GAZİANTEP UNIVERSITY GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES

REDUCING SCRAP BY USING STATİSTİCAL QUALİTY CONTROL TECHNIQUES: A CASE STUDY ON SYNTHETİC SACK PRODUCTİON PLANT

M. Sc. THESIS
IN
MECHANICAL ENGINEERING

BY
LUTFULLAH KAYADELEN
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GAZİANTEP ÜNİVERSİTESİ
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İSTATİSTİKSEL KALİTE KONTROL TEKNİKLERİNİN UYGULANMASI İLE FİRE AZALTILMASI: ÇUVAL FABRİKASINDA ÖRNEK BİR ÇALIŞMA

MAKİNA MÜHENDİSLİĞİ
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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science/Doctor of Philosophy.

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Tezin Adı: İstatistiksel Kalite Kontrol Tekniklerinin Uygulanması ile Fire Azaltılması: Çuval Fabrikasında Örnek bir Çalışma

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ABSTRACT

REDUCING SCRAP BY USING STATISTICAL QUALITY CONTROL TECHNIQUES: A CASE STUDY ON SYNTHETIC SACK PRODUCTION PLANT

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M. Sc in Mechanical Engineering
Supervisor: Asst. Prof. Dr. Abdullah AKPOLAT

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The work described in this thesis investigated how to implement statistical quality control (SQC) tools for the purpose of minimizing scrap in poly-propilen (PP) bag (sack) production systems. The study, provides a better understanding of usage of statistical techniques for decreasing scrap loss in production line. A historical data from the subprocesses collected and SQC problem solving tools was carried out on it.

A production process composed of subprocesses is a common phenomenon in industry. Each of the subprocesses contributes to various aspects of product quality. Ideally, a control chart can be set up on every subprocess to guarantee the quality of the final product. This is not practical, because of limited human and economic resources, and the management has to decide which subprocesses are to be given higher priorities. Priority determination methods have to be defined in each organization. Recently, it has been suggested that SQC techniques should be used for priorization to reach organizations' objectives and competitiveness through market by ISO 9001:2000 Quality Management System standard and 6 Sigma Excellence Model. Implementation of such systems requires knowledge of basic statistical methods. In this thesis, it was implemented the priorization tools on PP bag production company as suggested above standard and model to reduce scrap loss. Scrap loss decreased 35 % in factory at the end of these implementations.

Keywords: Statistical quality control, scrap, sources of scrap, production.

ÖZET

İSTATİSTİKSEL KALİTE KONTROL TEKNİKLERİNİN UYGULANMASI İLE FİRE AZALTILMASI: ÇUVAL FABRİKASINDA ÖRNEK BİR ÇALIŞMA

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Yapılmış olan bu çalışma bir poli-propilen (PP) çuval(torba) üretim tesisinde firelerin azaltılması amacı ile istatistiksel kalite kontrol (İKK) araçlarının nasıl uygulanabileceğini araştırdı. Bu çalışma üretim hattında firelerin azaltılması için istatistiksel tekniklerin kullanımının daha iyi anlaşılmasını sağlar.Alt proseslerden geçmişe ait veriler toplandı ve İKK problem çözme araçları bu verilerin üzerinde uygulandı.

Üretim prosesi endüstrinin doğası gereği alt proseslerden oluşur. Her alt proses ürün kalitesini değişik yönlerden etkiler. İdealde,son ürün kalitesini garanti altına alabilmek için her alt prosese bir kontrol tablosu uygulanabilir. Bu pratik olmayan,bununla birlikte,zaten sınırlı olan insan ve ekonomik kaynaklar nedeni ile yönetim alt proseslerin hangisinin daha yüksek önceliğe sahip olacağına karar vermelidir. Her kuruluş önceliklendirme belirleme metodlarını tanımlamalıdır.Son zamanlarda, kuruluşların hedeflerine ulaşması ve pazardaki rekabet edebilirliklerini sürdürebilmeleri için önceliklendirme amaçlı İPK tekniklerinin kullanımı ISO 9001:2000 Kalite Yönetim Sistemi standardı ve 6σ Mükemmellik Modeli tarafından önerilmektedir. Bu tür sistemlerin uygulanması temel istatistiksel metodların bilinmesini gerektirir. Bu tezde, yukarıda belirtilen model ve standardın öngördüğü önceliklendirme araçları bir çuval fabrikası için fire azaltılması amacı ile uygulandı. Bu uygulamaların sonunda fabrika fire miktarı % 35 düşmüştür.

Anahtar Kelimeler: İstatistiksel kalite kontrol, fire, fire nedenleri, üretim.

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CHAPTER 1

INTRODUCTION

Quality is generally defined as the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs [1]. In an other word, “quality” means freedom from deficiencies—freedom from errors that require doing work over again (rework) or that result in field failures, customer dissatisfaction, customer claims, and so on [2]. Improved features and characteristics of a product or service enables increase customer satisfaction, make products salable, meet competition, increase market share, provide sales income, secure premium prices, the major effect is on sales and usually higher quality costs more. Secondly, freedom from deficiencies leads to companies reduce error rates, reduce rework, waste, scrap, reduce field failures, warranty charges, reduce customer dissatisfaction, reduce inspection, test, shorten time to put new products on the market Increase yields, capacity, improve delivery performance, major effect is on costs and usually, higher quality costs less.

The ability to meet the customer requirements is vital, not only between two separate organizations, but within the same organization. For industrial and commercial organizations, which are viable only if they provide satisfaction to the consumer, competitiveness in quality is not only central to profitability, but crucial to business survival. The consumer should not be required to make a choice between price and quality, and for manufacturing or service organizations to continue to exist they must learn how to manage quality. In today’s tough and challenging business environment, the development and implementation of a comprehensive quality management is not merely desirable – it is essential. As a result the idea and view of manufacturer has been changed dramatically. Today, not only the quality of end product is in focus but also stages of all manufacturing processes is underlined its importance. Since it is observed that the most economical way to get the required features are both quality deployment to all stages and follows to standards. In the organizations, quality and cost are two subjects always evaluated together. Quality requires continual improvements and efforts which are endless forever. To improve product quality, statistical quality control (SQC) techniques have been widely used in industry. SQC is generally described as the control of product quality by statistical methods. Various techniques developed by mathematical statisticians for the analysis of data may be used in the control of product quality. When implementing SQC in a new environment, however, a few practical problems will be encountered. In practice, most products are produced through a series of processes, each of which contributes to the product quality. It would be ideal if an SQC system could be set up for each process to ensure smooth running of the production line and the final quality of the product. Nevertheless, this is almost impossible, as usually there are many processes to be considered, and manpower and economic resources are too limited for a comprehensive coverage.

The aim of this thesis is to handle scrap loss reduction to enforce relationship between university and industry. It is to prioritize all processes involved according to their importance with respect to the quality of the final product and their present status in terms of SQC criteria. The priority list can serve as a guide for management to allocate the limited resources [3]. Since the prioritization procedure usually involves hundreds of processes and conflicting decision-making attributes, the Statistical Quality Tools are applied as a framework to develop meaningful measures of priority of processes, reflecting both the statistical and technical concerns in the build-up of SQC systems.

This thesis will be organized as follows. Chapter 2 reviews the basic methodology of quality and its standards and models like ISO 9001:2000 standard and 6σ Excellence Model. Finally, the quality development for processes is summarized.

Chapter 3 introduces the main definitions of quality tools as histogram, Pareto analysis, cause and effect analysis and scatter diagrams.

Chapter 4, presents the collected historical data from the subprocess of PP bag production company for the purpose of minimizing scrap and in the second part of this chapter illustrates these data for implementing statistical quality control (SQC) schemes.

Finally, chapter 5 summarizes conclusions from this study and presents the future work.

CHAPTER 2

WHAT IS QUALITY?

2.1 Introduction

This chapter will provide a brief overview of the quality movement and a summary of the basic concepts of total quality management. Second section of this chapter describes resources the quality, which deals with application of TQM in the manufacturing and service industries; and ISO 9001:2000 which is for those individuals interested in sharing information and 6σ excellence model.

2.2 History of Quality Development

Product quality is needed now as never before. Poor quality, especially in a world of globalization, equates to costs of nonconformance in the area of billions of dollars and, most importantly, oftentimes costs human life.

The quality movement can trace its roots back to medieval Europe, where craftsmen began organizing into unions called guilds in the late 13th century [4]. These guilds were responsible for developing strict rules for product and service quality. Inspection committees enforced the rules by marking flawless goods with a special mark or symbol [5].

Until the early 19th century, manufacturing in the industrialized world tended to follow this craftsmanship model. The factory system, with its emphasis on product inspection, started in Great Britain in the mid-1750s and grew into the Industrial evolution in the early 1800s.

In the early 20th century, manufacturers began to include quality processes in quality practices. The modern quality movement has its roots in both Britain and America. British statisticians contributed seminal work which led to the development of techniques for statistical quality control; while the applied work of Walter A. Shewhart in 1924 (a physicist in the inspection department at Western Electric Company) was America's contribution. Shewhart suggested that better quality could be achieved at a lower cost if one moved from a system of inspecting products for defects, and instead looked at production processes [6]. Monitoring and improving these processes would result in elimination of defects at the source, and thus result in lower costs. Shewhart's ideas played a direct role in the 1935 publication of the first British Standards Institute standard on quality control. Despite some heightened concern with industrial quality during World War II and the development of military procurement standards (the beginnings of ISO 9000) in both Great Britain and the United States, the next real marker on the road to quality didn't occur until 1950 [6]. In that year Armand V. Feigenbaum (who worked at General Electric) studied on total quality control, W. Edwards Deming began working with the Japanese on quality improvement and developing his ideas on statistical process control, and in 1951 Joseph Juran. At this point, the key ideas of quality management- continual improvement, management responsibility, statistical controls, and organization-wide investment in quality- were all in place. However, while these ideas took root and flourished in Japan, they were largely unknown in the rest of the industrialized world. British industry failed to develop a widespread interest in quality until the 1980s, although there was some activity over the years.

Quality circles were tried beginning in the mid1970s as a means of suggestions for improving quality and responding to competition from the Japanese [7]. While extremely popular, quality circles were ultimately not particularly successful, for a number of reasons. However, the concepts of employee empowerment and teamwork introduced by quality circles were crucial in setting the stage for TQM. The widespread use of quality circles, the dawning understanding of the immense importance of customer satisfaction, and the sense of urgency centering around quality problems and economic competition gave TQM the opening it finally needed in the 1980s to break through in the western world. Shortly thereafter, Americans "discovered" the other three management experts who had so much to do with the development of total quality management: W. Edwards Deming who by this time had developed a fourteen-point approach to improving quality (emphasizing a need to change organizational culture and making extensive use of statistical measures of quality), Joseph Juran and his ten-point approach to quality management (with a focus on reducing the cost of quality), and Armand Feigenbaum (with an emphasis on longterm commitment to quality as a way of managing an organization). Since the early 1980s the terms total quality management (TQM), total quality control, quality assurance, and continual quality improvement all have been used more or less interchangeably. These terms describe a management style aimed at improving the performance of an organization and meeting customer expectations through continual analysis and refinement of its processes for producing goods or services. The pursuit of product quality requires that an organization create a quality framework. The ISO 9001:2000 quality management system (QMS) is an internationally established quality framework.

By the last decade of the 20th century, TQM was considered a fad by many business leaders. But while the use of the term TQM has faded somewhat, particularly in the United States, its practices continue. In the few years since the turn of the century, the quality movement seems to have matured beyond Total Quality. New quality systems have evolved from the foundations of Deming, Juran and the early Japanese practitioners of quality, and quality has moved beyond manufacturing into service, healthcare, education and government sectors.

Today, the area of quality control has been broadened to Total Quality Management (TQM). TQM is presented as a philosophy with a wide range of techniques that cover activities on all company levels. In leading companies attention is now moving to subjects like environment, innovation and reuse. These companies, especially small and medium enterprises (SME), do not manage to apply SPC techniques successfully. In some cases applying such a technique does not lead to an improvement of the technical performance. In other cases the activities leading to a better technical performance also lead to a reduced financial performance.

Lack of confidence in potential benefits often even prevents companies from trying to implement SPC techniques.Often factors such as lack of management commitment and training, are said to be the reason for a failing implementation. [8]

2.3. Meaning of Quality

This section deals with the fundamental concepts that underlie the subject of managing for quality. It defines key terms and makes critical distinctions. It identifies the key processes through which quality is managed. It demonstrates that while managing for quality is a timeless concept, it has undergone frequent revolution in response to the endless procession of changes and crises faced by human societies.

Quality in a World of Globalization is needed now as never before. Poor quality, especially in a world of globalization, equates to costs of nonconformance in the area of billions of dollars and, most importantly, oftentimes costs human life. The main issue is quality evaluation, because quality is vital to the organization survival and growth. Therefore one needs to systematically study a process variability to assure its quality. The only way of doing it is by using statistical methods. [9]

The Meanings of "Quality**"** of the many meanings of the word "quality," two are of critical importance to managing for quality:

1. "Quality" means those features of products which meet customer needs and thereby provide customer satisfaction [10]. In this sense, the meaning of quality is oriented to income. The purpose of such higher quality is to provide greater customer satisfaction and, one hopes, to increase income. However, providing more and/or better quality features usually requires an investment and hence usually involves increases in costs. Higher quality in this sense usually "costs more."

2. "Quality" means freedom from deficiencies—freedom from errors that require doing work over again (rework) or that result in field failures, customer dissatisfaction, customer claims, and so on [10]. In this sense, the meaning of quality is oriented to costs, and higher quality usually "costs less."

The definitions of "quality" include certain key words that themselves require definition.

- Product*:* The output of any process. To many economists, products include both goods and services. However, under popular usage, "product" often means goods only.
- Product feature*:* A property possessed by goods or services that is intended to meet customer needs.
- Customer*:* Anyone who is affected by the product or by the process used to produce the product. Customers may be external or internal.
- Customer satisfaction*:* A state of affairs in which customers feel that their expectations have been met by the product features.
- Deficiency*:* Any fault (defect or error) that impairs a product's fitness for use. Deficiencies take such forms as office errors, factory scrap, power outages, failures to meet delivery dates, and inoperable goods.
- Customer dissatisfaction*:* A state of affairs in which deficiencies (in goods or services) result in customer annoyance, complaints, claims, and so on.

2.4 ISO 9001:2000 Quality Management System

To attain quality, it is well to begin by establishing the "vision" for the organization, along with policies and goals. Managing for quality makes extensive use of three such managerial processes [11]:

- Quality planning
- Quality control
- Quality improvement.

Table 2.1 shows that each of these three managerial processes has its own unique sequence of activities. Each of the three processes is also a universal—it follows an unvarying sequence of steps. Each sequence is applicable in its respective area, no matter what is the industry, function, culture, or whatever.

