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POLO TERRITORIALE DI COMO

Use of TQM Techniques and QC tools toward Sustainable Development

Company's Tesina: Lucky Plastic Industries pvt.Ltd

SUPERVISOR:

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Master of Science Final Project by

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Contents:

Abstract:

TQM Techniques and Quality control tools are an important mechanism used widely at manufacturing field to monitor the overall quality of all operations to get the sustainable development in industry. Quality control can be applied to all kind of manufacturing operations. The significant application of the Quality analysis elements to the operation will make the process more reliable and stable and best product quality. For the case study, plastic sheet manufacturing process is selected. A complete manufacturing process consists of raw material mixing, extruder, Calendar rolls, cooling train, and cutting section. The dimensions of the forming sheet are one of the critical process parameters along with process temperature. These parameters must be tightly controlled to its tolerance to ensure that the sheet works properly when subjected to the forming process. To ensure the process is under the production control and will get the best product quality, TQM techniques, quality control and SPC methods are being used. The process control data is obtained from the process and analysed; the root cause problems and errors are identified. The problems are further discussed and some recommendations are made to make the process more efficient to get the best quality product. Statistical process control monitors the process and magnifies the small deviations of the process from the actual control limits. Thus the manufacturing process can be controlled directly and good quality product meeting all the specifications can be produced.

Key words. TQM, Sustainable development, Quality control, SPC, case study, Plastic, Lucky plastic industry.

CHAPTER: 1

1 Company Introduction:

Start Info: Founded in 1993
Address: 3.5 Km, Manga-Raiwind Road, District Lahore, Lahore, Pakistan-55270 Short Description Pakistan's largest manufacturer and exporter of Rigid PVC, ABS, HIPS, PP, HDPE Sheets.

1.1 Long Description:

Established in 1993, Lucky Plastic Industries Pvt. Ltd. (LPIL) is the first to introduce plastic sheet extrusion, co-extrusion and Rigid PVC sheet calendaring in Pakistan. Since its inception, the company has been engaged in the production and supply of various kinds of plastic sheets including Rigid PVC, GPPS, PP, and ABS, HIPS, HDPE and Cast Acrylic sheets. Recently, Polystyrene Foam Packaging (Polystyrene Paper) has been added to the product range in order to cater to the disposable food packaging market. A huge market – both local and foreign – is therefore being served mainly including pharmaceutical, food packaging and household goods manufacturing industries. Customers from international market mostly belong to countries including South Africa, Lebanon, India, Sri Lanka, Bangladesh, Poland, Egypt and Turkey.

1.1.1 Products Films:

Rigid PVC, APET, RPET, PETG, PET GAG Extruded Sheets (Monolayer): HIPS, ABS, PP, GPPS, HDPE, PET Co-Extruded Sheets (Multilayer): HIPS & GPPS, ABS & PMMA Packaging & Tableware: Foam Boxes & Trays, Spoons etc.

LPIL believes in comprehensive solutions and therefore values its R&D efforts to come up with and adopt new formulations and technologies to provide supreme quality products. The company has recently established a new manufacturing facility at Manga Raiwind road for the production of PVC, GPPS, PP, ABS, HIPS and HDPE sheets; where focus has been kept on assuring that the operations conform to quality, health, safety, hygiene and environmental standards. Furthermore, it is believed to be a vital step towards the company's efforts to increase the existing customer base as well as to give more value for money to existing customers and hence meet and even exceed their expectations. The workforce at LPIL is dedicated to performing the best and hence, works in line with the company's goals and objectives. Our qualified engineers make sure that the customer requirements are fully met and therefore take meticulous care of the technical specifications of the customized products we offer to our valued customers. Moreover, our commitment towards quality ensures that our products are defect-free and that any non-conformances are prevented in the first place.

1.1.2 Group Companies:

Pak Petrochemical Industries is a sister concern of LPIL which was founded in 1994. Located at National Highway Karachi, it is the only manufacturer of all types of Polystyrene resins (General Purpose, High-Impact and Expandable Polystyrene) in Pakistan and its product range is well-honoured and time-tested even in developed markets like South Africa, Belgium, Luxemburg, Turkey, Iran and Germany.

Cast Acrylic sheets are being manufactured under the banner of Pak Poly Industries - a separate entity specialized in the manufacturing of Cast Acrylic sheets with the full production line from polymerization, monomer regeneration and to final processing and sizing. The group has majority interest in Vietnam Polystyrene Company, Vietnam, established in 2006; it has annual production capacity of 15,000 tons.

1.1.3 Mission Statement:

We will bring about a revolution in plastic industry through state-of-the-art, environment friendly technology, dynamic leadership, dedicated human resource and strong customer base.

We will always strive to become a complete solution provider to our customers for all their needs related to the material, technology and management.

1.1.4 Quality Commitment:

Using Total Quality Management approach, we are dedicated to continually improving our products, services and operations. Moving forward in this regard, we strive to stay in compliance with cGMP, food hygiene standards (FDA & WHO standards and regulations) as well as with health, safety & environmental standards. Believing that there is always room for improvement, we consider quality as a journey, not a destination; and therefore our improvements in quality are driven by focus on advancement of the Quality Control laboratory as well as that of the processes that in turn demonstrate our moral obligation towards providing quality products to our valued customers.

1.1.5 Quality Policy:

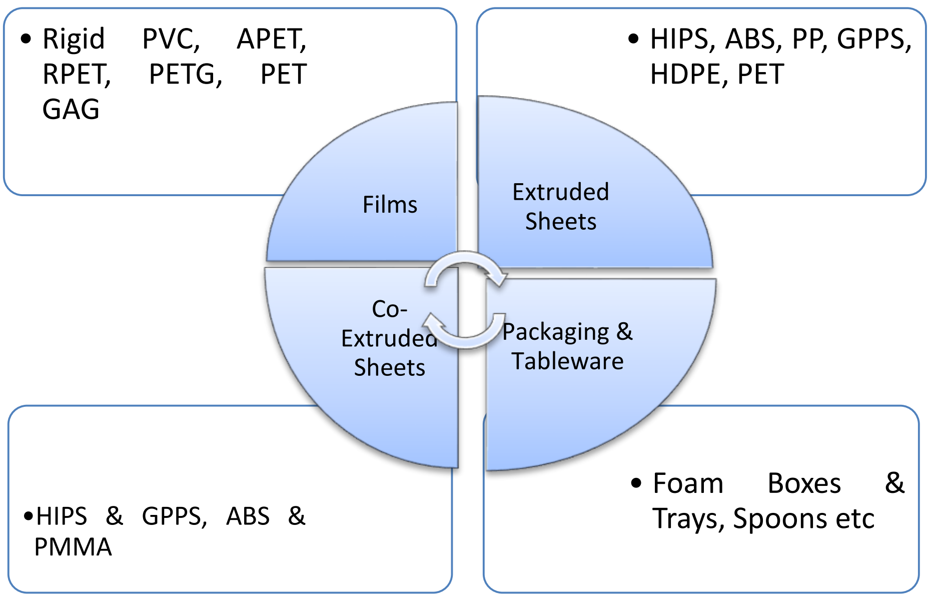
Pursuing customer-oriented solutions, we at LPIL are resolutely committed to: Offer quality and value-added products and services by constantly striving to improve our operations and maintaining our expertise through adopting cutting edge technology.

1.1.6 Manufacturing Facility:

LPIL is a dedicated company with a wide range of expertise in producing rigid sheets/films of PVC, PP, PE, HDPE, HIPS, GPPS and ABS, along with PSP tableware disposable products.

Since beginning, we've relied on our resources - both facilities and people to grow in the field of plastic sheets manufacturing. Our modern manufacturing facility spread over 4,68,000 sq. ft. uses contemporary technology for raw material handling, manufacturing, transportation, slitting and packaging of finished goods products in a manner that respects the needs and concerns of our valued customers, employees and the community. It also boasts of modernized quality control lab equipped with testing facilities according to international standards.

1.1.7 Company's product lines include:



1.1.8 Calendaring:

Calendaring is one of the most versatile processes for manufacturing high-quality films & sheets in large volumes. Process is mainly used for producing Polyvinyl Chloride (PVC) films and sheets. Calendaring process helps in making surface treatment like embossing and enhancing physical properties of films by stretching them as per requirement. Our manufacturing facilities are equipped with modern and hi-tech calendaring units with very precise temperature, speed and pressure control systems which results in high quality production.

Raw Material Handling, Compounding, Calendar Feeding and Mixing Units Raw material handling is the most crucial part in film making process through calendaring. At LPIL, our engineers make sure that all formulations (additions of stabilizers, lubricants, impact modifiers and processing aids) are made according to customer requirements and appropriate measures are taken while handling the materials ensuring that final product is free of dust particles and any other contaminations.

Compounding is done in continuous mixers. The dry blend is force-fed into the extruder. Uniform compounding provides for minimal heat history and consistent feed rate, colour, gauge, and surface.

1.1.9 Calendaring Configuration:

Several types of calendaring rolls configurations are used to manufacture Rigid PVC film worldwide. Our production units consist of one inverted L and one M-type calendar. These calendaring configurations are highly recommended for manufacturing of Rigid PVC sheets. These calendars are PLC controlled; operate at different precisely controlled temperatures and speeds.

1.1.10 Tempering Rolls/Embossing Unit:

The embossing unit is used to imprint special features on the film. Special effects/textures can be produced by applying a variety of surfaces on the embossing roll.

1.2 Extrusion:

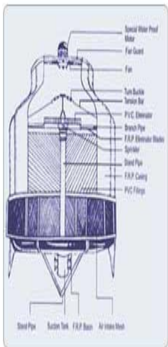
Extrusion is a continuous process by which a thermoplastic material is melted and extruded through a flat die onto a chill roll, where it is quenched and re-solidified. The resulting sheet is cut off into custom sizes after passing through haul off unit.

1.2.1 BMR & Expansion in Rigid PVC Production Line:

It is a moment of great pleasure for us sharing the news that we have successfully completed expansion and up gradation of Rigid PVC Film segment. We have not only doubled the output but also, and more importantly, a significant improvement in product quality has achieved. We have dovetailed expansion with process improvements in line with cGMP. We are confident that as a result our products have met even the most stringent quality standards. We thank our patrons and friends in Pharmaceutical Sector who have provided us with the guideline in every step of the way and shared their valuable knowledge with us.

1.2.2 Rigid PVC Sheet - Cooling Tower Grade:

Keeping in view the industry's ever growing requirement of specialized materials for excellent results and elevated efficiencies, LPIL has now introduced specialized PVC rigid sheet for cooling tower fills. Manufactured to rigid specifications, PVC Sheet – Cooling Tower Grade is now available in perfect matt finish. The new, heat and moisture resistant, plastic sheet designed to be used in relatively hot and humid environment thus making it ideal for cooling tower fill application. This specialized grade exhibits following characteristics, considered vital among the performance indicators of any heat exchanger. Suitable matt finish for the right residence time and minimized fouling



1.2.3 Improved mechanical properties:

- Excellent formability
- High service temperature (65 ºC or 149 ºF)
- Intrinsic self-extinguishing properties
- Very good resistance against chemical attack, aging and natural decay
- Improved weather ability and UV resistance (Optional)
- Long life & economic

1.2.4 Products:

PVC Sheets/Films: Following types of Rigid PVC Sheets/films are being manufactured at Lucky Plastic Industries:

[redacted]

[redacted]

- Pharmaceutical & Confectionary Grade:

These sheets have Excellent forming ability & impact resistance with very low VCM contents. These films are made by special non-toxic formulation making the product an excellent choice for pharmaceutical and food packaging sectors. Enhanced shelf-life grades of clear and coloured films & sheets are also available.

- General Purpose Grade:

These films have excellent process ability, transparency and impact resistance, suitable for packaging of toys, gifts, clothes, cosmetics and food products. We also produce UV resistant films to meet the requirements of our customers.

- Glitter Grade:

Metallizable film grade which can be treated with a special metallic colour printing & lamination, used for holographic printing, glitters (Zari), decoration ribbons, wrapping papers, labels, tapes & Christmas trees.

- Fold Moulding Grade:

With excellent vacuum forming properties these films are impact and chemical resistant. The film can be fold moulded without any crease whitening for packing boxes of stationery, toys, tools and gifts. Customized anti-static & UV resistant films are also produced.

- Cooling Tower Grade:

The UV stabilized film possesses excellent chemical and bacterial resistance, suitable for cooling tower fins and waste water treatment panels.

- Matt & Printing Grade:

These films are suitable for lamination & printing. Specialized formulation and UV resistance enable this product to act as excellent substrate for printing inks with improved weather ability. Rigid PVC Sheets/Films are available in various thicknesses ranging from 60 microns (0.06 mm) to 800 microns (0.8 mm) and in the width ranging from 1 In (25 mm) to 27 In (685 mm). All grades are available in the form of rolls weighing up to 150Kgs and straight sheets in customized sizes. The Product is manufactured under strict quality control to comply with food contact regulations. Utmost care is used in the selection and sourcing of raw materials and no material is allowed in Production Process which does not meet food contact criteria.

- High Density Polyethylene-HDPE Sheets:

HDPE is more rigid and harder than low density materials and is three times better in compressive strength. HDPE complies with FDA requirements for direct food contact applications. HDPE Sheets are manufactured using extrusion grade HDPE resin. These sheets can be compounded with UV stabilizer and antistatic agent if required by our customers to fulfil the application requirements.

Applications:

- Food cutting boards
- Corrosion resistant wall coverings
- Sliver Cans for textile spinning mills
- Pipe flanges
- Lavatory partitions
- Radiation shielding
- Prosthetic devices
- Protective sheets for trucks to safe products from being scratched or dented
- Corrosion protective liners

- Polypropylene PP Sheets:

Polypropylene sheets are being manufactured using both PP Homo polymer and PP Impact Copolymers according to application needs.

- PP Homo polymer Sheets:

The stiffness and ease of orientation of PP Homo polymer, makes it more suitable for use in application where more strength is desired. PP is more heat resistant than that of HDPE. Extruded sheet for thermoforming requires low heat flow rate to provide adequate melt strength and we make sure that right material grade is being used. These sheets have excellent chemical resistance and can easily be thermoformed.

Applications:

- Beautiful sun protective shades in various colours
- Structural tanks and covers
- Ducts and hoods
- Tank linings
- Vacuum formed trays
- Plating barrels and tanks
- Orthopaedic devices

- PP Copolymer Sheets:

PP Impact Copolymer is blended with rubber to provide high impact strength. The introduction of a second monomer results in a product that exhibits better cold impact strength than the standard homo polymer grade. Although the material is more pliable, the chemical and thermal resistances are slightly reduced. Our technical assistance team can be contacted any time for right material choice.
These sheets can be compounded with UV stabilizers, antioxidants and fire retardants as per customer requirements to be used for outdoor applications.

Applications:

- Prosthetic devices
- Vacuum formed parts
- Structural tanks and covers
- Plating tanks
- Ducts and hoods

General Purpose Polystyrene-GPPS Sheets:

GPPS is a thermoplastic material with outclass properties. It can easily be formed into finished products and needs very little maintenance. It is light weight, versatile and has excellent thermal and electrical insulation properties. Much of its advantages over other thermoplastics stem are due to its amorphous nature, which results in better clarity and ease in fabrication. At LPIL, the sheets are manufactured using low flow rate GPPS resin with high molecular weight which is the strongest of all PS resins. Our sheets are available in many customised colours and attractive designs.


Applications:

- Doors & Windows
- Interior decoration items
- Partitions
- High Impact Polystyrene - HIPS Sheets

HIPS are a blend of GPPS with butadiene rubber. HIPS sheet is known for its ease in thermoforming, processing, good dimensional stability, impact strength and rigidity. It has resistance for many chemicals like alkali, salts, lower alcohols, and many acids. Normal limiting factors for HIPS are heat resistance, oxygen permeability, light (UV) stability and resistance to oily chemicals.

Applications:

HIPS have a high dielectric strength and are widely used for:

- Ship, Automobile and Aerospace applications
- Laminated electronic circuits
- High frequency insulation sheeting
- Insulators, and other electrical applications
- Inner bodies of refrigerators and freezers
- Acrylonitrile Butadiene Styrene - ABS Sheets

The versatility of ABS is derived from its three nonnumeric building blocks - Acrylonitrile, Butadiene & Styrene. Each component imparts a different set of useful properties to the final polymer. Acrylonitrile primarily offers chemical resistance and heat stability, Butadiene delivers toughness and impact strength, and the Styrene component aids ABS with rigidity and process ability. ABS sheet is stronger than HIPS sheet. It can be thermoformed, sawed, routed, glued and heat formed.

Applications:

- Appliance casings
- Crisper trays
- Instrument panels
- Prototypes
- Inner bodies of refrigerators and freezers
- Stacking sheets
- Bath tubs
- Bathroom panels
- Window Panels
- Ship, Automobile and Aerospace applications
- Co-Extruded Sheets

LPIL has the capability to produce Styrene's and its Co-Polymers in multi layered, multi-polymer sheets. The maximum number of layers is 5.

- Specifications:

  - Thickness: 1 - 6 mm
  - Maximum Width: 1600 mm
  - Length: Customized
  - Color: Customized

1.2.5 Typical Co-Extruded Sheets:

- ABS & PMMA:

PMMA/ABS/PMMA co-extruded sheets are mainly used for sanitary ware, refrigerator, freezer and their door liners. It has advantages of excellent hardness, perfect wear ability, easy forming, high-gloss surface, etc. These materials combine the impact strength of ABS and the scratch resistance of PMMA, and are especially used for the production of sanitary ware. They have become the best choice for promoting and upgrading traditional plastic casting sheets. These plastic sheets are now being widely used in the sanitary ware industry in Western countries.

- HIPS & GPPS:

HIPS capped with thin layer of GPPS gives excellent gloss finish to the sheet. Inner bodies and doors of refrigerators and freezers are made by forming of sheets. Special grades are used keeping in view the refrigerant being used by the manufacturer i.e. R14lb or Cyclo Pentane.

- Polystyrene Foam Packaging:

P-PAK is LPIL's brand in the field of disposable packaging made of Polystyrene Paper (PSP), which is USFDA approved food contact packaging material - that has the ability to outperform other conventional options in the area of single-use food packaging. It brings along such brilliant features that no other alternative can offer.

The superior insulation characteristic of P-PAK helps maintain the optimal temperature of food longer than any other similar alternative and still can be held comfortably. It is extremely light-weight, does not deform and thus keeps its shape when holding take-out meals. Moreover, it protects against moisture & guards against leaks so there is no wastage of food. Not to mention, it also eliminates need for double packing.

