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Design of Quality Improvement System Framework for Ceramic Tile Manufacturing – A Review

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Abstract**:** In ever increasing global competition in local and international market, improving quality and productivity is a matter of survival for any company. However, due to the characteristics of the ceramic tile manufacturing, quality improvement gains more importance. This paper describes the work underway to design a quality improvement system framework for ceramic tile manufacturing. This paper discusses different tools and techniques available for quality improvement with main focus on Statistical Process Control (SPC) tools and methods which have been widely recognized as effective approaches for process monitoring and diagnosis.

Keywords: Statistical Process Control, Quality Improvement, System Framework, Ceramic Tile Manufacturing

I. Introduction

The ceramic tile manufacturing can be characterized as a flow type process consists of various stages. The main stages in ceramic wall tile manufacturing process are :

- Raw material milling
- Pressing
- Pre glaze firing (Drying)
- Glaze preparation
- Glazing
- Tile Printing
- Post glaze firing
- Final Inspection and Sorting
- Packaging

Key quality attributes in ceramic wall tile manufacturing are :

- Dimensional attributes (length, width & thickness)
- Appearance (Finish, Glaze & Printing Quality)
- Strength of tiles

Quality is defined as the fitness for use or purpose at the most economical level. It is an integral part of the process of design and manufacture. It can be assured by having effective procedures and controls at various stages.

There are many tools and techniques available for quality improvement. Statistical Process Control (SPC) is a powerful collection of problem-solving tools useful in achieving manufacturing process stability and improving capability through the reduction of variability. It may be used when a large number of similar items is being produced. The underlying assumption is that good items are produced when processes are in control with respect to target values. The main objective of SPC is to give a signal when the process changes, i.e. its mean moves away from the target value and/or its variability increases. In essence, SPC is used to support manufacturing operations. When a signal shows that the process is changing, it is the up to the machine operator to trigger a corrective action. Traditionally, the most important SPC tool is control chart, which graphically represents process data and shows whether the process is under statistical control or not. (4)

The system framework for quality improvement that represents company-wide activities to improve the quality level of products and works through customer orientation, continuous quality improvement, and employee involvement to establish and sustain competitive advantage. It also includes the different aspects of competitive performance of manufacturing plants: quality, cost, delivery, and flexibility. As observed by consumers and researchers, Japanese manufacturers are routinely producing extreme high- quality products at very low cost with short production cycle time and new product development time. Thanks to the foolproof process and utilization of statistical process control, the variation of process is identified and eliminated. Minimization of process variance results in a reduction of scraps and reworks; thus, reduce the production cost. The reduction of defected product also leads to a reduction of time delay for rework, inspection, and time for machine stop. These allow the production run faster with shorter consuming time from material receiving to customer delivery. High conformance quality product, short cycle time, and multi- skill workers allow the plant having abilities to change volume mix and product mix. In summary, high product quality is associated with the low cost, on-time delivery, and high flexibility. (10)

II. Literature Review

[1] Marcello Colledani, Tullio Tolio, Anath Fischer, Benoit Iung, Gisela Lanza, Robert Schmitt, Jozsef Vancza, "Design and management of manufacturing systems for production quality", CIRP Annals - Manufacturing Technology 63 (2014) 773–796

Basic hypothesis of a new production quality paradigm for modern, zero-defect oriented, manufacturing industries has been formalized . This paradigm relies on a strong interaction among production logistics, quality and maintenance functions. The major interactions among production logistics, quality and maintenance variables have been formalized and mapped into a model that can represent a practical tool to support companies to characterize significant trade-offs in their plants. The most advanced methodologies and enabling technologies facilitating the implementation of this new paradigm in industry have been revised and directions for future research have been provided.

[2] Dr.-Ing. Kerstin Schwab, "Holistic Methodological Model for introducing Industrial Quality Management Methods to Manufacturing in Small and Medium Sized Enterprises", The Manufacturing Engineering Society International Conference, MESIC 2013, Procedia Engineering 63 (2013) 895 – 902

The Holistic Methodological Model is presented for introducing QM-Methods and is based on the Deming Circle. It encompasses three modules: a Maturity Level Module to analyze the needs of manufacturing in an SME regarding QM; a Level-oriented Introduction Module to simplify complex QM-Methods so that the inhibitions by the workforce can largely be reduced and an Effectiveness Module to continuously evaluate the economic aspects of the QM-Method. These modules can be applied throughout the lifecycle of industrial QM-Methods. Each Module has an integrated Plan-Do- Check-Act Cycle. Furthermore, a regular run-through of the entire model can support SMEs when evaluating their installed and soon-to-be-installed QM-Methods.

