads to cost reduction **(Grigg & Walls, 2007a, b; Mason & Antony, 2000)**.

LITERATURE SURVEY

A producer is basically interested to see that the product is of acceptable quality to the customers, as it improves the competitive ability of the company and increases the sales, and no supplier can be in business if he fails to respond to the expectations of the customers, whether it is a part of the specifications or not. Since the quality of products has become an important aspect, the management should try to maintain the desirable quality at reasonable costs, for which they have to concentrate on a number of factors, such as the product design and specifications, the product process, the raw materials, machines and equipment's, the expertise and skill of the persons who handle them and inspection of the final product. In nutshell, the management should maintain the quality of materials, quality of man power, quality of machines, quality of their activities etc.

The quality of men, machine, materials etc. depends upon the clear and comprehensive programmed that must be capable of attempting some important tasks like:

- Coordinating the activities of quality control and quality assurance
- Developing wide quality systems and procedures
- Advising and helping in evolving quality programmed
- Auditing and implementing the quality system periodically.
- Developing and organizing the training and retraining programmed etc.

An effective programmed for attaining the above tasks certainly reduce the cost of production by minimizing the tangible and intangible losses due to poor quality, such as, materials scrapped or junked, labor and overheads in product scrapped, repairs on salvageable product, extra operations added because of the presence of defects, excess inspection costs, discount on seconds, charges on quality guarantee-free replacement, down grading of products, repair and processing of returned materials, delays and stoppages caused by defectives, customer goodwill etc.

2.1.1 QUALITY MANAGEMENT ISSUES

- Today many companies are realizing mainly three problems,
- The sharp increase in customers' quality requirements
- Becoming, present quality practices and techniques as out-mode, due to increased demand for higher quality products.
- An increase in quality costs at higher rate. These problems pose two main challenges to the management as Considerable improvement in the quality of products and quality practices
- Substantial reduction in the overall costs of maintaining quality.

The above challenges and problems demand an effective quality management. Where, the quality management is an effective system for integrating the quality development, quality maintenance and quality improvement efforts of the various groups in an organization. So as to enable marketing engineering, production and service at the most economical levels which allow for all customer satisfaction.

In simple words, quality management is that which guides the coordinated actions of people, machines and information to achieve the goals. The quality management has a very wide coverage as it deals with many aspects at different stages.

Some of them are as follows:

- Marketing: Evaluates the level of quality, which customers want and for which they may be willing to pay.
- Engineering: Reduces the marketing evaluation to exact specification.
- Purchasing: Chooses contracts with, and retains vendors for parts and materials.
- Manufacturing Engineering: Selects the jobs, tools and process for production.
- Manufacturing Supervision and Shop Operators: Exert a major quality influence during parts making, subassembly and final assembly.
- Mechanical Inspection and Functional Test: Check conformance to specifications.
- Shipping: Influences of packaging and transportation.
- Installation and Product Service: Ensure proper operation by installing the product according to proper instructions and maintaining it through service.

2.1.2 MEASUREMENT

The measurements of quality, costs, customer satisfaction, systems conformance etc, are the most important aspects, since they provide bases for the effective quality management and also essential for the organizational success. Thus, the following are some important aspects, which have to be measured carefully and systematically for the effective evaluation of quality management.

QUALITY: Timely measurement and reporting of quality level data are very much useful for assessing quality performance, setting quality-level goals and evaluating corrective actions or efforts. Such information becomes the basis for establishing and improving goals, priority schedules etc.

COST: The periodic collection and analysis of quality costs monitor the cost effectiveness of the quality system, which is fundamental to achieve the goal of full customer quality satisfaction at reasonable quality costs.

CUSTOMER SATISFACTION: The useful predictor of customer satisfaction is the intensive examination of small samples of finished product. The result of this type of customer centered quality audit, together with other measurements after the product is in use, evaluate the effectiveness of the quality system from the view point of the customer and alert the management for taking rapid product corrective action. They provide valuable input towards the development of new models and similar products.

SYSTEM CONFORMANCE: The assessment of the quality—system procedures, identifying the deviations from such system, provide some data which is helpful to management to determine the adequate quality plans, quality responsibilities and procedures. This in turn, pinpoints the areas where improvements are necessary.

2.1.3 RELATIONSHIP BETWEEN STATISTICAL PROCESS CONTROL AND STATISTICAL QUALITY CONTROL

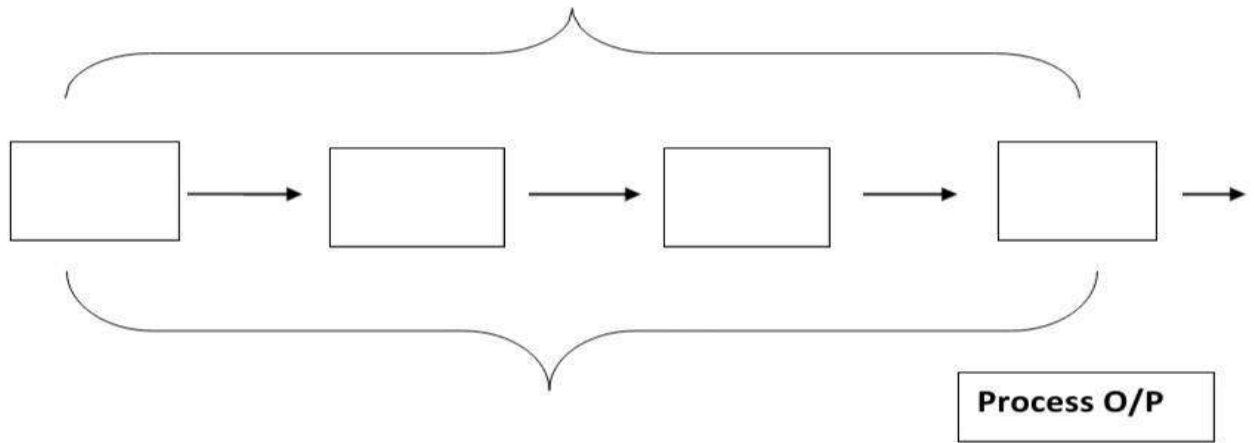


Fig.2.1 SPC & SQL

2.1.4 APPLICATIOND OF SPC – THREE PHASES

- Understanding the process and the specification limits
- Eliminating assignable sources of variation, so that the process is stable.
- Monitoring the ongoing production process, assisted by the use of control charts, to detect significant changes of mean or variation.

2.1.5 SPC – TWO PHASES

- The first phase is the initial establishment of the process.
- The second phase is the production use of process.

2.1.6 IMPACT OF QUALITY AND IMPROVING WAYS IN AN ORGANIZATION:

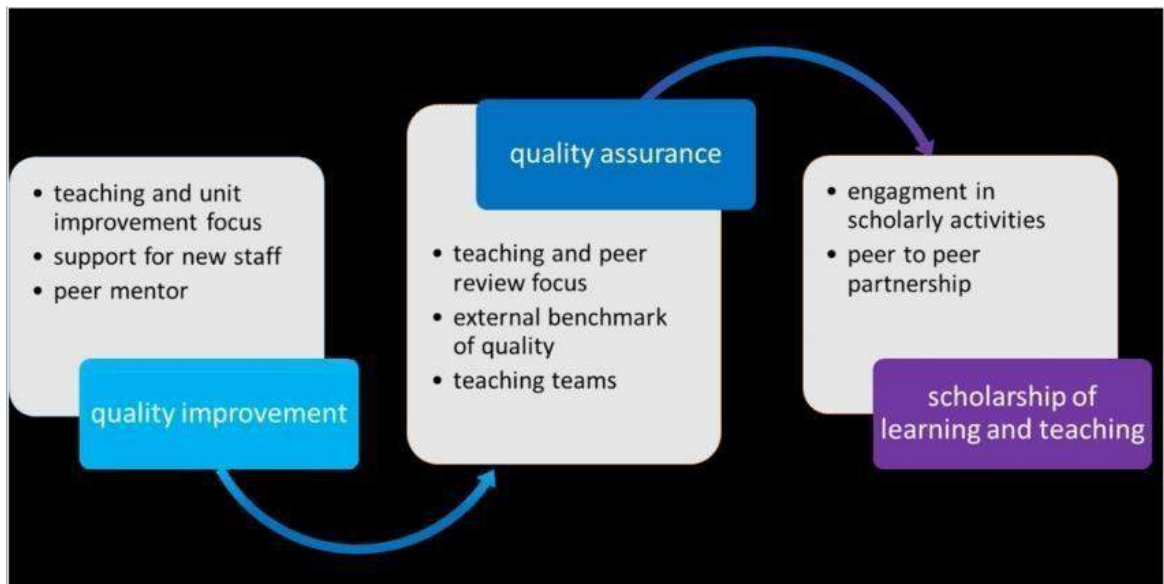


Fig 2.2 Quality Improvement Ways

- The result of SPC is reduced scrap and reworks costs, reduced process variation and reduced material consumption. SPC states that all processes exhibit intrinsic variation. However, sometimes process exhibit excessive variation that produces undesirable or unpredictable results.
- SPC, in manufacturing process optimization context, is used to reduce variation to achieve the best target value. These techniques have been adopted by organizations throughout the globe in recent years, especially as a component of quality improvement initiatives like Six Sigma. The widespread use of control chart procedures has been grandly assisted by statistical software packages and data collection systems.