1.2.6 P-PAK Range:

- Fast Food Boxes:

  This range of take-out boxes can be used for many kinds of foods including burgers, sandwiches, rice, pasta, BBQ etc

- Pizza Boxes:

  For easy take-away of various sizes of pizzas, this range is to replace the conventional pizza packing.

- Meat/Confectionery Trays:

  Available in different sizes and depths, this multi-purpose range can be used for a variety of items including meat & poultry, as well as confectionery and other bakery items.

- Round Bowls & Plates:

Available in different sizes and depths, this multi-purpose range can be used for a variety of items.

- Egg Trays:

A reliable packing to keep eggs safe during transportation

The product is manufactured under-strict quality control to comply with food contact regulations. Utmost care is used in the selections and sourcing of raw materials and no material is allowed in Production Process which does not meet food contact criteria.

Title	Image	Code	Description
Prawn Tray		LPI-01	163 x 125 x 20 (mm³)
Pizza Box (Large)		LPI-06	330 x 23
Dates Tray		LPI-08	206 x 157 x 17
Burger Box (Large)		LPI-09	183 x 143 x 76
Rice Box		LPI-10	318 x 232 x 49
Burger Box (Small)		LPI-11	147 x 137 x 72
Egg Tray (Large)		LPI-12	305 x 225 x 29
Biryani Box (Large)		LPI-13	318 x 232 x 49

Plate (Small)		LPI-14	180 x 26
Plate (Large)		LPI-15	220 x 26
Egg Tray (Small)		LPI-16	244 x 155 x 29
Meat Tray (Large)		LPI-17	188 x 152 x 43
Bowl		LPI-18	170 x 40
Bar BQ Box		LPI-19	xyz
Meat Tray		LPI-20	xyz
Three Compartment Box		LPI-21	245 x 190 x 97
Biryani Box (Small)		LPI-22	225 x 148 x 72

CHAPTER: 2

2 Background and Problem Discussion:

The performance of TQM Lucky Plastic Industries and is measured comparing statistically three major performance indicator Customer satisfaction, Employee satisfaction and Operational effectiveness. To establish a link between TQM and performance and showing the need for the adoption of total quality culture in the local industry sector.

- Purpose:
  The purpose of this thesis is to highlight the benefit and the use of TQM in sustainable development and its implementation in the Lucky Plastic industries by examining the basic principles of TQM in the industry. The impact of TQM implementation of the three performance indicator will be assessed.

- Method:
  Quantitative and Qualitative method Primary data is collected from the Industry website and also by interviewing some people via Skype and via email. Secondary data is gotten from articles, journals and online resources.

- Theory:
  The theory section looks at different concepts of quality as defined and viewed by various authors. Also the benefits and hindrances of TQM implementation were reviewed.

- Analysis:
  We have used a different hypothesis to measure the difference in the meaning Use of TQM in sustainable development in the industry by keeping in mind the three performance indicators.

2.1 INTRODUCTION:

2.1.1 THE BACKGROUND OF THE STUDY:

Total Quality Management (TQM) is a management philosophy which focuses on the work process and people, with the major concern for satisfying customers and improving the organizational performance. It involves the proper coordination of work processes which allows for continuous improvement in all business units with the aim of meeting or surpassing customer's expectations. It emphasizes on totality of quality in all facets of an organization with the aim of reducing waste and rework to reduce cost and increase efficiency in production.

TQM is applicable to for any of the organization irrespective of size, and motives, even the public sector organization are fast adopting the ideology in order to make them effective in meeting public demands. However, the adoption of the ideology by most organization has been hampered due to their non compliance with the procedures and principles of TQM implementation in Sustainable Development. While some organization, did not understand the use of TQM in Sustainable development and being run TQM like a program which they expect to function and perform all of its functions by itself, others have used a half hearted approach to it, by using some bits and pieces of the principles in gaining Sustainable Development. This philosophy has caused the most of the failure for most organization in meeting up to their expected target by implementing this ideology in getting Sustainable Development. There is a need to continue to buttress the benefits that accrue to organizations by the implementation of TQM in getting Sustainable Development, especially in developing economies, such as India, Srilanka, Nepal, Pakistan, and China, where the adoption of these principles seems farfetched for organizations. The Lucky Plastic industries give us a true picture of the shortcomings of organizations in their quest to make profit at the expense of quality. With the spate of changes going on in the country due to government reforms, the nature of competition seem to be changing from what it used to be. The influx of foreign and local investors into different sectors of the economy has given rise to intense competition, thus the need for organizations to look internally into their operational procedures and change strategically to meet up with the challenges.

2.1.2 RESEARCH MOTIVATION:

The change in consumer behavior has made most producers of goods and services to tailor their products to meet the requirement of potential buyers. Thus, most organizations are concerned about how to satisfy their customers through improved services which is tailored to meet or exceed the expectation of customers. Even as organizations strive to meet customer's expectation, there still exist some flaws in the process involved in service delivery. Rather than take the whole process as a matter of importance, most local Industries in Pakistan has narrow down their quality approach to few operations in other to cut the cost. The emergence of new industries into the market is now changing the face of competition in the industries sector, as these industries tend to adopt a total quality management ideology to gain the Sustainable Development. This advantage will brings them into the good stage from where they can view the terms of increased patronage over time. If quality approach is not taken seriously by the industries, they might have no time to lose customers which might eventually drive them out of business. Thus there is the need for change in organizational culture and structure to give room for a new approach to service delivery. The implementation of TQM in gaining sustainable development can be beneficial to all the industries, when the principles are effectively adopted, the effective implementation of TQM will increase customer satisfaction with the service offerings.

The improvement in quality can result in increased market share and profitability. Implementation of TQM further ensures that organizations change how they perform activities so as to eliminate inefficiency, improve customer satisfaction and achieve the best practice (Porter, 1996).

Porter noted that constant improvement in the effectiveness of operation is essential but not a sufficient factor for organization to be profitable. According to Sila, (2007) TQM helps in improving the quality of products and also reduces the scrap, rework and the need for buffer stock by establishing a stable production process. He argued that TQM will reduce the cost of production and time of production. Many other TQM practices such as training, information system management, relationship with suppliers etc have a positive impact on operational performance.

2.1.3 The Need of Benchmarking in the Lucky Plastic Industries:

Benchmarking is one of techniques used by TQM firms in their continuous improvement drive. According to Rank Xerox, cited in (Cross and Leonard, 1994) 'benchmarking is defined as the continuous process of measuring product services and processes against strongest competitors or those renowned as world leaders in their field'. The idea behind this is to understand and evaluate the present position of a business in relation to the best practices and draw up areas for improving performance. As a tool in TQM, it helps to identify the processes involved in quality performance and facilitate the performance strategic function of a business (Vorley and Tickle, 2001).

For any organization to be competitive it must keep abreast the best practices in the industry, this will ensure that such organization meets the expectations of customers. Thus benchmarking should be a continuous process in strive to meet organizational objective of satisfying her customers.

The quest to deliver quality services in the Lucky Plastic Industry requires to continually updating their services, so as to meet up with the demands of customers and remain competitive. While the old industries which are regarded in this research as non-TQM need to update their service orientation by benchmarking their services with that of the TQM industries so that they can also put their steps in Sustainable development, this can only be supported with an ideology which is focused on satisfying customers demand and which allows for continuous improvement. The TQM industries on the other hand will have to continue to improve their services by looking at what obtains in other parts of the world in order to meet or surpass customers' expectations. This will provide them a better way to get towards their goals.

2.1.4 OBJECTIVE AND AIM OF THE RESEARCH:

The main objectives of this research are to highlight the benefit of TQM implementation in the Lucky Plastic industry by examining the basic principles of TQM in the industry. It will thus compare and contrast the performance of TQM industries and Non TQM industries by measuring statistically three major added values namely:

- Customer satisfaction
- Employee satisfaction
- Operational effectiveness

The outcome of these comparison if positive, will show the need for benchmarking by the non- TQM industries, in other to derive the value created by its implementation, if not the researcher will assess the problems associated with the implementation of this ideology by the TQM industries by drawing inferences from the various interviews conducted outside the use of data gathered from the questionnaire.

2.1.5 Foundation:

TQM is built on a foundation of ethics, integrity and trust. It fosters openness, fairness and sincerity and allows involvement by everyone. This is the key to unlocking the ultimate potential of TQM. These three elements move together, however, each element offers something different to the TQM concept.

- **Ethics –** Ethics is the discipline concerned with good and bad in any situation. It is a two-faceted subject represented by organizational and individual ethics. Organizational ethics establish a business code of ethics that outlines guidelines that all employees are to adhere to in the performance of their work. Individual ethics include personal rights or wrongs.

- **Integrity –** Integrity implies honesty, morals, values, fairness, and adherence to the facts and sincerity. The characteristic is what customers (internal or external) expect and deserve to receive. People see the opposite of integrity as duplicity. TQM will not work in an atmosphere of duplicity.

- **Trust –** Trust is a by-product of integrity and ethical conduct. Without trust, the framework of TQM cannot be built. Trust fosters full participation of all members. It allows empowerment that encourages pride ownership and it encourages commitment. It allows decision making at appropriate levels in the organization, fosters individual risk-taking for continuous improvement and helps to ensure that measurements focus on improvement of process and are not used to contend people. Trust is essential to ensure customer satisfaction. So, trust builds the cooperative environment essential for TQM.

2.1.6 Bricks:

Based on the strong foundation of trust, ethics and integrity, bricks are placed to reach the roof of recognition. It includes:

- **Training –** Training is very important for employees to be highly productive. Supervisors are solely responsible for implementing TQM within their departments, and teaching their employees the philosophies of TQM. Training that employees require are interpersonal skills, the ability to function within teams, problem solving, decision making, job management performance analysis and improvement, business economics and technical skills. During the creation and formation of TQM, employees are trained so that they can become effective employees for the company.

- **Teamwork –** To become successful in business, teamwork is also a key element of TQM. With the use of teams, the business will receive quicker and better solutions to problems. Teams also provide more permanent improvements in processes and operations. In teams, people feel more comfortable bringing up problems that may occur, and can get help from other workers to find a solution and put into place. There are mainly three types of teams that TQM organizations adopt.

- Quality improvement teams or excellence teams (QITs) – These are temporary teams with the purpose of dealing with specific problems that often recur. These teams are set up for period of three to twelve months.

- Problem solving teams (PSTs) – These are temporary teams to solve certain problems and also to identify and overcome causes of problems. They generally last from one week to three months.

- Natural work teams (NWTs) – These teams consist of small groups of skilled workers who share tasks and responsibilities. These teams use concepts such as employee involvement teams, self-managing teams and quality circles. These teams generally work for one to two hours a week.

- **Leadership –** It is possibly the most important element in TQM. It appears everywhere in organization. Leadership in TQM requires the manager to provide an inspiring vision, make strategic directions that are understood by all and to in still values that guide subordinates. For TQM to be successful in the business, the supervisor must be committed in leading his employees. A supervisor must understand TQM, believe in it and then demonstrate their belief and commitment through their daily practices of TQM. The supervisor makes sure that strategies, philosophies, values and goals are transmitted down throughout the organization to provide focus, clarity and direction. A key point is that TQM has to be introduced and led by top management. Commitment and personal involvement is required from top management in creating and deploying clear quality values and goals consistent with the objectives of the company and in creating and deploying well defined systems, methods and performance measures for achieving those goals.

2.1.7 Binding Mortar:

- **Communication –** It binds everything together. Starting from foundation to roof of the TQM house, everything is bound by strong mortar of communication. It acts as a vital link between all elements of TQM. Communication means a common understanding of ideas between the sender and the receiver. The success of TQM demands communication with and among all the organization members, suppliers and customers. Supervisors must keep open airways where employees can send and receive information about the TQM process. Communication coupled with the sharing of correct information is vital. For communication to be credible the message must be clear and receiver must interpret in the way the sender intended.

There are different ways of communication such as:

- **Downward communication –** This is the dominant form of communication in an organization. Presentations and discussions basically do it. By this the supervisors are able to make the employees clear about TQM.

- **Upward communication –** By this the lower level of employees are able to provide suggestions to upper management of the affects of TQM. As employees provide insight and constructive criticism, supervisors must listen effectively to correct the situation that comes about through the use of TQM. This forms a level of trust between supervisors and employees. This is also similar to empowering communication, where supervisors keep open ears and listen to others.

- **Sideways communication –** This type of communication is important because it breaks down barriers between departments. It also allows dealing with customers and suppliers in a more professional manner.

2.1.8 Roof:

- **Recognition –** Recognition is the last and final element in the entire system. It should be provided for both suggestions and achievements for teams as well as individuals. Employees strive to receive recognition for themselves and their teams. Detecting and recognizing contributors is the most important job of a supervisor. As people are recognized, there can be huge changes in self-esteem, productivity, quality and the amount of effort exhorted to the task at hand. Recognition comes in its best form when it is immediately following an action that an employee has performed. Recognition comes in different ways, places and time such as,

- **Ways –** It can be by way of personal letter from top management. Also by award banquets, plaques, trophies etc.

- **Places –** Good performers can be recognized in front of departments, on performance boards and also in front of top management.

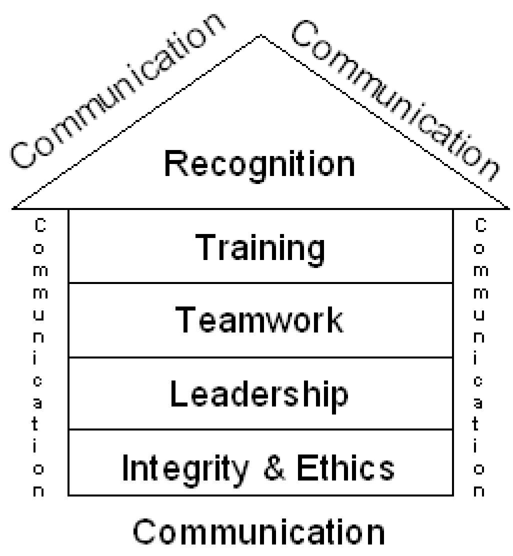
- **Time –** Recognition can give at any time like in staff meeting, annual award banquets, etc.

2.1.9 The Eight Elements of TQM:

Total Quality Management (TQM) is a management approach that originated in the 1950s and has steadily become more popular since the early 1980s. Total quality is a description of the culture, attitude and organization of a company that strives to provide customers with products and services that satisfy their needs. The culture requires quality in all aspects of the company's operations, with processes being done right the first time and defects and waste eradicated from operations.
To be successful implementing TQM, an organization must concentrate on the eight key elements:

- Ethics
- Integrity
- Trust
- Training
- Teamwork
- Leadership
- Recognition
- Communication

This paper is meant to describe the eight elements comprising TQM.



2.1.10 Key Elements:

TQM has been coined to describe a philosophy that makes quality the driving force behind leadership, design, planning, and improvement initiatives. For this, TQM requires the help of those eight key elements. These elements can be divided into four groups according to their function. The groups are:

- Foundation – It includes: Ethics, Integrity and Trust.
- Building Bricks – It includes: Training, Teamwork and Leadership.
- Binding Mortar – It includes: Communication.
- Roof – It includes: Recognition.

2.2 Synergies of TQM and SD:

TQM as a management system could be expanded to include components of SD. The TQM Focus on improved economic sustainability constitutes one area of potential synergy. A sound profit is necessary for economic sustainability, but it is not the sole requirement. Profit needs to be complemented with work to minimize internal losses which contribute to Unsustainable performance. One way of assessing these losses is to use theory based on the cost of poor quality (CPQ), with a focus on sustainability (Isaksson, 2005). The indications are that high CPQ equate to low sustainability. This suggests increased focus on improving process performance as a way to improve sustainability. Methodologies from TQM such as process management should be applicable for not only improving the economic performance but also the environmental and social performance.

2.2.1 TQM-SD Management System:

A chosen combination of values, methodologies and tools from TQM and SD could be seen as a management system of its own and in this paper is referred to as TQM-SD. Arguing from a quality perspective (Jonker, 2000) claims that the increasing role of organizations makes it necessary to become more value-driven and that it is important to include the values of sustainability and accountability. Furthermore, (Zairi and Peters, 2002) state that social responsibility of business organizations is not only a gesture, but rather a critical driver of corporate performance. The highlighted components of the proposed system are the values of “stakeholder focus”, “system sustainability”, “accountability”, “focus on processes” and “systems perspective”; the methodologies of business process management and the GRI-guidelines; the tools of process maps and process indicators.

The choice is to be seen as delimitation in this study and does not indicate that other values, methodologies and tools are less important. The current work only focuses on a few of the components in a TQM-SD system. The intention is to build a process-based framework that can be used to highlight possible further TQM-SD synergies. Process-based system models are proposed with the intention of locating all main change elements, including the components of a TQM-SD management system in the models. This will be achieved by creating building blocks around a basic process model and generic process measurements, which are then used to create a descriptive model for the organization as part of a stakeholder system.

2.2.2 Sustainable Development by TQM:

Sustainability is defined as ‘the ability of an organization to adapt to change in the Business environment to capture contemporary best practice methods and to achieve and maintain superior competitive performance’. Quinn (2000) describes sustainability as the development that meets present needs without compromising the ability of future generations to meet their own needs. Without sustainability, there is little benefit to be gained from TQM. TQM looks at quality as a long-term business strategy, which strives to provide products and/or services to satisfy fully both internal and external customers by meeting their explicit and implicit expectations. At the core, is the issue of measurement, which is the source of strength, continuity and sustainable performance?

2.2.3 TQM and the sustainable development:

Since the first Version of standards from ISO 9000 series for “The Quality System”, in ISO 9004 standard, recommendations were presented to organizations that implemented quality system and set the next goal to improve it. After the major revision in 2000 of ISO 9000 Series, only one model of “Quality Management System” was held, and the recommendation for improving the organization’s results, which had such a system implemented, were also presented in ISO 9004. After the periodic review in 2009, ISO 9004 has become a guide for “Management for the Sustainable success of an Organization. A quality management approach”. The standard transformation was necessary because, after a major economic crisis, balance of organizations can be restored only through a continuous and systematic improvement of its overall results. The argument that supports this idea is that, in essence, based on the recommendations of ISO 9004:2009, quality management system developed on the basis of the strategic management concepts results. Among the recommendations of ISO 9004 standard to be met in order to achieve the sustainable success, we can exemplify the following:

- Identify all the stakeholders and their requirements and expectations.
- Determine the results that the organization would have to get to achieve the long-term satisfaction of stakeholders.
- Anticipate resources, including skills and technologies necessary to achieve the objectives.

- Decision making on organizational changes necessary to ensure a proper framework for the deployment of operating processes.
- Development of policies needed for the organization's vision and values to be accepted and supported by stakeholders.
- Establishment of the organizational objectives taking into account both the requirements and expectations of stakeholders and the monitoring and evaluation results of the external environment of the organization and its strategic capability assessment.
- Development and implementation of processes for continuous improvement, including benchmarking studies, learning and innovation;
- Identification and assessment of risks.