[3] K. AMASAKA, Aoyama Gakuin University, Japan, "Proposal and Implementation of the "Science SQC" Quality Control Principle", Mathematical and Computer Modelling 38 (2003) 1125-1136

The "science SQC" has been proposed as a demonstrative-scientific methodology and its effectiveness on the basis of verification studies conducted by Toyota Motor Corporation has been discussed. This study outlines a new SQC principle "science SQC", as a demonstrative-scientific methodology, which enables the principle of TQM to be improved systematically. "Science SQC" is proposed as a new, systematic, and organizational SQC application methodology for the manufacturing industry. Toyota Motor Corporation has demonstrated that this methodology can improve the quality of work of engineers in every stage of their business process and contribute to creating products of excellent quality. In the future, "science SQC" will be positioned as a quality control principle and applied to solving various practical problems. And with the accumulation of demonstrative studies, "next generation TQM (TQM-S)" designed to improve the principle of TQM will hopefully be established.

[4] Gasper Skulj, Rok Vrabic, Peter Butala, Alojzij Sluga, "Statistical Process Control as a Service: An Industrial Case Study", Forty Sixth CIRP Conference on Manufacturing Systems 2013, Procedia CIRP 7 (2013) 401 – 406

The service-driven approach for SPC is proposed, in which SPC is outsourced through the use of modern information and communication technologies, such as web services. This Statistical Process Control as a Service approach is illustrated and discussed through an industrial case study. The focus of the SPC service is on control charts with statistical tools and transparent online graphical representation of results in real time. eSPC is created as a lightweight and inexpensive building block that can act as a replacement for paper SPC and documentation in small or large distributed manufacturing companies. The case study illustrates how to use the SPC service in a small company to increase its capabilities in process quality management and process control.

[5] Dorde Vukeli, Janko Hodolic, Tone Vrecic, Peter Kogej, "Development of a System for Statistical Quality Control of the Production Process", Facta Universitatis Series: Mechanical Engineering Vol. 6, No 1, 2008, pp. 75 – 90

Statistical quality control methods for evaluation of process stability and capability have been discussed. By coupling computer with measurement devices, information measurement systems are being made, whose basic tasks are automation measuring and quality control of manufacturing processes, mathematical processing of measured results in real time, storing of measured results, documenting of measured results, process management, etc. There is a preview of structure and functioning of the developed applicative software for statistical process control.

[6] E.M. Smeti, N.C. Thanasoulias , L.P. Kousouris , P.C. Tzoumerkas, "An approach for the application of statistical process control techniques for quality improvement of treated water", Desalination 213 (2007) 273–281

The focus is on the use of statistical tools for the improvement of quality control. The measurements of turbidity, residual chlorine and aluminium in the Polydendri tank for the year 2004 were of particular interest due to their potential fluctuations during the aforementioned time interval. Results are presented by means of thorough descriptive statistics and diagrams and statistical process control techniques have been employed for the evaluation of control limits regarding turbidity in particular with a view to checking, analyzing and finally improving the quality of the process.

[7] Nasreddin Dhafr, Munir Ahmad, Brian Burgess, Siva Canagassababady, "Improvement of quality performance in manufacturing organizations by minimization of production defects", Robotics and Computer-Integrated Manufacturing 22 (2006) 536–542

Methodology for quality improvement in manufacturing organizations have bee developed. This methodology comprises a model for the identification of various sources of quality defects on the product; this model includes an analysis tool in order to calculate defect probability, a statistical measurement of quality, and a lean manufacturing tool to prevent the presence of defects on the product. The techniques described in this paper were developed for an improvement project in a plastic parts painting manufacturing facility of a first-tier supplier to the automotive industry. Data were collected from the manufacturing plant, which indicated that the daily defect rates were significant, ranging between 10% and 15%. A process attribute chart (HPAC) has been introduced to monitor the defects every hour. Upper and lower control limits were given and an SPC graph is plotted every hour for the three major defects. If the defects go above the upper control limits, the team meets to solve the issues. Over ten weeks' study after implementing changes, there was a 9% reduction in defects. The proposed quality improvement methodology caused significant reductions in the defect rate in a very short period of time. This reduction in defects implies that the selected tools are suitable for establishing the required improvement. The integration of improvement tools within one framework was found to be an effective way of making substantial improvements in manufacturing performance.

