Statistical Control Process: A Historical Perspective

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Abstract:- One of the most powerful tools in thestatistical quality process is the statisticalmethods.First developed in the 1920's byWalter Shewhart, the control chart found widespread use during World War II and has been employed, with various modifications, ever since. There are many processes in which thesimultaneous monitoring or control of two ormore quality characteristics is necessary.

Reviewing statistical process control tools and providing a description about necessity of using these tools for improving the production process and providing some applications of statistical process control.This study covers both the motivation for statistical quality process and a discussion of some of the techniques currently available. The emphasis focuses primarily on the developments occurring since the mid-980's

Keywords: statistics, quality control, shewhartchart, control chart, praetorchart, diagram

I. INTRODUCTION

In 1924, Doctor Walter Shewhart founded the first statistical charts from Bell Telephone Laboratories in order to control production process [13, 14]. Therefore, he was known as the founder of statistical quality control. Generally, this period was known as the starting point of statistical process control. However, application of statistics in industry did not start in this period. The reason behind this issue was that production managers did not believe that statistical procedures should be generated an applied in the production process. They also did not believe that there should be statistics experts in manufacturing facilities. After professor Shewhart researches, two other colleagues Dodge and Roming investigated application of statistics theory in sampling. They published results of their work in 1944 as "Dodge and Roming Inspection Tables Dodge". These tables were later used as basic scientific statistical quality control.

In 1937, during World War II, the purchase of millions of tons food, ammunition, clothing, medicine, etc. by U. S military - without any scientific method to monitor them - forced U. S military leaders to turn to statistical quality control. This military action on the one hand led America to victory in World War II and on the other hand established quality control science (statistically) in the world.

After the World War II ended, a national organization was established called the Association of U. S quality control. This association in line with managing publication of industrial quality control magazine became the largest statistical quality control center which aimed to promote application of statistical quality control in the continent of America.

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In this paper, he led the association to devote a separate department to Industrial Research and Statistics. The association's magazine also published a supplement on statistics. This movement was the beginning of quality control in the UK. This movement grew faster in UK than U.S.

The British Standards Association published a book titled as "Application of statistical methods in standardization of industries and quality control". By publishing this book, they showed their interest in new ways to control quality. This issue led to the fact that UK industries used new statistical quality control methods in producing most of their products by 1937.

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Years later, the quality control procedures made way to other countries in the world from the America and the United Kingdom. With guidance of Doctor Edwards Deming, statistical quality control methods were developed in Japan up to world's best quality control systems. Ishikawa was one of the most influential Japanese individuals regarding development and education of quality control procedures. He launched his quality control studies in 1950 [15]. He visited Bell Labs in 1958 and met Shewhart for the first time. After the World War II ended, a national organization was established called the Association of U. S quality control.

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Control charts that were first presented by Shewhart have developed until recently; thus, they are considered as one of extensive topics of statistical process control. These charts include a variety of control charts which consist of various modes including: univariate, multivariate, ordinal data, combined charts, etc. Following individuals have conducted extensive studies on statistical process control field of study, particularly control charts: Taguchi, Hotelling, Crowder, Hunter, Page, Croasdale, Daudin, Woodall and Montgomery, Davis, John Holland, Saniga, Aparisi, He and Grigoryan. In recent years, the application of statistical process control in most productive and unproductive units has increased. It ensures greater customer satisfaction and economic life of the units.

Methods:

With increasing advent of human knowledge, technological development and dependency of human society to technology, the technologies have attained great qualitative and economic status. Thus, the production of high quality and low cost products are considered as key to life of the organizations. As a result, companies which have accepted following principles as basic rules for their improvement can compete with each other in the new era and continue their economic activities [in the global market]: continuous improvement of their [economic] processes and products. The needs to compete over price and quality of products have resulted in the fact that many organizations - which were aware of competitive status [of products in the market] - have focused on optimizing the design and manufacture of products. This new focus has greatly influenced the quality and price of product realization cycle. As a result, this issue has resulted in emergence of new filed of competition for organizations which is: design and manufacture of high quality and low price products and processes [1]. Statistical quality control means the application of statistical methods and principles at all stages including: design, production, maintenance and services. This control aims to meet economic demands and needs. In fact, one of the main goals of production systems is reduction of total cost of the product which consists of two major components: pre-sale cost (construction costs) and post-sale costs to the customer (cost of application). In this regard, all product realization activities can be divided into following sections [2]:

- Pre-construction activities (including marketing, product design, construction process design activities and ...)
- During construction activities (including manufacturing activities)
- Post-construction activities (including packaging, storage, transportation activities, etc.)