Although I have mentioned only briefly the main recommendations of ISO 9004:2009, from the presented ones, it results that the quality management system for the sustainable success of an organization must ensure processes of objectives, strategies, monitoring the external environment, feed-back necessary for continuous improvement as in.

1
- Establishing the Objectives and Strategies necessary to meet the stakeholders requirements.

2
- Monitoring the external environment and also the capability of the organization.

3
- Providing the feed-back required for continuous improvement,innovation and the identification of the necessary organizational changes.

Therefore, the strategic elements within quality are outlined, which gives a prospective and projective thinking that is specific to modern organizations oriented towards a sustainable development in an extremely dynamic, complex and hostile environment. The sustainable success of an organization is achieved by its capability to meet the needs and expectations of customers and other stakeholders, equally and on long term. Sustainable success can be achieved by an effective management of the organization, by an environmental awareness of the organization, by learning and applying appropriate improvements, innovations, or both of them.

2.2.4 The Concept of Sustainable Development by TQM:

TQM is mainly concerned with Sustainable Development in all work, from high level strategic planning and decision-making, to detailed execution of work elements on the shop floor. It stems from the belief that mistakes can be avoided and defects can be prevented. It leads to continuously improving results, in all aspects of work, as a result of continuously improving capabilities, people, processes, and technology and machine capabilities.

Continuous improvement must deal not only with improving results, but more importantly with improving capabilities to produce better results in the future. The five major areas of focus for capability improvement are demand generation, supply generation, technology, operations and people capability.

A central principle of TQM is that mistakes may be made by people, but most of them are caused, or at least permitted, by faulty systems and processes. This means that the root cause of such mistakes can be identified and eliminated, and repetition can be prevented by changing the process.

There are three major mechanisms of prevention:

- Preventing mistakes (defects) from occurring (mistake-proofing or poka-yoke).
- Where mistakes can't be absolutely prevented, detecting them early to prevent them being passed down the value-added chain (inspection at source or by the next operation).
- Where mistakes recur, stopping production until the process can be corrected, to prevent the production of more defects. (Stop in time).

2.2.5 SPC and TQM:

Statistical Process Control (SPC) is a method of monitoring a process during its operation in order to control the quality of the products while they are being produced rather than relying on inspection to find problems after the fact. The value of SPC is that by monitoring the process you can identify and take action on special causes of variation and other non-normal processing conditions. Therefore, bringing the process under statistical control and reducing variation.

SPC is not strictly about statistics or control, it is about competitiveness. Organizations, whatever their nature, compete on three issues: **quality, delivery and**

price. There cannot be many people in the world who remain to be convinced that the reputation attached to an organization for the quality of its products and services is a key to its success and the future of its employees. Moreover, if the quality is right, the chances are the delivery and price performance will be competitive too.

A number of benefits can be attributed to SPC. Continuous improvement and maintenance of quality and productivity can be achieved, and through the SPC process complexity can be reduced. By identifying and reducing process complexity, errors will be reduced and productivity improved through the substitution of sampling for 100 percent inspection. SPC also provides a common internal language for management, supervision, quality assurance/control, and product operations to discuss problems, solutions, decisions, and actions.

2.2.6 OBJECTIVES AND BENEFITS OF SPC:

- OBJECTIVES:

Statistical process control (SPC) is quantitative problem solving, consisting of diagnostic techniques to assist in locating problem sources and prescriptive techniques to help solve problems. Many of these techniques are based on statistical principles. SPC also makes it possible to determine whether or not the process is improving.

A process is any repeatable sequence of events or operations leading to either a tangible or intangible outcome. The use of SPC shows that a process is:

In statistical control, that is, the process variation appears to be random or Out of statistical control, that is, the process exhibits non random variation.

- BENEFITS:

A number of benefits can be attributed to SPC. Continuous improvement and maintenance of quality and productivity can be achieved, and through the SPC process complexity can be reduced. By identifying and reducing process complexity, errors will be reduced and productivity improved through the substitution of sampling for 100 percent inspection. Following are the major benefits attached to statistical process control.

- Improve Product Quality:

  One way to improve product quality is to reduce the variation in the output of your process. By identifying the sources of variability that go into the manufacture of your product, and using SPC to analyze their impact, identify problems, and monitor the results you can improve achieve your quality goals.

- Reduce Scrap and Rework:

  Scrap and rework costs consist of not only loss of labour and material, but the unexpected organizational cost on managing and handling these scrapped parts. Since SPC analysis provides trends of your process capabilities you can take action to correct process problems before scrap is generated.

- Increase Manufacturing Yield:

  Fewer scrapped parts mean a higher yield for your investment in materials and equipment. It also means a more productive workforce.

- Meet Customer Requirements:

  Customers want to see evidence that your processes will produce parts that meet their requirements. In the process industries, the customers specifically ask for evidence that your organization can use SPC for the monitoring and measurement of your process capabilities. Implementing SPC allows satisfying the customers while improving the product.

CHAPTER: 3

3 Implementation of TQM techniques and QC tools in Lucky Plastic industry:

To manage the quality issues in production of PVC sheet in Lucky Plastic Industry, they are using different techniques and quality control tools.

- Cause and effect analysis
- Check sheets/tally sheets
- Control charts
- Graphs
- Histograms
- Pareto analysis
- Scatter analysis

CAUSE AND EFFECT DIAGRAM (also called Ishikawa or fishbone chart):

Identifies many possible causes for an effect or problem and sorts ideas into useful categories.

- VARIATIONS:

Cause enumeration diagram, process fishbone, time delay fishbone, CEDAC (cause and effect diagram with the addition of cards), desired result fishbone, reverse fishbone diagram.

The fishbone diagram identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories.

When to Use a Fishbone Diagram

- When identifying possible causes for a problem.
- Especially when a team‘s thinking tends to fall into ruts.

3.1 FISHBONE DIAGRAM PROCEDURE:

Agree on a problem statement (effect). Write it at the centre right of the flipchart or whiteboard. Draw a box around it and draw a horizontal arrow running to it.

Brainstorm the major categories of causes of the problem. If this is difficult use generic headings:

- Methods
- Machines (equipment)
- People (manpower)
- Materials
- Measurement
- Environment

- Write the categories of causes as branches from the main arrow.

- Brainstorm all the possible causes of the problem. Ask: Why does this happen? As each idea is given, the facilitator writes it as a branch from the appropriate category. Causes can be written in several places if they relate to several categories.

- Again ask why does this happen? About each cause. Write sub causes branching off the causes. Continue to ask why? And generate deeper levels of causes. Layers of branches indicate causal relationships.

- When the group runs out of ideas, focus attention to places on the chart where ideas are few.

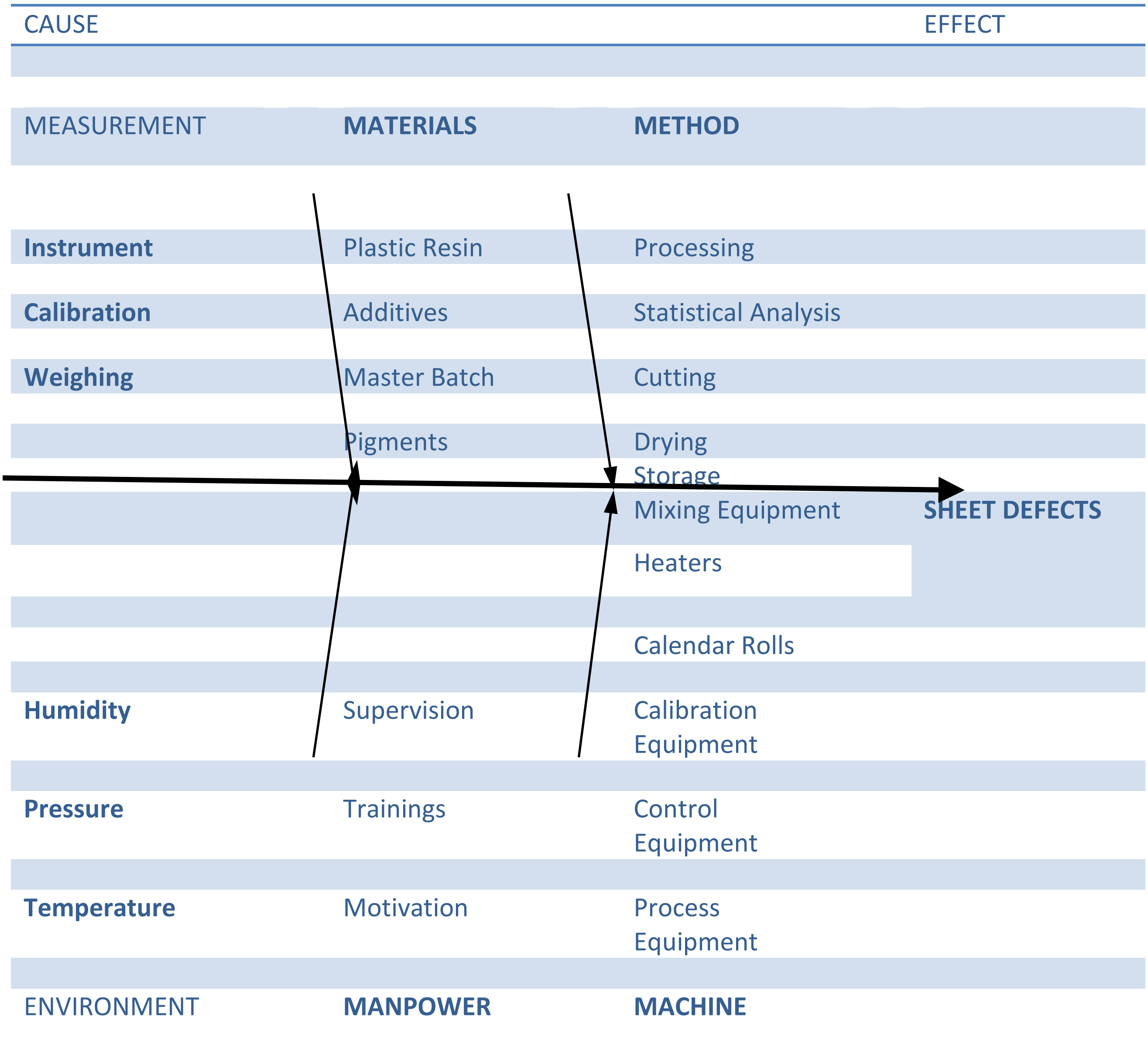


Fig.1 Cause & Effect Diagram

3.1.1 CHECK SHEET:

(Also called: defect concentration diagram) is a structured, prepared form for collecting and analyzing data. This is a generic tool that can be adapted for a wide variety of purposes.

When to Use a Check Sheet

- When data can be observed and collected repeatedly by the same person or at the same location.
- When collecting data on the frequency or patterns of events, problems, defects, defect location, defect causes, etc.
- When collecting data from a production process.

3.1.2 CHECK SHEET PROCEDURE:

- Decide what event or problem will be observed. Develop operational definitions.
- Decide when data will be collected and for how long.
- Design the form. Set it up so that data can be recorded simply by making check marks or Xs or similar symbols and so that data do not have to be recopied for analysis.
- Label all spaces on the form.
- Test the check sheet for a short trial period to be sure it collects the appropriate data and is easy to use.
- Each time the targeted event or problem occurs, record data on the check sheet.

Check Sheet Example

The figure below shows a check sheet used to collect data on Sheet defects. The tick marks were added as data was collected over several weeks.

Sheet Defects	1ST Quarter	4Th Quarter	Final Analysis	Total
Thickness Variation	IIIII IIIII IIIII	IIIII	II	37
Color Variation	IIIII IIIII IIIII	IIII	I	30
Bubbles in Sheet	IIIII IIIII IIIII	III	I	24
Black Particles	IIIII I	II	I	9
Wrong Quantity	IIII	II		6
Shrinkage	III	I		4
Gloss	I	I		2
Wavy Edges	I	I		2
Diagonal	I	I		2

Fig.2 Check Sheet Diagram

3.1.3 CONTROL CHARTS:

(Also called: statistical process control) is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

Control charts for variable data are used in pairs. The top chart monitors the average, or the cantering of the distribution of data from the process. The bottom chart monitors the range, or the width of the distribution. If your data were shots in target practice, the average is where the shots are clustering, and the range is how tightly they are clustered. Control charts for attribute data are used singly.

When to Use a Control Chart

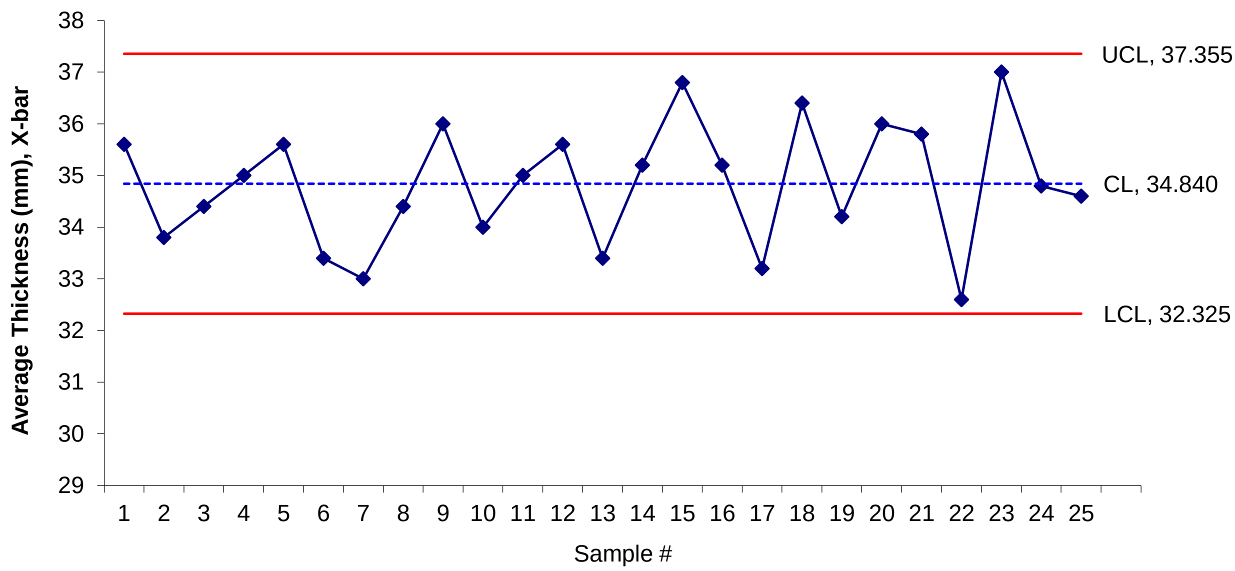
- When controlling ongoing processes by finding and correcting problems as they occur.
- When predicting the expected range of outcomes from a process.
- When determining whether a process is stable (in statistical control).
- When analyzing patterns of process variation from special causes (non-routine events) or common causes (built into the process).
- When determining whether your quality improvement project should aim to prevent specific problems or to make fundamental changes to the process.

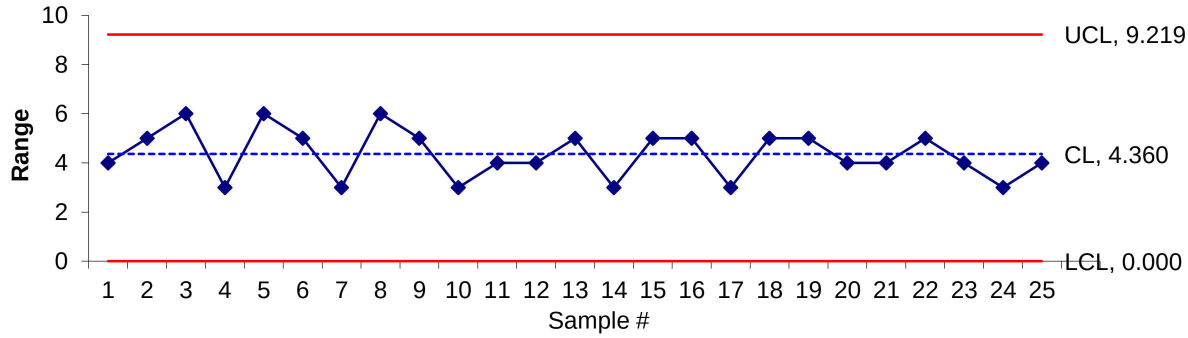
3.1.4 CONTROL CHART PROCEDURE:

- Choose the appropriate control chart for your data.
- Determine the appropriate time period for collecting and plotting data.
- Collect data, construct your chart and analyze the data.
- Look for out of control signals on the control chart. When one is identified, mark it on the chart and investigate the cause.
- Document how you investigated, what you learned, the cause and how it was corrected.