2.1.7 CONSEQUENCES OF POOR QUALITY



Fig 2.3 Consequence of poor quality

2.1.8 CAUSES OF VARIATION

Common and Special cause are the two distinct cause of variations in a process as defined by statistical thinking and methods of Walter A. Shewhart and Edward Deming.

Common cause are also called natural patterns are usual, historical, quantifiable variation in a system.

Special causes are unusual, not previously observed, non-quantifiable variation.

2.1.9 PROJECT MANAGEMENT PROCESS

Fig 2.4 PMC



2.1.10 QUALITY ASSURANCE APPROCHES



Fig 2.5 QPA

2.1.11 RESEARCH GAP

- Depending upon the collection of literature, SPC is widely used to enhance the level of quality in major industries. The quality level of a product is highly focused in all industries to avoid the sequence at the end of a customer/ consumer and to make a reputation among the market and to maintain a brand image.
- Other than SPC there are some other techniques used in large scale industries like Six Sigma, ERP etc are widely used technique, thereby control charts and QC tools are used in a small and medium scale industries.
- The control chart is the easiest and best technique to determine the process in control. Thereby, any deviation occurs it is easy to predict and it can be rectified at the early stages to make efficient product and cost effectiveness.

Many scientists and research scholars had made a great invention and different techniques to make a better and quality product to satisfy the customer. Customer satisfaction plays a major role among the markets and in a business industry to make the product successful.

CHAPTER 3

METHODOLOGY

3.1 PROJECT TYPE

Project quality management is broken down into 3 main phases

- Quality planning.
- Quality assurance.
- Quality control.

In this project, it shows the brief analysis of SPC tools using % analysis, Interview method (Linkert scale) technique and SPC tool is used to compare the variability level and to study the impact of the technology used in industries. Planning is the first step to ensure the quality level and a test project should be conducted to verify the product can be manufactured and it is economical and commercial to use to attract and satisfy the customers.

3.2 TARGET RESPONDENTS

The number of respondents considered here for the project is 95 to ensure the quality and respondents behavior, analysis, Categorization on different age groups, Educational qualification of data etc. The following table represents the respondents behavior and to predict the results approximately.

3.3 AGE ANALYSIS

TABLE 3.1 RESPONDENTS AGE

AGE	No of respondents
21-30 Years	27
31-40 Years	42
41-50 Years	23
Above 51	3

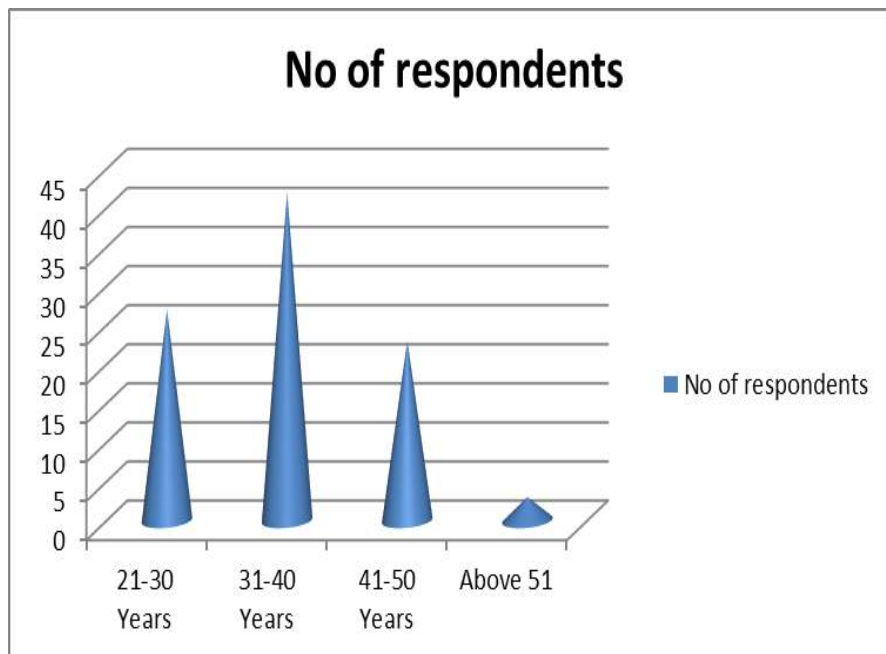


Fig 3.1 Representation of respondents

3.3.1 INFERENCE

The above graph shows the number of respondents under the age of 21-30 is 27. Under the age group 51 has a low level of respondents. The graph clearly represents the different age group of respondents.

3.4 EDUCATIONAL QUALIFICATION OF RESPONDENTS

TABLE 3.4 EDUCATIONAL QUALIFICATIONS

EDUCATIONAL QUALIFICATION	NO OF RESPONDENTS	PERCENTAGE OF RESPONDENTS
SSLC	20	21.2%
HSC	13	13.4%
UG DEGREE	44	46.5%
PG DEGREE	18	18.9%
TOTAL	95	

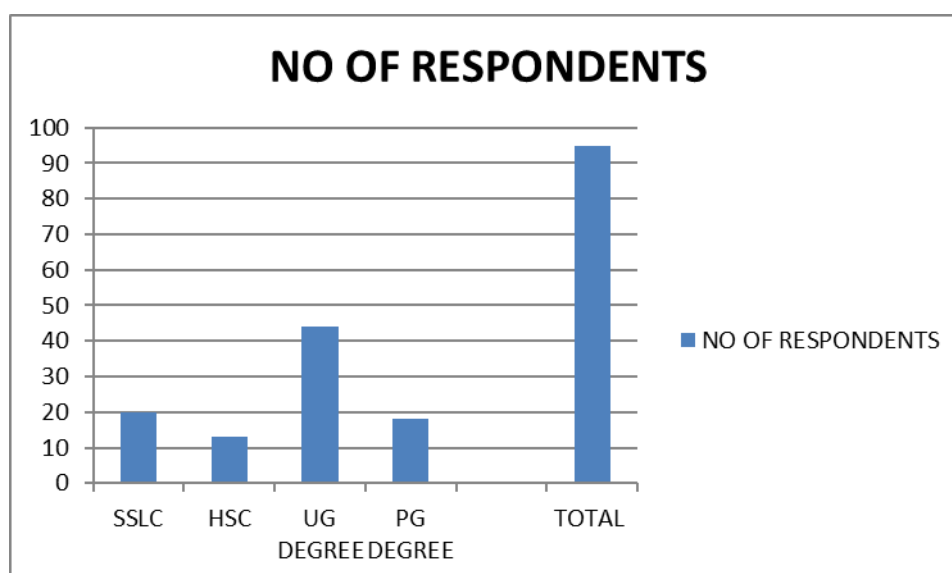


Fig 3.4 Educational Qualification of respondents

3.4.1 INFERENCE

The above graph shows the representation of educational qualification of the respondents highest is 44(UG respondents) & lowest is 18 (PG Degree) to view the survey more predictable. The SSLC has 20 respondents out of 95 and the HSC has 10 respondents out of 95. The UG degree has highest role to view and observe the respondents.

