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The Quality Control Tools used for Sustainability of Quality

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Abstract: Quality Control (QC) is an active process that detects defects in a product claimed to be ready for delivery, so it can be said that QC is the key to maintaining quality. Although quantitative quality control methods based on numbers and measurements provide tangible implications with more reliable results, qualitative measurements are also important for the quality control process. When manufacturers apply appropriate quantitative and qualitative quality control methods in their production processes, they can identify problems in products and produce appropriate solutions. In this research, quality control practices are examined and their effects on the sustainability of quality are investigated. In addition, the functioning of Quality Control methods is revealed, and the usage areas and forms of the methods are examined with examples. While evaluating the Quality and Quality Control methods, which are discussed in a wide range, other titles under the title of Quality are also included within the framework of this study. In today's conditions, the improvement of concepts such as time, less cost, and quality production that gains in value in the production process is directly related to the adequacy of quality control. The aim of this paper is to solve the quality problems in the production process of manufacturing organizations by investigating various technical quality control methods used to improve all these concepts. By eliminating the quality problems and minimizing the losses, the profitability level of the organization will be increased, along with this, the quality will be improved and become sustainable.

Key words: quality, quality control, 7 tools of quality control, quantitative and qualitative quality control.

1. Introduction

The term quality is widely used by practitioners and academics, although there is no generally accepted definition as different definitions of quality are appropriate under different circumstances. While not a universally accepted definition, quality can be defined by this definition, written by the world's largest international standards developer and publisher (ISO 9000, 2005), by keeping in mind the ever-changing standards: Quality is a situation when a set of inherent characteristics consistently fulfill the continuously changing requirements of the organization's customers and other stakeholders [1].

Quality, a source of competitive advantage, should remain a hallmark of Company products and services. High quality is not an added value; it is an essential basic requirement. Quality does not only relate solely to the end products and services a company provides but also relates to the way the Company employees do their job and the work processes they follow to produce products or services. The work processes should be as efficient as possible and continually improve. Each employee in all organizational units is responsible for ensuring that their work processes are efficient and continually improving [2]. At this point, Quality Control (QC) is the most basic requirement for the sustainability of quality.

The QC, which plays an important role in maintaining quality and updating it according to expectations, may generally be defined as a system that maintains a desired level of quality, through feedback on product/service characteristics from a specified standard [3].

Quality and quality control are inseparable puzzle pieces. When quality control is carried out by conditions and requirements and the right quality control instruments are used, it makes a great contribution to the process of maintaining and improving quality. In this research, quality control methods and quality control processes will be examined and the importance of quality control tools on the sustainability of quality will be investigated.

In today's competitive environment, manufacturers have created needs such as lower production costs, more production in less time, high quality products, trouble-free production processes. There are different quality control tools applied to improve product quality according to expectations. In this article, these quality control tools and processes will be examined. In addition, the use of different quality control tools to improve production quality are determined. There are too many defects in the production process, which adversely affect the profitability, productivity and production quality of companies. This research aims to examine the research work done by the researchers, to produce technical solutions to various defects and make improvements in the production process.

2. Literature review

The Quality control mechanism plays an important role in maintaining and improving quality according to expectations. Processes can be intervened with different quality control equipment according to needs and conditions. With the quality control mechanism of the processes being carried out up-to-date and continuously, it is ensured that the quality is by the ever-changing expectations.

Customer satisfaction determines the success of a new product, and only high-value products meet the needs of customers who expect them to perform correctly throughout their entire lifecycle. To meet such requirements, a minimum variation of parameters must be ensured in the production processes and in the product itself. From a basic part to composite parts, they must be designed and manufactured to a high quality level and be reliable and safe in use [4].

To ensure the sustainability of quality, there are three primary types of quality inspections: pre-production, in-line, and final. There are a variety of details that must be inspected and approved during each phase in order to detect and correct quality problems.