[Polystyrene Sheet Defects]
[18 June,2014]

Quality Characteristic	Average Thickness (mm), X-bar
Sample Size, *n*	5
k	3





Statistics from Data Table

R-bar	4.360
Process Mean, □-hat	34.840
Process St.Dev., □-hat	1.874
$□_{X\text{-bar}}$	0.838

Process Capability

Upper Spec Limit, USL	40
Lower Spec Limit, LSL	30
C_p	0.889
CPU	0.918
CPL	0.861
C_{pk}	0.861
Percent Yield	99.21%

Control Limits for X-bar Chart

$CL_{X\text{-bar}}$	34.840	
$UCL_{X\text{-bar}}$	37.355	$CL+k□_{X\text{-bar}}$
$LCL_{X\text{-bar}}$	32.325	$CL-k□_{X\text{-bar}}$
□	0.0027	
ARL	370.4	samples

Control Limits for R Chart

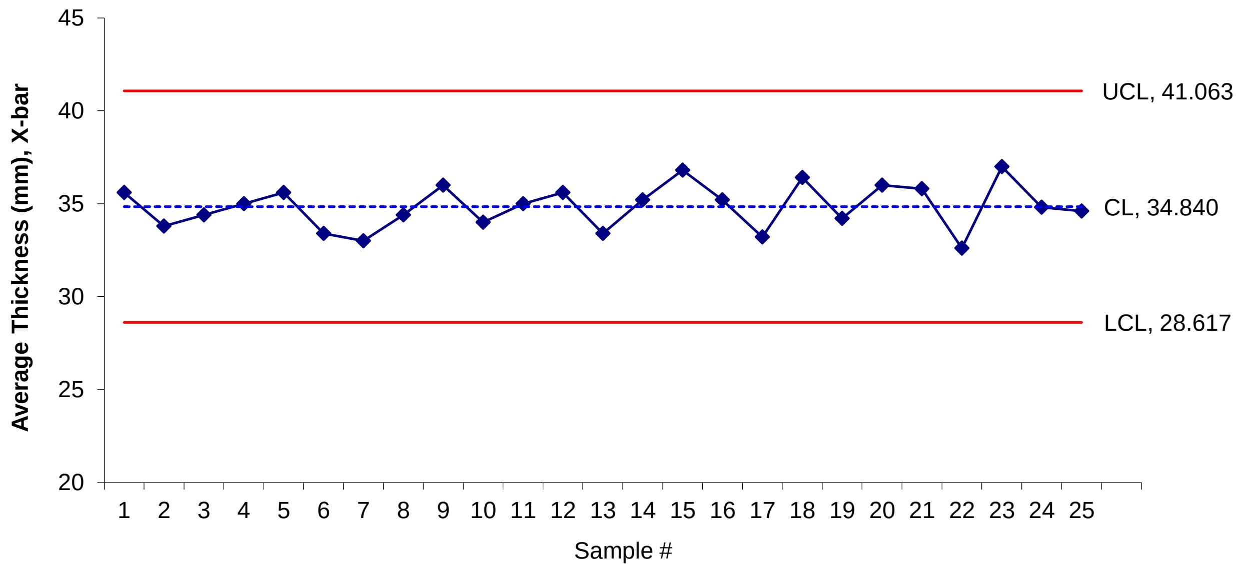
CL_R	4.360
UCL_R	9.219
LCL_R	0.000

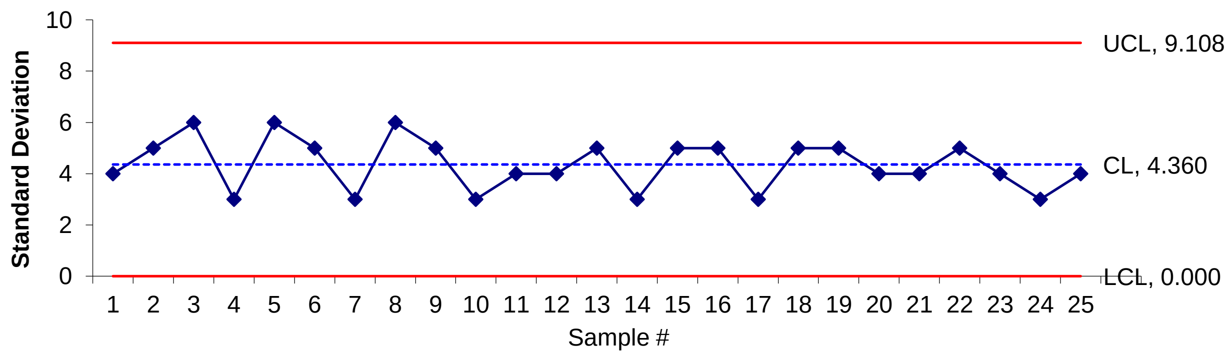
Data Table			X-bar Chart			R Chart		
1	35.6	4	34.840	37.355	32.325	4.360	9.219	0.000
2	33.8	5	34.840	37.355	32.325	4.360	9.219	0.000
3	34.4	6	34.840	37.355	32.325	4.360	9.219	0.000
4	35	3	34.840	37.355	32.325	4.360	9.219	0.000
5	35.6	6	34.840	37.355	32.325	4.360	9.219	0.000
6	33.4	5	34.840	37.355	32.325	4.360	9.219	0.000
7	33	3	34.840	37.355	32.325	4.360	9.219	0.000
8	34.4	6	34.840	37.355	32.325	4.360	9.219	0.000
9	36	5	34.840	37.355	32.325	4.360	9.219	0.000
10	34	3	34.840	37.355	32.325	4.360	9.219	0.000
11	35	4	34.840	37.355	32.325	4.360	9.219	0.000
12	35.6	4	34.840	37.355	32.325	4.360	9.219	0.000
13	33.4	5	34.840	37.355	32.325	4.360	9.219	0.000
14	35.2	3	34.840	37.355	32.325	4.360	9.219	0.000
15	36.8	5	34.840	37.355	32.325	4.360	9.219	0.000
16	35.2	5	34.840	37.355	32.325	4.360	9.219	0.000
17	33.2	3	34.840	37.355	32.325	4.360	9.219	0.000
18	36.4	5	34.840	37.355	32.325	4.360	9.219	0.000
19	34.2	5	34.840	37.355	32.325	4.360	9.219	0.000
20	36	4	34.840	37.355	32.325	4.360	9.219	0.000
21	35.8	4	34.840	37.355	32.325	4.360	9.219	0.000
22	32.6	5	34.840	37.355	32.325	4.360	9.219	0.000
23	37	4	34.840	37.355	32.325	4.360	9.219	0.000
24	34.8	3	34.840	37.355	32.325	4.360	9.219	0.000
25	34.6	4	34.840	37.355	32.325	4.360	9.219	0.000

Fig.3 (A) Control Chart Diagram

[Polystyrene Sheets Defects]
[18 June,2014]

Quality Characteristic	Average Thickness (mm), X-bar
Sample Size, *n*	5
k	3





Statistics from Data Table

s-bar	4.360
c_4	0.9400
Process St.Dev., σ-hat	4.638
Process Mean, μ-hat	34.840
$\sigma_{X\text{-bar}}$	2.074
σ_S	1.583

Process Capability

Upper Spec Limit, USL	45
Lower Spec Limit, LSL	25
C_p	0.719
CPU	0.730
CPL	0.707
C_{pk}	0.707
Percent Yield	96.88%

Control Limits for X-bar Chart

$CL_{X\text{-bar}}$	34.840
$UCL_{X\text{-bar}}$	41.063
$LCL_{X\text{-bar}}$	28.617
α	0.0027
ARL	370.4 samples

Control Limits for S Chart

CL_S	4.360
UCL_S	9.108
LCL_S	0.000

Data Table			X-bar Chart			R Chart		
Sample	*X-bar*	*St. Dev., s*	CL	UCL	LCL	CL	UCL	LCL
1	35.6	4	34.840	41.063	28.617	4.360	9.108	0.000
2	33.8	5	34.840	41.063	28.617	4.360	9.108	0.000
3	34.4	6	34.840	41.063	28.617	4.360	9.108	0.000
4	35	3	34.840	41.063	28.617	4.360	9.108	0.000
5	35.6	6	34.840	41.063	28.617	4.360	9.108	0.000
6	33.4	5	34.840	41.063	28.617	4.360	9.108	0.000
7	33	3	34.840	41.063	28.617	4.360	9.108	0.000
8	34.4	6	34.840	41.063	28.617	4.360	9.108	0.000
9	36	5	34.840	41.063	28.617	4.360	9.108	0.000
10	34	3	34.840	41.063	28.617	4.360	9.108	0.000
11	35	4	34.840	41.063	28.617	4.360	9.108	0.000
12	35.6	4	34.840	41.063	28.617	4.360	9.108	0.000
13	33.4	5	34.840	41.063	28.617	4.360	9.108	0.000
14	35.2	3	34.840	41.063	28.617	4.360	9.108	0.000
15	36.8	5	34.840	41.063	28.617	4.360	9.108	0.000
16	35.2	5	34.840	41.063	28.617	4.360	9.108	0.000
17	33.2	3	34.840	41.063	28.617	4.360	9.108	0.000
18	36.4	5	34.840	41.063	28.617	4.360	9.108	0.000
19	34.2	5	34.840	41.063	28.617	4.360	9.108	0.000
20	36	4	34.840	41.063	28.617	4.360	9.108	0.000
21	35.8	4	34.840	41.063	28.617	4.360	9.108	0.000
22	32.6	5	34.840	41.063	28.617	4.360	9.108	0.000
23	37	4	34.840	41.063	28.617	4.360	9.108	0.000
24	34.8	3	34.840	41.063	28.617	4.360	9.108	0.000
25	34.6	4	34.840	41.063	28.617	4.360	9.108	0.000

Fig.3 (B) Control Chart Diagram

In Our case scenario of Polystyrene Sheet Defects

Product:	Polystyrene	
Type of Defect:	Thickness Variation	
Unit of Measure:	quart	
Mean Number Defects per Unit:	15.00	defects per quart
	C-Chart	
Upper Control Limit:	26.62	defects per quart
Lower Control Limit:	3.38	defects per quart

Thickness Variation	30
Color Variation	20
Bubbles in Sheet	5
Black Particles	20
Wrong quantity	27
Shrinkage	12
Gloss	20
Wavy edges	10
Diagonal	15

Obs	Count Defective	p-chart LCL	UCL
1	30	3.38105	26.61895
2	20	3.38105	26.61895
3	5	3.38105	26.61895
4	20	3.38105	26.61895
5	27	3.38105	26.61895
6	12	3.38105	26.61895
7	20	3.38105	26.61895
8	10	3.38105	26.61895
9	15	3.38105	26.61895

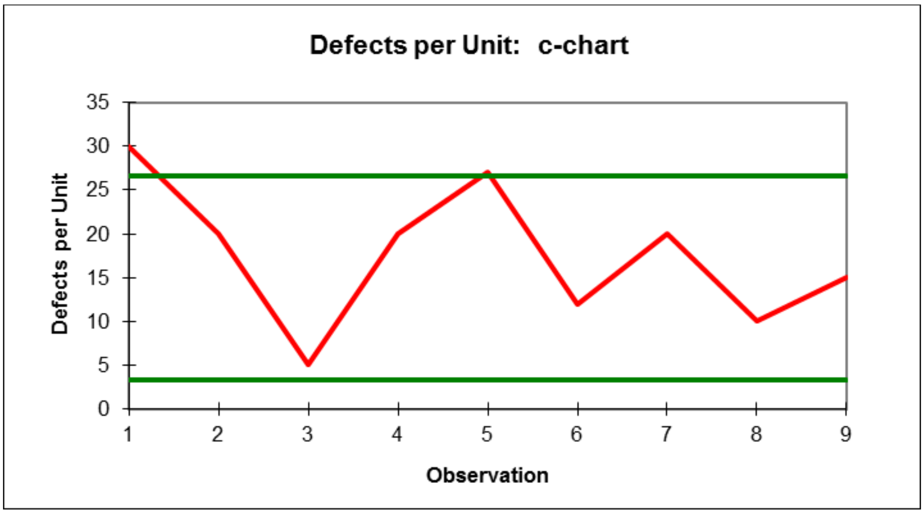


Fig.3 (C) Control Chart Diagram

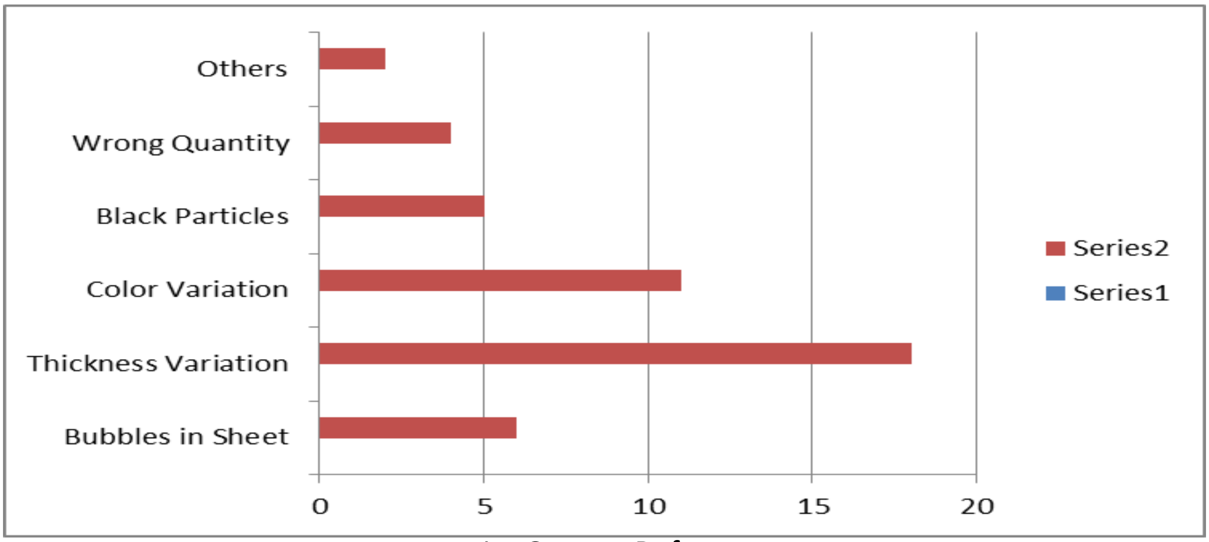
3.1.5 GRAPHS / CHARTS:

3.1.5.1 COMMON TYPES OF CHARTS / GRAPHS:

- Bar Graphs
- Line Graph
- Pie Chart

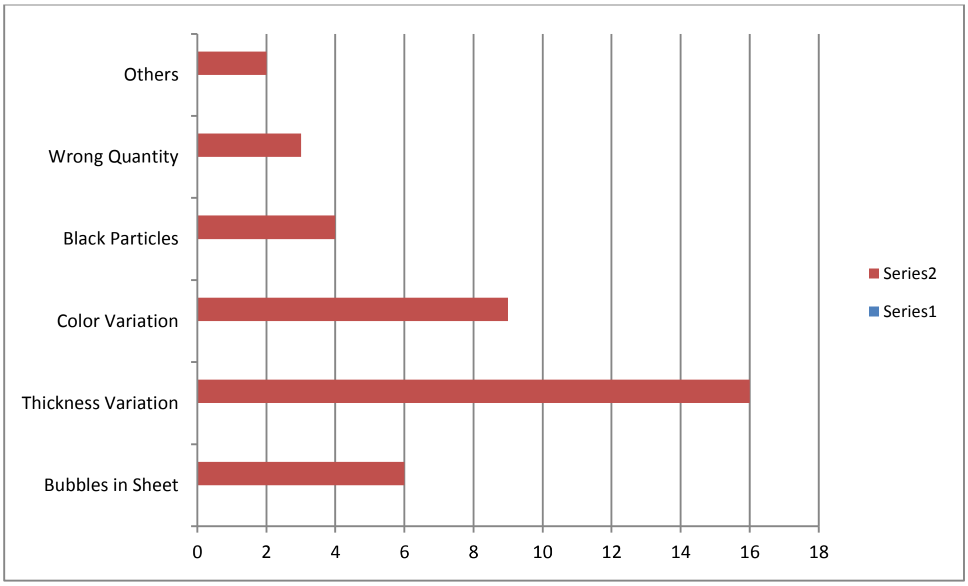
3.1.6 BAR GRAPHS:

- Bar Graphs are used to indicate the magnitude or frequency of parameters in the form of bars
- Used for comparison of parameters



1st Quarter Defects

Fig. 4(A) Bar Graph



2nd Quarter Sheet Defects

Fig. 4(B) Bar Graph

3rd Quarter Sheet Defects

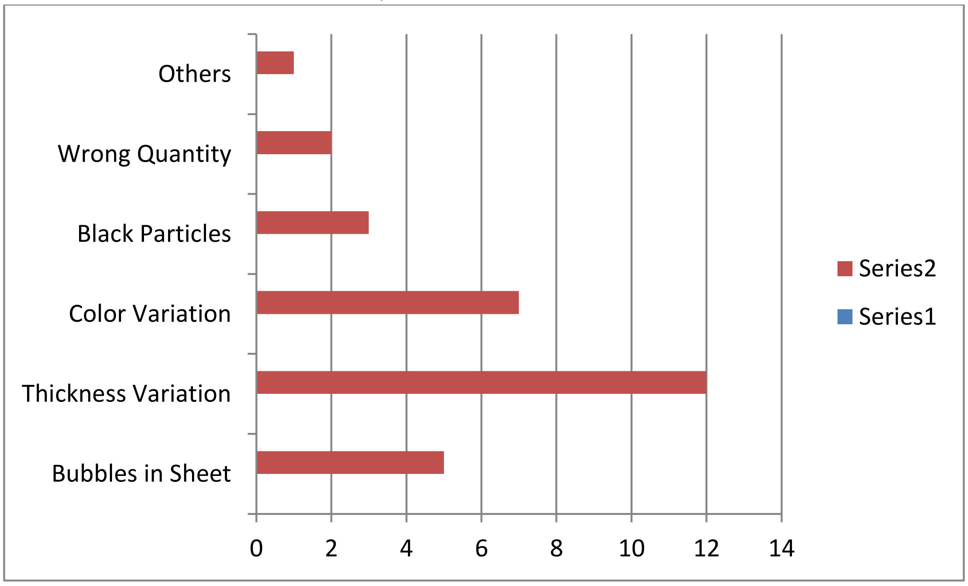


Fig. 4(C) Bar Graph

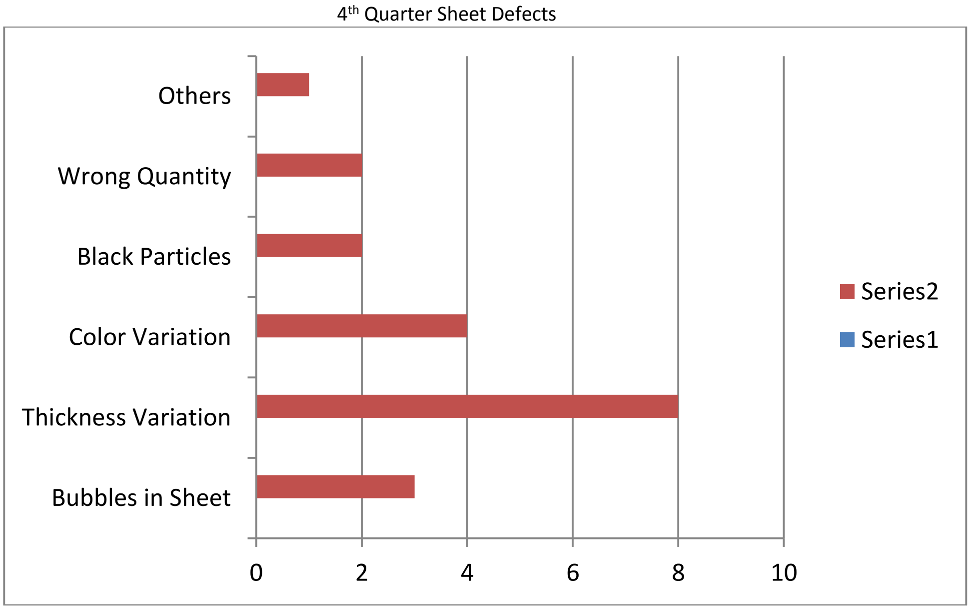


Fig.4 (D) Bar Graph

The above Four Bar Charts reveals the overall defects occurred in Polystyrene Sheet. In order to further illustrate the problem the values are shown in percentage through Pie Chart. So that it can be more easily able to understand the core problems needed to be addressed immediately.