3.5 YEARS OF EXPERIENCE OF RESPONDENTS

TABLE: 3.5 YEARS OF EXPERIENCE

YEAR OF EXPERIENCE	NO OF RESPONDENTS	% OF RESPONDENTS
Up to 1 Years	11	11.50%
2-5 Years	28	29.40%
6-8 Years	25	26.31%
9-12 Years	19	20.00%
Above 12 Years	12	12.63%
Total	95	

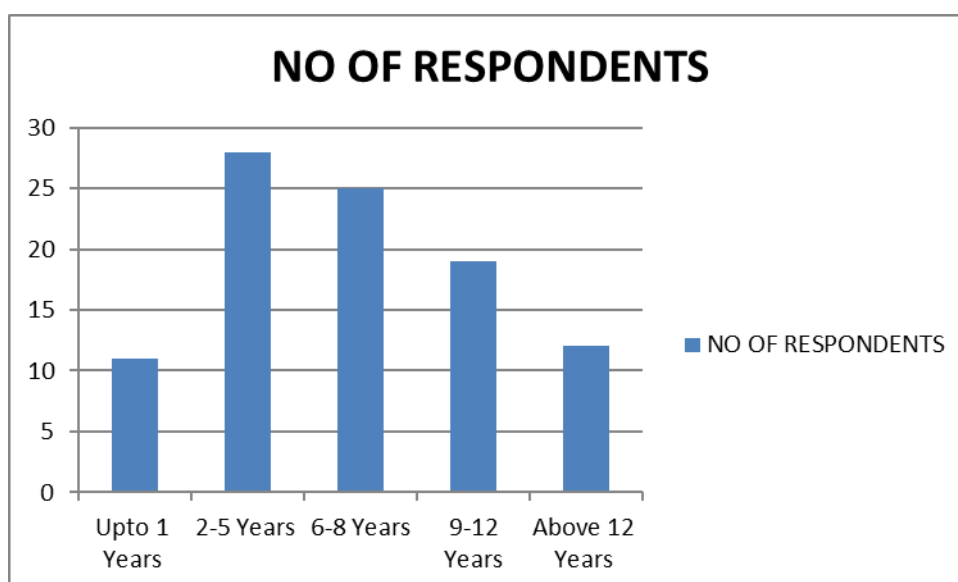


Fig 3.5 Representation of respondents

3.5.1 INFERENCE

The above table indicates that, 1 percent of the respondents having the experience of below 1 year, 48 percent of the respondents experience of 2 – 5 years, 31 percent of the respondents having the experience of 6 – 8 years, 8 percent of the respondents are having the experience of 9 – 12 years and 12 percent of the respondents are having above 12 years of experience.

3.6 LIMITATIONS

The limitations of the process area as follows

- Time requirements.
- Cost considerations.
- Quality measurements.
- Possible lack of cooperation's.
- Improper monitoring of the process leads to ineffective results.
- Ineffective team work leads to decrease in level of quality.

3.7 SAMPLING METHODS

3.7.1 STATISTICAL PROCESS CONTROL:

SPC is method of measuring and controlling quality by monitoring the manufacturing process. Quality data is collected in the form of product or process measurements or readings from various machines or readings from various machines or instrumentation.

SPC is an effective method to drive a continuous improvement. By monitoring and controlling a process, we can assure that it operates at its full potential. Manufacturing companies today ever increasing competition. Therefore companies must concentrate on what they can be controlled.

3.7.2 7 STEPS TO SET UP STATISTICAL PROCESS CONTROL:

The following steps to be controlled to set up statistical process control in an industry are as follows

- Select critical –to –quality product characteristics.
- Select critical processes.
- Do machines calculate SPC by themselves?
- Gather data and process knowledge – what impacts the output of the process?
- Based on the conclusions of the previous step, control those independent variables that have a sizeable impact on the process of output.
- Look for ways to reduce variation.
- Keep it up in the long term.

3.7.3 DATA COLLECTION:

Data collection is the process of assembling for the purpose of particular investigation of entirely new data, presumably not already available in the sources. It is the process of gathering and measuring information on targeted variables in an established system.

3.7.4 METHODS OF DATA COLLECTION:

- Census
- Sampling
- Observational Study
- Experimental

3.7.5 DATA COLLECTION AND SAMPLING TECHNIQUES:

3.7.5.1 TYPES OF DATA COLLECTION:

There are 2 types of data area s follows

- **Primary data** – Collected as a fresh and happen to original in character.
- **Secondary data** – collected by someone else and which have already been passed through statistical process.

3.8 TECHNIQUES USED:

Interview method is used for data collection for determining statistical quality process control. Secondary data is collected from journals, articles etc used to analyze effectively and to predict the results.

3.8.1 INTERVIEW METHOD:

This method of collecting data involves presentation of oral verbal stimuli and reply in terms of oral –verbal responses. Interviewer can collect supplementary information about respondent's personal characteristics and environment which has value in interpreting results.

3.8.2 STAGES OF INTERVIEW INVESTIGATION:

- Thematizing
- Designing
- Interviewing
- Transcribing
- Analyzing
- Verifying & Reporting

3.8.3 MERITS:

- A structured interview method is possible to reach a large number of people at the same time.
- Less dependency for electronic recording devices.
- Interview methods are more personal in nature.
- It collects data intensively and extensively.
- Access to qualitative data and ability to explore probe responses.

3.8.4 DEMERITS:

- The main disadvantage of interviews is the handling of the
- Personal information of the candidates. They have to make sure the information of the candidates is kept safe.
- Employing interviewers and trainers can be expensive and time
- Consuming.
- Possibility of interviewer bias.
- Lack of Anonymity.
- For unstructured and unplanned interviews, it is difficult to collect all the necessary data and analysis of such data will take time, since they are less specific and cover more areas and aspects of the subject.

3.8.5 FACTORS TO BE CONSIDERED BEFORE USING DATA:

- Reliability of data.
- Suitability of data.
- Adequacy of data.

3.8.6 SELECTION OF PROPER METHODS FOR COLLECTION OF DATA:

- Nature, Scope and object of inquiry.
- Availability of funds.
- Time factor.
- Precision Required.

3.9 INSTRUMENT TECHNIQUE:

For interview technique, the researcher is the instrument. Interview is one of the techniques used in qualitative research. Use proper steps in interview and interview protocol properly during the process of interview.

3.9.1 SAMPLING FRAMEWORK:

A sampling framework is the source material or device from which a sample is drawn. Having the established frame, there are number of ways for organizing it to improve efficiency and effectiveness. An ideal sampling framework will have following qualities are as follows

- All units have a logical, numerical identifier.
- The frame is organized in a logical, systematic fashion.
- No elements from outside the population of interest are present in the frame.

3.9.2 RESEARCH DESIGN:

A research design is the arrangement of condition for collection and analysis of data in a manner that aims to combine relevant to the research purpose with economy in procedure.

3.9.3 SAMPLE SIZE:

A Sample size of 95 respondents was taken for the study. Sample size refers to the number of respondents selected from the geographical area to constitute sample.

3.10 SAMPLING TECHNIQUE:

The researcher adopted the non –probability convent sampling technique. There is no possibility of equal chance for the samples of all population.

3.10.1 SAMPLE REPRESENTATIVE SEGMENT OF THE POPULATION:

- Who is to be surveyed?
- How many should be surveyed?
- How sample should be chosen?
- Non-probability sampling?

3.10.2 SECONDARY DATA:

Secondary data is collected from journals, articles etc used to analyze effectively and to predict the results.

3.11 DATA PROCESSING:

In data processing collected data will be analyzed completely to ensure and predict the results based on respondents data collection to view how quality is more important to all industries.