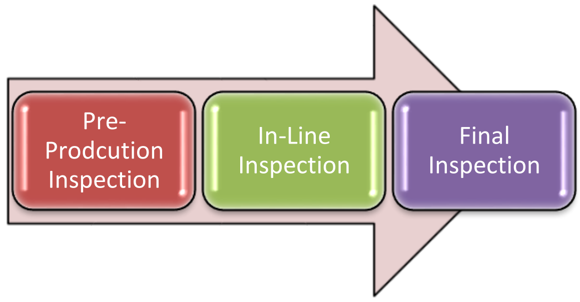

Fig. 1. Three Main Stages of Quality Inspection

During the quality control, all products can be checked one by one or samples can be taken for inspection. In some cases, checking all products one by one may not be a profitable option for manufacturers in terms of cost-benefit. This is where quality control through sample checking comes into play. Sample checkings involve selecting a small number of items from a bigger batch or lot to check a range of their specifications such as appearance, workmanship, safety, functions, etc. prior to mass production. Basically, a sample of the products are extracted from the bunch and inspected for quality, rather than the whole lot. Inspectors will be looking for potential defects and will compare the physical objects and products to design plans and drawings to ensure the correct measurements have been met. Style and color are other things which can be checked as well as shipping marks and packaging. [5].

The inspection methods that used by this company are sampling inspection and 100% inspection. Sampling inspection is conduct on the semi-finished product or work-in-process products. Meanwhile, 100% inspection is conduct for all the products in the company and ended with segregate out the good products and nonconformance products. Sampling inspection either for the grading or for checking the correctness of the grading should be done most accurately, because unless the sample is truly representative of the entire lot, correct grading cannot be done. The general characteristics of the commodity should be preliminarily inspected before drawing samples from the lot. Meanwhile, 100% inspection determining whether a commodity in a particular lot complies with the standard specifications applicable to it or any other specification stipulated in the trade contract. [6].

The significance of pre-production for assessing a product prior to production are emphasised by researchers. Ironically, while significant research has advanced the broad understanding of process improvement methods in product design and manufacture, the pre-production process is an area within design and manufacture which has received little attention [7]. In pre-production, validation is an assessment method which "reflects a product's fitness for use and application, or a system's suitability to achieve its objectives" [8]. Inspecting the product's conformity with predetermined technical requirements and suitability for full-scale production has become a pre-production necessity. Therefore, the reasons for going into pre-production are testing, validation and verification of products, while the ultimate goal is to ensure product quality and reliability.

A Pre-Production Inspection (PPI) is generally conducted once raw materials are received and the factory is ready to begin production. A PPI can cover a number of different areas. Some common agendas are verifying that raw materials match the quality specified in the contract, checking a prototype product or golden sample, ensuring the factory is ready for mass production. During the pre-production phase, raw materials should be tested before entering production. This may include a number of tests to examine the material for weight, dimensional stability, pilling resistance, torqueing, pile retention, stretch recovery, and much more. Components including closures, zippers, elastics and other embellishments such as beads, rhinestones, sequins and rivets should also be tested for regulatory requirements. Since quality issues are often a result of defects in the materials, inspections during the pre-production phase allow auditors to address any issues before production begins. Ultimately, by inspecting the materials up front, brands and retailers can avoid unanticipated costs and delays [9].

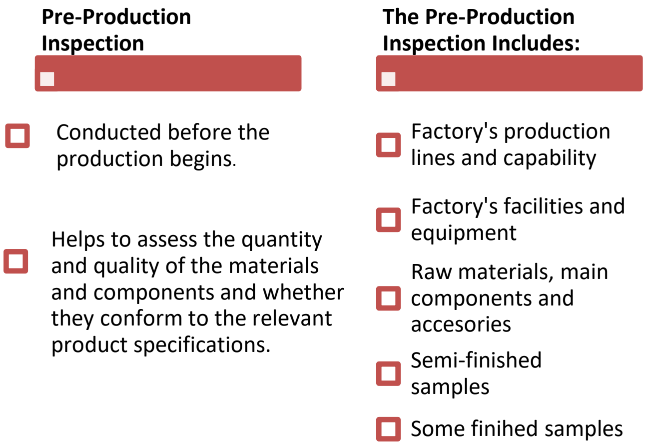

Fig. 2. Pre-Production Inspection

The in-line quality control process incorporates inspection points across the production line. These points inspect the product for quality in terms of various standards or specifications. The gauges used in this process are specific to the task assigned. Certain inspection points are also likely to have multi-purpose gauges. The in-line quality control is swifter than the offline systems. This is primarily because the inspection takes place along the process without any additional time required for removal or replacement. The data gathered from these inspections can be used to align the production process in real-time to maintain limits of tolerance which can reduce wastage and downtime [10].

During Production Inspection (DPI) or in another saying DUPRO, is a quality control inspection conducted while production is underway, and is especially good for products that are in continuous production, that have strict requirements for on-time shipments and as a follow-up when quality issues are found prior to manufacturing during a pre-production inspection. These quality control inspections are conducted during production when only 10-15% of units are completed. DPI should be made as soon as possible after the production process has started. By detecting the problems that may be encountered in terms of quality in the production process as early as possible, it is possible for the factory or supplier company to intervene with the least loss.