[8] Ali Mostafaeipour, Ahmad Sedaghat, Ali Hazrati, Mohammadali Vahdatzad, "The use of Statistical Process Control Technique in the Ceramic Tile Manufacturing: a Case Study, International Journal of Applied Information Systems, Foundation of Computer Science FCS, New York, USA Volume 2– No.5, February 2012

It was discussed that how implementation of SPC helps for quality improvement. Defects were categorized on their frequencies by examining defective tiles produced in the manufacturing plant. By implementing control diagrams significant result was observed. Also, system troubleshooting was performed by examining the process and its related machines. After identifying and resolving the given defect and reevaluating the process by the mentioned diagrams, the quality of observed ceramic tiles were improved significantly.

[9] C.N. Nnamani, S.H. Fobasso, "Statistical Quality Control of Manufactured Products (Case Study of Packaging at Lifespan Pharmaceutical Limited)", International Journal of Pure Applied Sciences and Technology, 15(1) (2013), pp. 20-30

The level of quality control in the company has been investigated by inspection of some randomly selected finished products on daily bases. The physical observations (number of defectives) from the company were analyzed using statistical tools such as Descriptive Statistics (proportion and mean counts of defectives) and Control Chart for Attributes (P-chart and NP-chart). This work shows that there are many points that fall out of the control limits. This means that the production process is out of control and needs a thorough and complete process inspection and verification.

[10] Anh Chi Phan, Ayman Bahjat Abdallah, Yoshiki Matsui, "Quality management practices and competitive performance: Empirical evidence from Japanese manufacturing companies", Int. J. Production Economics 133 (2011) 518–529

The results of an empirical study on the relationship between quality management practices and competitive performance in Japanese manufacturing companies have been presented. The data was gathered from two surveys including the common sample of twenty-seven Japanese manufacturing companies in the 1990s and the 2000s. Statistical techniques are used to compare the degree of implementation of the eleven quality management practices and their impact on different dimensions of competitive performance between two periods. Findings of this study highlight the stability and consistency of the Japanese quality management, which can be used as one of the strategic weapons for maintaining competitive advantage of Japanese manufacturing companies.

III. Methodology for Design of Quality Improvement System Framework

The methodology includes all tools and techniques for design of quality improvement system framework for ceramic tile manufacturing. This system framework aims for continuous quality improvement and integrates all tools for identification of defects and takes corrective actions and also actions to prevent defects from further occurrences.

Statistical process control (SPC) involves the use of various methods to measure and analyze a process. SPC methods are applicable in both manufacturing and non manufacturing situations, but most of the applications are in manufacturing.

The overall objectives of SPC are : (1) improve the quality of the process output, (2) reduce process variability and achieve process stability, and (3) solve processing problems

There are seven principal methods or tools used in SPC; these tools are sometimes referred to as the "magnificent seven":

1. Control charts : These are one of the most widely used and effective statistical tools for determining the process stability and variability. The chart consists of the upper control limit (UCL) and lower control limit (LCL) with control limits imposed on the center of it, for effective measuring of the quality characteristics. There are two types of control charts : (1) control charts for variables - $\bar{X}$ and R chart and (2) control charts for attributes – P chart and C chart

2. Histograms : The histogram is probably the most important member of the SPC tool kit. It is a statistical graph consisting of bars representing different values or ranges of values, in which the length of each bar is proportional to the frequency or relative frequency of the value or range. It is a graphical display of the frequency distribution of the numerical data and it enables the analyst to quickly visualize the features of a complete set of data.

3. Pareto Charts: This chart is a special form of histogram, in which attribute data are arranged according to some criterion such as cost or value. When appropriately used, it provides a graphical display of the tendency for a small proportion of a given population to be more valuable than the much larger majority.

4. Check Sheets : It is a data gathering tool generally used in the preliminary stages of the study of a quality problem. The operator running the process is often given the responsibility for recording the data on the check sheet, and the data are often recorded in the form of simple check marks.

5. Defect Concentration Diagrams: This is a graphical method that has been found to be useful in analyzing the causes of product or part defects. The defect concentration diagram is a drawing of the product with all relevant views displayed, onto which have been sketched the various defect types at the types

and corresponding locations, the underlying causes of the defects can possibly be identified.

6.Scatter Diagrams : The scatter diagram is useful to identify a possible relationship that exists between two process variables in many industrial problems involving manufacturing operations. A scatter diagram is simply a x-y plot of the data taken of the two variable in question. The shape of the data points considered in aggregate often reveals a pattern or relationship between the two variables.