3.11.1 TOOLS FOR ANALYSIS:

The statistical tools used in the study are as follows

Control charts – control charts have the essence of statistical process control is to assure that the process is random (in a controlled manner).It defines the range of accepted variables or values. The process include

- Measure
- Compare
- Evaluate
- Correct
- Monitor
- Results

TABLE 3.11.1 % NO OF RESPONSES (UNFAVORABLE RESPONSES)

Statement	Total Responses	Number Unfavorable	% unfavorable
S1	95	14	14.74%
S2	95	10	10.53%
S3	95	8	8.42%
S4	95	7	7.37%
S5	95	10	10.53%
S6	95	8	8.42%
S7	95	12	12.63%
S8	95	9	9.47%
S9	95	10	10.53%
S10	95	7	7.37%

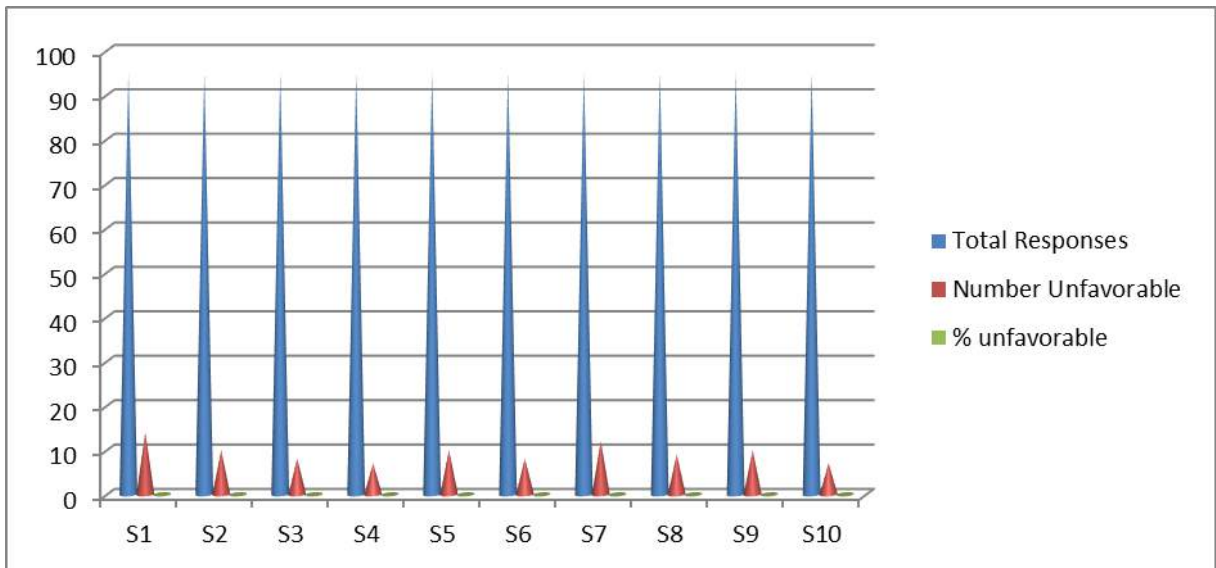


Fig 3.11.1 Representation of unfavorable responses

INFERENCE

The above representation shows that statement 10 & 4 has lowest response.

3.12 FAVOURABLE RESPONSES APPROACH

**TABLE 3.12 NO OF FAVOURABLE
RESPONSES**

Statement	Total Responses	Number favorable	% favorable
S1	95	10	10.53%
S2	95	8	8.42%
S3	95	12	12.63%
S4	95	15	15.79%
S5	95	6	6.32%
S6	95	7	7.37%
S7	95	9	9.47%
S8	95	14	14.74%
S9	95	3	3.16%
S10	95	11	11.58%

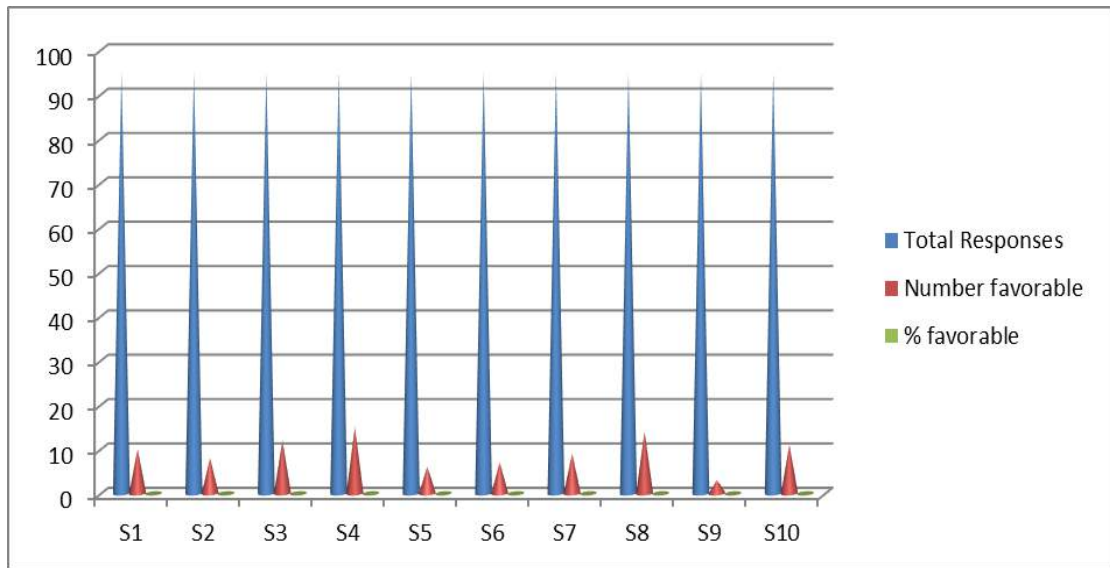


Fig 3.12 No of responses

3.12 INFERENCE

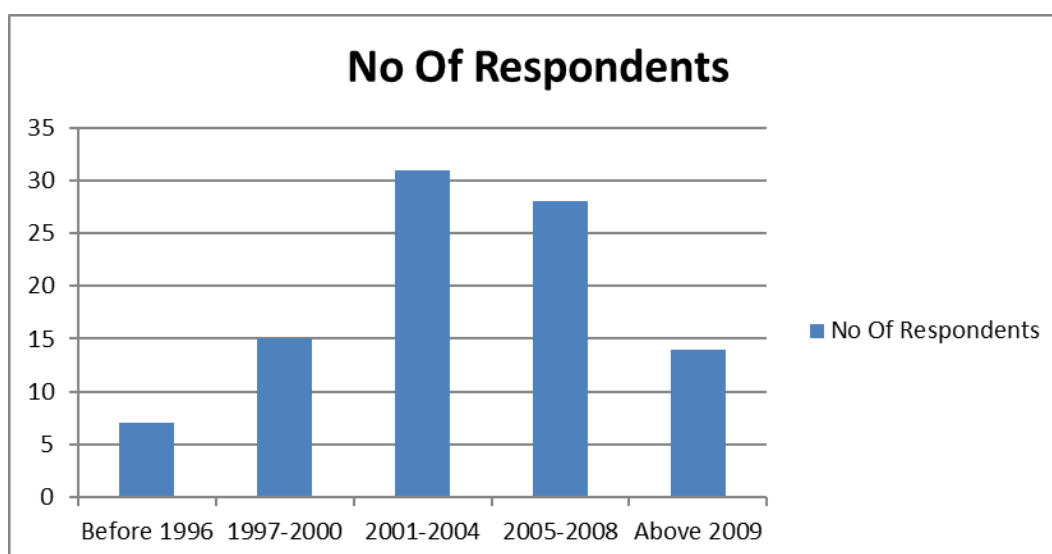
The above representation shows the favorable responses. The highest no of response is Statement 4 and lowest no of responses is statement 9. It depends on the variability of an individual.

3.13 ESTABLISHMENT OF THE ORGANISATION

TABLE 3.13 ESTABLISHMENT OF THE ORGANIZATION

ORGANISATION STARTED	NO OF RESPONSES	% OF RESPONSES
Before 1996	7	7.36%
1997-2000	15	15.70%
2001-2004	31	32.63%
2005-2008	28	29.47%
Above 2009	14	14.73%
Total	95	

Fig 3.13 Representation of the organization



3.13 INFERENCE

The above graph predicts that the establishment of the organization from before 1996 to above 2009. In the certain period business environment has increased widely to produce new and quality and innovative products to the customers. In the year 2001 -2004 it shows wide range of organizations have been set up to enhance better quality products.

3.14 TOOLS FOR ANALYSIS

3.14.1 CONTROL CHARTS:

Control charts have two limits that separate random and non- random variation. There are 2 attributes

- Control chart for attributes Mean & Range chart(X&R)
- Control chart for variables - P chart & C chart

3.14.2 CONTROL CHART FOR ATTRIBUTES:

The R charts is used to monitor the process dispersion

Although the sampling distribution is normal, the concept for use of range chart is given as follows.

3.14.3 FORMULA USED FOR R-CHART:

- $R = \sum X/N$
- $UCL = D_4 \bar{R}$
- $LCL = D_3 \bar{R}$

Where D_3 and D_4 values are obtained from table

3.14.4 ADVANTAGES OF USING RANGE CHARTS:

The mean charts are sensitive to shifts in process mean, where range charts are sensitive to changes in process dispersion. It is used to monitor the process.