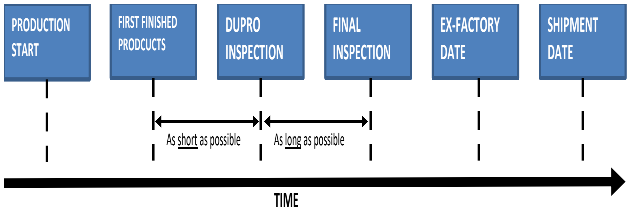

Fig. 3. Timing of DUPRO in manufacturing process

Final Inspection in the manufacturing process, and refers to the inspection performed in the final stage of the manufacturing process. In this test, whether the complete goods meet the requirements as a product or not is determined in order to prevent the loss in customer confidence, various problems, and damages in advance. On top of that, the manufacturing process includes Acceptance Inspection and Inspection between Processes, both of which are performed for such constituent items as purchased raw materials, processed parts, and assemblies, and they are not done for complete goods. In the Final Inspection, the whole of the product including the requests from customers is inspected.

A "packed product" is ready for shipment (i.e. in a closed export carton with full shipping marks). In many cases, the inspector accepts up to 20% of unpacked products per reference. This way, the inspection can often take place without delaying the shipment. The conformity of the products is checked against a list of criteria defined by the buyer (product quantity, workmanship, function, safety, aspect, size, packing…). Buyers are advised to ask their inspectors to keep track of which cartons were opened. This way, a 2nd "spot" inspection can give an idea of how seriously the control was performed [11].

The Quality Control process consists of some basic steps. First, the production process to be controlled is selected, and then the targeted quality standards for the product are determined. The performance after production is measured and the quality standards of the targeted and final product are interpreted, if there is a difference between the two, R&D studies are carried out, and the product is put into production again to reach the targeted quality measure.

There are 7 quality tools that are very effective in solving quality problems at the Quality Control stage. These; Stratification, Histogram, Check Sheet, Cause and Effect Diagram (Fishbone or Ishikawa Diagram), Pareto Chart, Scatter Diagram, Shewhart Chart.

Fig 4. 7 Quality Control Tools

The Fishbone Diagram which is called "The Cause and Effect Diagram" is based on the logic of "All the causes that create the problem are caused by some sources" through the cause-effect relationship; It is created to show, visualize and analyze the causes that produce the results. Causes are divided into main categories in order to identify the sources causing the error and sub-reasons such as people, methods, materials, measurements, environment, etc. are added to these categories. The main purpose is to prevent quality errors that may occur. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories. When identifying possible causes for a problem and a team's thinking tends to fall into ruts it's a useful method [12, 13].

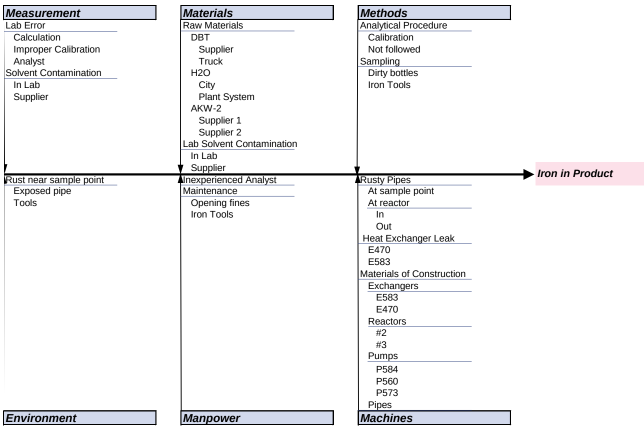

Fig. 5. Fishbone Diagram: Iron in Product

The Fishbone Diagram Example in *Figure 5* was drawn by a manufacturing team to try to understand the source of periodic iron contamination. The team used the six generic headings to prompt ideas. Layers of branches show thorough thinking about the causes of the problem. Note that some ideas appear in two different places. "Calibration" shows up under "Methods" as a factor in the analytical procedure, and also under "Measurement" as a cause of lab error. "Iron tools" can be considered a "Methods" problem when taking samples or a "Manpower" problem with maintenance personnel [12].

