A Review of Quality Engineering Tools and Techniques Practices in Malaysia's and Indonesia's Automotive Industries and an Agenda for Future Research

Putri, Nilda Tri[1] and Yusof, S.M.[2]
[1]Dept. of Industrial Engineering, Faculty of Engineering,
Andalas University, Padang, West Sumatra, Indonesia
[2]Dept. of Manufacturing & Industrial Engineering, Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia (UTM),
Skudai, Johor, Malaysia
Email: nilda_tp@yahoo.com[1] and shari@fkm.utm.my[2]

Studies of Quality Engineering (QE) usually focused on the areas of process control tools in production and improvement tools used to improve existing production processes and its title typically covers such as Statistical Process Control (SPC), Taguchi Methods and Design of Experiment. Only a few studies that looks into a comprehensive implementation of QE Tools and Techniques especially in Malaysia and Indonesia automotive industries. This paper aims to review the QE tools and techniques practices of Malaysia and Indonesia Automotive Industries in their quality improvement efforts. This paper also highlights the importance of implementation of QE tools and techniques in company in various countries and the problems encountered when using QE tools and techniques found in the literature. The further research will identify and evaluate the critical success factors for the successful implementation of QE. The Analytic Hierarchy Process (AHP) approach is going to be employed to prioritize the critical factors for implementing QE. The AHP approach is used in this study because it can help researchers to formulate an appropriate model to evaluate critical success factors and develop strategies to implement QE tools and techniques in Malaysia and Indonesia automotive industries. Furthermore, it is believed that the developing of conceptual model will need for successful QE practices in Malaysia and Indonesia automotive industries based on empirical research.

Keyword: quality engineering, framework, AHP approach, automotive industry

I. INTRODUCTION

In recent years, many organizations have looked upon continuous improvement and total quality management (TQM) as the means by which they could maintain a competitive edge [1]. Implementation of TQM becomes a top management agenda in many organizations in the pursuit of positive business benefits, such as better product quality, higher customer satisfaction and less quality costs. Tari [2] noted that TQM is much more than a number of critical factors and it also includes other components, such as tools and techniques for quality improvement. When critical success factors (CSFs) are in placed, the use of tools and techniques provides a means to define the real issues, identify the root causes, develop and test solutions and implement a permanent solution. McQuarter, R.E., Scurr, C.H., Dale, B.G., and Hillman, P.G. [3] noted that many of difficulties encountered in the use and application arise because some or all of the critical success factors were missing.

Bunney and Dale [4] concluded that most of researchers on the subject of quality management agree that the use and selection of quality management tools and techniques are vital to support and develop the quality improvement process. Yusof and Aspinwall [5] identified quality tools and techniques as one of the critical success factors in implementing TQM. Other researchers have also placed quality tools and technique as a success factor of TQM implementation but they defined them as elements of continuous quality improvement (Conca, Llopis and Tari [6]; Antony, Leung and Knowles [7]). Therefore, the use and application of tools and techniques require close attention to be paid to a number of CSFs to make it effective and efficient.

This paper looks at the various researches relating to the implementation of Quality Engineering (QE) tools and techniques in many countries. The background section reviews the concept of QE, its importance and gives a short description about the reasons for QE tools and techniques failure. The next section reviews the previous study related with QE tools and techniques practices in Malaysia and Indonesia and provides comparison of previous issues of quality that has been conducted in Malaysia and Indonesia. The final section presents the conclusions based on the literature review and suggests future research directions.

Background

Different authors have given various definitions of QE. Krishnamoorthi [8] defined the term QE as:

the discipline that includes the technical methods, management and costing approaches, statistical problem-solving tools, training and motivational methods, computer information systems, and all the sciences behind them that are needed for

978-1-4244-2330-9/08/$25.00 ©2008 IEEE

designing, producing and delivering products and services to satisfy customer needs.

Taguchi [9] described quality engineering as the technique used to improve performance and reduce functional variations caused by three types of noises, namely, environmental conditions (outer noise), deterioration (inner noise) and manufacturing imperfection. He noted that the overall aim of quality engineering is to produce products that are robust to all noise factors. Taguchi separates quality control activities into two parts, which are off-line quality control and on-line quality control [10].

Gaspersz [11] defines quality engineering (QE) as the analysis of a manufacturing system at all stages to maximize the quality of the process and the product it produces. QE have become very important in every organization including whether manufacturing industry, ceramic and paint industry, chemical manufacturer, hospital, education, business and others, and there are many tools and techniques created to be implemented in order to be leader among their challenge [12].

It is necessary to provide a distinction between quality management (soft aspects of quality) and quality engineering (technical aspects of quality) for setting the focus and the direction for further development. This is also necessary to gain better understanding on issues affecting each aspect. Putting everything under the TQM banner may be proper when addressing quality issues from integration and conceptual perspectives. The next section presents the importance of QE tools and techniques for the successful TQM implementation and reasons for QE tools and techniques failures in different studies.