3.1.7 PIE CHARTS:

Pie Charts are used to indicate the percentage share or distribution of components

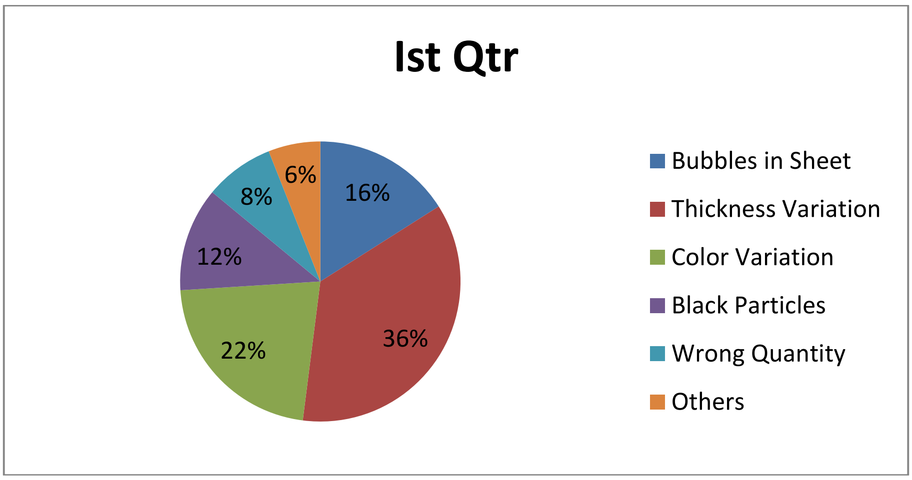


Fig.5 (A) Pie Chart

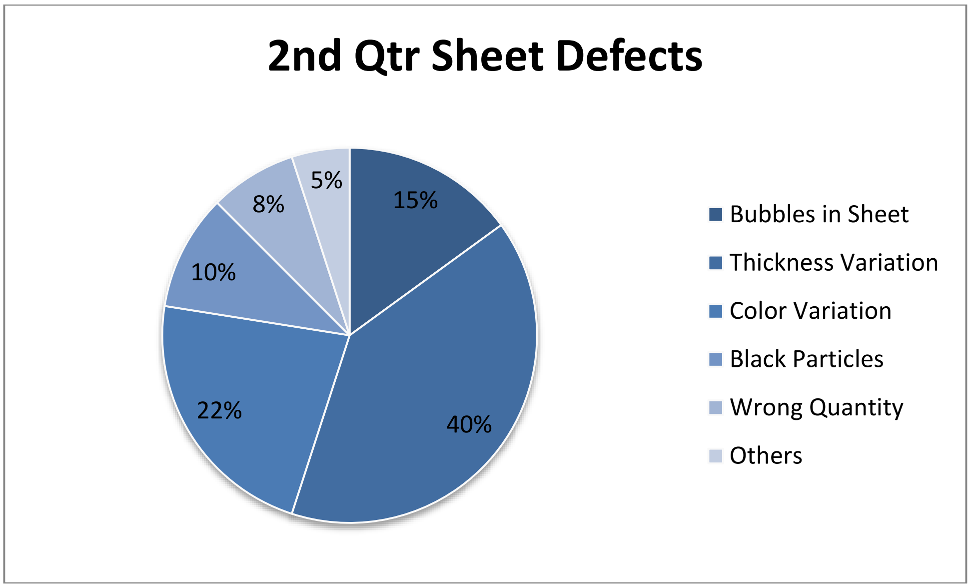


Fig.5 (B) Pie Chart

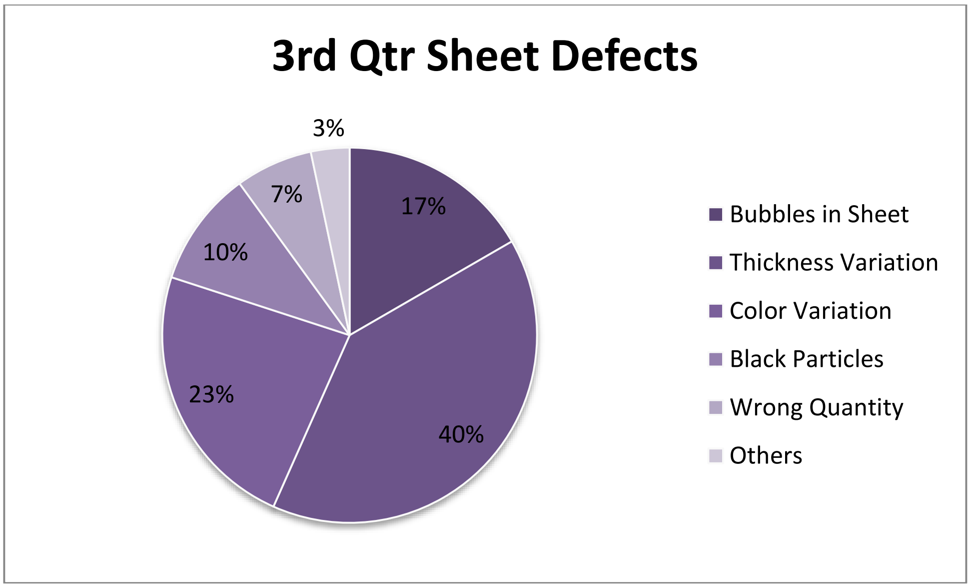


Fig.5 (C) Pie Chart

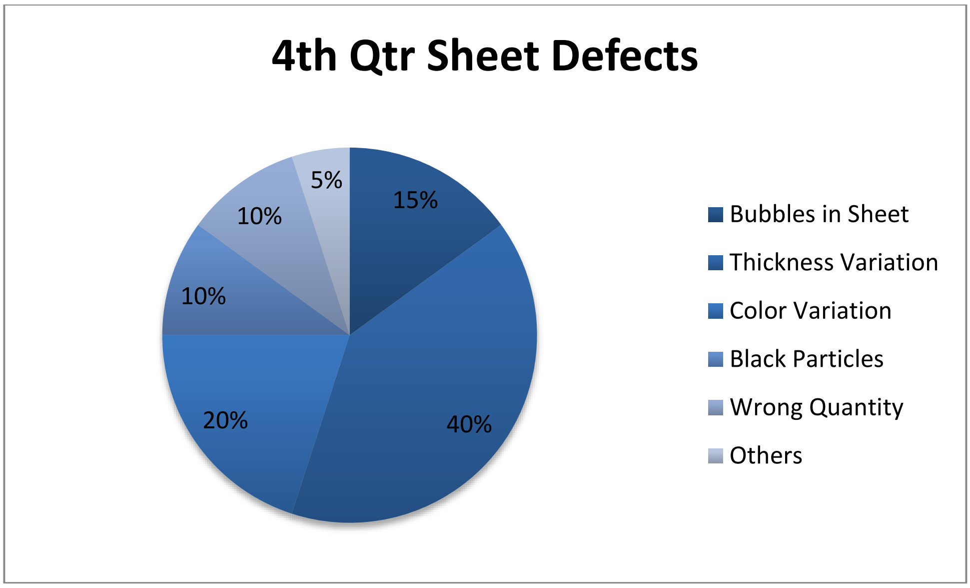


Fig.5 (D) Pie Chart

3.1.8 Line Graphs:

Line Graphs are used to indicate the trend of parameters against time

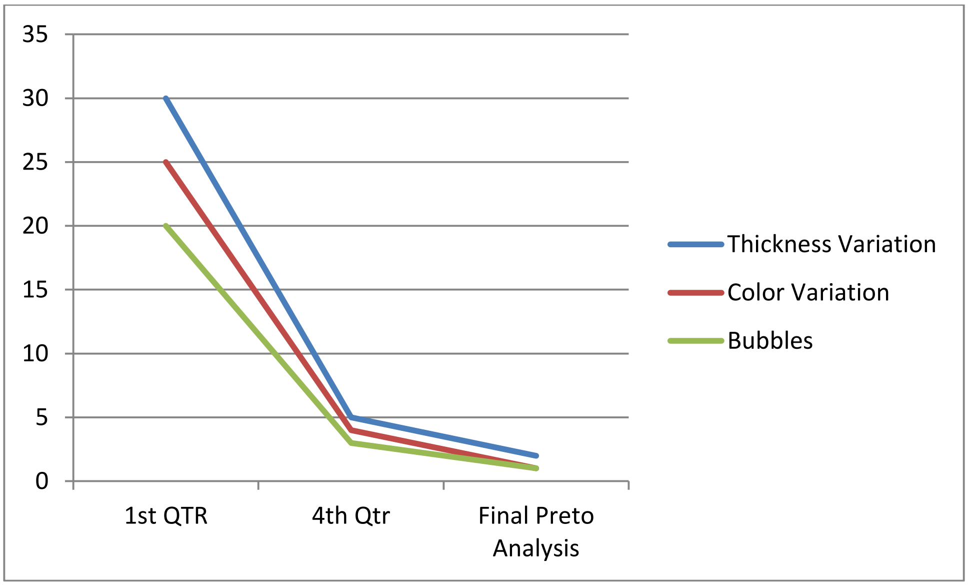


Fig.6 Line Graph

3.1.9 PARETO CHART:

A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant.

When to Use a Pareto Chart

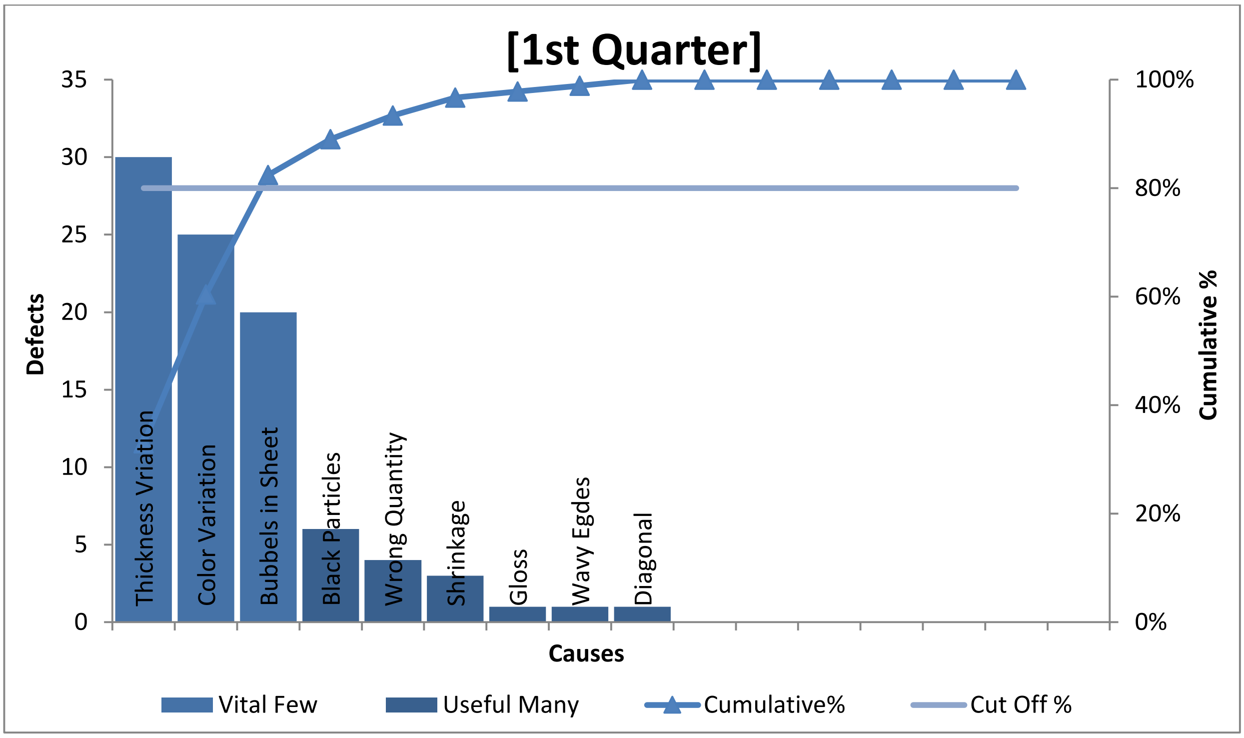
- When analyzing data about the frequency of problems or causes in a process.
- When there are many problems or causes and you want to focus on the most significant.
- When analyzing broad causes by looking at their specific components.
- When communicating with others about your data.

3.1.9.1 PARETO CHART PROCEDURE:

- Decide what categories you will use to group items.
- Decide what measurement is appropriate. Common measurements are frequency, quantity, cost and time.
- Decide what period of time the Pareto chart will cover: One work cycle? One full day? A week?
- Collect the data, recording the category each time. (Or assemble data that already exist.)
- Subtotal the measurements for each category.
- Determine the appropriate scale for the measurements you have collected. The maximum value will be the largest subtotal from step 5. (If you will do optional steps 8 and 9 below, the maximum value will be the sum of all subtotals from step 5.) Mark the scale on the left side of the chart.
- Construct and label bars for each category. Place the tallest at the far left, then the next tallest to its right and so on. If there are many categories with small measurements, they can be grouped as other.
- Steps 8 and 9 are optional but are useful for analysis and communication.

- Calculate the percentage for each category: the subtotal for that category divided by the total for all categories. Draw a right vertical axis and label it with percentages. Be sure the two scales match: For example, the left measurement that corresponds to one-half should be exactly opposite 50% on the right scale.

- Calculate and draw cumulative sums: Add the subtotals for the first and second categories, and place a dot above the second bar indicating that sum. To that sum add the subtotal for the third category, and place a dot above the third bar for that new sum. Continue the process for all the bars. Connect the dots, starting at the top of the first bar. The last dot should reach 100 percent on the right scale.



The first 3 Causes cover 82.42% of the Total Defects

		Cumulative Percentage Cutoff:	80%
#	Causes	Defects	Cumulative%
1	Thickness Vriation	30	33.0%
2	Color Variation	25	60.4%
3	Bubbels in Sheet	20	82.4%
4	Black Particles	6	89.0%
5	Wrong Quantity	4	93.4%
6	Shrinkage	3	96.7%
7	Gloss	1	97.8%
8	Wavy Egdes	1	98.9%
9	Diagonal	1	100.0%
10			100.0%
11			100.0%
12			100.0%
13			100.0%
14			100.0%
15			100.0%

Fig.7 (A) Pareto Chart Showing Sheet Defects

As it is obvious from Pareto analysis that vital few are the three i.e. Thickness variation, Color Variation and Bubbles in Sheet In order to cope up with the above problem we start working to improve.

3.2 THICKNESS VARIATION:

After closely observing following were the main reasons for thickness variation defect.

- Untrained Associates not able to set die lips properly
- Calendar rolls diameter variation
- Improper roll nip
- Variation in pull ratio speed
- Unstable rolls temperature gradients
- Uncelebrated thickness checking instrument

In order to get rid of these reason we did following

- Proper training of Associates
- Calendar rolls were sent to market to check there diameter and to chrome the rolls
- Hydraulic Pressure were checked and gauges were calibrated in order to get proper pressure
- Motors were synchronized to eliminates problem of pull ratio speed
- Controllers causing sudden temperature changes were replaced with new one to control unstable temperature gradients
- Analogue micrometers were replaced with beta gauge infrared thickness measuring device

3.2.1 COLOR VARIATION:

The main reason for color variation was use of pigments which results in improper color distribution resulting problem of color variation in sheet. Until the master batches were not developed plasticizers were used to properly mix the colours.

Also tumbler mixer was used to mix resin and pigments instead of mixing in vertical mixer. The pigments were replaced with master batches and pre-colour resin.

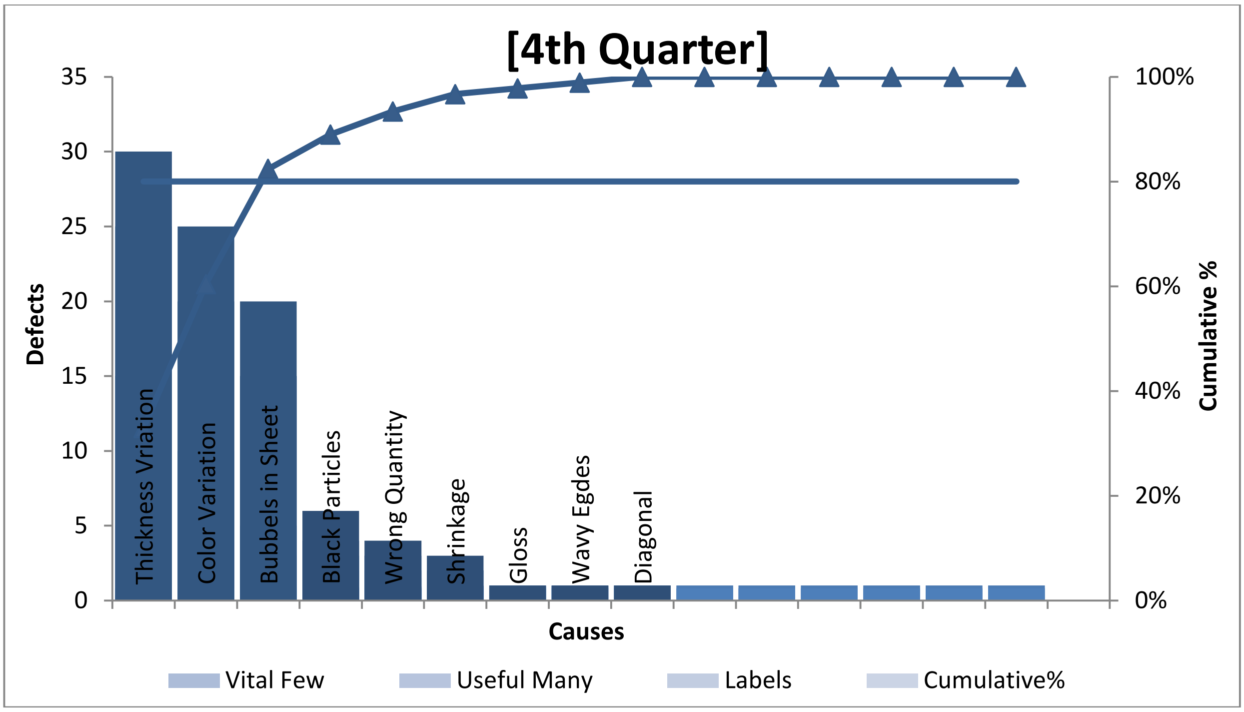
3.2.2 BUBBLES IN SHEET:

Following were the main reasons for bubbles in sheet

- Moisture contents in resin
- Improper material processing temperature
- Improper storage of raw material
- Vacuum pump was not working properly
- Pre drying hopper heaters were out of order