These three processes is vital for continual quality management which consists of a logical sequence of four repetitive steps for continuous improvement and learning: Plan, Do, Study (Check) and Act. [3]. This is known as the Deming cycle, or PDSA cycle. The association of ISO 9001:2000 requirements [10] with the PDCA cycle is possible.

Table 2.1 The three universal processes of managing for quality

Quality planning

- Establish Quality Goals
- Identify who the customers are
- Determine the needs of the customers
- Develop product features that respond to customers' needs
- Develop processes able to produce the product features
- Establish process controls; transfer the plans to the operating forces

Quality control

- Evaluate actual performance
- Compare actual performance with quality goals
- Act on the difference

Quality improvement

- Prove the need
- Establish the infrastructure
- Identify the improvement projects
- Establish project teams
- Provide the teams with resources, training, and motivation to:
    - Diagnose the causes
    - Stimulate remedies
    - Establish controls to hold the gains

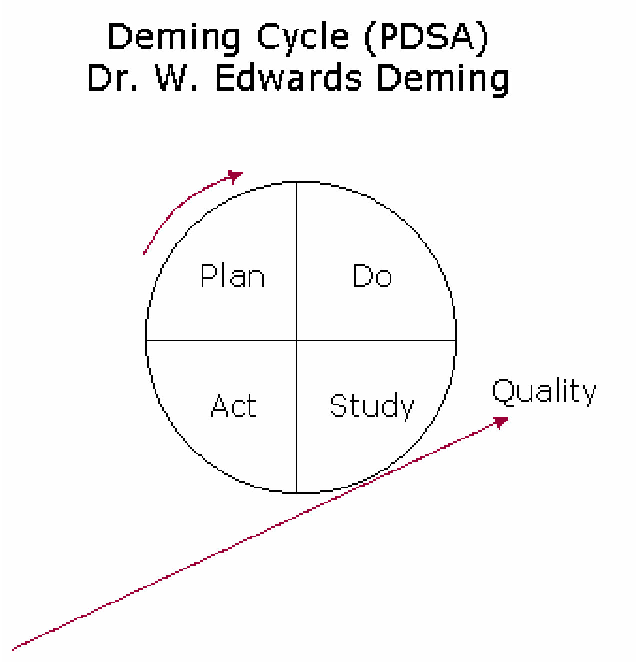

Figure 2.1 Deming Cycle

The definition of steps in this cycle:

- PLAN: plan ahead for change. Analyze and predict the results.
- DO: execute the plan, taking small steps in controlled circumstances.
- STUDY: CHECK, study the results.
- ACT: take action to standardize or improve the process.

The Deming Cycle is one of the methodologies used in international standartds. The requirements of international standard ISO 9001:2000 can be condensed into five linked requirements. ISO 9001:2000 basically requires the organization to:

1 Determine the needs and expectations of customers and other interested parties.(PLAN)

2 Establish policies, objectives and a work environment necessary to motivate the organization to satisfy these needs.(PLAN)

3 Design, resource and manage a system of interconnected processes necessary to implement the policy and attain the objectives.(DO)

4 Measure and analyse the adequacy, efficiency and effectiveness of each process in fulfilling its purpose and objectives. (CONTROL)

5 Pursue the continual improvement of the system from an objective evaluation of its performance.(ACT)

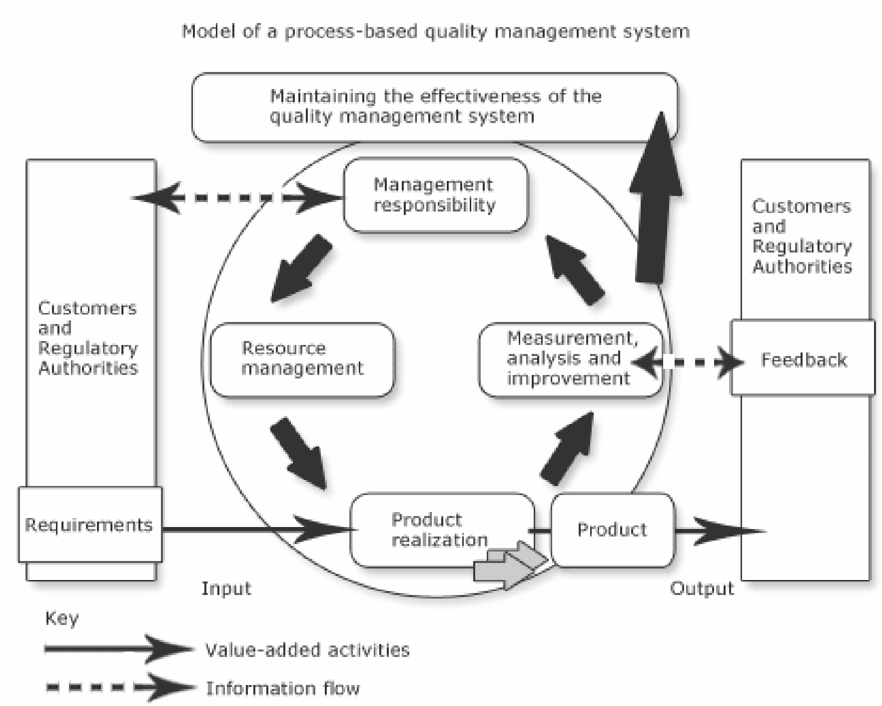

Figure 2.2 Model of process-based quality management system [10]

Secondly, ISO 9001:2000 clause number 8.4 (analysis of data) is mainly related to this forth requirement of standard. This clause requires you to plan how you will measure and monitor systems, processes and products. It also refers to the statistical techniques you may use in measurement and monitoring. The Clause 8.4 is briefly stated as: "Analysis of data is an important aspect of the system. It requires all the information from the measurement section to be brought together with a view to effecting improvement". The related clauses of standard are stated as follows:

1. General (Clause 8.1)

The organization shall plan and implement the monitoring, measurement, analysis and improvement processes needed.

a) to demonstrate conformity of the product,

b) to ensure conformity of the quality management system, and

c) to continually improve the effectiveness of the quality management system,

This shall include determination of applicable methods, including statistical techniques, and the extent of their use.

2. Monitoring and measurement of processes (Clause 8.2.3)

The organization shall apply suitable methods for monitoring and, where applicable, measurement of the quality management system processes. These methods shall demonstrate the ability of the processes to achieve planned results. When planned results are not achieved, correction and corrective action shall be taken, as appropriate, to ensure conformity of the product.

3. Monitoring and measurement of product (Clause 8.2.4)

The organization shall monitor and measure the characteristics of the product to verify that product requirements have been met. This shall be carried out at appropriate stages of the product realization process in accordance with the planned arrangements

Evidence of conformity with the acceptance criteria shall be maintained. Records shall indicate the persons) authorizing release of product

Product release and service delivery shall not proceed until the planned arrangements have been satisfactorily completed, unless otherwise approved by a relevant authority and, where applicable, by the customer.

4. Analysis of data (Clause 8.4)

The organization shall determine, collect and analyse appropriate data to demonstrate the suitability and effectiveness of the quality management system and to evaluate where continual improvement of the effectiveness of the quality management system can be made. This shall include data generated as a result of monitoring and measurement and from other relevant sources.

The analysis of data shall provide information relating to

a) customer satisfaction,

b) conformity of product requirements,

e) characteristics and trends of processes and products including opportunities for preventive action, and

d) suppliers.

At the same time, ISO 9001:2000 based on eight quality management principles, which, if applied effectively, lead to the satisfaction of all interested parties. This is a fundamental change from preventing failure to causing success. The explanations of eight quality management principles are:

- Principle 1 Customer focus

  Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.

- Principle 2 Leadership

  Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

- Principle 3 Involvement of people

  People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

- Principle 4 Process approach

  A desired result is achieved more efficiently when activities and related resources are managed as a process.

- Principle 5 System approach to management

  Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.

- Principle 6 Continual improvement

  Continual improvement of the organization's overall performance should be a permanent objective of the organization.

- Principle 7 Factual approach to decision making

  Effective decisions are based on the analysis of data and information

- Principle 8 Mutually beneficial supplier relationships

An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

These eight principles are the sole of ISO 9001:2000 standard. Seventh principle is based on clause number 8.4 (analysis of data) of standard.The key benefits for Principle 8 are as follows [12]:

First principle key benefits are

- Increased revenue and market share obtained through flexible and fast responses to market opportunities.
- Increased effectiveness in the use of the organization's resources to enhance customer satisfaction.
- Improved customer loyalty leading to repeat business.

Applying the principle of customer focus typically leads to:

- Researching and understanding customer needs and expectations.
- Ensuring that the objectives of the organization are linked to customer needs and expectations.
- Communicating customer needs and expectations throughout the organization.
- Measuring customer satisfaction and acting on the results.
- Systematically managing customer relationships.
- Ensuring a balanced approach between satisfying customers and other interested parties (such as owners, employees, suppliers, financiers, local communities and society as a whole).

Second principle benefits

- People will understand and be motivated towards the organization's goals and objectives.
- Activities are evaluated, aligned and implemented in a unified way.
- Miscommunication between levels of an organization will be minimized.

Applying this principle of leadership typically leads to:

- Considering the needs of all interested parties including customers, owners, employees, suppliers, financiers, local communities and society as a whole.
- Establishing a clear vision of the organization's future.
- Setting challenging goals and targets.
- Creating and sustaining shared values, fairness and ethical role models at all levels of the organization.
- Establishing trust and eliminating fear.
- Providing people with the required resources, training and freedom to act with responsibility and accountability.

- Inspiring, encouraging and recognizing people's contributions.

Third principle;

- Motivated, committed and involved people within the organization.
- Innovation and creativity in furthering the organization's objectives.
- People being accountable for their own performance.
- People eager to participate in and contribute to continual improvement.

Applying the principle of involvement of people leads to these points;

- People understanding the importance of their contribution and role in the organization.
- People identifying constraints to their performance.
- People accepting ownership of problems and their responsibility for solving them.
- People evaluating their performance against their personal goals and objectives.
- People actively seeking opportunities to enhance their competence, knowledge and experience.
- People freely sharing knowledge and experience.
- People openly discussing problems and issues.

And the forth principle,

Lower costs and shorter cycle times through effective use of resources.

- Improved, consistent and predictable results.
- Focused and prioritized improvement opportunities.

Applying the principle of process approach results in

- Systematically defining the activities necessary to obtain a desired result.

- Establishing clear responsibility and accountability for managing key activities.
- Analysing and measuring of the capability of key activities.
- Identifying the interfaces of key activities within and between the functions of the organization.
- Focusing on the factors such as resources, methods, and materials that will improve key activities of the organization.
- Evaluating risks, consequences and impacts of activities on customers, suppliers and other interested parties.

The fifth principle is about system approach to management and

- Integration and alignment of the processes that will best achieve the desired results.
- Ability to focus effort on the key processes.
- Providing confidence to interested parties as to the consistency, effectiveness and efficiency of the organization are benefits.

Applying the principle leads to

- Structuring a system to achieve the organization's objectives in the most effective and efficient way.
- Understanding the interdependencies between the processes of the system.
- Structured approaches that harmonize and integrate processes.
- Providing a better understanding of the roles and responsibilities necessary for achieving common objectives and thereby reducing cross-functional barriers.
- Understanding organizational capabilities and establishing resource constraints prior to action.
- Targeting and defining how specific activities within a system should operate.

- Continually improving the system through measurement and evaluation.

Sixth principle causes

- Performance advantage through improved organizational capabilities.
- Alignment of improvement activities at all levels to an organization's strategic intent.
- Flexibility to react quickly to opportunities.

Implemneting the principle of continual improvement brings

- Employing a consistent organization-wide approach to continual improvement of the organization's performance.
- Providing people with training in the methods and tools of continual improvement.
- Making continual improvement of products, processes and systems an objective for every individual in the organization.
- Establishing goals to guide, and measures to track, continual improvement.
- Recognizing and acknowledging improvements.

Benefits of the principle seven are

- Informed decisions.
- An increased ability to demonstrate the effectiveness of past decisions through reference to factual records.
- Increased ability to review, challenge and change opinions and decisions.

Application of principle of factual approach to decision making leads to:

- Ensuring that data and information are sufficiently accurate and reliable.
- Making data accessible to those who need it.
- Analysing data and information using valid methods.

- Making decisions and taking action based on factual analysis, balanced with experience and intuition.

Finally, the principle eight has three benefits. These are

- Increased ability to create value for both parties.
- Flexibility and speed of joint responses to changing market or customer needs and expectations.
- Optimization of costs and resources.

Applying this principle of mutually beneficial supplier relationships normally leads to

- Establishing relationships that balance short-term gains with long-term considerations.
- Pooling of expertise and resources with partners.
- Identifying and selecting key suppliers.
- Clear and open communication.
- Sharing information and future plans.
- Establishing joint development and improvement activities.
- Inspiring, encouraging and recognizing improvements and achievements by suppliers.

As a result, the data analysis is a part of an international standard ISO 9001:2000 and it is required and based on the statistical methods. So it leads to implementation of SQC techniques to all organization without justification.

2.5 Six Sigma Excellence Model

Six Sigma is both a philosophy and a methodology that improves quality by analyzing data with statistics to find the root cause of quality problems and to implement controls. Although Six Sigma is typically first implemented to improve manufacturing, the method can also be used in other business processes, such as product design and supply chain management.

Six Sigma is an effective approach to a broad-based quality control program. It is far more than the traditional approach, in which internal teams are created to reduce production defects, solve problems within one department, and address problems in isolation. Six Sigma is more than a quality control program with another name; it is a quality-based system for reorganizing the entire approach to work in every aspect: productivity, communication, involvement at every level, and external service. Because Six Sigma and its guidelines improve performance and communication on many levels, it changes not only the outcome (service, production, or communication) but affects the very way that we communicate with each other and with customers and vendors. The meaning of Six Sigma (6 σ) is perfection—impossible to achieve completely and all of the time—is a goal worth keeping in mind [13]. The origins of sigma are the letter in the Greek alphabet used to denote standard deviation, a statistical measurement of variation, the exceptions to expected outcomes. Standard deviation can be thought of as a comparison between expected results or outcomes in a group of operations, versus those that fail.The measurement of standard deviation shows us that rates of defects, or exceptions, are measurable. Six Sigma is the definition of outcomes as close as possible to perfection. With six standard deviations, we arrive at 3.4 defects per million opportunities, or 99.9997 percent. This would mean that at Six Sigma, an airline would lose only three pieces of luggage for every one million that it handles; or that the phone company would have only three unhappy customers out of every one million who use the phone that day. The purpose in evaluating defects is not to eliminate them entirely, but to strive for improvement to the highest possible level that we can achieve.