Among above-mentioned three activities, the first two activities have great influence on total cost of a product. Steps of pre-construction optimization method results in cost optimization of manufacture and deployment units. On the other hand, optimization methods related to activities during construction mainly results in preserving achievements of previous stages. These methods are used in the production stage. In this stage, a high quality product is designed; moreover, construction costs are specified [10]. If a product is expected to have customer's desired features, it must be produced by a sustainable or repeatable process. In other words, manufacturing process should have a little variability regarding specified goal of the product quality [11]. Statistical Process Control (SPC) is a powerful tool which can be helpful in two cases: process stabilization and improving efficiency of the process by reducing its variability. SPC can be used for any process. In total, seven tools of SPC are as follows [3]:

1. Record data sheets (control sheets
2. Histogram graph (histogram)
3. Defect concentration diagram
4. Pareto chart
5. Cause and effect diagram (fish bone)
6. Scatter diagram
7. Control chart

Although these tools are often called seven great tools which construct an integral part of the SPC, they are just technical aspects of SPC. In fact, The SPC is just an attitude or an idea. In other words, statistical process control is what all personnel of an organization wish for, so that they can continuously improve their system in terms of quality and productivity. Of course, such attitudes and ideas will be mostly successful when the management participates in quality improvement process [5]. In order to achieve clear vision of statistical process control tools, it is necessary to provide a brief description in this context as follows:

1- Record data sheets (control sheets): it will be mostly necessary to collect operational information about the process under study in early stages of implementing SPC. In such cases, control sheets are one of the useful tools that can be used. This sheet will help researchers collect useful information relevant to manufacturing process defects in a useful and appropriate way. The type of data that should be collected is important when designing a control sheet. In fact, number of the produced part in the production process or operation as well as date, analyst and any other information that may be involved in determining causes of undesired operation should be considered too. If control sheets are used as basic tool for subsequent calculations or if they are used as data entry in the computer, it is necessary to ensure that structure of the control sheets is suitable. This should be checked before any data is prepared, so that next goals can be achieved too. In some cases, experimental application of control sheets makes it possible to ensure that control sheets design is suitable [6].

2-Histogram graph (histogram): no two products are identical in the manufacturing process due to inevitable changes. With regard to changes in data of a process, the data can be analyzed using some statistical tools such as histogram graph. Histogram graph provides an image of the data in which three characteristics of distribution, central tendency of the distribution and dispersion or expansion of data distribution can be easily observed.

3-Defect concentration diagram: This diagram is an image of the product of a manufacturing process that shows all desired features of that product. By drawing such a diagram, defect location or locations on the product can be specified. By analyzing these defects, useful information about potential causes of these defects can be accessed. In fact, by examining a suitable number of products and by drawing various defects on defect concentration diagram, sources of defects can be easily identified. This diagram is one of the useful tools which is used to fix defects. This diagram can be used in plating, painting, casting and melting, machining and assembly industries [7].

4-Pareto chart: This chart is the most important tool among SPC tools. It is a frequency distribution (or histogram) for ordinal data. In this diagram, data is classified according to defects group. With this tool, the analyst can easily identify different types of defects which are observed more than other defects in the manufacturing process. It should be noted that this diagram does not necessarily indicate the most important defect of a product; however, it indicates defects which frequencies are higher than other defects [8]. Two methods can be used to plot this graph.

1. Using a weighting method to correct data frequency: In this method, the defect which is more harmful for the system is given more weight. In this way, causes of more important defects can be identified and fixed. This method tries to adjust this chart with Pareto law more closely. The one Pareto law in mentioned here says: "by fixing 20 percent of defects, 80 percent improvement can be achieved".