In order to eliminate the problem we took following steps

- Proper pre drying of resin
- All the heater of machine were checked and faulty one were replaced
- Storage area was properly covered as well as raw material was
- Vacuum pump was repaired
- Pre drying hopper heaters were replaced



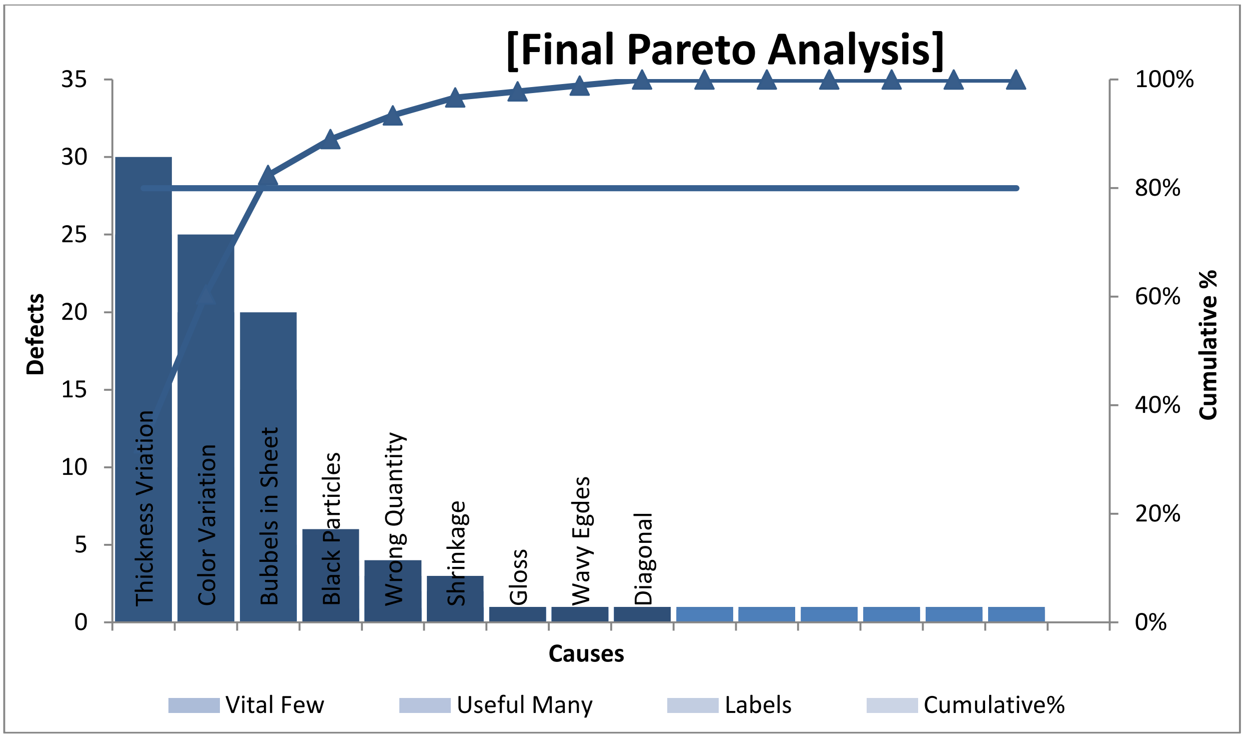
The first 6 Causes cover 84.62% of the Total Defects

Cumulative Percentage Cut off: 80%

#	Causes	Defects	Cumulative%
1	Thickness Variation	5	25.6%
2	Color Variation	4	46.2%
3	Bubbles in Sheet	3	61.5%
4	Black Particles	2	71.8%
5	Wrong Quantity	1.5	79.5%
6	Shrinkage	1	84.6%
7	Gloss	1	89.7%
8	Wavy Edges	1	94.9%
9	Diagonal	1	100.0%
10			100.0%
11			100.0%
12			100.0%
13			100.0%
14			100.0%
15			100.0%

Fig.7 (B) Pareto Chart Showing Sheet Defects

It is obvious from the second Pareto analysis chart that the problems reduced drastically and we covered a lot. The changes made were successful though still there are some complain and for this again few steps were taken.



The first 4 Causes cover 100. % of the Total Defects

#	Causes	Defects	Cumulative%
		Cumulative Percentage Cutoff:	80%
1	Thickness Vriation	2	40.0%
2	Color Variation	1	60.0%
3	Bubbels in Sheet	1	80.0%
4	Black Particles	1	100.0%
5	Wrong Quantity	0	100.0%
6	Shrinkage	0	100.0%
7	Gloss	0	100.0%
8	Wavy Egdes	0	100.0%
9	Diagonal	0	100.0%
10			100.0%
11			100.0%
12			100.0%
13			100.0%
14			100.0%
15			100.0%

Fig.7 (C) Pareto Chart Showing Sheet Defects

3.2.3 LINE GRAPHS:

Line Graphs are used to indicate the trend of parameters against time. Here Pareto charts data are used to show the trend of parameters against time

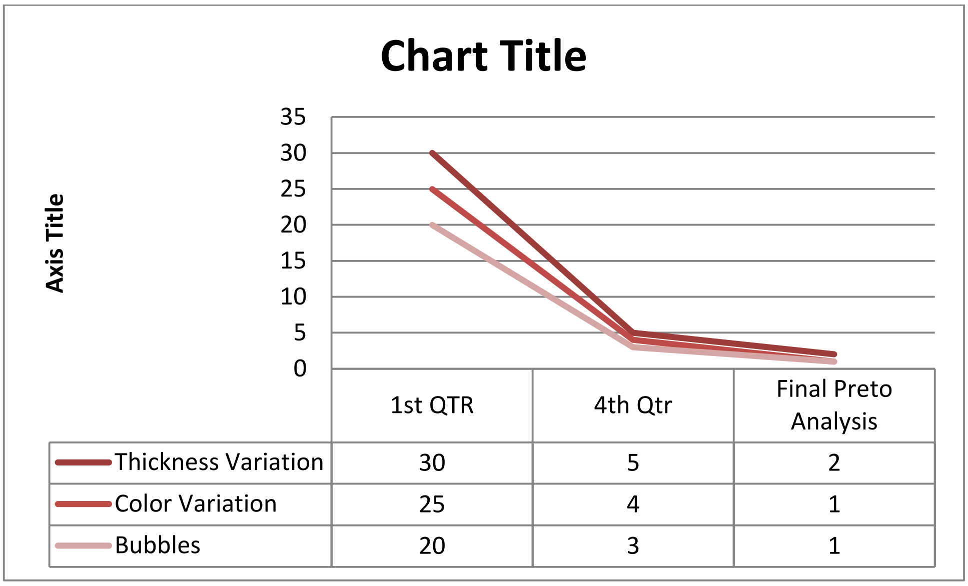


Fig.8 Line Graph

3.2.4 HISTOGRAM:

A histogram is the most commonly used graph to show frequency distributions. The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs. It looks very much like a bar chart, but there are important differences between them.

When to Use a Histogram

- When the data are numerical.
- When you want to see the shape of the data‘s distribution, especially when determining whether the output of a process is distributed approximately normally.
- When analyzing whether a process can meet the customer‘s requirements.
- When analyzing what the output from a supplier‘s process looks like.
- When seeing whether a process change has occurred from one time period to another.
- When determining whether the outputs of two or more processes are different.
- When you wish to communicate the distribution of data quickly and easily to others.

3.2.5 HISTOGRAM PROCEDURE:

- Collect at least 50 consecutive data points from a process.
- Use the histogram worksheet to set up the histogram. It will help you determine the number of bars, the range of numbers that go into each bar and the labels for the bar edges.
- Draw x- and y-axis on graph paper. Mark and label the y-axis for counting data values. Mark and label the x-axis with the L values from the worksheet. The spaces between these numbers will be the bars of the histogram. Do not allow for spaces between bars.
- For each data point, mark off one count above the appropriate bar with an X or by shading that portion of the bar.

3.2.6 HISTOGRAM ANALYSIS

- Before drawing any conclusions from your histogram, satisfy yourself that the process was operating normally during the time period being studied. If any unusual events affected the process during the time period of the histogram, your analysis of the histogram shape probably cannot be generalized to all time periods.
- Analyze the meaning of your histogram‘s shape

Thickness of Sheet		
2	2.1	2.22
2.01	2.1	2.25
2.02	2.12	2.3
2.02	2.15	2.31
2.04	2.15	2.32
2.04	2.15	2.33
2.05	2.16	2.35
2.08	2.18	2.36
2.09	2.2	2.37
2.09	2.2	2.4

Intervals/Bin	Frequency
2-2.05	7
2.05-2.1	5
2.1-2.15	4
2.15-2.2	4
2.2-2.5	2
2.5-2.3	1
2.3-2.35	4
2.35-2.4	3

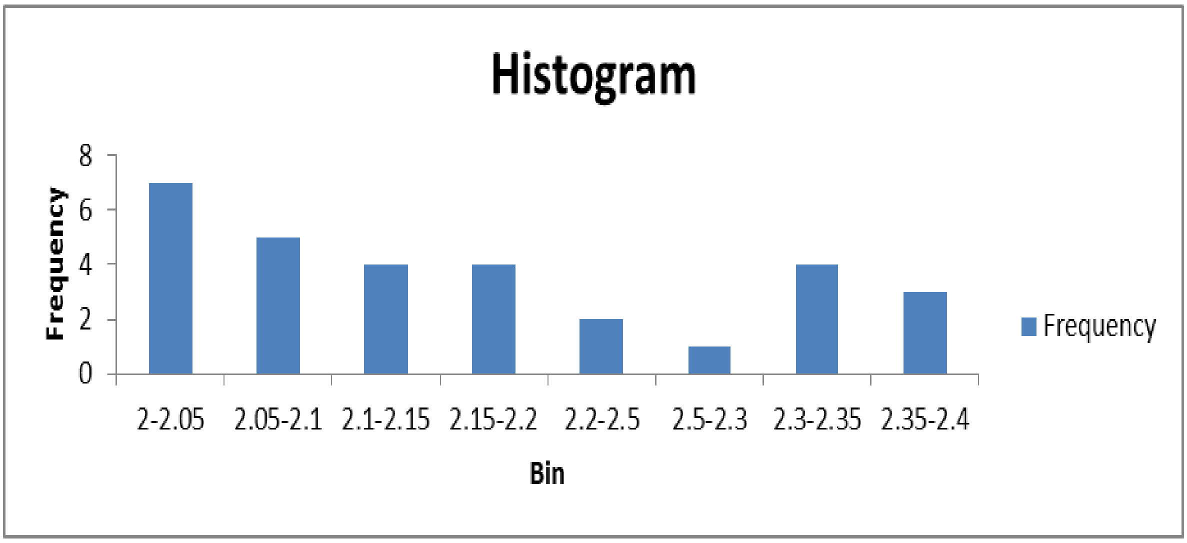


Fig.9 Histogram

3.2.7 SCATTER DIAGRAM:

(Also called: scatter plot, X–Y graph). The scatter diagram graphs are pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line.

When to Use a Scatter Diagram

- When you have paired numerical data
- When your dependent variable may have multiple values for each value of your independent variable.
- When trying to determine whether the two variables are related, such as positive co- relation, negative co-relation.
- When trying to identify potential root causes of problems.
- After brainstorming, to determine objectively whether a particular cause and effect are related.
- When determining whether two effects that appears to be related both occur with the same cause.
- When testing for autocorrelation before constructing a control chart.

3.2.8 SCATTER DIAGRAM PROCEDURE:

- Collect pairs of data where a relationship is suspected.
- Draw a graph with the independent variable on the horizontal axis and the dependent variable on the vertical axis. For each pair of data, put a dot or a symbol where the x-axis value intersects the y-axis value.
- Look at the pattern of points to see if a relationship is obvious. If the data clearly form a line or a curve, you may stop. The variables are correlated. You may wish to use regression or correlation analysis now. Otherwise, complete steps 4 through 7.
- Divide points on the graph into four quadrants. If there are X points on the graph.
- Count X/2 points from top to bottom and draw a horizontal line.
- Count X/2 points from left to right and draw a vertical line.
- If number of points is odd, draw the line through the middle point.
- Count the points in each quadrant. Do not count points on a line.
- Add the diagonally opposite quadrants. Find the smaller sum and the total of points in all quadrants.
- A = points in upper left + points in lower right B = points in upper right + points in lower left Q = the smaller of A and B
- N = A + B
- Look up the limit for N on the trend test table.
- If Q is less than the limit, the two variables are related.
- If Q is greater than or equal to the limit, the pattern could have occurred from random chance.
- Scatter Diagram Example
- The ZZ-400 manufacturing team suspects a relationship between product purity (percent purity) and the amount of dust particles (measured in parts per million or ppm). Purity and dust particles are plotted against each other as a scatter diagram, as shown in the figure below.

- There are 24 data points. Median lines are drawn so that 12 points fall on each side for both percent purity and ppm dust particles.

- To test for a relationship, they calculate:

A = points in upper left + points in lower right = 9 + 9 =18 B = points in upper right + points in lower left = 3 + 3 = 6 Q = the smaller of A and B = the smaller of 18 and 6 = 6 N = A + B = 18 + 6 = 24

Then they look up the limit for N on the trend test table. For N = 24, the limit is 6. Q is equal to the limit. Therefore, the pattern could have occurred from random chance, and no relationship is demonstrated.

Quality Tools

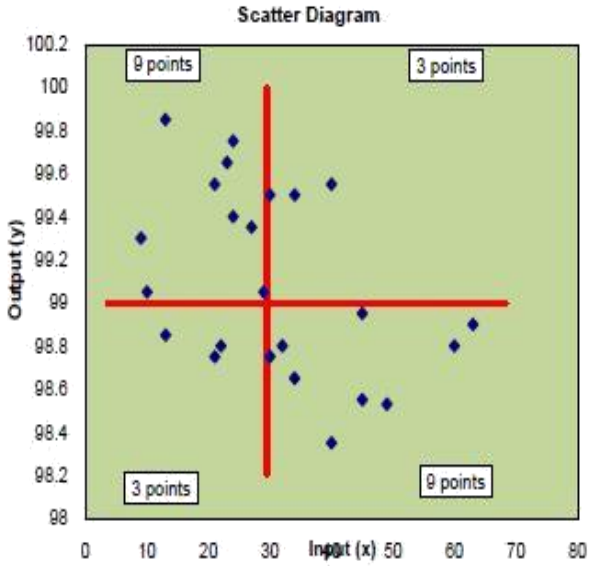
Description

This template illustrates a Scatter Diagram, also called a Scatter Plot or XY Graph. Scatter Diagrams show the relationship between an input, X and the output, Y.

Instructions

Enter up to 90 data points in the cells provided. The Scatter Diagram is displayed. The number of points in each quadrant is calculated. A test for correlation is performed using a trend table. Further information on this test can be found by following the link above.

	Results
# in 1st Q	3
# in 2nd Q	9
# in 3rd Q	3
# in 4th Q	9
A = 9 + 9	18
B = 3 + 3	6
Q = min	6
N = # pts	24
Trend test limit	6
Q < Limit?	No
Correlated?	No



	Input (x)	Output (y)		Input (x)	Output (y)		Input (x)	Output (y)		Input (x)	Output (y)		Input (x)	Output (y)
1	63	98.9	19	40	99.55	37			55			73		
2	60	98.8	20	34	99.5	38			56			74		
3	49	98.53	21	30	99.5	39			57			75		
4	40	98.35	22	24	99.75	40			58			76		
5	45	98.55	23	23	99.65	41			59			77		
6	45	98.95	24	13	98.85	42			60			78		
7	30	98.75	25			43			61			79		
8	34	98.65	26			44			62			80		
9	32	98.8	27			45			63			81		
10	21	98.75	28			46			64			82		
11	22	98.8	29			47			65			83		
12	29	99.05	30			48			66			84		
13	27	99.35	31			49			67			85		
14	13	99.85	32			50			68			86		
15	10	99.05	33			51			69			87		
16	9	99.3	34			52			70			88		
17	21	99.55	35			53			71			89		
18	24	99.4	36			54			72			90		

CHAPTER: 4

4 Costs calculation & Sustainable development in Lucky Plastic Industries:

4.1 (Using modern Quality techniques reduction in Costs to get Sustainable development):

In recent years, competitive environment of companies has been getting harder and harder. In order to have sustainable competitive advantage, companies should produce their products to entirely supply customer's needs, wants and demands. Subsequently, companies need to have more quality products to remain competitive with other companies.

To gain a competitive advantage over rivals companies, a company should produce highly quality products. While producing high quality product the company should also take into account its quality costs. As a result quality and quality costs gain vital importance for a company to survive in a highly competitive market.

The significance of this report is to comprehend the necessisity of the quality system for a company which operates in the global and local markets. Another gist of the report is to provide recognition of quality costs system benefit to the profit and brand or company name. The quality costs system cause decreasing in the production costs and increasing in the company fame which will be perceived as producing qualified products.

The aim of this report is to show the importance of the quality costs for my company which competes in a highly competitive market, and also demonstrate the necessity of quality costs system so as to have high qualified product with a low quality costs. As it is well known the quality cost is not the responsibility of a department or an individual on the contrary, every person in an organization should be responsible to quality.

Highly qualified products can be reached by the collaboration of departments in an organization. The report contributes to the literature by documenting the concepts of quality, quality costs, and the classification of quality costs and quality costs measurement.

4.1.1 Literature review:

To be able to analyze the measuring and reporting costs of quality, some concepts should be clear first. The three basic concepts of this report will be introduced. These concepts are quality and quality costs, classification of quality costs and lastly quality costs measurement

The concept of quality has been defined for many quality gurus. So there are many definitions of quality. Quality is the features of products which meet customer needs and thereby provide customer satisfaction. Quality means freedom from deficiencies (Juran & Godfrey, 1998). According to D.C Montgomery, Quality means fitness to use and also he defined quality as inversely proportional to the variability (Montgomery, 2005).

In addition to those definitions, some of other quality gurus defined quality as;

- Crosby (1979,p.7)defines quality as **"conformance to requirements"**
- Feigenbaum,s(1983,p.7)definition of quality is **"the total composite product and service characteristics of marketing , engineering, manufacturing and maintenance through which the product and service in use will meet the expectations of the customers"**
- As Ishikawa(1985,p.45) suggests, quality means **"quality of work, quality of service, quality of information, quality of process, quality of division, quality of people, including workers, engineers, managers and executives, quality of system, quality of company , quality of objectives, etc."**
- Pirsig, s definition (1984, p.206) of quality is that **"Quality is a characteristics of thought and statement that is recognized by a non thinking process. Because definitions are a product of a rigid, formal thinking, quality cannot be defined."**

To sum up those definitions, quality is the whole good and service characteristic features of fulfilment power for stated and demanded needs. In other words, many quality gurus defined quality in terms of the degree of the product's conformance to its requirements to maintain customer satisfaction and in terms of a product that is contains no defects.