3.14.5 CONTROL CHART FOR VARIABLES:

Control charts for attributes are used when the process characteristics is counted rather than measured. Two types of control charts are as follows,

- P-Chart – It is used to monitor the proportional defectives in a process.
- C –Chart –It is used to monitor the number of defects per

3.15 C-CHART:

When the goal is to control the number of occurrences per unit, a C-Chart is used. The underlying sampling distribution is Poisson distribution. Use of Poisson distribution determines that defects occur over some continuous and that the probability of more than one defect at any particular point is negligible. The mean number of defects per unit is C and the standard deviation is c .

3.15.1 FORMULAS USED:

$$\begin{aligned} \text{➤ UCL} &= \sqrt{\bar{c} + 3\sqrt{\bar{c}}} \\ \text{➤ LCL} &= \sqrt{\bar{c} - 3\sqrt{\bar{c}}} \end{aligned}$$

If the value of c is unknown, it is estimated by using formula

$C = \text{Number of defects/Number of samples.}$

3.15.2 ADVANTAGES:

- It is used only when the number of occurrences per unit measure can be counted.
- It is in a controlled manner.
- Simple and easy to predict the results.
- When the control charts is used and it is in the optimal stage, it assures the process are in constantly monitoring and secure and that product will be easier to rectify if the above the satisfied level.

Variable Data Charts		
Chart Type	Subgroup Size	Control Limits
$\bar{X}$ and R Average and Range Chart	< 10 Usually 3-5	$\bar{X}$ Central Line: $\bar{\bar{X}} = \frac{(\bar{X}_1 + \bar{X}_2 + \dots + \bar{X}_k)}{k}$ $\bar{X}$ UCL = $\bar{\bar{X}} + A_2 \bar{R}$ $\bar{X}$ LCL = $\bar{\bar{X}} - A_2 \bar{R}$ R Central Line: $\bar{\bar{R}} = \frac{(R_1 + R_2 + \dots + R_k)}{k}$ R UCL = $D_4 \bar{R}$ R LCL = $D_3 \bar{R}$
$\bar{X}$ and mR Individuals and Moving Range Chart Note: $\widetilde{mR}$ = Median Moving Range	1	$\bar{X}$ Central Line: $\bar{\bar{X}} = \frac{(X_1 + X_2 + \dots + X_k)}{k}$ $\bar{X}$ UCL = $\bar{\bar{X}} + (3.14 \times \widetilde{mR})$ $\bar{X}$ LCL = $\bar{\bar{X}} - (3.14 \times \widetilde{mR})$ mR Central Line: Median Moving Range mR UCL = $3.87 \times \widetilde{mR}$

FIG 3.15.1 VARIABLE CHART

Fig 3.15.2 Attribute chart formula

Attribute Data Chart Formulas		
Chart Type	Subgroup Size	Control Limits
p Chart Fraction Defective	Variable or Constant	Central Line: $\bar{p} = \sum np / \sum n$ UCL = $\bar{p} + 3\sqrt{\bar{p}(1-\bar{p})/n}$ LCL = $\bar{p} - 3\sqrt{\bar{p}(1-\bar{p})/n}$
np Chart Number Defective	Constant	Central Line: $n\bar{p} = \sum np / k$ UCL = $n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$ LCL = $n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$
c Chart Number of Defects	Constant	Central Line: $\bar{c} = \sum c / k$ UCL = $\bar{c} + 3\sqrt{\bar{c}}$ LCL = $\bar{c} - 3\sqrt{\bar{c}}$
u Chart Number of Defects Per Unit	Variable or Constant	Central Line: $\bar{u} = \sum c / \sum n$ UCL = $\bar{u} + 3\sqrt{\bar{u}/n}$ LCL = $\bar{u} - 3\sqrt{\bar{u}/n}$

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

DATA ANALYSIS

In this chapter we discuss about the data results and prediction of level of quality and its impact.

4.1.1 PERCENTAGE ANALYSIS

In percentage analysis we have different criteria results are predicted and it is represented in a graph for easy representation

Criteria 1: **RESPONDENT'S AGE** - In this method, under the age group of 31 -40 has highest percentage level thereby, predict to have the results in a medium stage due to less number of experience in an industry. Better experience leads to good results.

Criteria 2: **QUALIFICATION OF RESPONDENTS** - In this stage the UG degree holders had been responded highly with a technical knowledge at the highest % of 46% lead to good improvement in the organization and easy method to achieve good results of quality of a product. Any defects can be catches up or arrested at the early stages due to technical knowledge of a person leads to promote good results.

Criteria 3: **YEARS OF EXPERIENCE** - Any individual works in any organization have good experience and to gain knowledge in practical leads to more accurate results. Experienced individual contribute their practical knowledge to ensure that the product fall within the specified limit and necessary actions to be taken to minimize the error and to achieve the quality product thereby industry reputation is maintained and to satisfy the customer/consumer with an innovative products. In this region, 2 -5 years of experience has highest percentage 29.40% out of 95 respondents 28 respondents fall under this category.

Criteria 4: **ESTABLISHMENT OF THE ORGANIZATION** - The establishment of the organization also plays a major role in maintaining the level of quality. Increased years of establishment of the organization shows maintaining and improving the quality standard levels to satisfy and retaining the customer is the main goal of an every organization. In this 2001 -2004 has highest level of organizational set up 31 respondents and has a leading percentage of 29.47 %.

4.1.2BY USING LINKERT SCALE ANALYSIS

By using the favorable and unfavorable approach we can predict the results are favorable to the research by maintain the level of quality in all industries

- In unfavorable % it has a highest value of Statement 1 14 respondents and 14.74 %.
- In favorable % approach Statement 4 has highest % of 15.74% out of 95 respondents 15 respondents are favorable to this statement.

4.1.3 CONTROL CHART

In most manufacturing companies, including garment industry, quality characteristics are categorized into variable and attribute characteristics.

Variable quality characteristics: Quality characteristics that are measurable and are expressed on numerical scale are called variable.

Attribute quality characteristics: Quality characteristics that cannot be measured or expressed on a numerical scale are called attribute characteristics. They are mostly expressed as good/ Bad, Acceptable/Rejected, Passed/Failed. A quality characteristics said to be an attribute if it is classified as conforming (is a quality characteristic that does not meet its stipulated specification).

4.2 UNFAVOURABLE APPROACH ANALYSIS USING CONTROL CHART

**TABLE 4.2 UNFAVOURABLE APPROACH ANALYSIS OF
CONTROL CHART**

Statement	% unfavorable
S1	14.74%
S2	10.53%
S3	8.42%
S4	7.37%
S5	10.53%
S6	8.42%
S7	12.63%
S8	9.47%
S9	10.53%
S10	7.37%

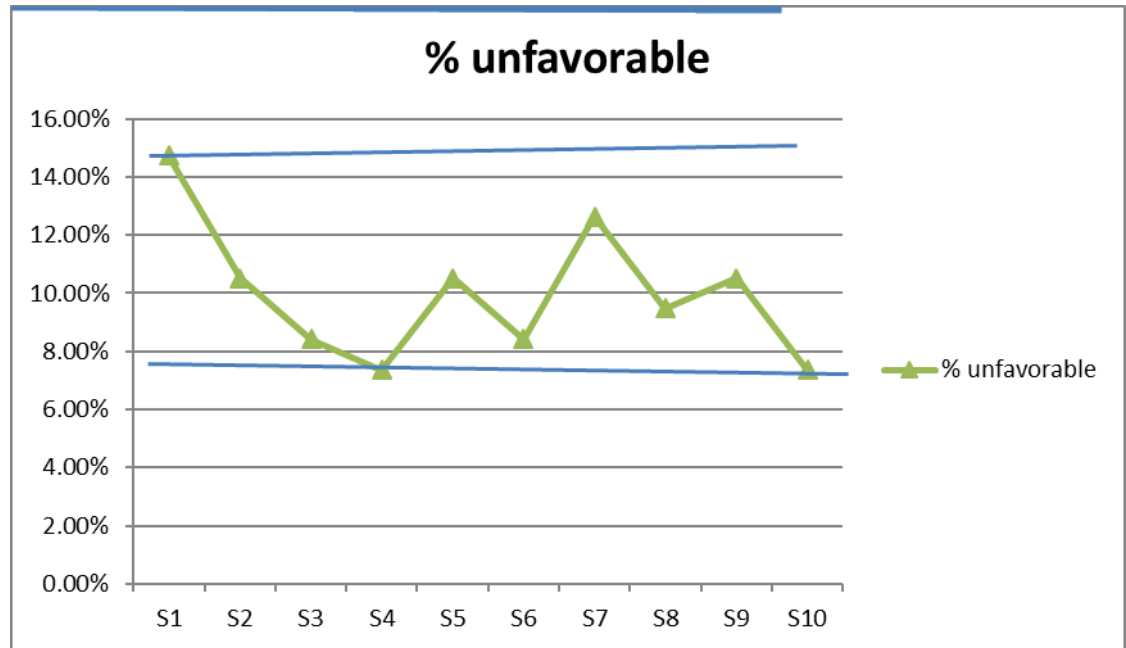


Fig 4.2 % Unfavorable

INFERENCE

The UCL value of 14.74% and LCL value of 7.37% has determined from the above graph which is indicated.