2. Using Cost Pareto Chart in lines with analysis of Pareto Chart: Cost Pareto Chart - like the first method - tries to identify defects that impose additional costs on the system the Pareto chart is relatively used in non-manufacturing processes of quality improvement methods. Its applications in quality improvement programs depend on analyst's creativity.

5-Cause and effect diagram (Fish-bones): When a defect, error or mistake is identified in the production process, its potential causes should also be identified. Cause and effect diagram shows the relationship between quality feature and relevant factors. Drawing this diagram is not an easy task. It is even said that successfully solving a quality control problem depends on successfully drawing cause and effect diagram. Because of the similarity between cause and effect diagram and fish bone, this diagram is known as fish bone diagram. Steps needed to create a cause and effect diagram are as follows: 1 - organizing a team who works to improve quality of potential causes of a problem. 2 - Problem or defect analysis with help of quality improvement team. 3 - Problem or effect definition as central line of relevant diagram. 4 - Drawing some boxes as major potential groups and connecting them to the center line. 5 - Identifying factors related to each group and placing each cause below its corresponding boxes. 6 - Identifying the most effective problems and ranking causes. 7 - Performing corrective measures.

This chart represents one of the most powerful tools in analyzing process problems. On the one hand, preparation of this chart is considered as a tool which disentangles problems. On the other hand, it will strengthen group activity with organizing quality improvement team.

6-Dispersion or scatter graph: This graph is a helpful graph which is used to understand potential relationship between two variables. Data is supplied in pairs in order to draw this graph. The way points are drawn on the diagram represents the relationship between variables.

7-Control charts: Control charts are kinds of tools that can specify stability or instability of process status according to quality feature. Process stability is known as statistical control or briefly as control 3. When this control is applied, the best possible operation is performed under production system terms including method, input materials, equipment, skilled operators, etc. The process instability is known as out of control or briefly out of control 4. This typically indicates that there is a specific cause or a disturbance in the process which results in location transfer or distribution change of dispersion process or both of them. This location transfer or dispersion of process distribution is statistically compared and analyzed by statistical methods using location or dispersion of process distribution. The location or dispersion of process distribution is specified under their related stability [1, 2]. There would be a consistent pattern of the system if impact of noise sources on quality of a system is characterized by a normal or expected oscillation [12]. If this oscillation changes, there would be no consistent pattern. This kind of sustained oscillations is caused by factors that are very difficult to identify. These causes are called random causes. Instead of random causes, those factors that characterize the effectiveness and value of the quality feature are effective and noticeable; moreover, they can easily be identified. These causes are known as non-random or identifiable causes. Thus, when random causes are just present in a process, the process is under statistical control, in which case distribution parameters of the process are expected to belong to the production system. However, when a non-random cause is present in a system in which parameters' variability of quality feature distribution is beyond expected level, the process is out of statistical control. Thus, SPC provides information about stability status of quality features in a desires process. Control chart consists of center line, upper control limit and lower control limit. At each stage, statistical sampling is calculated based on obtained results and it is plotted on the graph. If the point is located between upper and lower control limits, the process is under control; otherwise, the process is out of control. It is also possible that all points may be located within control limits. However, the process is deemed out of control because there is a non-random trend between points. Therefore, rules are set based on agreement between researchers, so that control charts would be similar to each other; moreover, estimated parameters would be identical in this method.

The returns of the organizations will be noticeably significant if organizations implement statistical process control techniques successfully. Although it seems that SPC is a set of statistical tools used to resolve problems, successful implementation of SPC is beyond what is learned from SPC; moreover, it is also beyond just simply using SPC. However, the presence and commitment of the management in the quality improvement process is considered as a vital and integral part of SPC successful implementation. In addition, using work groups or teams in the organization is also important. Most of the seven great tools including cause and effect diagrams, Pareto charts, defects concentration graphs can also be useful (used) when team work groups or teams are organized.