Quality cost is a cost for detection and anchoring of low quality about goods and services. Simply, costs of quality are the costs which occur because poor quality may or does exist (Hansen & Mowen, 2006). Quality costs are a measurement of the costs particularly related with the accomplishment or non-accomplishment of product or service quality. To make those explanation more specific, Jack Campanella (1999, p.4) defined cost of quality as;

"More specifically, quality costs are the sum of the cost incurred by (a) investing in the prevention of non-conformances to requirements, (b) appraising a product or service for conformance to requirements, and (c) failing to meet requirements."

In the definition of Campanella, it is understood that the quality costs consists of three main parts; Prevention Costs, Appraisal Costs, Failure Costs.

The required quality activities would incur costs and quality costs are categorized into three main parts – Prevention, Appraisal and Failure Costs- Those can be also stated as PAF (**P**revention-**A**ppraisal-**F**ailure) model (Jaju & Lakhe, 2009). Failure costs should be taken into consideration as two subtopics which are called internal and external failure costs.

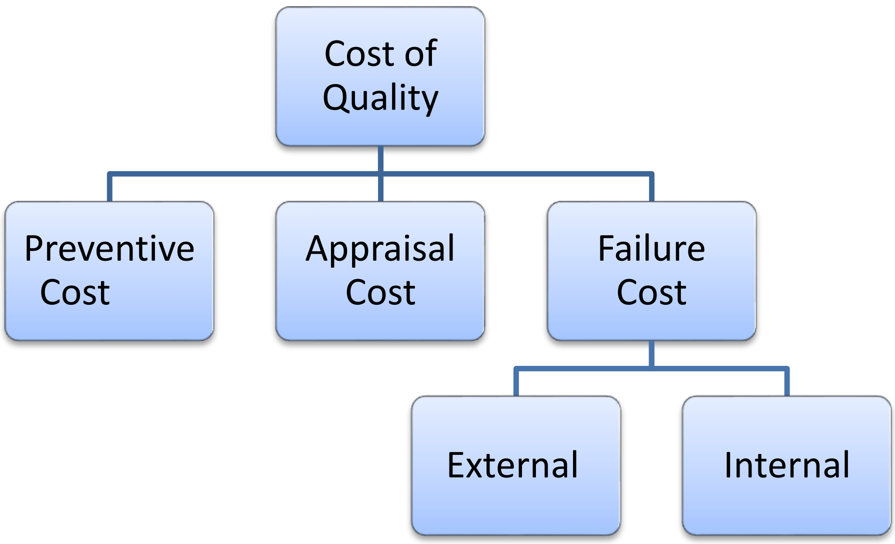


Figure 1: Classification of Cost of Quality

In figure 1, three main classifications of quality activities costs have been shown. Those costs do not occur at the same period of the production process. So it should be also classified as time period in which they occurred.

Prevention Costs are the preliminary activities costs to reach quality goals for producing goods and services and avoid deviations of those goals (Kırlıoğlu, 1998).Prevention costs are occurred to prevent low quality in the goods or services being produced (Hansen & Mowen, 2006). Prevention costs are related with quality planning, designing, implementing and managing the quality system, auditing the system, supplier surveys, and process improvements (Rodchua, 2006).

Appraisal Costs are activity costs of measuring the suitability of the product to customer's needs. It is incurred to identify non-conformance to requirements (Oliver & Qu, 1999). Those costs are related with the supplier's and customer's assessment of purchased materials, processes, intermediates, products and services to assure conformance with the specified requirements (Tsai, 1998).

Internal Failure Costs are the costs of low quality product which are realized before sales of the product. In other words, these costs arise when the outcomes of production fail to meet stated quality specifications and are noticed before transfer of those low quality products to the customers (Vahevanidis et al., 2009).

External Failure Costs are failure costs which come up after delivering the products to the customer (Kaner, 1996). Those costs take place for the reason that the products and services do not conform to specification or requirements and those products do not satisfy customer needs after being delivered to customers (Hansen & Mowen, 2006). It is also incurred by amending failures after transferring the finished goods and products to the customers (Low & Yeo, 1998).

Additionally, Quality cost classification can be grouped in time periods, for example, prevention costs encompass the stage of both pre-production and during production and appraisal costs cover the three stages of production – preproduction, production and after production stage. Failure costs are divided into two subtopics which internal failure costs and external failure costs.

Internals failure costs encompass the period of both production and after production stages. External failure costs just related with the stage of after sale (Barfield et al., 2002)

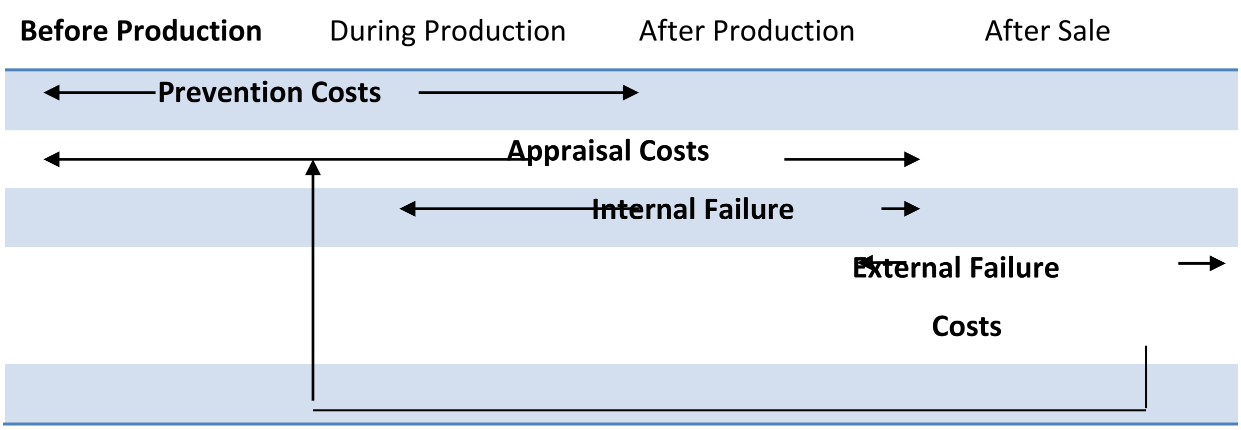


Figure2. Time-Phased Model for Quality Costs (Barfield et al., 2002)

The Cost of Quality Measuring helps to find out where unnecessary quality costs are occurred, thus management can take actions to eliminate that kind of costs and this elimination will reduce the occurrence of poor quality costs, In other saying, the quality costs measurements serves management to determine which areas of operation required preventive measures (Low & Yeo, 1998).

To Measure quality costs related data should be collected from quality activities of a company and so as I did. After collection of data which are related with quality costs components, they should be analysed before using in an action. This analysis consists of the relationship between costs component and other costs components and searches the effect of total costs.

Quality costs are analyzed in weekly, monthly, quarterly, yearly, etc. periods. Company structure should be taken into account in determining the period of analysis. In order to analyze quality costs, companies need to use some techniques. The analysis techniques for quality costs can be listed as;

- Pareto Analysis
- Ratio Analysis
- Correlation Analysis
- Regression Analysis
- Bar Graph/Pie Charts

Pareto Analysis is one of the most used techniques in cost of quality analysis. This technique was developed by Wilfred Pareto who is a nineteenth century Italian social scientist and economist. He gave his surname to the technique.Pareeto principle is universally known as the 80/20 rule. Pareto found out this principle by pinning down that 80 percent of Italy's national income is shared by 20 Percent of the Italy's population. With the help of Pareto diagrams, problems can be put in order of importance, problems of costs analysis can be easily performed and relative occurrence number could be searched simply. In other words, Pareto analysis can be utilized to recognize cost drivers which are accountable for the most of cost occurred by ranking the cost driver in order of value (Tsai, 1998).

The technique of Ratio Analysis is aimed to identify the aspects of the quality costs performance to aid decision making. Ratio analysis consist of rationing quality costs to revenue, production costs, direct labor costs and rationing total quality costs within themselves (Ozcan, 2012).

Correlation analysis represents the direction and the power of the relationship between variables. In correlation analysis, the results do not give cause-effect relationship, because there is no dependent and independent variable in this technique.
Regression analysis examines the relationship between one dependent variable and one or more than one independent variables. In other words, this technique tries to explain the changes in dependent variable with the help of independent variables.

4.1.2 Data and Methodology:

The data of this study is gathered from Lucky Plastic Industries (Pvt.) Ltd which was founded in 1990 in, Pakistan. The company is a plastic products manufacturer.

The data has been collected from accounting department. The company's accounting Manager gave the raw data of the company quality costs. I have analyzed these costs for reporting quality costs.

According to the data, I drew table 1, 2 and 3. With the help of these tables, I made a ratio and trend analysis of company's quality costs. The data consists three years which are 2010, 2011, 2012. In the study trend and ratio analysis have been performed for measuring and reporting the firm quality costs.
Analysis of Quality costs in the firm. The table below displays the company's sales and production amount Pakistani Rupee (here after PKR). The sales and production amount have been given for three years. Additionally, the table contains of total quality costs in the firm for three years.

Data	Years		
Total sales (PKR)	629,053.415	695,866.750	786,859.486
Total Production costs (PKR)	515,326.274	563,708.245	643,590.468
Total Quality Costs(PKR)	10,028.516	11,712.822	12,64.655
The Ratio of Quality Costs to sales	1.59%	1.68%	1.61%
The Ratio of QC to Production Costs	1.95 %	2.08%	1.96%

Table1. Some Ratios and Ratio Components in the Firm

According to the firm information, the ratios of total quality costs to total sales have been calculated for given three years. And the ratios of total quality costs to total production costs have also been calculated .In the aspect of the information in the previous sections, these calculations have been performed as follows.

In 2010, the company's total sales are 629,053.415 PKR. In the same years, the total quality costs are 10,028.516 PKR. So the ratio of total quality costs to sales can be found out as follows

$$\frac{\mathbf{10,028.52}}{\mathbf{629,053.42}} \quad 1.59\%$$

It can be concluded that the amount of total quality costs is only 1.59 % of the total sales in 2010

$$\frac{\mathbf{10,028.52}}{\mathbf{515,326.27}} \quad 1.95\%$$

The calculation above demonstrates that the ratio of total quality costs to total production cost is about 1.95 %. For the years 2011 and 2012, total quality costs to sales and total quality costs to total production have been calculated by the same way and written down in the figure above.

This ratio is not too much for an early stage of quality costs analysis applier's company.

In other words, the firm analyses its quality costs not long ago, so the rates is in the acceptable limits. Besides this ratios can be reduced for more efficient quality costs system.

When analyzing quality costs components, it will be useful for monitoring quality costs. Regarding this classification, quality costs components will be given as costs items. With the help of this costs items, the percentage amounts of each costs item will be also calculated and given for the years.

Components of Quality costs	Costs (PKR)	Ratio (%)
Prevention Costs	1,782.614,36	14.1
Quality Planning	518.348,86	4.1
Quality Circle	75.855,93	0.6
The training of Quality	202.282,48	1.6
Inspection and Testing Instruction	113.783,90	0.9
Suppliers Quality Planning	214.925,14	1.7
Preventive Maintenance	480.420,89	3.8
Other Preventive Costs	176.997,17	1.4
Appraisal Costs	5031.776,69	39.8
Inspection and tests of Purchased materials	1036.697,71	8.2
Control, maintenance and calibration of measurement instruments	101.141,24	0.8
Process inspection and tests	1150.481,61	9.1
Consumable materials for laboratory and tests	581.562,13	4.6
Products inspection and tests	1984.896,84	15.7
Other appraisal costs	176.997,17	1.4
Internal failure costs	4450.214,56	35.2
Salvage	2225.107,28	17.6
Reproduction and Rework	1656.187,81	13.1
Re-inspection	480.420,89	3.8
Corrective actions	88.498,59	0.7
External Failure Costs	1378.049,40	10.9
Product Returns	998.769,75	7.9
Transportation damage	50570,62	0.4
Warranty costs	328709,03	2.6
Total Quality Costs	12642.655	100.0

Table 2. Total Quality costs as each cost items for the components in the year of 2012

In the Table 2, the non-conformance costs are under the half of the total quality costs. This demonstrates that the firm is going in the right way. The company gives more importance for conformance costs day by day, so the non-conformance costs decreases naturally. These changes will benefit the company in more ways than one. The figure below should be reported to the managers for monitoring quality costs activities by management. The importance of quality costs increases day by day.

The next table shows the total costs as categorization groups. As it is mentioned before, the quality costs have two components which are conformance and non-conformance costs. And these components costs are given in the chart. Moreover, conformance costs are divided into two cost elements that are prevention costs and appraisal costs. The amounts of these costs are also given yearly in the table. The conformance costs are increasing for the given years. It rose up two times from the amount of 2010 to 2012 amount. It is good for a company to increase its prevention activities in order not to confront defects after selling the products out. Besides, the amount of prevention costs in conformance costs is too small. The firm should concentrate more on prevention costs.

Cost of Quality	2010	2011	2012
Conformance Cost	3098.811,45	5177.067,33	6814.391,05
Preventive Costs	631.796,51	1147.856,56	1782.614,36
Appraisal Costs	2467.014,94	4029.210,77	5031.776,69
Non-Conformance Costs	6929.704,56	6535.754,67	5828.263,96
Internal Failure Costs	4693.345,49	4767.118,55	4450.214,56
External Failure Costs	2236.359,07	1768.636,12	1378.049,40
Total Quality Costs	10028.516	11712.822	12.64.655

Table 3. The Amount of Quality Costs in Classification through Years

On the other hand, in the table above, the non-conformance costs have been shown in two parts which are internal and external failure costs. The company has endured too much internal failure costs. And the company should increase its preventive activities and decrease the internal failure costs. When it comes to external failure costs are going down for each given year.

With the help of Table 3, it can be seen that conformance costs-prevention and appraisal costs- are increasing for each year. Additionally, non-conformance costs –internal and external failure costs- are decreasing for each year. It also shows that the huge amounts of total quality costs are occurred after production stage. The internal failure costs are the biggest costs in the total quality costs for every year. This situation represents that the defects are realized after the stage of production.

Cost of Quality (%)	Year		
	2010	2011	2012
Preventive Cost	6.3	9.8	14.1
Appraisal Cost	24.6	34.4	39.79
Internal Failure Cost	46.7	40.69	35.19
External Failure Cost	22.3	15.09	10.9

Table 4. The Cost of Quality Categorization in percentage

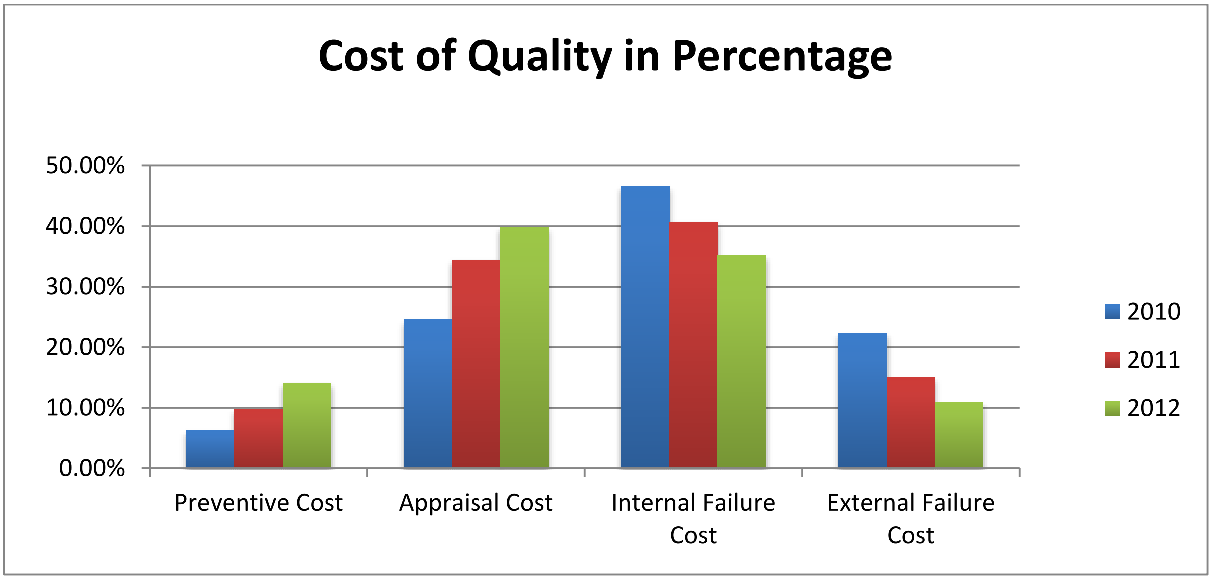


Figure 3: Cost of Quality in percentages (2010, 2011, 2012)

In general, the movements of quality costs component are in a right way, even though the non-conformance costs are more than conformance costs are more than conformance costs. In the chart it can be seen that the amount of prevention costs is under the 15 % of the total quality costs which means the firm do not pay enough importance for the prevention activities. Although the trend of external failure costs is declining, the external failure costs have too much portion of total quality costs. Having too many external failures costs brings more costs than the firm can measure.

4.1.3 The Application Results:

The quality costs activities in Lucky Plastic Industries are concentrated in non-conformance activities. In other words, the firm is highly interested in internal and external costs. So, non-conformance costs are monthly reported to management. Besides, the firm does not give required importance for prevention and appraisal costs measurement, Therefore, conformance costs are just reported yearly period, even though firm is giving more importance to conformance costs than before.

On the other hand, while paying the non-conformance costs more importance than the conformance costs in the firm, the company endures more costs than it can measure. That is to say, the firm can bear the quality costs more than in numbers; there may be a non-visual negative effect on the firm. For instance, the firm may confront the loss of customers, bad brand recognition and poor employee motivation and so on. Furthermore, the efficient quality system causes benefit the company in more way than one. It decreases the non-conformance costs and increases profitability of the firm. The firm would have sustainable competitive advantage in the market.

It is found out that the company cannot measure its quality costs adequately, for this reasons quality reporting system in the company is not efficient. The company needs to give more importance to the quality costs measuring and reporting activities.

4.1.4 After report, Corrective actions taken, Complete working Details:

In order to further improve the situation we started focusing on internal Failure cost and the main culprit selected was Re-work and Re-Production. The main reason were studied, .i.e. why we are reproducing. Following points were highlighted by the concerned department heads from Mechanical, Electrical, production and Quality.

- Due to frequent load shedding the machine stopped time to time, increasing scrap quantity by Production Manager.
- We do not have auto change over switch for generator which creating above cited problems by Manager Electrical.
- Production department most of the time show a cold shoulder to QC inspector in case of problem highlighting. Which leads to rejection in final inspection by Manager QC?