4.3 FAVOURABLE APPROACH ANALYSIS USING CONTROL CHART

**TABLE 4.3 FAVOURABLE APPROACH ANALYSIS OF
CONTROL CHART**

Statement	% favorable
S1	10.53%
S2	8.42%
S3	12.63%
S4	15.79%
S5	6.32%
S6	7.37%
S7	9.47%
S8	14.74%
S9	3.16%
S10	11.58%

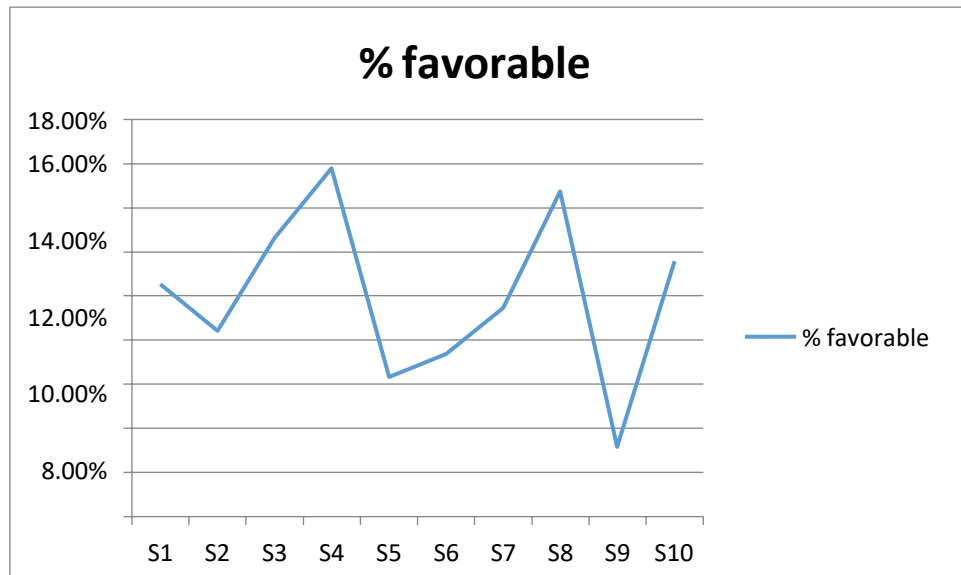


Fig 4.3 favorable %

INFERENCE

The UCL Value is 15.79% and LCL value is 3.69% is predicted from the above graph.

4.4 .P CHART

It is one of the attribute chart which helps to determine a fraction defective with number of samples. The formula used to detect the variations among the samples.

The below table and chart represents the fraction defective.

TABLE 4.4 P CHART TABLE

DATE	% defects
1	19.1
2	20
3	17.7
4	15.2
5	21.3
6	16
7	14.9
8	18.3
9	18.9
10	18.2
11	18.8
12	17.5
13	19.2
14	20.1
15	21.5
16	18
17	19.5
18	17.8
19	19.4
20	16.6
21	13.3

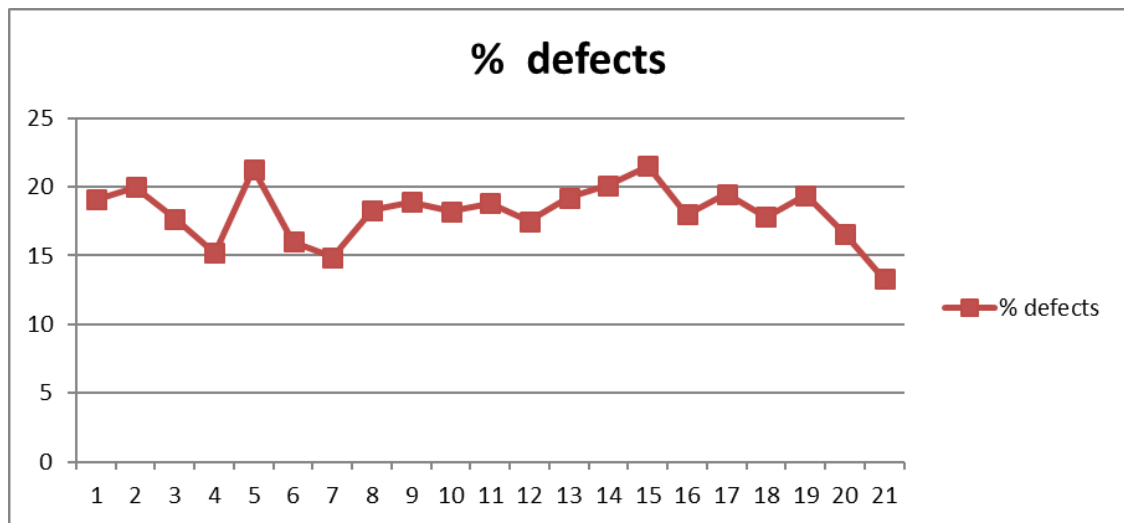


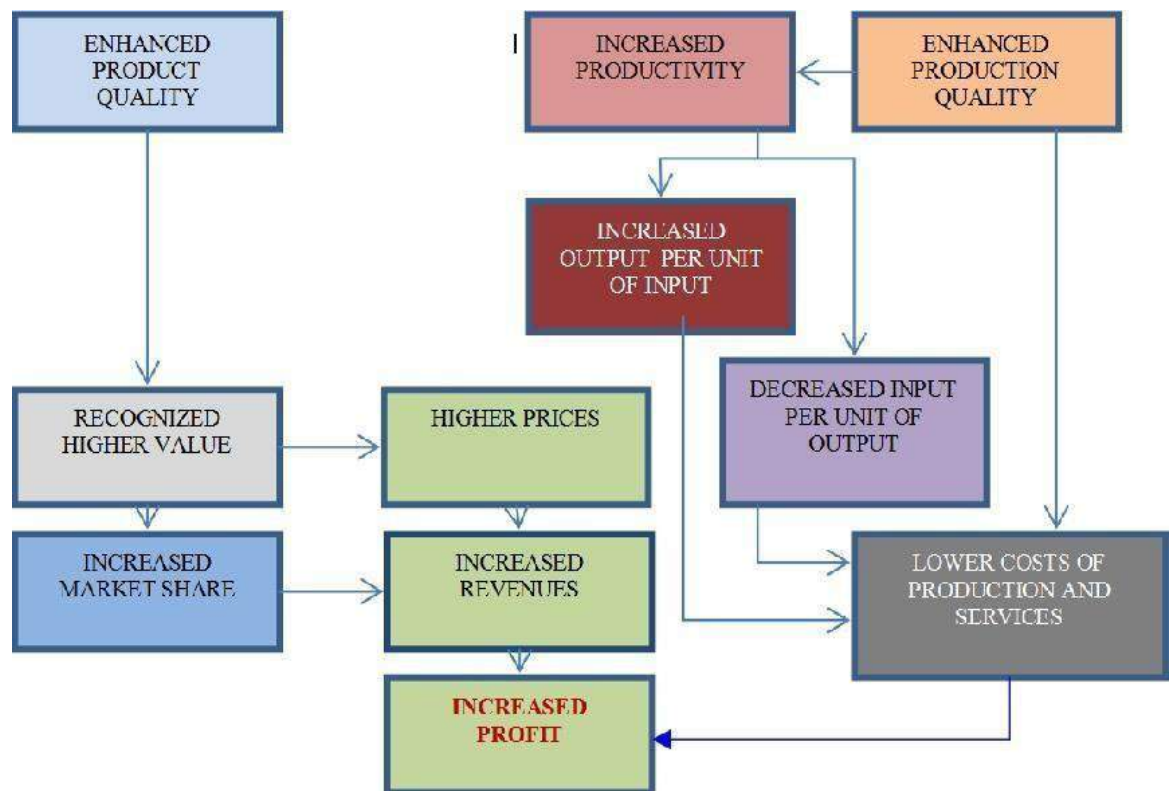
Fig 4.4 Defects

INFERENCE

The above chart clearly represents the defects of the different days. Above 15 days, the graph comes down the average value predicted.