In next section, we explain the tactical elements of the Six Sigma project, using a system called *DMAIC* (define, measure, analyze, improve, control). The whole process begins when management identifies top priorities of the entire Six Sigma program. These highest-priority projects should reflect what management considers the most urgent concerns: drains on cash flow and profits, inefficient processes, ineffective internal controls, lack of coordination between marketing and administrative sections, and declining market share. So the strategic importance of Six Sigma will touch upon many areas and ultimately is likely to impact every employee in the company. The dual purpose of Six Sigma-improving the methodology of quality improvement, while also changing the whole corporate culture-relies on the use of predictable and formal tactical programs. This is where DMAIC comes into play. The strategic definition of Six Sigma leads to the action plan, which is articulated in the tactical phases of DMAIC.

There are five specific phases in the Six Sigma tactical application. These are collectively referred to as DMAIC [14]. This tactical system is the core of Six Sigma, and following its sequence determines the success of each Six Sigma project. The working sequence and checkpoints of DMAIC are summarized in the process map shown in Figure 2.3.

In all phases of developing the Six Sigma program, we should remember to continually be aware of the customer's point of view. The tactics of Six Sigma are process oriented so it is easy to lose sight of the end purpose in the work itself. Little things make a big difference. From the customer's point of view, a step as simple as a follow-up telephone call to ask whether the customer was satisfied with the transaction is both refreshing and personal.

Note that in moving forward to the measure phase, the team may discover that it is necessary to return to define and make modifications. The same methodical step occurs from the analyze phase back to the measure phase and again from improve to analyze. In the analyze phase, the team may also discover that it is necessary to return to the define stage and restate part of the initial assumptions of the project. In the analyze phase for statistical techniques implementation is important. The purpose of Six Sigma should be kept in mind. We want to define the causes of defects, measure those defects, and analyze them so that they can be reduced. If it is necessary or helpful to produce visual representations of the processes and defects being studied, then they are worth the time and effort.

However, for most processes—as well as for most team members—a nontechnical approach will be far more effective.

The most important question asked in the six sigma approach is “what is important for your customer?” Every process has internal and external customers and the owners of the processes have to ask to theirselves how to satisfy their customer needs. The six sigma uses statistical quality control methods when the stage arrives to analyse phase.That means target 1 in 3 million defect is requires SQC basically.

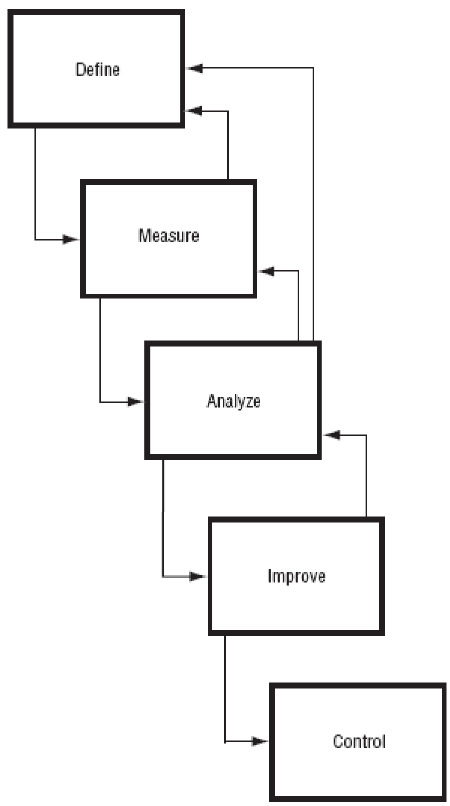

Figure 2.3 The working sequence and checkpoints of DMAIC.

CHAPTER 3

STATISTICAL QUALITY CONTROL AND PROCESS IMPROVEMENT

3.1 Introduction

This chapter provides information that may be applied during the implementation of a Statistical Quality Control (SQC) program that includes process control and sampling techniques. This information may be used by the production approval holder and its suppliers, hereafter referred to as the manufacturer. SQC programs are considered part of the manufacturer's overall quality system. However, there is no regulatory requirement for establishing an SQC program, and establishing such a program based on the provided information is voluntary.In this thesis we suggest such a program to help reduce nonconformances, process variation, scrap, and to improve product quality.

3.2 Basic Definitions of Statistical Techniques

SQC is generally described as the control of product quality by statistical methods. Various techniques developed by mathematical statisticians for the analysis of data may be used in the control of product quality. This chapter addresses two separate but related techniques, Statistical Sampling and Statistical Process Control

(SPC). The SQC techniques are defined in the next section of this chapter and Chapter 4 of this thesis details the application of SQC tools.
The terms used in these applications are:

a. Inspection by Attributes. A method of inspection whereby either the unit of product is classified simply as "defective" or "non-defective" or the number of nonconforming characteristics (defects) in the product is counted with respect to a given requirement(s).

b. Characteristic. A product feature requires an inspection in order to show conformance to engineering design specifications. The most commonly specified characteristic classifications are critical, major, and minor. These classifications are traditionally defined as follows:

1. Critical Characteristic – a characteristic based on judgement and experience that, if not met, would cause an unsafe condition.
2. Major Characteristic – a characteristic other than critical that, if not met, would reduce the usability of a product and could cause an unsafe condition.
3. Minor Characteristic – a characteristic that, if not met, would not reduce the usability of a product and would have no adverse effect on safety.

c. Statistical Process Control. A method used for measuring, analyzing, detecting, and controlling process variation. This method may include the following measurable quality characteristic control charts [15]:

- *X*-bar and *R* chart, the average and range
- *X*-bar and *s* chart, the average and standard deviation
- *p* chart, the ratio of defective
- *c* chart, the number of non-conformities per unit

Control charts; *X*-bar and *R* chart, the average and range and *X*-bar and *s* chart, the average and standard deviation are used for variables characteristics. *p* chart, the ratio of defective and *c* chart, the number of non-conformities per unit are used for attributes.

d. Statistical Quality Control. The application of statistical techniques (SPC and Statistical Sampling) to control a product characteristic to ensure it meets product specifications or the engineering design specifications.

e. Statistical Sampling. A method of inspection performed throughout the manufacturing process, according to sampling acceptance plans, and based on the laws of probability. Statistical sampling inspects defined characteristics on a portion of a lot to statistically determine if the entire lot is acceptable. 50 sample is least value of statistical sampling from a masses of numerical data to calculate standart deviation. [16].

f. Inspection by Variables. A method of inspection whereby a measurement is made to determine and record the numerical magnitude of a characteristic under consideration.

An SQC application should be part of the overall quality system, approved by quality management, and documented with a detailed written description of all key elements of the implementation [17]. Each manufacturer is unique with regard to size, facilities, personnel, resources, and methods of operation; therefore, different SQC techniques may be appropriate. The implementation should be tailored to the manufacturer's product and associated processes, and may include SPC for process control and statistical sampling for inspection and acceptance.

3.3 Statistical Process Control (SPC)

SPC to be: a methodology using control charts for assisting operators, supervisors, and managers to monitor quality of conformance and to eliminate special causes of variability of a process a technique to control quality using probability and statistics to determine and maintain the state of statistical control. Other tools, besides control charts, are often identified as being affiliated with SPC, including Pareto analysis, histograms, cause-and-effect or Ishikawa diagrams, scatter diagrams, etc. These tools are used in an integrative manner to systematically collect, summarize, and communicate data and information related to a process for the purpose of taking necessary corrective action.[18]

When properly implemented, SPC is a continuous verification of the manufacturing process to which it is applied, and may help to reduce defects in the specific characteristics being monitored. Although SPC should not be used for product acceptance, it may be implemented for two primary purposes:

- monitor, detect, and subsequently reduce variation in a manufacturing process
- determine if the process is capable of meeting engineering design specifications

Implementation should include a process capability study and a determination of the level of its application [16].

a. Process Capability. Process capability describes the ability of a process to produce characteristics that meet the engineering design specifications. A capable process should consistently produce characteristics that meet the engineering design specifications.

A capability study should be performed to ensure that the process is capable of yielding product characteristics that meet the engineering design specifications.

b. Process Control. A process is said to be in statistical control if the manufactured characteristic exhibits only random variation from the process output average. Random or natural variation occurs by chance, cannot be traced to a single cause, and can only be reduced by improving the process. The limits of random variation can be predicted, thus the conditions producing the variation are said to be under control. After a process is in statistical control and capable of meeting the engineering design specifications, the manufacturer should take the opportunity to evaluate whether further process improvements should be implemented for the purpose of reducing rejects and/or variation. In some cases, reduced process variation may result in improved product reliability.

SPC based on control charts has been found to be very effective means of reducing scrap and rework and improving processes and products. Generally associated with the production of engineering components the principles are no less applicable to the process industries. [20].

To work with control charts requires knowledge of some basic definitions such as mean, standart deviation, control limits:

Mean (or arithmetic average)

This is simply the average of the observations, the sum of all the measurements divided by the number of the observations.
For example, the mean of the four measurements of rod lengths 144 mm, 146 mm, 154 mm, and 146 mm is obtained:
144mm+146mm+154mm+146mm= 590mm
Sample Mean = 590mm / 4 = 147.5mm
When the individual measurements are denoted by xi, the mean of the n observations is denoted by X.
Hence, X = (x1 + x2 + x3 + · · · + xn) / n

Standard deviation

The standard deviation takes all the data into account and is a measure of the 'deviation' of the values from the mean. It is best illustrated by an example.
Consider the deviations of the first four steel rod lengths from the mean:

Value xi (mm)	Deviation (xi – X)
144	–3.5mm
146	–1.5mm
154	+6.5mm
146	–1.5mm
Mean X = 147.5m	Total = 0

Measurements above the mean have a positive deviation and measurements below the mean have a negative deviation. Hence, the total deviation from the mean is zero, which is obviously a useless measure of spread. If, however, each deviation is multiplied by itself, or squared, since a negative number multiplied by a negative number is positive, the squared deviations will always be positive:

Value xi (mm)	Deviation (xi – X)	(xi – X)2
144	–3.5	12.25
146	–1.5	2.25
154	+6.5	42.25
146	–1.5	2.25

Sample Mean X = 147.5 Total: ∑(xi – X)2 = 59.00

The average of the squared deviations may now be calculated and this value is known as the variance of the sample. In the above example, the variance or mean squared variation is:

∑(xi – X)2 / n

= 59.0 / 4 = 14.75

The standard deviation, normally denoted by the Greek letter sigma (σ), is the square root of the variance, which then measures the spread in the same units as the variable, i.e., in the case of the steel rods, in millimetres.

σ = √14.75 = 3.84 mm.

Generally Standart Deviation = √∑(Xi-X)2/ (n-1)

t-TEST

The t-test assesses whether the means of two groups are statistically different from each other. This analysis is appropriate whenever you want to compare the means of two groups.

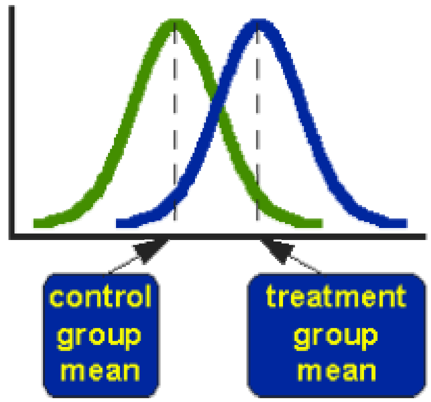

Figure 3.1. Idealized distributions for treated and comparison group posttest values.

Figure 3.1 shows the distributions for the treated (rigth) and control (left) groups in a study. Actually, the figure shows the idealized distribution -- the actual distribution would usually be depicted with a histogram or bar graph. The figure indicates where the control and treatment group means are located. The question the t-test addresses is whether the means are statistically different.

What does it mean to say that the averages for two groups are statistically different? Consider the three situations shown in Figure 3.2. The first thing to notice about the three situations is that the difference between the means is the same in all three. But, you should also notice that the three situations don't look the same -- they tell very different stories. The top example shows a case with moderate variability of scores within each group. The second situation shows the high variability case. the third shows the case with low variability. Clearly, it would be concluded that the two groups appear most different or distinct in the bottom or low-variability case. Why? Because there is relatively little overlap between the two bell-shaped curves. In the high variability case, the group difference appears least striking because the two bell-shaped distributions overlap so much.

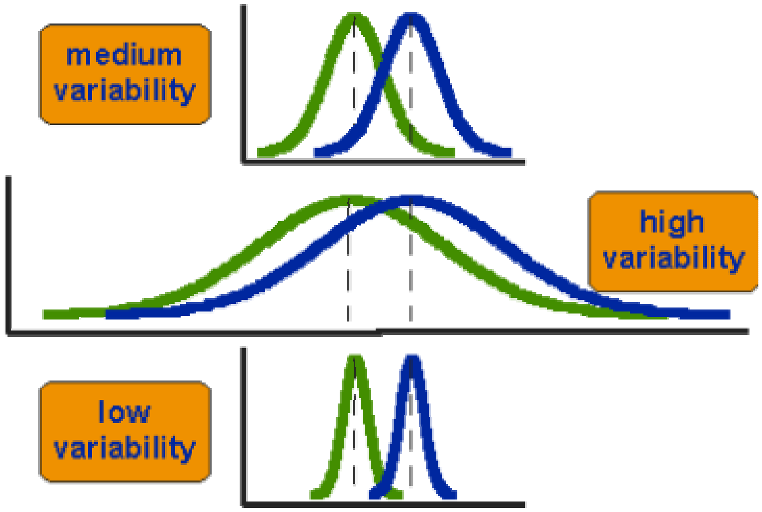

Figure 3.2. Three scenarios for differences between means

This leads to a very important conclusion: when we are looking at the differences between scores for two groups, we have to judge the difference between their means relative to the spread or variability of their scores. The t-test does just this.

Statistical Analysis of the t-test

The formula for the t-test is a ratio. The top part of the ratio is just the difference between the two means or averages. The bottom part is a measure of the variability or dispersion of the scores. The difference between the means is the signal that, in this case, we think our program or treatment introduced into the data; the bottom part of the formula is a measure of variability that is essentially to see the group difference. Figure 3.3 shows the formula for the t-test and how the numerator and denominator are related to the distributions.

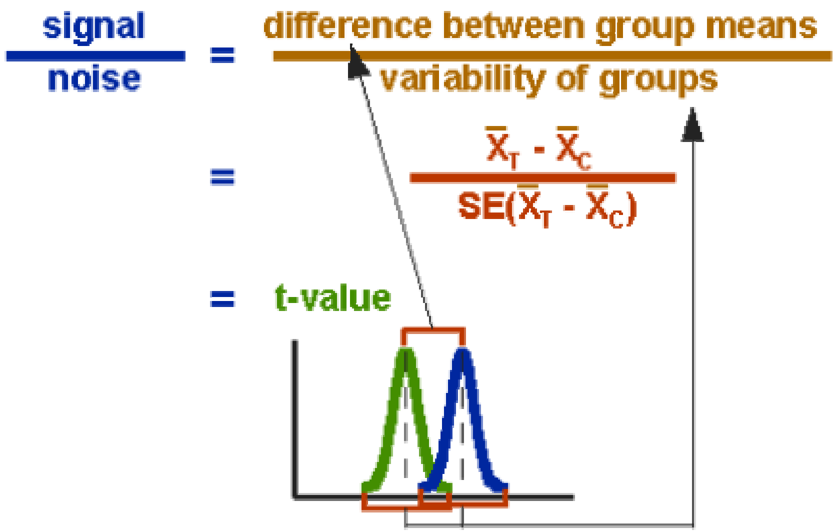

Figure 3.3 Formula for the t-test.