Control charts were developed by Dr. Walter A. Shewhart during 1920's while he was with Bell Telephone Laboratories. These charts separate out assignable causes. Control chart makes possible the diagnosis and correction of many productions troubles and brings substantial improvements in the quality of the products and reduction of spoilage and rework. It tells us when to leave a process alone as well as when to take action to correct trouble [14].

The Shewhart Chart serves to monitor and examine the quality process. The Shewhart control chart is a common control charting method applied in SPC (Statistical Process Control). It is a model based on a zero-order polynomial. The basis for this model is the assumption that the variations lying inside the control limits are the results of random causes and the variations lying outside the control limits are the results of assignable causes. These two types of variations are referred to as fluctuations and interruptions in a process operation. One approach that has been employed to provide a degree of separation between interruptions and drift is the use of moving averages as statistics for the Shewhart Control Chart. The benefit is the reduction of the influence of a single data point caused by an interruption. The drawback, however, is the lengthening of response time [15].

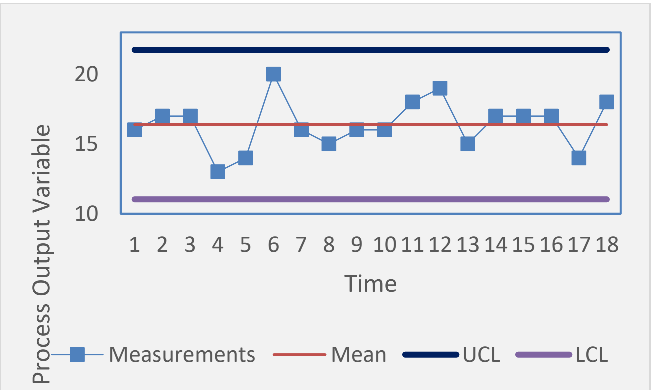

Fig. 6. Shewhart Control Chart: Process Output Variable - Time

Pareto Chart, on the other hand, ranks the reasons for increasing faulty production or customer dissatisfaction in quality control according to their importance.

Pareto analysis is based on the observation that operational results and economic wealth are not distributed evenly and that some inputs contribute more than others. It is referred to as the 80/20 rule, a nomenclature which has popularized a complex economic concept introduced by Vilfredo Pareto, a nineteenth-century Italian economist. The underlying concept is that the majority of problems (roughly 80%) are often caused by a small number of the sources (roughly 20%). The 80/20 rule implies that most efforts are not efficient and should be reduced. The strategic objective would be to leverage and maximize the efforts that produce most of the results. In strategic management, Pareto analysis is linked to the analysis of an organization's internal environment. It is particularly useful to identify internal strengths and weaknesses through the evaluation of an organization's internal resources and capabilities, which are the source of its core competencies and which in turn, create a competitive advantage.

Vilfredo Pareto insignificant in his work discovered that there could be a mathematical model between the majority and the significant minority (Mc. Cann, 2001). The connection of Pareto's mathematical model with the 80/20 rule is based on Joseph M. Juran's appeared when he wrote down his observations (Craft, Leake, 2002). Juran called the principle of "significant minority 20%, insignificant majority 80%" the Pareto Principle (Crawford, 2001).

80% of success is done in 20% of the time used; on the other hand, 80% of the time spent yields only 20% of the products (Koch, 2011). For example, 80% of the world's energy production consumed by 15% of the world's population. 80% of traffic congestions are on the roads It originates from 20. The 80/20 principle only accounts for about 20% of many impacts in our daily lives. that it is really important to give weight to this 20% for our personal time management. also emphasizes the need [16].