According to above-mentioned material, urgency and importance of using statistical process control in production systems can be understood. Basically SPC is applied to the extent that it is not only used in the manufacturing process but also in the non-manufacturing process (service). It helps these processes in improving their quality system (or it improves quality of the system). In fact, if definition of the system is adequate and suitable, SPC tools can often be used in non-manufacturing activities. These activities include financial, marketing, materials and supplies, services after sale, field services, engineering design and development, programing and designing software.

Conclusion:

In today's economy, delivering high quality and low cost products - whose unit production cost was specifically low - is considered as the key to [life of] corporate survival. According to importance of application of SPC for each organization, it can be concluded that continuous application and education of SPC seems necessary for improvement of level of knowledge of individuals who work in an organization as well as quality improvement methods.

In fact, the quality improvement goal based on SPC is continuous improvement of weekly, seasonally and yearly production process. This goal should be considered as part of the organization culture. According to importance and necessity of the SPC tools in each system, we attempt to investigate and collect conducted studies on some of statistical process control tools.

Definition of Technical Terms and Words:

Statistical Quality Control: Application of statistical principles and techniques in all phases of design, production, maintenance and service in order to meet economic demands is called statistical quality control.

Statistical Process Control: all activities which are performed using statistical techniques and principles in order to preserve achievements of previous stages - which were attained during the production stage - are called statistical process control. In other words, statistical process control is defined as statistical methods for process monitoring in order to identify specific causes of variability and give necessary warnings regarding corrective actions which should be done.

Control Charts:Control charts are statistical process control tools. They record variability distribution in one or several quality features. Then, they provide an image which shows how process has changed over time, i.e. its variability. It also shows process's relationship with quality feature(s).

Process Improvement:The application of modifications in guidelines of each process which led to better improve product quality is called process improvement. These modifications lead tohigher level of quality of the final product by identifying and reducing turbulence effects on the process.

REFERENCES

1. BamniMoghadam M. (2006), Statistical Quality Control, Volume I, Second Edition, published by Payam Noor University, Tehran
2. BamniMoghadam M. and Movahedi M. (2010), Planning, Controlling and Improving the quality, Volume 1, First Edition, Zeytoon Publication, Tehran
3. Montgomery, Douglas C. (1998). Statistical Quality Control, RasoulNoorossana (Translator), translated from the English version, Volume 1, Second Edition, University of Science and Technology, Tehran.
4. Statistical Terms and Words, Persian - English and English - Persian, Volume 1, Third Edition, Third Publication, Institute of Statistics, Tehran 2005.
5. Montgomery, D.C. (2001): Introduction to statistical quality control. New York, NY ,John Wiley and Sons
6. Duncan, A. J. (1986), " Quality Control and Industrial Statistics," Homewood, IL, Richard Irwin
7. Holland, J. H. (1975), "Adaptation in Natural and Artificial Systems," Ann Arbor, MI, University of Michigan press
8. Juran, J. M. and Gryna, F. M. (1980), " Quality Planning and Analysis," McGraw Hill, New York
9. Rao, S. S. (1996), "Engineering Optimization: Theory and practice," New York, NY, John Wiley and Sons.
10. Taguchi, G. (1986), "Introduction to Quality Engineering," Asian Productivity Organization, UNIPUB, White Plains, NY.
11. Woodall, W. H. and Montgomery, D. C. (1999), "Research Issues and Ideas in Statistical Process Control," Journal of Quality Control, 31, 376-386.
12. Dorris,A. L., and B.J. Foote (1978). "Inspection Error and Statistical Quality Control:A Survey," AIIE Transactions,Vol.10.
13. Shewhart, W. A., (1931)." Economic Control of Quality of Manufactured Product,"Van Nostrand, New York.
14. Shewhart, W. A., and Deming, W. E. (1939)." Statistical Methods from the Viewpoint of Quality Control,"Graduate School, Department of Agriculture, Washungton, DC.
15. Ishikawa, K. (1968), "Education and Training of Quality Control in Japanese Industry,"Tokyo,pp. 423-26
16. Deming,W .E .(1994), "Transcript of Speech to GAO Roundtable on Product Quality-Japan vs. the United States," Quality Progress, Vol. 27, No.3, pp. 39-44.