The top part of the formula is easy to compute -- just find the difference between the means. The bottom part is called the standard error of the difference. To compute it, it is taken the variance for each group and divide it by the number of people in that group. We add these two values and then take their square root. The specific formula is given as:

$$SE(\bar{X}_T - \bar{X}_C) = \sqrt{\frac{var_T}{n_T} + \frac{var_C}{n_C}}$$

Formula for the Standard error of the difference between the means.

Remember, that the variance is simply the square of the standard deviation.

The final formula for the t-test is given as:

$$t = \frac{\bar{X}_T - \bar{X}_C}{\sqrt{\frac{var_T}{n_T} + \frac{var_C}{n_C}}}$$

The t-value will be positive if the first mean is larger than the second and negative if it is smaller. Once it is computed the t-value it has to be to look it up in a table of significance to test whether the ratio is large enough to say that the difference between the groups is not likely to have been a chance finding. To test the significance, it şis necessarry to set a risk level (called the alpha level). In most social research, the "rule of thumb" is to set the alpha level at 0.05. This means that five times out of a hundred you would find a statistically significant difference between the means even if there was none (i.e., by "chance"). It is also necessary to determine the degrees of freedom (df) for the test. In the t-test, the degrees of freedom is the sum of the persons in both groups minus 2. Given the alpha level, the df, and the t-value, it can be looked the t-value up in a standard table of significance (available as an appendix in the back of most statistics texts) to determine whether the t-value is large enough to be significant. If it is, it can be concluded that the difference between the means for the two groups is different (even given the variability).

The t-test, one-way Analysis of Variance (ANOVA) and a form of regression analysis are mathematically equivalent and would yield identical results.

CONTROL LIMITS

If a single quality characteristic has been measured or computed from a sample, the control chart shows the value of the quality characteristic versus the sample number or versus time. In general, the chart contains a center line that represents the mean value for the in-control process. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL), are also shown on the Figure 3.4. These control limits are chosen so that almost all of the data points will fall within these limits as long as the process remains in-control. The figure below illustrates this.

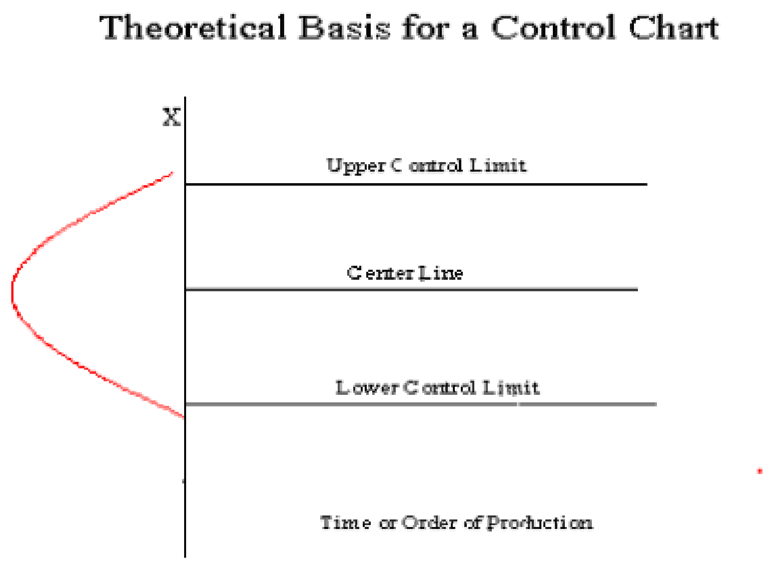

Figure 3.4 Chart demonstrating basis of control chart

There are two types of variation: 1) variation due to common causes and 2) variation due to special causes. More than 80% of the variations of a process parameter is due to common causes such as equipment malfunction, gradual deterioration of calibration, wear and tear in machinery, poor scheduled maintenance and many more. These variation are due to inherent process variability and can not be completely eliminated. Also most of the common causes of variations can not be corrected by the operator or supervisor. Thus common causes need management's attention for elimination. Computer-aided real time analysis of the process data may be used to predict such causes and corrective action could be taken by management to immediately remove the causes. About 20% of the variations of a process parameter are due to special causes such as incorrectly tuned loop, maladjusted machinery, material, operator and/or other input factors. If the manufactured product specification falls outside the established control limits, there are always some identifiable reasons for it. These causes of variations are also called assignable causes. A computer-aided approach in real-time would be a speedy and convenient way to determine these assignable causes. Corrective action could be taken immediately through local action for such problems. However, one very important point to be remembered is not to confuse between control problems and the special causes concerning SPC [21].

Statistical process control (SPC) is the most widely used technique, primarily in manufacturing. The SPC process identifies whether an observed output or measurement from a system represents a process that is in control or one that has shifted out of control. While variation is present in virtually all processes, only natural, or random, variation is present in an in control process. In contrast, an out of control condition signals the presence of assignable or special cause variation. This type of variation must be identified and eliminated to return the process to a state of statistical control. [22]

3.4 Statistical Quality Control (SQC)

Process improvements are often achieved through specific opportunities, commonly called problems, being identified or recognized. A focus on improvement opportunities should lead to the creation of teams whose membership is determined by their work on and detailed knowledge of the process, and their ability to take improvement action. The teams must then be provided with good leadership and the right tools to tackle the job. By using reliable methods, creating a favourable environment for teambased problem solving, and continuing to improve using systematic techniques, the never-ending improvement cycle of plan, do, check, act will be engaged. This approach demands the real time management of data, and actions on processes – inputs, controls and resources, not outputs. It will require a change in the language of many organizations from percentage defects, percentage ‘prime’ product, and number of errors, to process capability. The climate must change from the traditional approach of ‘If it meets the specification, there are no problems and no further improvements are necessary’. The driving force for this will be the need for better internal and external customer satisfaction levels, which will lead to the continuous improvement question, ‘Could we do the job better?’ In this part, some basic tools and techniques were briefly introduced. Certain of these are very useful in any problem identification and solving context, namely Pareto analysis, cause and effect analysis, scatter diagrams and stratification.

The effective use of these tools requires their application by the people who actually work on the processes. Their commitment to this will be possible only if they are assured that management cares about improving quality. Managers must show they are serious by establishing a systematic approach and providing the training and implementation support required. In today's competitive market, one of the problems of small companies is insufficient investments and lacking sufficient qualified employee having practical and theoretical knowledge for the job. Statistical quality control methods are quite different from traditional methods and they have made great contribution to improvements in companies dealing with mass production. In traditional methods, the product is manufactured first and then it is checked to determine whether it meets the quality requirements. The product that does not meet the quality requirements is rejected and sent back to the machines for remachining or correction otherwise it is thrown away as scrap. If faulty products are too much, in order to eliminate the assignable causes or the problem necessary corrections are made by examining production period. However, statistical quality control is the vital part of production. Instead of checking the finished product after production, it is applied at every period of production. If this period is under control, the next period is considered, otherwise the assignable causes are discovered and corrected.[23]

The systematic approach mapped out in Figure 3.5 should lead to the use of factual information, collected and presented by means of proven techniques, to open a channel of communications not available to the many organizations that do not follow this or a similar approach to problem solving and improvement. Continuous improvements in the quality of products, services, and processes can often be obtained without major capital investment, if an organization marshals its resources, through an understanding and breakdown of its processes in this way. Organizations which embrace the concepts of total quality and business excellence should recognize the value of problem solving techniques in all areas, including sales, purchasing, invoicing, finance, distribution, training, etc., which are outside production or operations – the traditional area for SQC use [24]. A Pareto analysis, a histogram, a flowchart, or a control chart is a vehicle for communication. Data, whether the numbers represent defects or invoice errors, the information relates to machine settings, process variables, prices, quantities, discounts, customers, or supply points are irrelevant; the techniques can always be used. Some of the most exciting applications of SQC and problem-solving tools have emerged from organizations and departments which, when first introduced to the methods, could see little relevance to their own activities. Following appropriate training, however, they have learned how to, for example:

- Pareto analyse sales turnover by product and injury data.
- Brainstorm and cause and effect analyse reasons for late payment and poor purchase invoice matching.
- Histogram absenteeism and arrival times of trucks during the day.
- Control charts the movement in currency and weekly demand of a product.

Word processor operators have used cause and effect analysis and histograms to represent errors in output from their service.

SQC has considerable applications for non-manufacturing organizations, in both the public and private sectors. Data and information on patients in hospitals, students in universities and schools, people who pay (and do not pay) tax, draw benefits. If it were to be used in a systematic way, and all operations treated as processes, far better decisions could be made concerning the past, present and future performances of these operations. The tools for SQC are explained as follows:

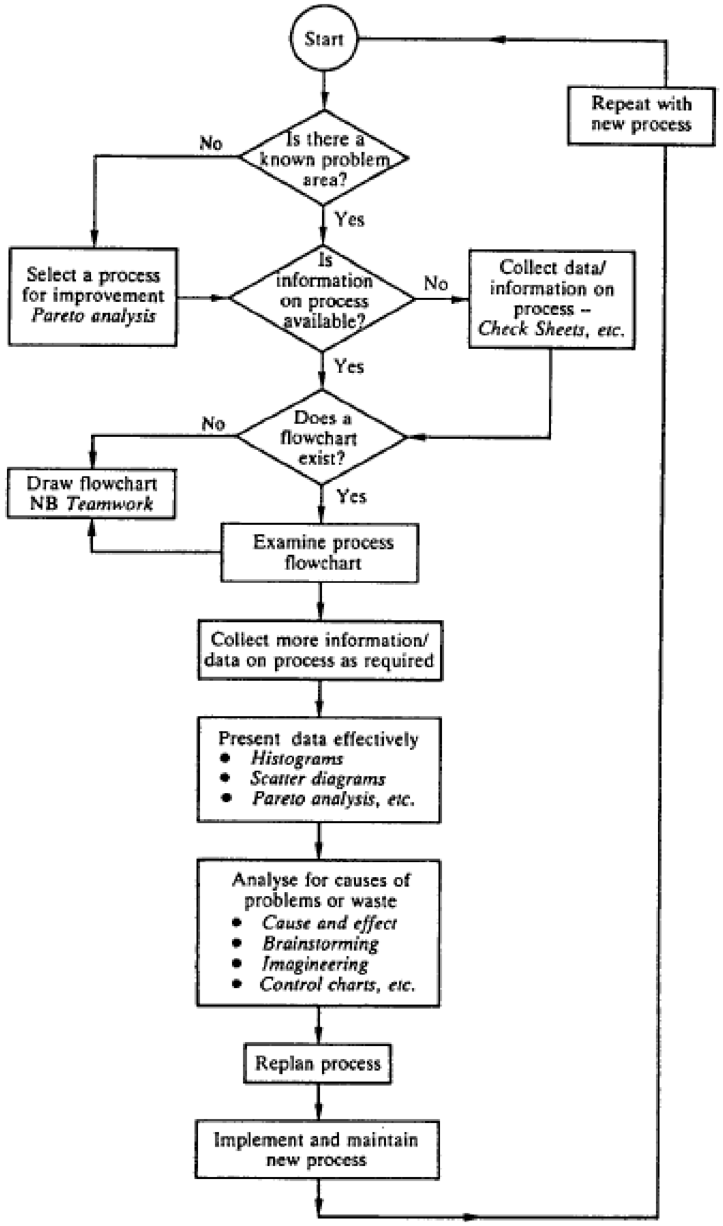

Figure 3.5 Strategy for continual process improvement

3.4.1 Histogram

Every day, throughout the world, in offices, factories, on public transport, shops, schools and so on, data are being collected and accumulated in various forms: data on prices, quantities, exchange rates, numbers of defective items, lengths of articles, temperatures during treatment, weight, number of absentees, etc. Much of the potential information contained in this data may lie dormant or not be used to the full, and often because it makes little sense in the form presented.

Consider, as an example, the data shown in Table 3.1 which refer to the diameter of pistons in Ref [30]. It is impossible to visualize the data as a whole. The eye concentrates on individual measurements and, in consequence, a large amount of study will be required to give the general picture represented. A means of visualizing such a set of data is required. Look again at the data in Table 3.1. Is the average diameter obvious? Can you tell at a glance the highest or the lowest diameter? Can you estimate the range between the highest and lowest values? Given a specification of 55.0 ± 1.00 mm, can you tell whether the process is capable of meeting the specification, and is it doing so? Few people can answer these questions quickly, but given sufficient time to study the data all the questions could be answered.

If the observations are placed in sequence or ordered from the highest to the lowest diameters, the problems of estimating the average, the highest and lowest readings, and the range (a measure of the spread of the results) would be simplified. The reordered observations are shown in Table 3.2. After only a brief examination of this table it is apparent that the lowest value is 55.0 mm, that the highest value is 56.2 mm and hence that the range is 1.2 mm (i.e. 55.0 mm to 56.2 mm).

Table 3.1 Diameters of pistons (mm) – raw data

56.1	56.0	55.7	55.4	55.5	55.9	55.7	55.4
55.1	55.8	55.3	55.4	55.5	55.5	55.2	55.8
55.6	55.7	55.1	56.2	55.6	55.7	55.3	55.5
55.0	55.6	55.4	55.9	55.2	56.0	55.7	55.6
55.9	55.8	55.6	55.4	56.1	55.7	55.8	55.3
55.6	56.0	55.8	55.7	55.5	56.0	55.3	55.7
55.9	55.4	55.9	55.5	55.8	55.5	55.6	55.2

Table 3.2 Diameters of pistons ranked in order of size (mm)

55.0	55.1	55.1	55.2	55.2	55.2	55.3	55.3
55.3	55.3	55.4	55.4	55.4	55.4	55.4	55.4
55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.6
55.6	55.6	55.6	55.6	55.6	55.6	55.7	55.7
55.7	55.7	55.7	55.7	55.7	55.7	55.8	55.8
55.8	55.8	55.8	55.8	55.8	55.9	55.9	55.9
55.9	56.0	56.0	56.0	56.0	56.1	56.1	56.2

The average is probably around 55.6 or 55.7 mm and the process is not meeting the specification as three of the observations are greater than 56.0 mm, the upper tolerance.

The histogram is one type of graph but graphs also include pie charts, run charts and pictorial graphs. In all cases they are extremely valuable in that they convert tabulated data into a picture, thus revealing what is going on within a process, batches of product, customer returns, scrap, rework, and many other aspects of life in manufacturing and service organizations, including the public sector.