- We don’t have spares for machine and we are compelled to do all the time repair work by Manager Maintenance.
- When Machine is stopped for maintenance it takes 6 to 8 hrs for reheating also the generation of scrap quantity and downgraded product is increased by Manager Production.
- QC inspector rejects excessive material however in my opinion they reject ok product and mark them faulty by Manager Quality.
- The change of additives and raw material time to time is hurdle in consistent product and main reason for rejection by Manager Production.
- When Maintenance / Electrical department is asked for some problem their response is very lazy in nature they should response quickly to the situation by Manager Production
- The major portion of internal rejection of finished goods is due to contamination in form of wooden pieces in the sheet originating from wooden pellets Manager Quality
- The raw material placed in an uncovered area and bags get highly contaminated by Manager Quality
- The slitting Machine require complete maintenance oil leakages is a cause of rejection/scrap

These 8 points were when discussed with Factory Owner and Director by Plant Manager. He called a meeting. All the department heads were there. The tasks were given to each department head and a time frame was given for next meeting with improved and controlled situation. The appraisal and Preventive budget of the company has to be increased in order to remove such non-conformities.

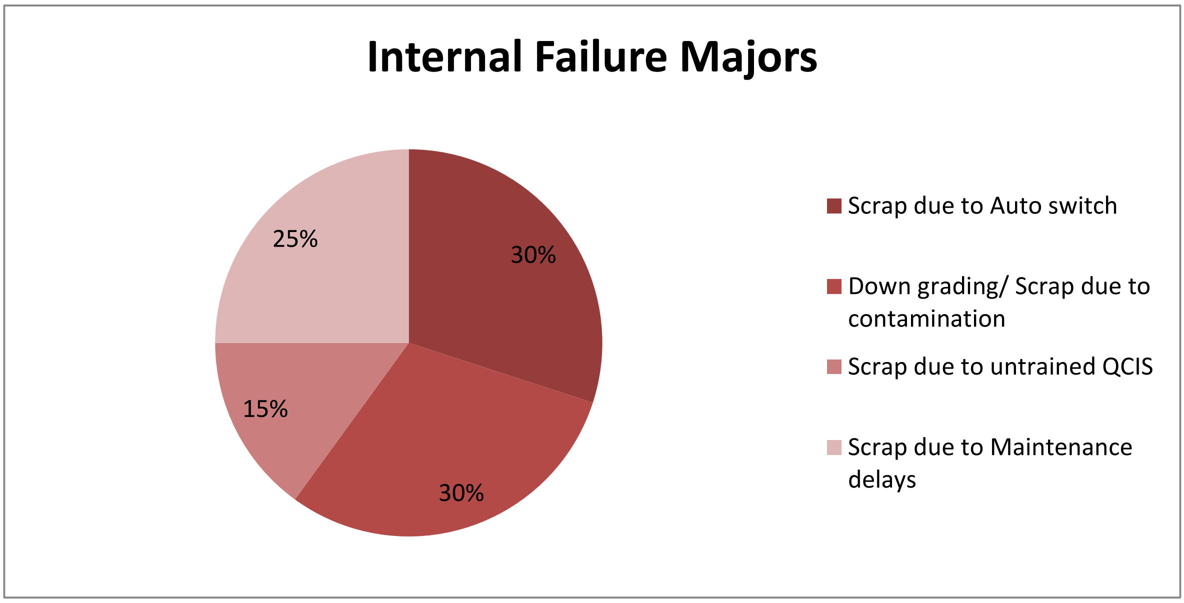


Figure 4. Major Internal Failures

Steps Taken

- A stock level for critical spares was defined and orders were placed.
- A list of approved suppliers was reviewed and re-assessment was made.
- Auto change over switch was installed.
- Quality Inspector was re-trained and tolerance levels were re-defined.
- Work order form was amended and a column of problem notifying and correction time was included.
- Production Manager taken strict action against those who are non cooperative with quality personnel.
- The problem of wooden pieces in the sheet was taken into account and wooden pellets were replaced with Plastic Pellets.
- A Separate place for raw material storage was allocated properly covered and ventilated to avoid foreign contamination from raw materials and additives.

After effects of such actions

- Machine stoppages were reduced drastically after replacing faulty parts.
- When purchases were made from approved and authentic resources for additives and raw material suppliers the rejection rate were reduced during and before delivery.
- After defining tolerance level for quality control the rejection rate also reduced.
- The Factory Owner and Director raised preventive and appraisal costs.
- The internal Failure reduced to 27 %.

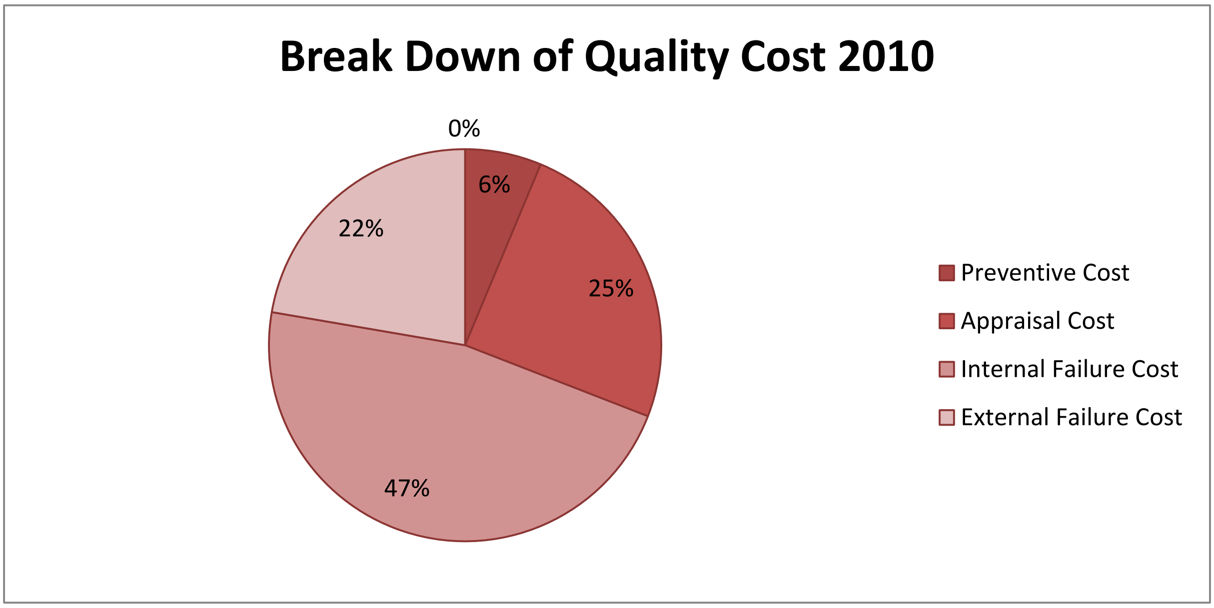
Then a raw data was again collected from accounting department for year 2013

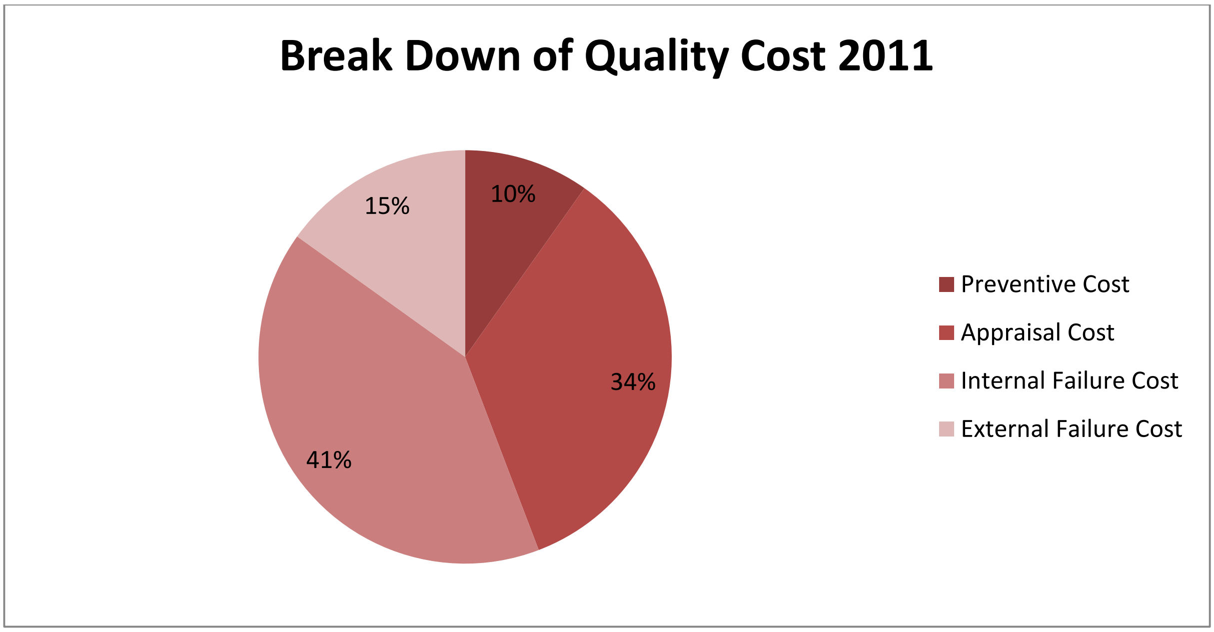
Cost of Quality(PKR)	Year			
	2010	**2011**	**2012**	**2013**
Preventive Cost	63179651	114785656	178261436	196230193
Appraisal Cost	246701494	402921077	503177669	500023456
Internal Failure Cost	469334549	476711855	445021456	308967543
External Failure Cost	223635907	176863612	137804940	100012314
Total COQ	**1002851601**	**1171282200**	**126465501**	**1105233506**

Table 5. The Cost of Quality Categorization in PKR

Cost of Quality (%)	Year			
	2010	2011	2012	2013
Preventive Cost	6.3	9.8	14.1	17.75
Appraisal Cost	24.6	34.4	39.79	45.24
Internal Failure Cost	46.7	40.69	35.19	27.95
External Failure Cost	22.3	15.09	10.9	9.04

Table 6. The Cost of Quality Categorization in percentage





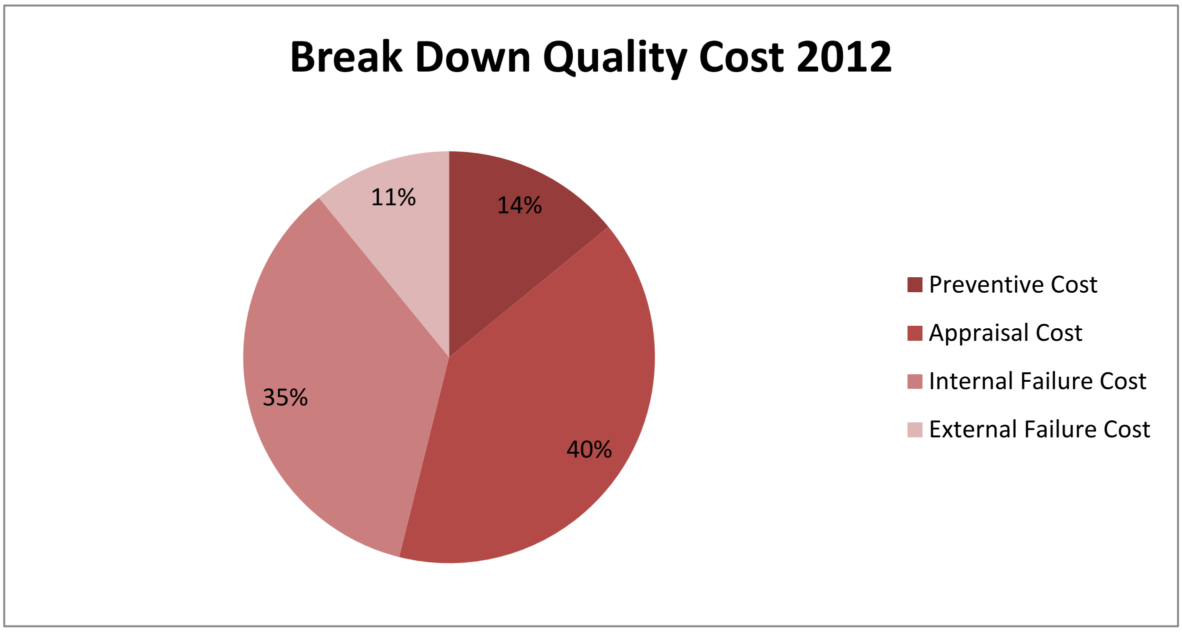


Figure 5, 6, 7. Cost of Quality Break Downs (2010, 2011, 2012)

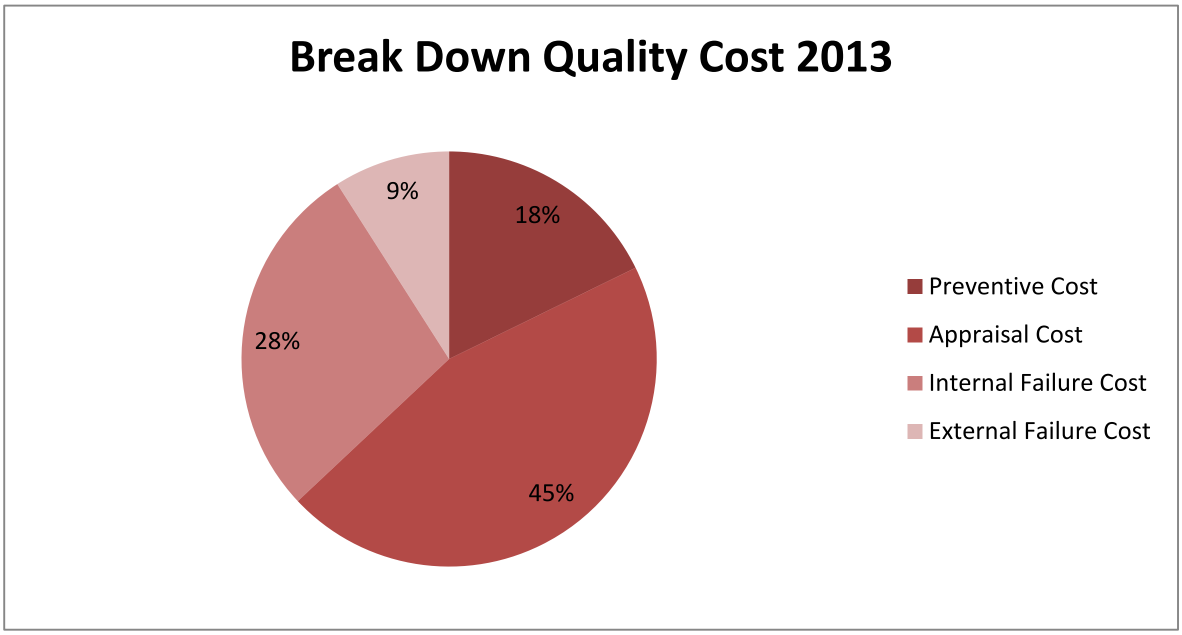


Figure 8. Cost of Quality Break down in (2013)

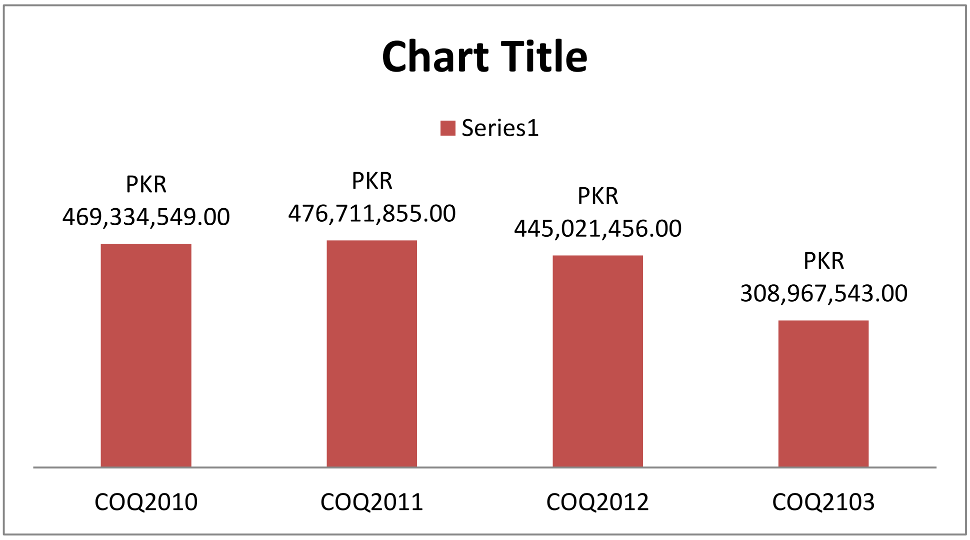


Figure 9. Cost of Internal Failures in 4 years

Chapter: 5

5 Project Result

For Process quality improvement Lucky Plastics implemented the Quality tools, management techniques and targeted the following results:

5.1 IMPROVED PRODUCT QUALITY:

Lucky plastics have improved product quality by reducing the variation in the output of the process. By identifying the sources of variability which goes into the manufacturing of the product, and using SPC to analyse their impact, identifying problems, and monitoring the results the company has improved and achieve positive steps towards the quality goals.

5.2 REDUCTION IN SCRAP AND REWORK:

Scrap and rework cost consists not only of loss of labour and material, but the unexpected organizational cost on managing and handling these scrapped parts. Since SPC analysis provided trends of company's process capabilities the data has been taken to correct process problems before scrap is generated.

5.3 INCREASE IN MANUFACTURING YIELD:

Fewer scrapped parts mean a higher yield for the investment in materials and equipment. It helped the company with more productive workforce.

5.4 MEETING CUSTOMER REQUIRMENTS:

Customers want to see evidence that company's process is capable of producing parts that meet their requirements. In the process industries, the customers specifically ask for evidence that your organization can use SPC for the monitoring and measurement of your process quality. Implementing SPC helped satisfying the customers while improving the product.

6 Conclusion:

The main purpose of the project was to analyse and eradicate the causes that affect product quality, quality of the process and results in customer complains. The Factors were deeply studied and analysed through SPC tools and we effectively went through these tools to find out where the company is standing. The results show that the company has improved considerably by applying these tools. We divided company's problems and complain in 4 quarters and each quarter was studied, corrective actions have been taken by the company and finally the company reached at a point where its rework or rejection reduced to a minimum level. In conclusion the SPC tools has improved the product and process quality of Lucky plastics and the company is determined in keeping the quality at its best by using these tools.

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