

## The relationship between the quality engineering and Taguchi methodology

Mehmet Cakmakci<sup>1\*</sup>, Numan M. Durakbasa<sup>2</sup>, Mahmut Kemal Karasu<sup>1</sup>,  
and Gokcen Bas<sup>2</sup>

Dokuz Eylul University, Engineering Faculty - Industrial Engineering Department<sup>1\*</sup>,

Corresponding author\*, mehmet.cakmakci@deu.edu.tr

Vienna University of Technology, Dept. of Interchangeable Manufacturing and Ind. Metrology<sup>2</sup>

**Abstract:** Quality engineering is an interdisciplinary science which is concerned with not only producing satisfactory products for customers but also reducing the total loss. Quality engineering involves engineering design, process operations, after-sales services, economics and statistics. Although the Taguchi Robust Design is the first concept comes to mind when thinking of quality engineering, the definition of this major has been used in different manners in the literature. There are also differences on the definition of the quality which has been made by experts. The aim of this study is to contribute to the literature to avoid deviations on definition of the concept of "Quality Engineering", which has not been defined yet by ISO Standards Institute.

**Keywords:** Quality, quality engineering, efficiency of quality engineering, Taguchi design, quality improvement

### 1. Introduction

Before making the definition of the concept of quality engineering and describing the relationship between the quality engineering and the Taguchi methodology, there are important benefits of making the definition of quality. It is seen that the concept of the quality has been made in various ways by experts in the literature.

The very first definition of quality was made by Walter Shewhart as the “subjective and objective aspect of commercial interest” [1]. Juran defined quality as “fitness for use” where Crosby extended the definition as the “conformance to requirements”. Deming added the time frame to the definition and made his own as “the present and the future need of the customer”. Quality is the degree of meeting customer expectations by combined product characteristics of engineering and manufacture from Feigenbaum’s view. For Taguchi, the quality is not only the loss caused by the intrinsic functions of the product but also the loss on a society after the departure of the product from the producer. According to ISO 8402, quality is the totality of features and characteristics of a product or service that have a bearing on its ability to satisfy stated or implied needs [2-3].

As seen every quality expert has his own quality definition. From all of these definitions it can be deduced that the quality is a multidimensional concept and has unique characteristics for each product or service group. Then on which part of the story of a product or service from design to after sales services should be focused to cope with quality problems? The observations of Deming are valuable to answer this question. He saw that the point of creation of the quality problems mostly (85%) lies in the manufacturing processes of which managers are responsible for, where direct operator related quality problems are only 15% of the whole. In parallel, Taguchi indicates that product and process design has much more effect on the quality of the product or service, than manufacturing and inspection [4]. So in order to prevent from the quality problems before they occur on the production line or after shipment, design of the product and processes must be carefully handled, and be kept track on to monitor and eliminate the variations.

The variations on products or processes are the potential causes of the quality problems. Montgomery provided a definition of quality related to variability as: “quality is inversely proportional to variability” [5]. In order to reduce the variability the exact needs of the customers must be well understood and these needs must be balanced with process capabilities and source of variations. This is something beyond SPC or DOE individually and aims prevention than protection [6]. Although there are several rules in defining the values of parameters or tolerances which aim to reduce the variability; there is no overall concept for modelling the functional behaviour in order to derive geometrical parameters for the design process [7].

In the literature quality control activities are divided into two sections; the first one is the offline quality control (or quality engineering) which implies quality control activities at the product planning, design, and production engineering phases, and the second one is the online quality control that is the quality control activities during actual production [8]. For offline quality control activities, experimental design is a valuable tool to reduce variability on manufacturing processes, provide gap reduction between the real and target requirements and minimizes the development time and cost. Taguchi’s orthogonal arrays provide faster achievement with less number of experiments [9].

Concepts can be considered as ideas, objects or events that help us understand the world around us, misconceptions, on the other hand can be described as ideas that provide an incorrect understanding of such ideas, objects or events that are constructed based on a person’s experience including such things as preconceived notions, non-scientific beliefs, naïve theories, mixed conceptions or conceptual misunderstandings [10].

As it’s mentioned in the foregoing discussions there are differences on the definition of the quality which has been made by experts. The aim of this study is to contribute to the literature to avoid deviations on definition of the concept of "Quality Engineering", which has not been defined yet by ISO Standards Institute.

## **2. Taguchi’s Contributions to Quality Engineering**

As Montgomery stated, the quality is inversely proportional to variability. Hence, to be able to produce a qualified product, the main source of variation must be well understood. Mainly there are three source of variation; manufacturing variation, deterioration variation and usage variation [11]. Initial design is determining phase for the quality level of product during its whole life. So the design phase must take all possible variation sources into account and should find a way to define the levels of controllable inputs that make the product and process less impressionable from the changes on uncontrollable inputs / noise.