3.4.2 Pareto analysis

In many things we do in life we find that most of our problems arise from a few of the sources. The Italian economist Vilfredo Pareto used this concept when he approached the distribution of wealth in his country at the turn of the century. He observed that 80–90 per cent of Italy's wealth lay in the hands of 10–20 per cent of the population [31]. A similar distribution has been found empirically to be true in many other fields. For example, 80 per cent of the defects will arise from 20 per cent of the causes; 80 per cent of the complaints originate from 20 per cent of the customers. These observations have become known as part of Pareto's Law or the 80/20 rule. The technique of arranging data according to priority or importance and tying it to a problem-solving framework is called Pareto analysis. This is a formal procedure which is readily teachable, easily understood and very effective. Pareto diagrams or charts are used extensively by improvement teams all over the world; indeed the technique has become fundamental to their operation for identifying the really important problems and establishing priorities for action.There are always many aspects of business operations that require improvement: the number of errors, process capability, rework, sales, etc. Each problem comprises many smaller problems and it is often difficult to know which ones to tackle to be most effective.

3.4.3 Cause and effect analysis

In any study of a problem, the *effect* – such as a particular defect or a certain process failure – is usually known. Cause and effect analysis may be used to elicit all possible contributing factors, or *causes* of the effect. This technique comprises usage of cause and effect diagrams and brainstorming. The cause and effect diagram is often mentioned in passing as, 'one of the techniques used by quality circles'. Whilst this statement is true, it is also needlessly limiting in its scope of the application of this most useful and versatile tool [32]. The cause and effect diagram, also known as the Ishikawa diagram (after its inventor), or the fishbone diagram (after its appearance), shows the effect at the head of a central 'spine' with the causes at the ends of the ‘ribs’ which branch from it. The basic form is shown in Figure 3.6. The principal factors or causes are listed first and then reduced to their sub-causes, and sub-sub-causes if necessary. This process is continued until all the conceivable causes have been included.

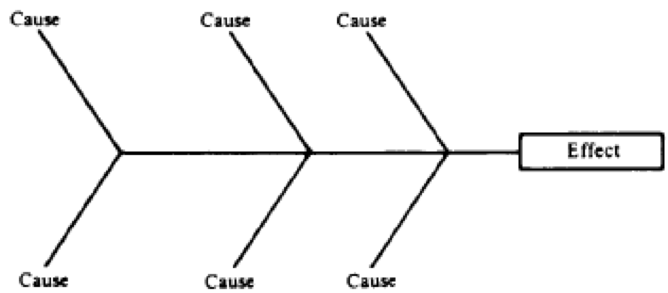

Figure 3.6 Basic form of cause and effect diagram

The factors are then critically analysed in light of their probable contribution to the effect. The factors selected as most likely causes of the effect are then subjected to experimentation to determine the validity of their selection. This analytical process is repeated until the true causes are identified. When constructing the cause and effect diagram an essential feature of the cause and effect technique is brainstorming which is used to bring ideas on causes out into the open. A group of people freely exchanging ideas bring originality and enthusiasm to problem solving. Wild ideas are welcomed and safe to offer, as criticism or ridicule is not permitted during a brainstorming session. To obtain the greatest results from the session, all members of the group should equally and all ideas offered are recorded for subsequent analysis.

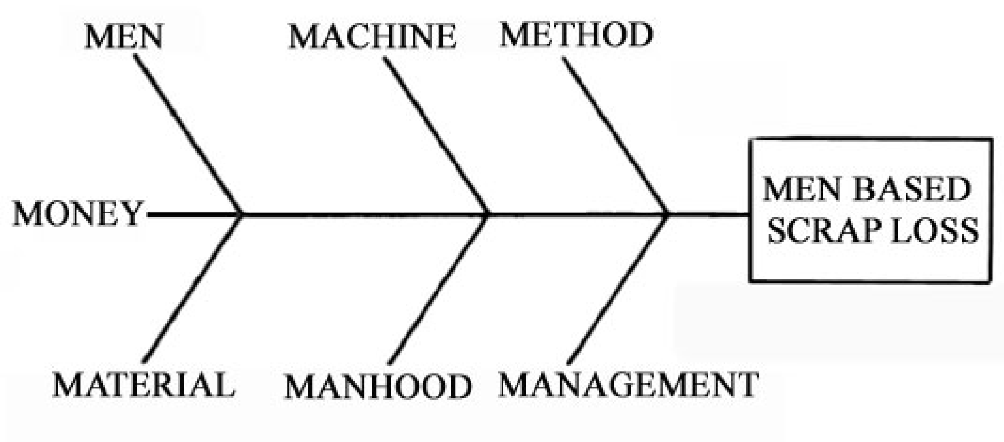

Figure 3.7 Example of a cause and effect diagram

The construction best illustrated with an example of Figure 3.7. The production manager in a tea-bag manufacturing firm was extremely concerned about the amount of wastage of tea which was taking place. A study group had been set up to investigate the problem but had made little progress, even after several meetings. The lack of progress was attributed to a combination of too much talk, arm-waving and shouting down – typical symptoms of a non-systematic approach.

3.4.4 Scatter diagrams

Scatter diagrams are used to examine the relationship between two factors to see if they are related. If they are, then by controlling the independent factor, the dependent factor will also be controlled. For example, if the temperature of a process and the purity of a chemical product are related, then by controlling temperature, the quality of the product is determined. Figure 3.8 shows that when the process temperature is set at A, a lower purity results than when the temperature is set at B. In Figure 3.9 we can see that tensile strength reaches a maximum for a metal treatment time of B, while a shorter or longer length of treatment will result in lower strength.

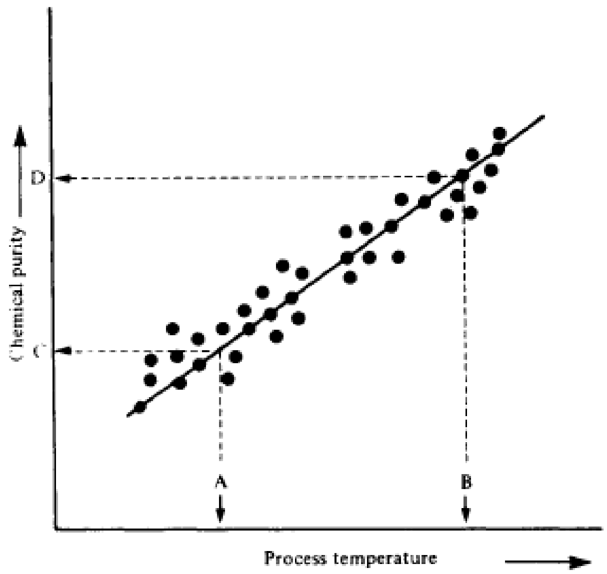

Figure 3.8 Scatter diagram – temperature versus purity

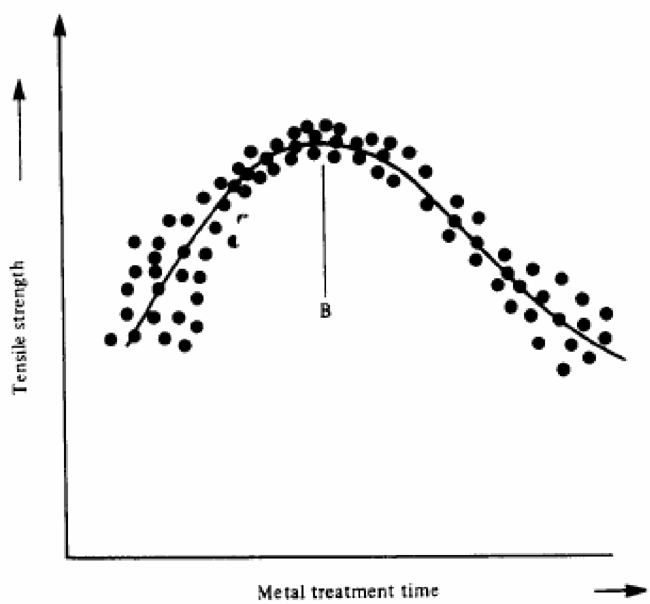

Figure 3.9 Scatter diagram – metal treatment time versus tensile strenght

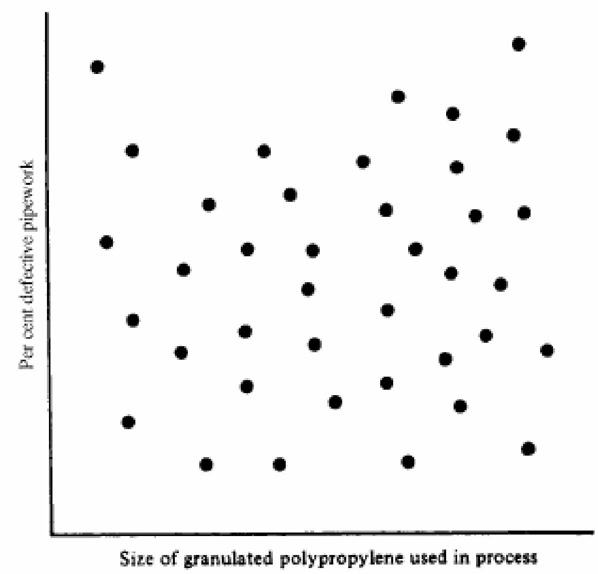

Figure 3.10 Scatter diagram without relationship

In both Figures 3.8 and 3.9 there appears to be a relationship between the 'independent factor' on the horizontal axis and the 'dependent factor' on the vertical axis. A statistical hypothesis test could be applied to the data to determine the statistical significance of the relationship, which could then be expressed mathematically. This is often unnecessary, as all that is necessary is to establish some sort of association. In some cases it appears that two factors are not related. In Figure 3.10, the percentage of defective polypropylene pipework does not seem to be related to the size of granulated polypropylene used in the process.

Scatter diagrams have application in problem solving following cause and effect analyses. After a sub-cause has been selected for analysis, the diagram may be helpful in explaining why a process acts the way it does and how it may be controlled [33]. Simple steps may be followed in setting up a scatter diagram:

- Select the dependent and independent factors. The dependent factor may be a cause on a cause and effect diagram, a specification, a measure of quality, or some other important result or measure. The independent factor is selected because of its potential relationship to the dependent factor.

- Set up an appropriate recording sheet for data.
- Choose the values of the independent factor to be observed during the analysis.
- For the selected values of the independent factor, collect observations for the dependent factor and record on the data sheet.
- Plot the points on the scatter diagram, using the horizontal axis for the independent factor and the vertical axis for the dependent factor.
- Analyse the diagram. This type of analysis is yet another step in the systematic approach to process improvement.

3.4.5 Stratification

This is the sample selection method used when the whole population, or lot, is made up of a complex set of different characteristics, e.g. region, income, age, race, sex, education. In these cases the sample must be very carefully drawn in proportions which represent the makeup of the population. Stratification often involves simply collecting or dividing a set of data into meaningful groups [34]. It can be used to great effect in combination with other techniques, including histograms and scatter diagrams. If, for example, three team teams are responsible for the output described by the histogram (a) in Figure 3.11, 'stratifying' the data into the team groups might produce histograms (b), (c) and (d) and indicate process adjustments that were taking place at team changeovers.

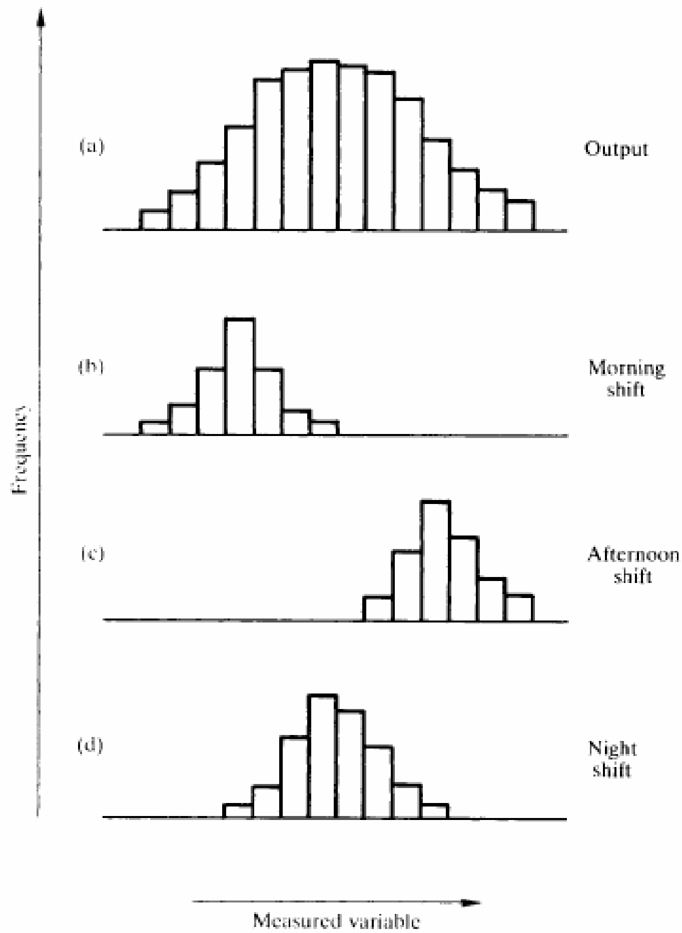

Figure 3.11 Stratification of data into team teams

3.4.6 Summarizing problem solving and improvement

It is clear from the examples presented in this chapter that the principles and techniques of problem solving and improvement may be applied to any human activity, provided that it is regarded as a process. The only way to control process outputs, whether they are artefacts, paperwork, services, or communications, is to manage the inputs systematically. Data from the outputs, the process itself, or the inputs, in the form of numbers or information, may then be used to modify and improve the operation. Presenting data in an efficient and easy to understand manner is as vital in the office as it is on the factory floor and, as we have seen in this chapter, some of the basic tools of SPC and problem solving have a great deal to offer in all areas of management. Data obtained from processes must be analysed quickly so that continual reduction in the variety of ways of doing things will lead to never-ending improvement. In many non-manufacturing operations there is an 'energy barrier' to be surmounted in convincing people that the SQC approach and techniques have a part to play. Everyone must be educated so that they understand and look for potential SQC applications [30]. Training in the basic approach of:

- no process without data collection;
- no data collection without analysis;
- no analysis without action;

will ensure that every possible opportunity is given to use these powerful methods to greatest effect.

Process improvements often follow problem identification and the creation of teams to solve them. The teams need good leadership, the right tools, good data and to take action on process inputs, controls and resources. A systematic approach is required to make good use of the facts and techniques, in *all* areas of all types of organization, including those in theservice and public sectors.