4.5 DELIVERABLES

From the above diagrammatic representation shows that the process of manufacturing should be in control within the specified limits to determine the process is in control.



To enhance better quality product different techniques can be followed. The above diagram shows clearly how the quality affects the organization and ways to achieve quality. Based on Productivity, quality also focused to ensure and to meet the standard quality level.

4.5.1 PARAMETERS FOR SUCCESSFUL IMPLEMENTATION OF SPC

- Management Issues
- Engineering Skills
- Statistical Skills
- Teamwork Skills

4.5.2 PROCESS IMPROVEMENT

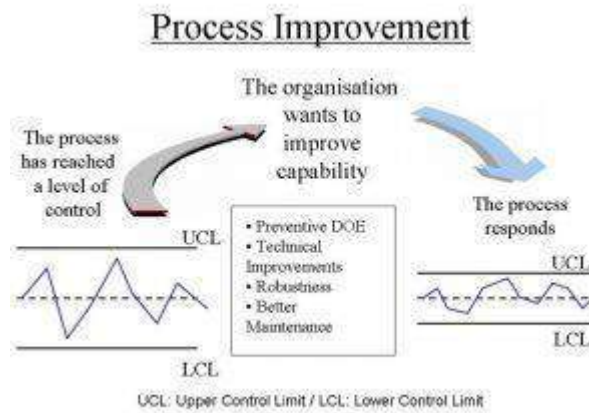
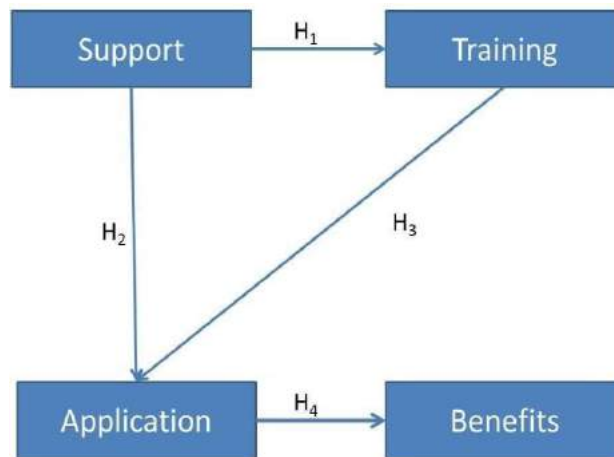


Fig 4.5 Process Improvement

4.5.3 IMPACT OF SPC IN AN ORAGNAIZATTION



4.5.4 QUALITY IMPROVEMENT MODEL PROCESS

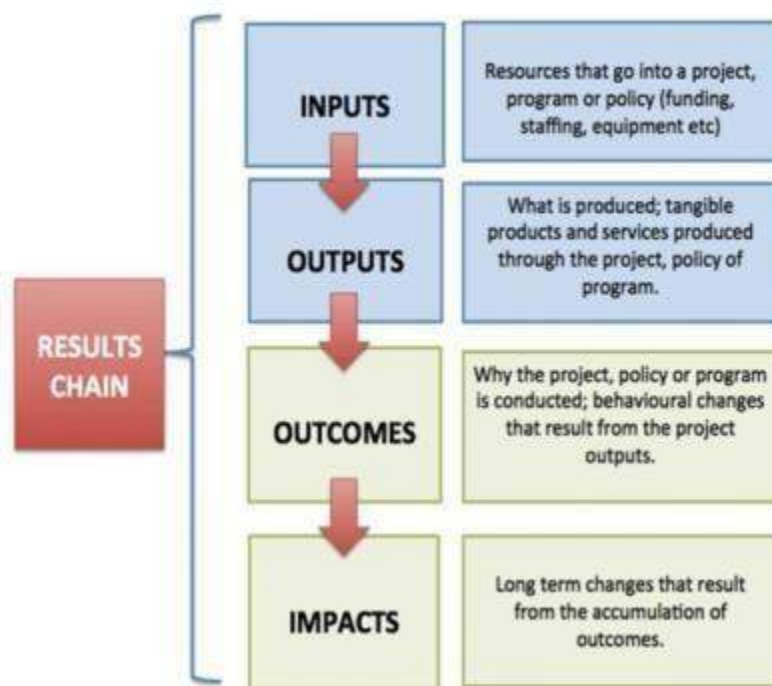


FIG 4.5.3 QUALITY IMPROVEMENT MODEL PROCESS

4.5.4 QUALITY IMPROVEMENT PROCESS

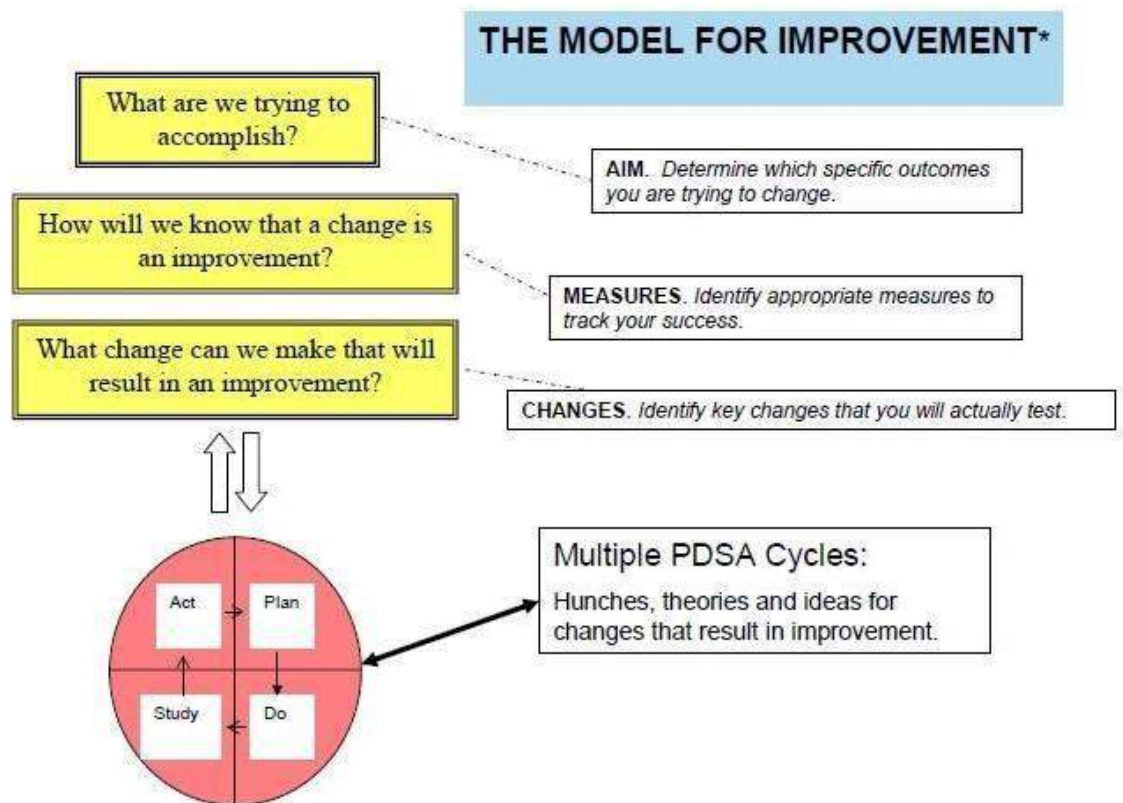


FIG 4.5.4 QUALITY IMPROVEMENT MODEL

5.1 SUMMARY OF FINDINGS

CHAPTER 5

CONCLUSIONS

The main key research is to identify various advantages to implement SPC in industry and to identify the further practice of control charts using SPC in an organization to achieve better quality level.