There are numerous of factors that can directly affect the product or process’s stability. Some of these factors are controllable where some others are uncontrollable or expensive and hard to control. Moreover different combinations of these factors cause different quality problems. With the proactive approach, in the initial design phase, these factor combinations should be simulated. Here, the experimental design is a valuable tool for simulation. This tool is not only a statistical approach but also a technique that can be used in research and development, and as a support and complementary of other quality approaches to minimize cost, enhance quality and maintain reliability of the results [12]. By exploring the attitude surface of a process performance against the different levels of inputs via experimental design, the important factors which have greater affect on quality can be deducted and variations can be eliminated by manipulating these factor.

Since the number of these factors makes full factorial experimental studies infeasible, Taguchi proposed his technique which is based on Karl Gauss's quadratic loss function and orthogonal arrays (OAs) that use the non-linearity of response parameters to decrease the sensitivity of the quality characteristic to variability [13]. With the OAs, Taguchi systematically manipulated the controllable factors and could determine which factors (product and process parameters) are most sensitive to variation or noise and which factor level settings (parameter values) minimize the variability in the desired performance parameter with less of experiments and in less time [14-16].

Besides being only an experimental design technique, Taguchi method is an extremely beneficial technique for high-quality system design. Moreover he presented the experiment designs as OAs library that lets engineer to use directly without reinventing the wheel. He used a performance metric called signal-to-noise (S/N) ratio that combines the mean and standard deviation to analyse data from a robust design [17].

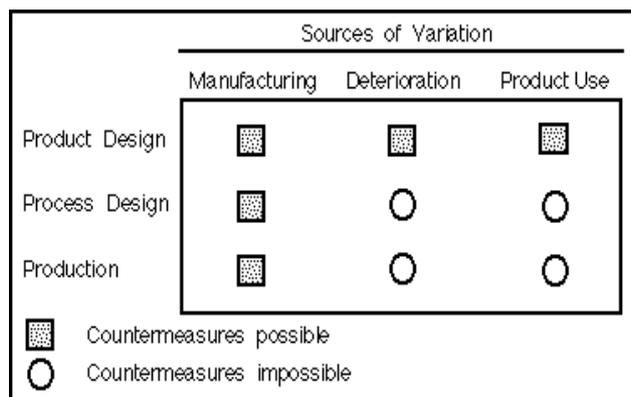


Figure 1. Sources of variation [11].

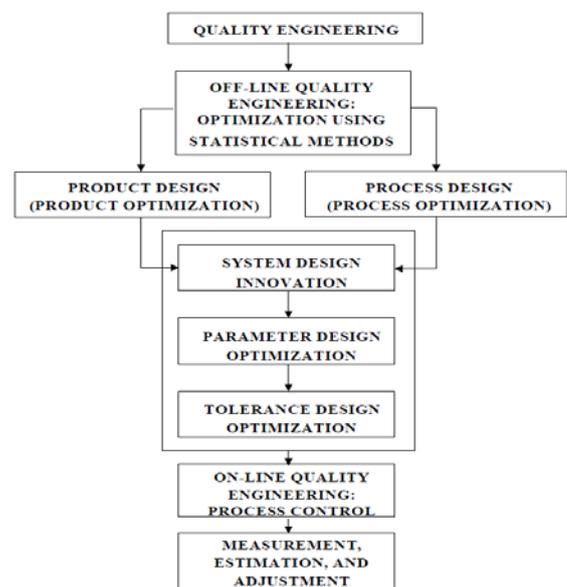


Figure 2. Quality engineering [4].

From the viewpoint of quality engineering, robust design activities should be conducted by research and development departments before actual products are planned [18].

### 3. Quality Engineering Techniques and Where they are standing, on or off the line?

Quality Engineering is defined as “the branch of engineering which deals with the principles and practice of product and service quality assurance and quality control” [19]. Juran groups the activities conducted in the companies to assure quality in three processes: quality planning, quality control and quality improvement. Quality improvement activities are mostly conducted as projects and have a proactive approach so distinguish itself from quality control activities which are on-line and reactive in nature [20].