7.Cause and Effect diagram : To analyze the potential causes of a problem Cause and Effect diagram is used. It is also known as fishbone diagram because of its characteristic appearance. This diagram analyses main elements for the variations to occur, namely; Specification, Worker, Method, Process, Equipment, Materials. This diagram takes an end effect and analyses the causes related to it. [11]

These statistical tools especially Control chart, Histogram and Cause and Effect diagram can be used to improve process performance as important elements of the system frame work for quality improvement in ceramic tiles manufacturing.

IV. CONCLUSION

After reviewing different research papers, we can conclude that there are different methods and techniques available for quality improvement in ceramic tile manufacturing. Among all techniques, Statistical process control is a well-established and successful method which provides a general purpose, and consistent framework for monitoring and improving the quality of a process. It is successfully used in many industries where the quality of final products is important. The integration of improvement tools within one framework can be an effective way of making substantial improvements in quality of ceramic tile manufacturing. By considering the nature of ceramic tile manufacturing, the use of statistical process control coupled with use of appropriate software can give fruitful result.

REFERENCES

[1] Marcello Colledani, Tullio Tolio, Anath Fischer, Benoit Iung, Gisela Lanza, Robert Schmitt, Jozsef Vancza, “Design and management of manufacturing systems for production quality”, CIRP Annals - Manufacturing Technology 63 (2014) 773–796

[2] Dr.-Ing. Kerstin Schwab, “Holistic Methodological Model for introducing Industrial Quality Management Methods to Manufacturing in Small and Medium Sized Enterprises”, The Manufacturing Engineering Society International Conference, MESIC 2013, Procedia Engineering 63 (2013) 895 – 902

[3] K. AMASAKA, Aoyama Gakuin University, Japan, “Proposal and Implementation of the “Science SQC” Quality Control Principle”, Mathematical and Computer Modelling 38 (2003) 1125-1136

[4] Gasper Skulj, Rok Vrabic, Peter Butala, Alojzij Sluga, “Statistical Process Control as a Service: An Industrial Case Study”, Forty Sixth CIRP Conference on Manufacturing Systems 2013, Procedia CIRP 7 (2013) 401 – 406

[5] Dorde Vukeli, Janko Hodolic, Tone Vrecic, Peter Kogej, “Development of a System for Statistical Quality Control of the Production Process”, Facta Universitatis Series: Mechanical Engineering Vol. 6, No 1, 2008, pp. 75 – 90

[6] E.M. Smeti, N.C. Thanasoulias , L.P. Kousouris , P.C. Tzoumerkas, “An approach for the application of statistical process control techniques for quality improvement of treated water”, Desalination 213 (2007) 273–281

[7] Nasreddin Dhafr, Munir Ahmad, Brian Burgess, Siva Canagassababady, “Improvement of quality performance in manufacturing organizations by minimization of production defects”, Robotics and Computer-Integrated Manufacturing 22 (2006) 536–542

[8] Ali Mostafaeipour, Ahmad Sedaghat, Ali Hazrati, Mohammadali Vahdatzad, “The use of Statistical Process Control Technique in the Ceramic Tile Manufacturing: a Case Study, International Journal of Applied Information Systems, Foundation of Computer Science FCS, New York, USA Volume 2– No.5, February 2012

[9] C.N. Nnamani, S.H. Fobasso, “Statistical Quality Control of Manufactured Products (Case Study of Packaging at Lifespan Pharmaceutical Limited)”, International Journal of Pure Applied Sciences and Technology, 15(1) (2013), pp. 20-30

[10] Anh Chi Phan, Ayman Bahjat Abdallah, Yoshiki Matsui, “Quality management practices and competitive performance: Empirical evidence from Japanese manufacturing companies”, Int. J. Production Economics 133 (2011) 518–529

[11] Mikell P. Groover, “Automation, Production Systems, and Computer – Integrated anufacturing, 2nd Edition, 2001, Pearson Education, Asia.page 654-680

[12] Quality Planning and analysis by J. M. Juran and Frank M. Gryna, 3rd Edition, Tata McGraw-Hill Pub., India

[13] Statistical Quality Control by R. C. Gupta, 6th Edition, 2001, Khanna Publishers, India

[14] Quality Control and Application by Bertrand L. Hansen and Prabhakar M. Ghare, 2nd Indian reprint, Prentice-Hall of India