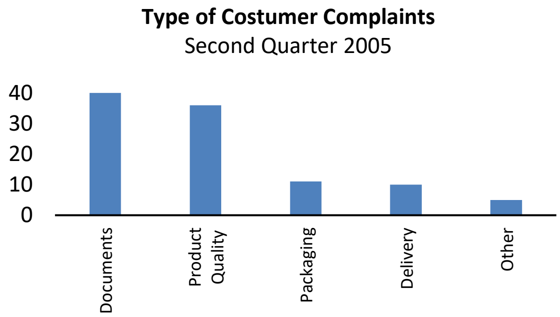

Fig. 7. Pareto Chart: Customer Complaints

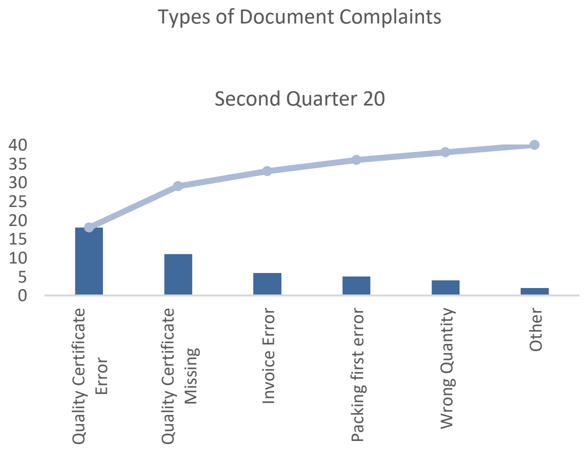

Fig. 8. Pareto Chart: Document Complaints

Figure 7 shows how many customer complaints were received in each of the five categories and *Figure 8* takes the largest category, "documents," from *Figure 7*, breaks it down into six categories of document-related complaints, and shows cumulative values.

The Scatter Diagram helps us see in detail what sources are causing our problem. While creating the Scatter Diagram, first a cause-effect table is drawn, then a Scatter Diagram is drawn in order to see the connections of the resources we have with each other. The Scatter Diagram along with the cause-effect chart analyzes the sources of quality problems.

Stratification is defined as the act of sorting data, people, and objects into distinct groups or layers. It is a technique used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be difficult to see. This data collection and analysis technique separates the data so that patterns can be seen and is considered one of the seven basic quality tools.

Stratification method can be used before collecting data, when data come from several sources or conditions, such as shifts, days of the week, suppliers, or population groups and when data analysis may require separating different sources or conditions.

The ZZ-400 manufacturing team drew a scatter diagram to test whether product purity and iron contamination were related, but the plot did not demonstrate a relationship. Then a team member realized that the data came from three different reactors. The team member redrew the diagram, using a different symbol for each reactor's data (Figure 9) [17].

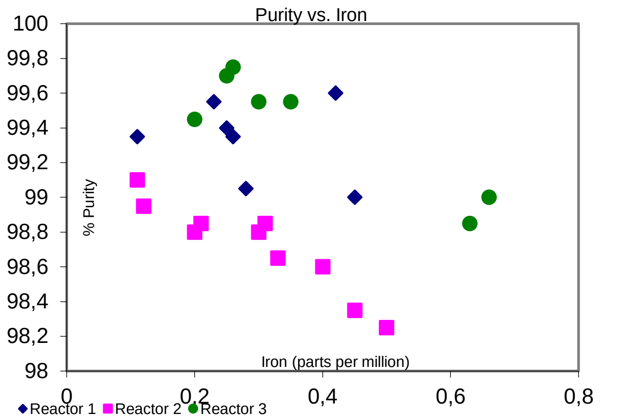

Fig. 9. Stratification Diagram: Purity vs. Iron

Mirko et al. (2009) designed and developed an effective layout for using these QC in the organizations based on the performance of them, in order to apply appropriately these quality tools for solving quality problems and quality improvement, as demonstrated in Figure 9. Accordingly, the following Figureinterprets how the 7 QC should be employed from first step to end of production processes for identifying the problems of quality performance and controlling them [18].

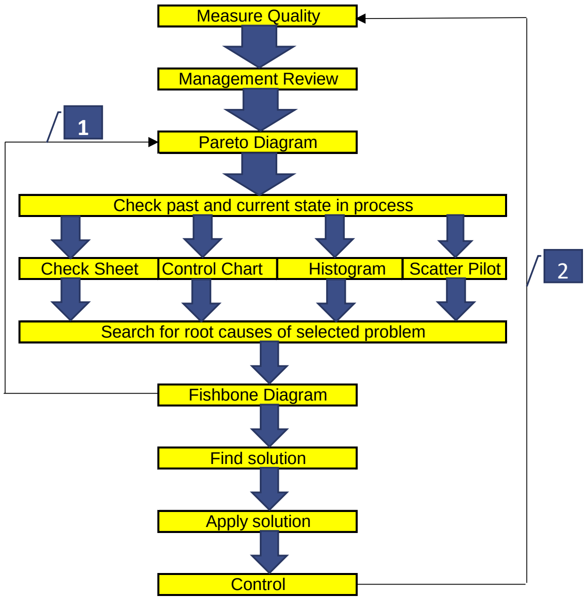

Fig. 10. An appropriate layout for using 7QC tools with the aim of improving extremely quality performance (Mirko et al., 2009)

3. Conclusion

As a result, quality control and quality control methods are indispensable for the sustainability of quality. Which quality control tool should be used in which process should be determined appropriately and carried out in accordance with the standards. Although the results obtained by examining and converting numerical data for quality control are more measurable, it is possible to eliminate visible errors with one-to-one controls of people, and to detect defective products by sampling.