Pareto analysis recognizes that a small number of the causes of problems, typically 20 per cent, may result in a large part of the total effect, typically 80 per cent. This principle can be formalized into a procedure for listing the elements, measuring and ranking the elements, creating the cumulative distribution, drawing and interpreting the Pareto curve, and presenting the analysis and conclusions. Pareto analysis leads to a distinction between problems which are among the vital few and the trivial many, a procedure which enables effort to be directed towards the areas of highest potential return. The analysis is simple, but the application requires a discipline which allows effort to be directed to the vital few. It is sometimes called ABC analysis or the 80/20 rule.

For each effect there are usually a number of causes. Cause and effect analysis provides a simple tool to tap the knowledge of experts by separating the generation of possible causes from their evaluation. Brainstorming is used to produce cause and effect diagrams. When constructing the fishbone-shaped diagrams, the evaluation of potential causes of a specified effect should be excluded from discussion. Steps in constructing a cause and effect diagram include identifying the effect, establishing the goals, constructing a framework, recording all suggested causes, incubating the ideas prior to a more structured analysis leading to plans for action.

Scatter diagrams are simple tools used to show the relationship between two factors – the independent (controlling) and the dependent (controlled). Choice of the factors and appropriate data recording are vital steps in their use.

Stratification is a sample selection method used when populations are comprised of different characteristics. It involves collecting or dividing data into meaningful groups. It may be used in conjunction with other techniques to present differences between such groups.

The principles and techniques of problem solving and improvement may be applied to any human activity regarded as a process. Where barriers to the use of these, perhaps in non-manufacturing areas, are found, training in the basic approach of process data collection, analysis and improvement action may be required.

CHAPTER 4

IMPLEMENTATION OF STATISTICAL QUALITY CONTROL OF SYNTHETIC SACK PRODUCTION

4.1 Introduction

The aim of the chapter is the collection of factors that had led to quality improvement in synthetic sack production organization. The production steps of PP bags which are extrusion, weaving and confection explained to underline main steps of scrap losses. The data from production lines collected and presented by using a computer program MS Excel. The database is processed and implemented for SQC by using its quality tools. The scrap loss problem was discussed and a new unifying point of view for this problem was presented.

4.2 Production of Synthetic Sack

Poly-propilen (PP) sacks (bags) are mostly used in industries packacing its powder products into it (flour, salt, cement. etc). These bags are produced mainly in three steps which are string, weaving and confection lines. The raw material of production is poly propilen which is melted in extrusion (string) line in a temperature of 200-300 ^{o}C. The most important control parameter for PP is M. F. I. (melt flow index) and defined as the weight of polymer in grams flowing in 10 minutes through a nozzle of specific diameter and length by a pressure applied via prescribed alternative gravimetric weights for alternative prescribed temperatures. If this value is high (e.g. higher than 3 gr / 10 min) that means raw material is elegible and has good spetcs for production.

4.2.1 String line production

The extruded film coming from die is quickly formed as film by cold water pool. Then strengthened through oven and finalized through fixation cylinders which are driven by different speeds in rpm (ratio between cylinder speeds mıust be at least 5 for a good production performance). The string will be rounded to coils. Most important control parameter for the string is denier which is the weight of 90 m string per gram. Higher denier means higher weight of sacks. (Figure 4.1.a)

4.2.2 Weaving line production

The sacks are weaved by circular looms in different widths. There are two types of string used for weaving. The weaving strings are four or six pieces in a loom and called shuttle. On the other hand, according to the width of bag, second string which is backload string number will be changed. Generally, width of strings is 2.5 mm. For a 60 cm width bag 60 * 4 * 2 = 480 pieces backload string is required (1 cm bag requires 4 string). Important control parameters width and strength of weaved bags. (Figure 4.1.b)

4.2.3 Confection line

The PP bags are cut into different sizes. The bags are closed from one end’s by sewing machine. The length, opening of bag front and strenght of back sewing are important control parameters. Sometimes bags are ordered as printed. If it is the case first process is printing before cutting. Final process is everytime packacing by pressing 500 pieces together. (Figure 4.1.c)

(a)

(b)

(c)

Figure 4.1 The production line of sacks. (a) string line, (b) weaving and (c) confection lines.

4.3 Statistical Analyses

From this point, we are starting to implement and analyse the collected data by using SQC tools for the improvement. The observed results and graphs are organised by using MS Excel program. For this implementation, data is given below. The first records include the string line production data in Table 4.1.

From table 4.1, the total amaount of string line production which is collected for three months is available. Three days production rates are taken from production reports and the avarage value of these rates are recorded to this table. It is seen from Table 4.1, amount of end total is 177325 kg and the average production rate value for a team is 59108 kg. This shows the teams A and B produce higher then the average production rate however team C produces lower then the average production rate.

Table 4.1 Total production amount (kg) for string line which is including approved quality strings and scrap amounts together.

STRING LINE PRODUCTION AMOUNT(kg)			
TEAMS / DAYS	A	B	C
01.July	2050	1950	1950
04.July	2000	2025	1900
07.July	2050	2025	1950
10. July	2000	1975	1950
13. July	2025	2000	1925
16. July	1975	1900	1975
19. July	2000	2025	1900
22. July	2025	2025	1950
25. July	2050	2000	1900
28. July	1975	1975	1925
31. July	2000	2000	1900
03.Aug	1975	2025	1925
06. Aug	2000	2000	1900
09. Aug	1950	1975	1850
12. Aug	1975	2025	1875
15. Aug	2000	1975	1850
18. Aug	2025	2000	1900
21. Aug	2050	1975	1775
24. Aug	1975	2025	1900
27. Aug	2000	2025	1850
30. Aug	2025	2050	1950
02.Sep	1975	2000	1900
05. Sep	2000	1950	1900
08. Sep	2025	2025	1950
11. Sep	1950	2050	1925
14. Sep	1975	2025	1975
17. Sep	2000	2000	1900
20. Sep	2025	1950	1925
23. Sep	2050	1975	1875
26. Sep	1975	2025	1900
TOTAL AMOUNT (kg)	60100	59975	57250

The data of scrap due to string, weaving and confection lines of this production period is given in Table 4.2.

Table 4.2 Total production lines scrap amounts (kg) for each team

	STRING LINE SCRAP AMOUNT(kg)			WEAVING LINE SCRAP AMOUNT(kg)			CONFECTION LINE SCRAP AMOUNT(kg)			ALL LINE TOTAL SCRAP AMOUNT(kg)		
TEAMS / DAYS	A	B	C	A	B	C	A	B	C	A	B	C
01.July	13	12	18	3	4	7	1	2	3	17	18	28
04.July	12	13	19	4	5	6	1	1	4	17	19	29
07.July	13	13	19	4	3	9	1	3	3	18	19	31
10. July	12	12	19	3	4	5	2	2	5	17	18	29
13. July	12	12	19	4	3	6	1	1	2	17	16	27
16. July	11	11	20	5	7	8	1	3	3	17	21	31
19. July	12	13	21	3	6	9	1	2	4	16	21	34
22. July	13	13	19	3	5	6	2	1	5	18	19	30
25. July	13	12	18	3	4	7	3	2	3	19	18	28
28. July	11	12	21	4	3	7	2	4	5	17	19	33
31. July	12	12	19	5	6	9	2	2	6	19	20	34
03.Aug	11	12	17	3	7	8	1	3	5	15	22	30
06. Aug	12	12	18	5	3	9	1	1	3	18	16	30
09. Aug	11	11	23	4	4	8	1	2	5	16	17	36
12. Aug	11	12	22	3	5	5	3	4	6	17	21	33
15. Aug	12	11	21	4	7	7	2	3	4	18	21	32
18. Aug	12	12	22	5	6	6	2	1	3	19	19	31
21. Aug	13	11	25	4	5	9	2	2	5	19	18	39
24. Aug	11	12	25	5	4	5	1	3	6	17	19	36
27. Aug	12	12	23	3	3	8	1	4	4	16	19	35
30. Aug	12	13	21	3	3	7	1	2	3	16	18	31
02.Sep	11	12	26	4	4	9	2	1	5	17	17	40
05. Sep	12	11	19	5	5	9	1	1	6	18	17	34
08. Sep	12	12	22	3	5	6	1	1	4	16	18	32
11. Sep	11	13	23	4	3	7	3	2	3	18	18	33
14. Sep	12	12	25	5	4	8	2	3	4	19	19	37
17. Sep	13	12	19	3	4	7	3	4	6	19	20	32
20. Sep	13	11	18	4	3	8	1	1	5	18	15	31
23. Sep	13	11	19	4	3	9	2	2	3	19	16	31
26. Sep	12	12	23	3	5	6	3	3	4	18	20	33
TOTAL AMOUNT (kg)	360	359	623	115	133	220	50	66	127	525	558	970
END TOTAL AMOUNT (kg)	1342			468			243			2053		

Table 4.3 Fraction defective calculations

	SCRAP/PRODUCTION RATIO		
Date	Team A	Team B	Team C
01.July	0,0083	0,0092	0,0144
04.July	0,0085	0,0094	0,0153
07.July	0,0088	0,0094	0,0159
10. July	0,0085	0,0091	0,0149
13. July	0,0084	0,0080	0,0140
16. July	0,0086	0,0111	0,0157
19. July	0,0080	0,0104	0,0179
22. July	0,0089	0,0094	0,0154
25. July	0,0093	0,0090	0,0147
28. July	0,0086	0,0096	0,0171
31. July	0,0095	0,0100	0,0179
03.Aug	0,0076	0,0109	0,0156
06. Aug	0,0090	0,0080	0,0158
09. Aug	0,0082	0,0086	0,0195
12. Aug	0,0086	0,0104	0,0176
15. Aug	0,0090	0,0106	0,0173
18. Aug	0,0094	0,0095	0,0163
21. Aug	0,0093	0,0091	0,0220
24. Aug	0,0086	0,0094	0,0189
27. Aug	0,0080	0,0094	0,0189
30. Aug	0,0079	0,0088	0,0159
02.Sep	0,0086	0,0085	0,0211
05. Sep	0,0090	0,0087	0,0179
08. Sep	0,0079	0,0089	0,0164
11. Sep	0,0092	0,0088	0,0171
14. Sep	0,0096	0,0094	0,0187
17. Sep	0,0095	0,0100	0,0168
20. Sep	0,0089	0,0077	0,0161
23. Sep	0,0093	0,0081	0,0165
26. Sep	0,0091	0,0099	0,0174

4.3.1 The Test Statistic

In order to statistically test the difference between team defective ratios (p), a paired sample t-test is done between each two of three teams. The results of the t-tests performed are given below.

The Paired-TTEST results are herewith as given according to the calculations from Table 4.3:

TEAMS	Team A-Team C	Team A-Team B	Team B-Team C
Paired-TTEST Statistics	0,000	0,481075484	0,000

The results show that Team A and Team C defective ratios (p) are significantly different at α <0,001 and similarly Team B and Team C defective ratios (p) are significantly different at α<0,001. However Team A and Team B defective ratios (p) are not statistically different even at minimum acceptable significance level α=0,05 .

As a result, Team C is different than the others.

4.3.2 Scrap Comparison between Teams

From table 4.2, the total scrap amaount of all production lines is collected for three months. The avarege scrap rate value for a team is 22.81 kg. The value for team A, B and C are 17.5, 18.6 and 32.33 kg, respectively. This shows that teams A and B produce lower than the avarage scrap rate; however team C produces higher than the avarage production rate. The graphs of scraps are shown herewith.

The avarage scrap loss through teams is 68433 kg. We know from table 4.2 the scrap values for team A, B and C are 525, 558 and 970 kg respectively. This histogram given in Figure 4.2 shows that at the end of the three months, there is a sharp scrap loss difference between team C and the teams A and B comparatively.

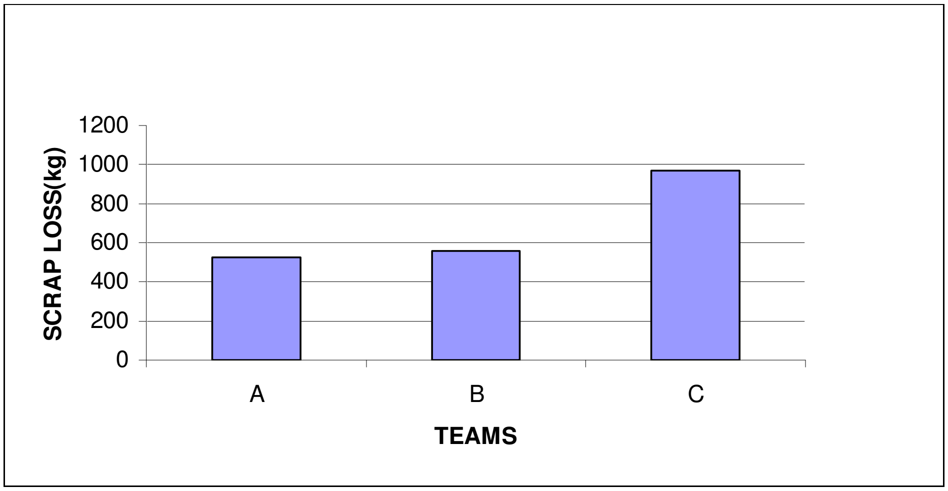

Figure 4.2 Comparison of total scrap for three teams

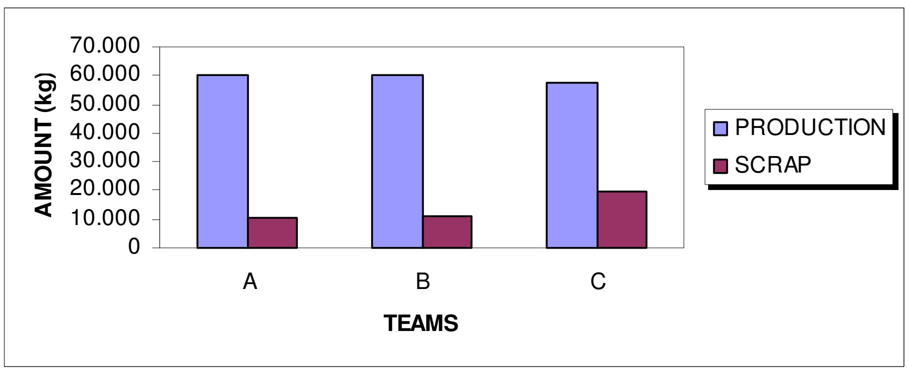

Figure 4.3 Production – scrap comparison

As it is observed from Figure 4.3, the relationship between production and scrap loss amount is comparable for teams A and B according to team C. But, for the team C, the scrap loss is increasing while its production rate is decreasing. The ratio between scrap to production rate percentages are 0.87 %, 0.93 % and 1.69 % for teams A, B and C respectively.

Combined figure of histograms in Figure 4.4 shows that the distribution of scrap loss is normal for teams accordingly. That means there isn't dramatic decrease or increase in the observed time interval. The minimum values for teams A, B and C fluctuate between 15, 15 and 28, maximum values 19, 22 and 40, respectively.