The SPC also shows a variation % and that variation level should be monitored continuously for better results. Designing and facilitating different working conditions, choosing critical quality characteristics of a process, Selection of variables and appropriate check points to be checked as a criteria level.

In any type of industry, quality level is to be maintained at a higher rate to enlance better results from an organization and to satisfy the customer.

5.2 SUGGESTIONS AND RECOMMENDATIONS

SUGGESTIONS

- Use of SPC software and tools in the implementation of SPC process.
- Identification of interrelations between the various processes of manufacturers.
- Determination of SPC system capability and performance

RECOMMENDATIONS

- Retrain workers regarding SPC in order to improve quality at minimum cost.
- Selection of workers should be based on interest and statistical skills in order to understand and interpret SPC easily.

5.3 CONCLUSIONS

Statistical Process control in manufacturing ensures real time analysis of the enterprise, resulting in cost effective manufacturing and efficient use of all resources. Manufacturing organizations are looking for SPC to analyze their impact, identify problems, and monitor the results you can achieve your quality goals.

SPC analysis provides trends of your process capabilities you can take an action to correct process problems before scrap is generated. SPC helps in reducing scrapped parts means a higher yield for your investment in materials and equipment.

Implementing SPC allows you to satisfy your customer while improving your product. These tools can help managers, process improvement practitioners, and research to use objective data and statistical thinking to make appropriate decisions.

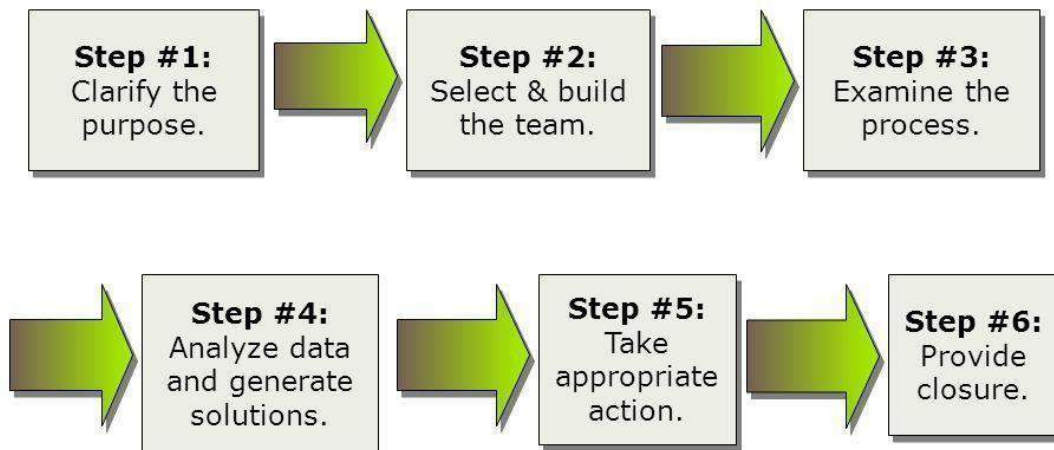
5.4 DIRECTIONS FOR FUTURE RESEARCH

Most SPC methods have been developed and modified over the years to maximize the information obtained from relatively scarce data. Now in industry overwhelming large amount of data. It may be necessary to desensitize standard methods in the presence of large amount of data to prevent detection of very small instabilities of no practical importance.

The scope of SPC should be broadened to include a much wider variety of methods for understanding variation over time, not just traditional control charting. Multi step production and processes and measurement processes should be considered.

It has already been mentioned that more research is needed on the effect of parameter estimation on control chart performance. Given the difficulties associated with interpreting results from multivariate control charts, more work is needed on graphical methods for data visualization. Data reduction methods are also important.

The Quality Improvement Process



MCPH Healthcare Consulting

REFERENCES

- Y.C .Lin, C.Y.Chou.On the design of variable sample size and sampling intervals X bar charts under Non normality, International Journal of Production Economics .Vol 96 No.2, 249-261, 2005.
- A.J.Jeri .The Shannon Sampling Theorem –Its various extensions and applications, review proceedings of IEEE Vol65, NO.11, 1565-1596, 1977.
- H.J.Lenz ,P .TH Wilrich.Frontiers in Statistical quality control ,Physica–Verlag ,Heidelberg,2006.
- Antony J.Mason B (2003),Key success factors of implementation of SPC, University of Warwick,Uk
- Rohani, J. M., Yusof, S. R. M., & Mohamad, I. (2009b). Statistical process control success factors and performance: an exploratory analysis. In Proceedings of the Advances in Quality Engineering and Management Reserch, Malaysia. Retrieved in 8 September 2016
- J.S.Ockland,Statistical Process Control ,6th edition ,2008
- Xie, M., & Goh, T. N. (1999). Statistical techniques for quality. The TQM Magazine, 11(4), 238-242. <http://dx.doi.org/10.1108/09544789910272913>.
- Xie, T. N. Goh and V. Kuralmani, Statistical Models and Control Charts for High Quality process, Springer Science + Business Media New York, pp. 4-5, 2002.
- Thuntee Sukchotrat , Seoung Bum Kim , Fugee Tsung "One-class-based classification Control charts for multivariate process monitoring " IIE Transactions.
- William, R., Kinney, JR., "Information Quality Assurance and Internal Control", 2000, McGraw-Hill, USA.
- Shewhart W. A., (1986), Statistical Method From the Viewpoint of Quality Control, Unabridged Dover,Toronto.
- Wisniewski M.: *Quantitative methods for Decision Makers*. Prentice Hall, 2006. – pp. 600
- Priscilla Wisner has proposed the statistical process control for quality improvement.
- Luis I. Alvarez-Gonzalez, Maria Leticia Santos-Vijande 2007, and TQM and firms performance: An EFQM excellence model research based survey, *Int. Journal of Business Science and Applied Management*, Volume 2, Issue 2, 2007. p-23
- Mason, B. & Antony, J., Is SPC Just about Control Charts.

- Unpublished work. Montgomery, D. C., Introduction to Statistical Quality Control, 6th Edition. New York: John Wiley and Sons, 2009.
- Shewhart, W. A., “Statistical Method from the Viewpoint of Quality Control”, Washington DC: The Graduate School of the US Department of Agriculture, 1939.
- Sultana, F., Islam, N.R., Azeem, A. Implementation of Statistical Process Control (SPC) For Manufacturing Performance Improvement. Journal of Mechanical Engineering, 2009, vol.40 (1), pp.15-21.
- Semel, F. J., David, J. K. and Gummeson, P.U., Statistical Process Control in Iron Ponder Production and New Product Development. Presented at the SAE Congress Detroit, Michigan, February 29-March 4, 1998, Hoeganaes Corporation, River Road & Taylors Lane Riverton, New Jersey.
- Fouad, R.H. and Mukattash, A., “Statistical Process Control Tools: A Practical guide for Jordanian Industrial Organizations”. Jordan Journal of Mechanical and
- Industrial Engineering, 2010, vol. 4(6), pp. 693 – 700.
- Ab Rahman, M. N., Zain, R.M., Nopiah, Z.M., Jaharah A. G., Baba Md D., Mohamad
- & Ismail A.R., Statistical Process Control in SMEs. A Case Study. 4th WSEAS/ IASME International Conference on Dynamical Systems and Control (Control’08), 2008, Corfu, Greece, October 26-28.
- Ab Rahman M.N. et al., the Implementation of SPC in Malaysian Manufacturing Companies. European Journal of Scientific Research, 2009, 26(3), pp. 453-464.
- Finison, L.J., Finison, K.S. and Bliersbach, C.M., The use of control charts to improve healthcare quality. Journal of Healthcare Quality, 1993, Vol. 15 No. 1, pp. 9-23.
- Arthur, B., Phillip, K., Jan, D., Richard, N. and Celia, H., “Statistical Inference at Work: Statistical Process Control as an Example”. Statistics Education Research Journal, vol. 7(2), pp.130-145, 2008.
- Stephanie J. R. and John H. R., “The Use Of Statistical Quality Control Charts In Monitoring Interviewers”, University of North Carolina, Chapel Hill, NC 27599, 1999.
- Sharaf El-Din M. A., Rashed, H. I. and El-Khabeery M. M., “Statistical Process Control Charts Applied to Steelmaking Quality Improvement”, Quality Technology & Quantitative Management, vol.3 (4), pp.473-491, 2006.