This study found that the implementation of all seven QC tools, as well as the pre-production, in-line and final inspection stages, are crucial for organizations to troubleshoot production processes. Undoubtedly, all of the above-mentioned quality tools should be considered and used by management to identify and resolve quality issues during the production of products and services.

Since the concepts of Quality and Quality Control are examined in a wide range, care should be taken not to go beyond the research subject and to preserve the specificity of the subject during the research. However, for the same reason, in terms of establishing cause-effect relationships, explanations should be based on reasons and explanations to the maximum extent without going out of context.

As a summary, these following conclusion were derived from the papers above;

- Many industries prefer to use 7 basic quality control tools because its simple and easy to apply.
- By applying 7 basic quality control tools and the other techniques, rework and rejection rate can be reduced and quality can be improved.
- Reducing rejection rate in products increases profitability in the organization and reduces waste.
- Quality control tools give positive affects when used together.
- For the sustainability of quality, the use of quality control tools together and continuously shows positive effects in many respects.

Literature

[1] Elshaer, Ibrahim Suez Canal University, Management department, Egypt, May 2012

[2] Manghani K. Quality assurance: Importance of systems and standard operating procedures. Perspect Clin Res. 2011 Jan;2(1):34-7. doi: 10.4103/2229-3485.76288. PMID: 21584180; PMCID: PMC3088954.

[3] Mitra A, Fundamentals of Quality Control and Improvement, Vol. 4, John Wiley & Sons, 2016, pp. 13-14

[4] Mrugalska B. & Tytyk E., Quality control methods for product reliability and safety, 2015, pp. 2730 – 2737

[5] HQTS, "What are the different types of inspection in quality control?", access: 21 July 2022, https://www.hqts.com/what-are-the-different-types-of-inspection-in-quality-control/

[6] Ngadiman Y. & Burairah H. & Bon A.T. & Abdul Hamid N.A. (2017) Factors that Influenced the Quality Inspection on the Production Line in ManufacturingIndustry , pp.1-2 , DOI:10.151/matecconf/20179510007

[7] Almgren, H. (2000) Pilot production and manufacturing start-up: the case of Volvo S80. International Journal of Production Research, Vol. 38 (17), pp. 4577-4588

[8] Hinckley, C.M. (2001) Make no mistake: An outcome-based approach to mistake-proofing, Productivity Press, Portland, OR.

[9] NGC Software, "How to benefit from three different types of Quality Inspections", access: 12 July 2022, https://www.ngcsoftware.com/post/140/how-to-benefit-from-three-different-types-of-quality-inspections/

[10] Oden Technologies, Quality Control In Manufacturing, access: 6 July 2022, https://qualityinspection.org/what-is-quality-inspection/

[11] ASQ, Fishbone Diagram, access: 10 July 2022, https://asq.org/quality-resources/fishbone

[12] Login Software, Quality Control and Quality Control Tools, access: 19 July 2022, https://www.login.com.tr/blog/kalite-kontrol-ve-kalite-kontrol-araclari

[13] Cheremisinoff P. N., Condensed Encyclopedia of Polymer Engineering Terms (2001), pp. 268-300

[14] Nikunjkumar A Parmar & Shubham Awasthi, Review on Quality Management using 7 QC Tools, International Journal of Trend in Research and Development, Volume 5(2), ISSN: 2394-9333, November 2018

[15] Sammut-Bonnici T. & Powell Taman, January 2015, "Pareto Analysis", John Wiley & Sons, Wiley Enclyclopedia on Management, DOI:10.1002/9781118785317.weom120202

[16] Bekereci Ü & Yazici M & Hamzaoglu E, January 2020, "Parameters Determined by Pareto Analysis Technique The Academic Use of Its Use in the Teaching Process Impact on their success", p. 203, DOI: 10.15285/maruaebd.541606

[17] Quality Engineering Systems, Stratification, Matthew Daniels, March 2013, https://sites.google.com/site/learnqes/the-seven-tools/stratification

[18] Neyestani B. (2017, March). "Seven Basic Tools of Quality Control: The AppropriateQuality Techniques for Solving Quality Problems in the Organizations.", https://doi.org/10.5281/zenodo.400832