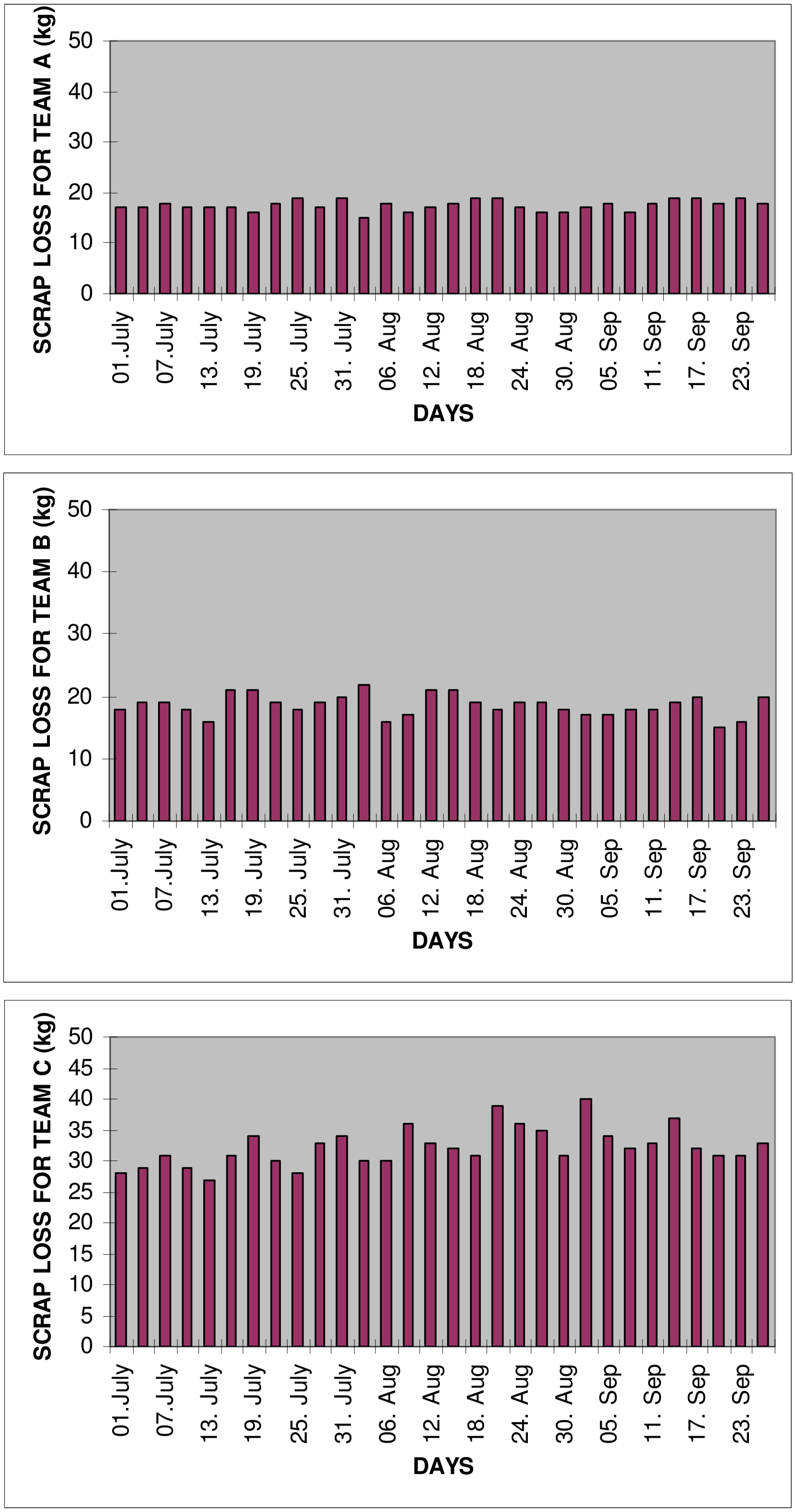

Figure 4.4 Total scraps for teams A, B and C

4.3.3 Scrap Trend for Teams

The exact meaning of Figure 4.5 is clear in the diagram of Figure 4.6. The paths of scraps are showing serious diffrerence for teams A, B and C. There is almost a coincidence between A and B paths.

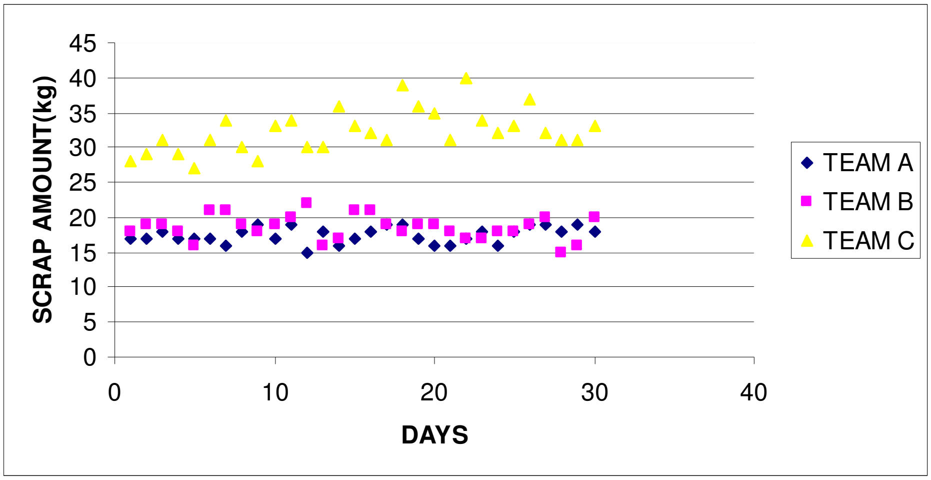

Figure 4.5 Total scrap scatter diagram for teams A, B and C

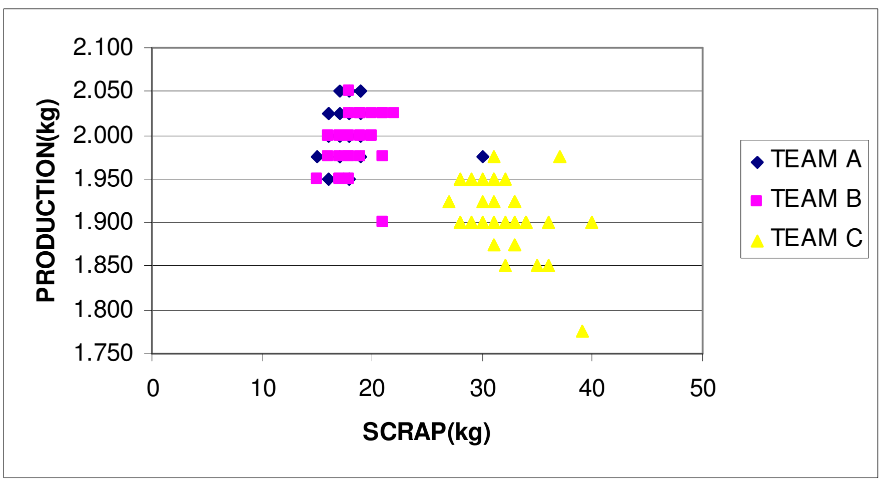

Figure 4.6 Production - scrap comparison scatter diagram for teams

As can be seen from Figure 4.6 it is a good example from engineering optimization point of view. The increase in production and decrease in scrap is an optimization issue for any production type. Here, there is a clear difference between team's efficiencies. The team C production rate is decreasing while its scrap is increasing according to the teams A and B trends.

In figure 4.7, the trends of teams for the near future are straigthly showing two different directions. The direction of teams A and B is higher production, less scrap trend. But the direction of team C is low production and more scrap trend. The trends are giving forecast chance to us and we need to work on team C.

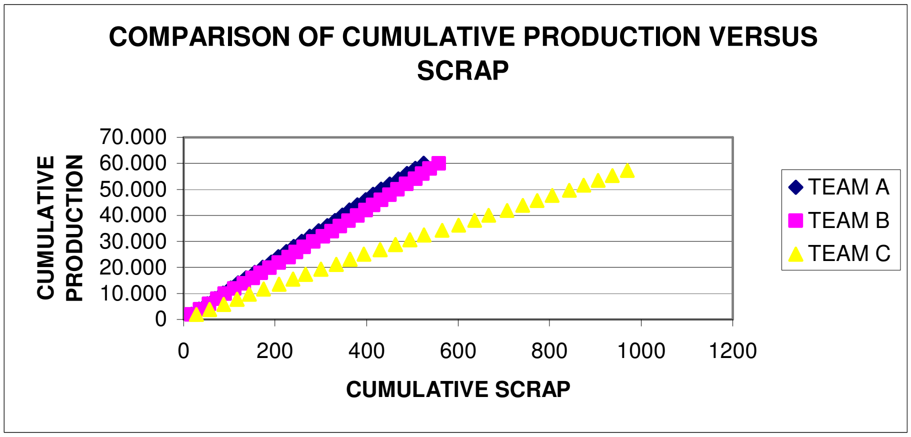

Figure 4.7 Cumulative production – scraps scatter diagram

4.3.4 Analyses of Scrap Reasons for Teams

The analyses are carried out in different stages. These are:

4.3.4.1 Pareto Analyses

To solve any problem effectively the efforts have to focus on important reason(s) which is/are causing it. Here from Figure 4.8, the most important part of the scrap loss is due to string line 65 % which can be seen at Table 4.4. Pareto analyse claim is proofed for 80/20 rule; because 88 % scrap loss (percentage(s) at Table 4.4) is consisting of 20 % of reasons.

Table 4.4 Pareto analyse table for total scrap.

SOURCE OF SCRAP	CATEGORY	AMOUNT	CUMULATIVE	PERCENTAGE
1	TOTAL STRING LINE SCRAP(kg)	1342	1342	65.37
2	TOTAL WEAVING LINE SCRAP (kg)	468	1810	88.16
3	TOTAL CONFECTION LINE SCRAP (kg)	243	2053	100

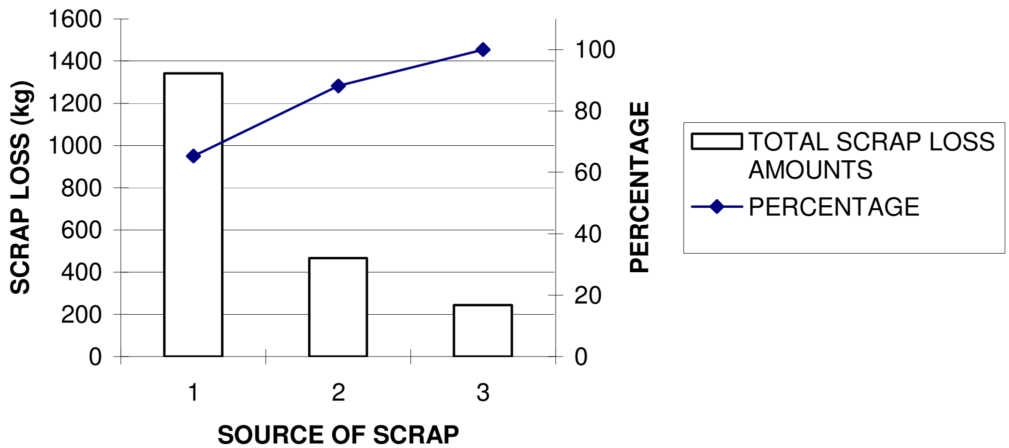

Figure 4.8 Total scrap Pareto

The collected data, to learn the reason asked for string line scrap loss, is presented at Table 4.5. The reasons of problem are asked by a multiple choosed questionary to concerned people who are team supervisors. Questionary include 7 M (men – machine – method - material - manhood – management - money) reason alternatives.

Table 4.5 Reasons expressed by supervisors for scrap

REASONS EXPRESSED FOR STRING LINE SCRAP LOSS							
TEAMS / DAYS	MEN	MACHINE	METHOD	MATERIAL	MANHOOD	MONEY	MANAGEMENT
01.July	4	1					
04.July	4	2					
07.July	5	1					
10. July	3	1					
13. July	3	2					
16. July	3	3					
19. July	5	1		1			
22. July	4	1					
25. July	4	1					
28. July	3	2		1			
31. July	3	1					
03.Aug	3	2					
06. Aug	3	1					
09. Aug	3	2	NOT SIGNED	1		NOT SIGNED	NOT SIGNED
12. Aug	3	2		1			
15. Aug	3	2		1			
18. Aug	3	1		1			
21. Aug	4	3		1	1		
24. Aug	3	3		1	1		
27. Aug	3	2		1			
30. Aug	4	2		1			
02.Sep	3	4		1			
05. Sep	3	3					
08. Sep	3	3		1			
11. Sep	4	3		1			
14. Sep	3	4		1	1		
17. Sep	4	2					
20. Sep	4	1					
23. Sep	4	1					
26. Sep	3	2		1			
TOTAL AMOUNT	104	59	0	15	3	0	0
END TOTAL AMOUNT	181						

Table 4.6 Pareto analyse table for string line scrap reason

REASON OF SCRAP	CATEGORY	AMOUNT	CUMULATIVE	PERCENTAGE
1	MEN	104	104	57.46
2	MACHINE	59	163	90.06
3	MATERIAL	15	178	98.34
4	MANHOOD	3	181	100

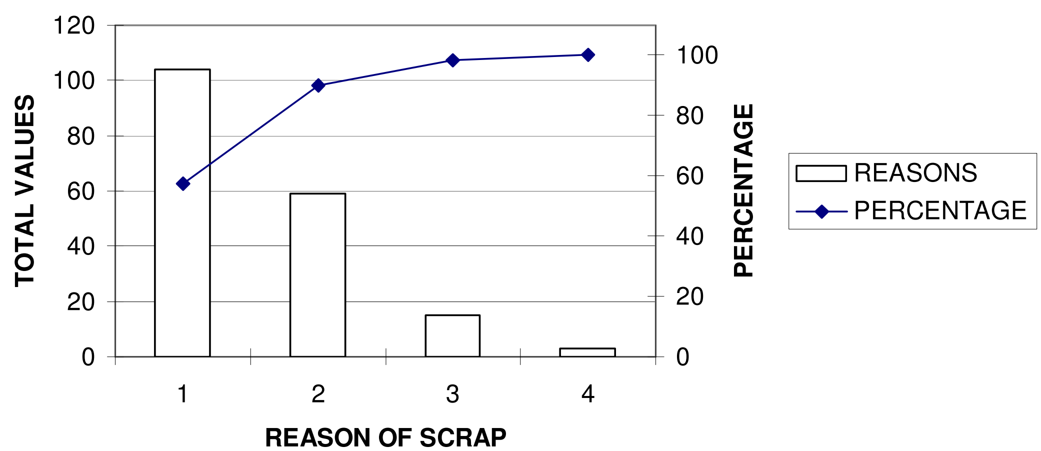

Figure 4.9 Pareto analyse table by using string line scrap reason

Here from Figure 4.9, the most important part of the string line scrap is due to man 57 %. Pareto analyse claim is also proofed for 80/20 rule; because 90 % scrap (problem) is consisting of 20 % of reasons. From these implementations, there are three strong extractions for the scrap:

1. The team C is giving excess scrap more than teams A and B respectively.

2. The most important part of scrap is consisted of string line scrap loss.

3. The main reason for the excess of scrap is men based.

4.3.4.2 Brain Storming

Keeping in mind those extractions, we applied brain storm through quality circle implementation. This circle is a group of people from different disciplines, constructing a team for solving this problem in Figure 4.10. In this stage brain storm which is a technique used for working with a rule such as “say your idea even if it is not logical according to you” is implemented [31]. These extractions are asked to six members of quality circle and they replied them stage by stage as given in Table 4.7. The member of quality circle in this case study is selected as Member of Managing Board (MMB), Production Manager (PM), Maintanance Manager (MM), Purchasing and Finance Manager (PFM), Work Force Representative (WFR) and Team Supervisor (SS). The replied anwsers accepted by members are given in Table 4.8:

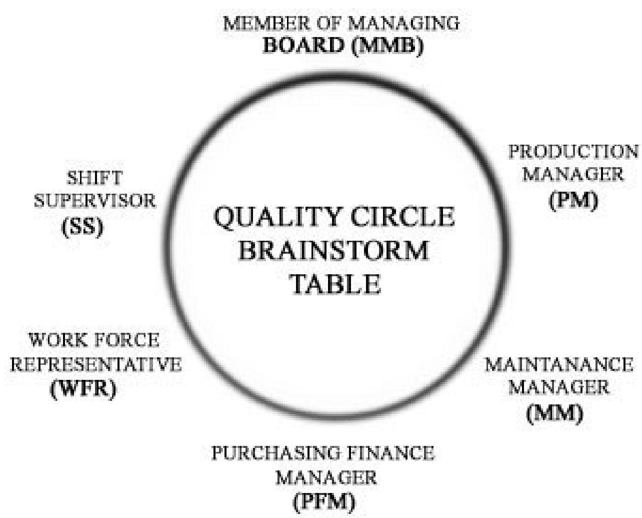

Figure 4.10 Quality circle with six members

Table 4.7 Brainstorm quality circle answer table for high scrap

Quality Circle for Brainstorm	Member of Board	Production Manager	Maintenance Manager	Purchasing and Finance Manager	Work Force Representative	Shift Supervisor
STAGE 1 Man	Lazy workers	Untrained staff	Inefficient use of machinery	-	New staff	Undisciplined staff
	-	Insufficient orientation	-		-	Unclear task definition
		-				-
STAGE 2 Machine	Unscheduled maintenance	Used spare parts quality	Insufficient spare parts	Expensive original parts	Old technology	Insufficient maintenance staff
	-	Montour misinformation to staff	Maintenance handbooks not available	-	Long repair time	Uncontrolled storage for spare parts
		-	-		-	-
STAGE 3 Method	-	-	-	-	-	-
STAGE 4 Material	-	Wrong mixture	-	-	Use of nonconforming spects materials	Late delivery of material
		-			-	-
STAGE 5 Manhood	-	-	-	-	-	-
STAGE 6 Money	-	-	-	-	Late payment	-
STAGE 7 Management	Undisciplined managing supervisor	Undefined shift rules	-	-	-	-
	-	-				

4.3.4.3 Quality Circle

The highest marked points of quality circle for brainstorm is collected and ranked grades from top to low.

Table 4.8 Acceptance of quality circle members for brainstorm results

Quality Circle for Brainstorm	MMB	PM	MM	PFM	WFR	SS	Total Score
Expensive orijinal parts	1	1	1	1			4
Insufficent spare parts			1			1	2
Lazy workers	1						1
Unclear task definition	1	1	1	1	1	1	6
Undisciplined staff	1	1	1	1	1	1	6
Untrained staff	1	1	1	1	1	1	6
Unscheduled maintanance	1						1
Insufficient orientation	1	1	1	1	1	1	6
Unefficient use of machinary	1	1	1	1	1	1	6
Old technology		1			1	1	3
Wrong mixture		1				1	2
New staff		1			1	1	3
Undisciplined managing supervisor	1	1	1	1	1	1	6
Undefined team rules	1	1	1	1	1	1	6
Late payment					1	1	2
Late delivery of material						1	1
Use of nonconforming spects materials		1			1	1	3
Uncontrolled storage for spareparts						1	1
Long repair time					1	1	2
Insufficient maintanance staff						1	1
Maintanance handbooks not available		1	1				2
Montours misinformation to staff		1	1				2

Used spare parts quality		1	1				2

Then the quality improvement for scrap loss is going to start with points total scored as 6. These points are mainly assigning variation, in this case study, due to special causes which are:

- Unclear task definition
- Undisciplined staff
- Untrained staff
- Insufficient orientation
- Unefficient use of machinery
- Undisciplined managing supervisor
- Undefined team rules.

So, it is understood that it is necessary to start a training program for the staff to reduce scrap loss. This program is implemented in 3 months including orientation to work, discipline rules in factory, efficient use of machinery. The team supervisor is replaced by new person and mandotary shift rules are delivered by receiving all staff signature.

4.3.5 Results of Statistical Analyses

Production and scrap results recorded after these statistical analyses and new situation are given in following tables.

Total production for string line which is including approved quality strings and scraps together after implementations of improvement activities are given in Table 4.9.

Table 4.9 Total production for string line

STRING LINE PRODUCTION(kg)			
TEAMS / DAYS	Team A	Team B	Team C
01. April	2000	1975	1975
04. April	2000	2025	2000
07. April	1950	2050	2025
10. April	1950	2000	2000
13. April	1975	2025	2025
16. April	1975	2025	2000
19. April	2000	2050	1975
22. April	2000	1975	1975
25. April	2050	2025	2000
28. April	1975	2000	1975
31. April	2000	2025	2000
03. May	2075	2025	1975
06. May	1975	2025	2025
09. May	2000	2025	1975
12. May	2050	2000	1975
15. May	2000	1975	2025
18. May	2025	2000	2000
21. May	2075	1975	2025
24. May	2000	2025	2000
27. May	2000	2025	1975
30. May	2025	2025	2000
02. June	2050	2000	2025
05. June	2000	1975	2025
08. June	2025	2000	1975
11. June	2025	2025	2025
14. June	2025	2000	2000
17. June	2000	1975	1975
20. June	2025	1975	2000
23. June	2050	2025	2025
26. June	2000	2000	1975
TOTAL AMOUNT (kg)	60300	60250	59950

Production volumes are recorded as much as same for all teams according to first study period as can be observed in Table 4.9.

Table 4.10 Total production lines scraps for each team after implementations of improvement activities.

	STRING LINE SCRAP (kg)			WEAVING LINE SCRAP (kg)			CONFECTION LINE SCRAP (kg)			ALL LINE TOTAL SCRAP (kg)		
TEAMS / DAYS	A	B	C	A	B	C	A	B	C	A	B	C
01. April	12	10	11	2	2	3	1	1	2	15	13	16
04. April	11	9	12	2	3	2	1	1	1	14	13	15
07. April	11	9	12	2	3	2	1	1	1	14	13	15
10. April	13	9	13	3	2	2	1	2	1	17	13	16
13. April	10	11	11	2	2	1	1	1	2	13	14	14
16. April	10	10	11	2	2	2	1	1	2	13	13	15
19. April	11	11	11	1	1	1	2	1	3	14	13	15
22. April	10	11	11	2	2	2	1	2	1	13	15	14
25. April	10	11	11	2	2	2	1	1	1	13	14	14
28. April	11	10	11	2	1	2	1	2	2	14	13	15
31. April	11	10	12	2	1	2	1	2	2	14	13	16
03. May	11	10	12	2	1	2	1	2	2	14	13	16
06. May	11	11	12	2	2	2	2	2	1	15	15	15
09. May	11	10	11	1	2	1	2	1	2	14	13	14
12. May	12	11	13	3	2	3	2	2	1	17	15	17
15. May	11	10	12	2	2	2	2	1	2	15	13	16
18. May	12	12	12	2	2	2	2	1	1	16	15	15
21. May	12	11	12	2	2	2	2	1	1	16	14	15
24. May	12	11	12	2	2	2	2	1	1	16	14	15
27. May	10	10	12	2	2	2	2	1	1	14	13	15
30. May	11	11	11	2	2	2	2	1	1	15	14	14
02. June	12	11	12	2	2	3	2	1	2	16	14	17
05. June	11	11	12	2	2	2	2	2	2	15	15	16
08. June	12	10	12	2	2	3	2	2	2	16	14	17
11. June	11	9	12	2	2	2	2	2	2	15	13	16
14. June	11	9	11	2	2	2	2	2	2	15	13	15
17. June	12	10	13	3	3	3	2	2	3	17	15	19
20. June	11	11	12	2	2	3	2	2	1	15	15	16
23. June	12	11	12	2	2	2	2	1	2	16	14	16
26. June	11	10	11	2	1	2	2	2	2	15	13	15
TOTAL AMOUNT (kg)	336	310	352	61	58	63	49	44	49	446	412	464
END TOTAL AMOUNT (kg)	998			182			142			1322		

As it can be seen from Table 4.10 total amount of scrap is reduced for teams A, B and C as 446, 412 and 464 kg respectively so total scrap is decreased from 2053 kg to 1322 kg at all as 35 %.

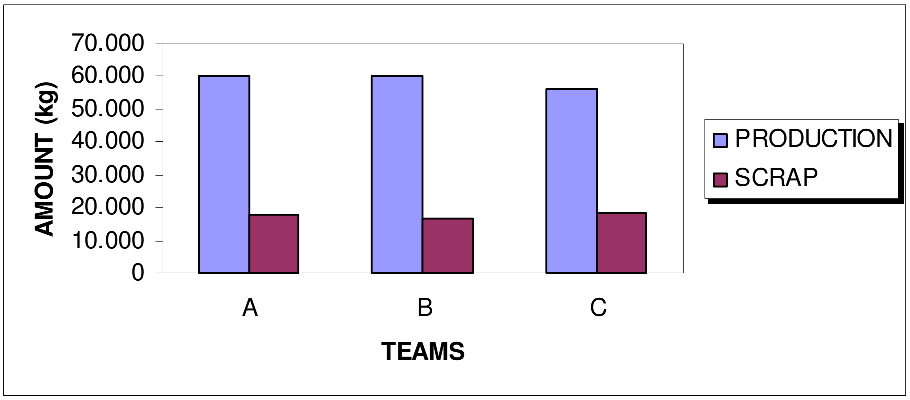

Figure 4.11 Productions scrap comparison for teams

It is very clear from Figure 4.11 that productivity is almost same in all teams after implementations.

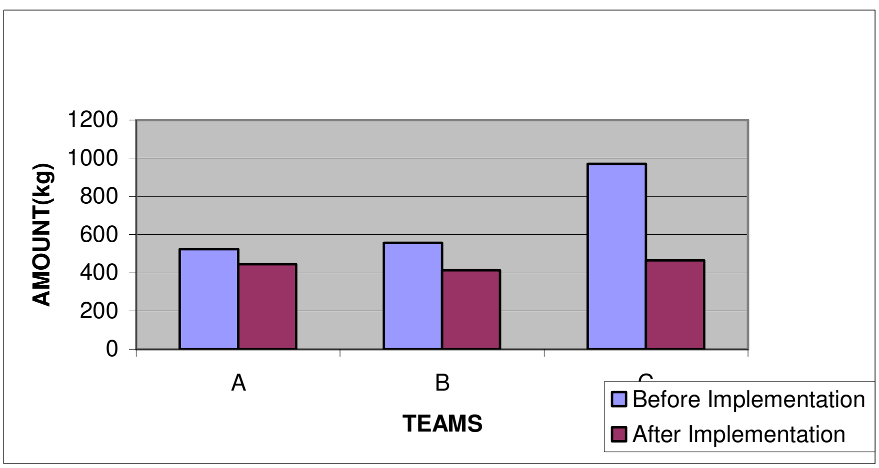

Figure 4.12 Scrap changes in teams

Reduction in the scrap changes is mainly observable for all teams at Figure 4.12. Most important scrap reduction which is much more then 50 % realized in team C.

CHAPTER 5

CONCLUSION AND FUTURE WORK

It is seen from this work, the statistical quality control methods are easily applicable for industries. The benefits to be derived from the application of statistical methods of quality control are many and varied. SQC generates a bonus increase in productivity, by reducing the size of the 'hidden plant' which is devoted to producing nonconforming products or services such as improve quality, and reduce their scraps, wastes and cost [32]. SQC methods result in deep understanding of the manufacturing environment by monitoring product and process quality.

Statistical techniques have to be selected correctly where they are suitably applicable. The most fundamental statistical quality control tools are cause-and-effect diagram, check sheet, control charts, histogram, Pareto chart, scatter diagram, stratification. Ideally, the common tools can be set up on processes according to environment of needs. Statistical quality control tools which are four of this seven briefly introduced for the implementation to a PP bag production company.

This thesis represents comments on some possible results of the current research. Histograms used for showing production and scrap loss frequency distributions and comparisons between teams A, B and C. It is observed that the resulted distributions for team C is lower production and higher scrap loss. Scatter diagram is other tool which is pairs of numerical data, one variable on each axis, to look for a relationship. This tool introduced that team C produces less value and high loss. Overall trend is in negative direction for team C but positive for teams A and B.

The next one Pareto analyse shows on a bar graph which factors are more significant. The prior factors to focus on it determined as string line between production steps. The reasons for high scrap loss on string line is choosed between 7 M (men – machine – method - material - manhood – management - money) by supervisors through teams. The 4 M is ranked in placements, which are men, machine, material and manhood. 57 % of reasons for scrap are voted as due to men through quality circle in brainstorm activity.

The most important extractions for this case study are:

- There is a slight difference between the performance of teams A, B/C
- The most important scrap loss producer step is string line
- It is clear that men based problems are source of high scrap loss.

It is strictly advised that the extractions for the continual improvement require training of team C staff in string line. The training has been carried on both theory and practice together. In service training, each staff has been followed and examined after stages. At the first stage of data collection, low production amounts and high scrap loss was recorded for team C. Next step, we implemented statistical methods to analyse and improve these unrequested case. The scrap loss decreased 35 % in the factory at the end of the implementations.

SQC has to be in consideration for new areas to compete internationally, both in home markets and overseas, or to improve cost effectiveness and efficiency. Organizations must continue to adopt a professional approach to the collection, analysis and use of the process data. It is intended to adopt SQC to syntetic bag factory to reduce scrap.

It is known that reduction of scraps is a big problem for any type of industry. As a future work, these implementations can be extended into any other sectors to increase production volume or decrease any kind of losses.

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