Quality engineering is a series of operational, managerial, and engineering approaches to ensure that the quality characteristics of a product are at the required levels from the viewpoint of the customer for the duration of the product life. To achieve a high quality product, quality engineering approaches must be applied over each phase of the product life cycle. As opposed to off-line quality engineering, on-line quality engineering refers to techniques employed to maintain quality during the manufacturing process (see in Fig. 2). Statistical quality control (SQC) or

statistical process control (SPC) is a primary on-line control technique for monitoring the manufacturing process or any other process with key quality characteristics of interest. The major goal of SQC (or SPC) is to monitor the manufacturing process, keep the values of mean and standard deviation stable, and finally reduce variability. Some additional quality techniques for on-line quality engineering include acceptance sampling and other quality inspection methods.

## 5. Conclusion

As it has been understood from this study, the concept of quality engineering has been used in different manners in the literature. The first concept that comes to mind when you think of the quality engineering is Taguchi Robust Design. Taguchi robust design, designs the quality as system design, parameter design, and tolerance design and has been used as the concepts of off-line quality engineering approach in the literature. What is understood from on-line quality engineering is the activities of quality control and quality improvement and carried out during manufacturing and bases on the comparison of what's planned and what's realised. Thus quality control is a part of on-line quality engineering rather than off-line phase and tries to ensure planned and/or improved values are satisfied during mass production.

## References

- [1] Sower E.V., Essentials of quality with cases and experiential exercises, NJ: John Wiley & Sons, Inc., 2011.
- [2] Robust design for quality engineering and Six Sigma. World Scientific Publishing Co. <http://www.worldscibooks.com/engineering/6655.html> 1 1 Introduction to Quality Engineering. <http://search-pdf-files.com/pdf/2346025-product-1986-definition-characteristics-serice> (accessed 24 February 2013).
- [3] Durakbasa M.N., Osanna P.H. Intelligent tolerancing and advanced metrology to support total quality management and modern industrial fabrication. International Journal "Total Quality Management and Excellence", 2011 ( 39) (1):27-31
- [4] Feng Q., Kapur K. C., Quality Engineering: Control, Design and Optimization, Handbook of Performability Engineering, 2008, pp 171-186.
- [5] Montgomery DC., Introduction to statistical quality control, 5th ed. New York: Wiley, 2005.
- [6] Crow K. Optimization and variation reduction in quality. McGraw Hill, 1991.
- [7] Weckenmann A., Hartmann. Contents lists available at SciVerse ScienceDirect Precision Engineering journal homepage: [www.elsevier.com/locate/precision](http://www.elsevier.com/locate/precision) Function-oriented method for the definition and verification of microstructured surfaces. W. PRE-5985; No. of Pages 10 Precision Engineering xxx (2013) xxx–xxx
- [8] Torng C-C, Chau C-Y., Liu H-R., Applying quality engineering technique to improve wastewater treatment. Journal of Industrial Technology. (1999);15:1-7.
- [9] Misra K. B., Quality Engineering and Management
- [10] Thompson F., Logue S., An exploration of common student misconceptions in science, International Education Journal, 2006, 7(4), 553-559.
- [11] Taylor W.A., Optimization and variation reduction on quality, 1991, McGraw Hill, US.
- [12] Taguchi G, Chowdury S, Wu Y (2005) Taguchi's quality engineering handbook. ASI Consulting Group, Livonia, Michigan
- [13] Kirby E. D., A parameter design study in a turning operation using the Taguchi method. The Technology Interface/Fall 2006.
- [14] Subulan K., Cakmakci M., A feasibility study using simulation-based optimization and Taguchi experimental design method for material handling—transfer system in the automobile industry. International Journal of Advanced Manufacturing Technology. (2012) 59:433–443.
- [15] Ross PJ (1989) Taguchi techniques for quality engineering, loss function, orthogonal experiments, parameter and tolerance design. McGraw Hill, New York
- [16] Montgomery DC (2005) Design and Analysis of Experiments. Wiley, NJ
- [17] Maghsoodloo S., Ozdemir G., Jordan V., Huang C-H. Strengths and Limitations of Taguchi's Contributions to Quality, Manufacturing, and Process Engineering. Journal of Manufacturing Systems. (2004);23(2) 73-126.
- [18] Taguchi G., Tsai S.-C., Quality Engineering (Taguchi Methods) For The Development Of Electronic Circuit Technology, IEEE Transactions on Reliability. Vol. 44, No. 2. 1995, 225-229.
- [19] [http://www.efcog.org/wg/ism/docs/OE\\_Roles\\_and\\_Responsibilities\\_9-4-09.pdf](http://www.efcog.org/wg/ism/docs/OE_Roles_and_Responsibilities_9-4-09.pdf), (accessed 06 May 2013).
- [20] De Mast J. Quality improvement from the viewpoint of statistical method. Quality and Reliability Engineering International. (2003);19:255-264