The Importance of QE Tools and Techniques

Bunney and Dale [4] concluded that the use of tools and techniques is a vital component of any successful improvement process. Bunney and Dale [4] also confirmed that the importance of the correct training at the right time to the right people if the benefit of tools and techniques is to be realized.

According to Kwok and Tummala [13], many quality control and improvement tools are used by Hong Kong companies to improve the quality of their product and services.

Spring, McQuater, Swift, Dale and Booker [14] stated that it is generally acknowledged that the use and application of quality tools and techniques within an effective problem-solving methodology are essential to understand and facilitate improvement in any process.

According to Rahman [15], the tools and techniques associated with each quality management approach are there to be used. However, techniques alone cannot bring organizations onto the path of continual improvement. It is essential first to establish a framework of total quality management for the organization by promoting a quality culture before applying any particular tool. Therefore, the tools and techniques must be considered as an integral part of the total quality system.

A review of the literature based QE tools and techniques implementation research published between 1995 and 2007 revealed that the majority of the studies were conducted in the manufacturing industries and only a very few articles focused on doing empirical research in the automotive industry. Most of the tools and techniques that have been used were focused on the areas of process control tools in production and improvement tools improve existing production processes such as SPC, Taguchi Method and Design of Experiment. Table 1 indicates the gap of study on QE tools and techniques implementation in various countries in different studies. The questions that are yet to be answered in previous researches are: What are the critical success factors found in literature contribute to quality engineering implementation, and how can these factors be constructed into a conceptual model for observing quality engineering implementation in automotive industries? How are the Malaysia's and Indonesia's automotive industries implementing QE tools and techniques? Is there an approach or a model appropriate for the automotive industries characteristics and environment?

TABLE I
The gap of study of QE tools and techniques (T & T) practices

Year	Author	Industry	Tools and techniques (T & T)	Country
1995	Mann & Kehoe [16]	TQM Firm	A wide range of quality tools	UK
1995	McQuater *et al*. [3]	Manufacturing	QM T & T (7 basic & new tools; advanced techniques)	UK, France, Germany
1997	Scheuermann *et al*. [17]	Hospital; Manufacturing; services	Qualitative & quantitative tools	USA
1997	Does & Schippers [18]	Manufacturing	Statistical Process Control (SPC)	Dutch
1997	Bunney & Dale [4]	Chemical manufacturer	Quality Management (QM) T & T	American
1998	Deleryd [19]	Not indicated	Process capability studies (PCS)	Swedish
1999	Deleryd *et al*. [20]	Ceramic industry	PCS and Design of Experiment (DoE)	Swedish
1999	Husband & Mandal [21]	Manufacturing (SME)	Quality methods (i.e. quality system & certification)	Australia
1999	Xie & Goh [22]	Manufacturing	Statistical technique (CCs; PC indices; DoE)	Not indicated
2000	Antony, *et al.* [23]	Manufacturing & services	SPC (Control charts/CCs)	UK
2000	Schippers [24]	Dutch company	SPC-related tools (process control tools in production processes)	Dutch
2000	Mason & Antony [25]	Manufacturing & services	SPC	UK
2002	Rungasamy *et al*. [26]	Manufacturing (SME)	SPC	UK
2002	Ozgur *et al*. [27]	Manufacturing	Basic tools and advanced/technical tools	Turkish
2003	Antony & Taner [28]	Not indicated (Education)	SPC	UK
2003	Miguel [29]	Different size & industrial sectors	QFD	Brazil
2003	Shamsuddin, Ahmed *et al*. [30]	Electrical & electronic; chemical; plastic; metal; food & beverage; tobacco; etc.	QM T & T	Malaysia
2004	Antony *et al*. [31]	Automotive manufacturer	Taguchi approach	Czech republic
2004	Lin, *et al*. [32]	American-; Japanese- and Taiwanese-owned firms	QM practices	Taiwan
2005	Noviyarsi & Yusof [33]	Automotive supplier	QE T & T (basic & advanced tools)	Malaysia
2005	Thia, C.W., *et al*. [34]	Manufacturing	New product development tools: QFD; DoE; conjoint analysis; benchmarking	Singapore
2006	Costa, Nuno R. P., *et al*. [35]	Ceramic & paint industry	Design of Experiment (DoE)	Portuguese
2006	Hermann et al. [36]	11 business sector	QFD	Germany; France; England; Sweden; Italy
2006	Hagemeyer & Gerhenson [37]	Manufacturing	Six sigma tools	America
2007	Muzalwana, *et al*. [38]	Automotive	Statistical approach	Malaysia

Referring to Table 1, there are very few researches trying to look into the implementation of QE in Malaysia and Indonesia especially in automotive industry. Since there are no previous researches trying to investigate the critical factors for successful QE implementation in Malaysia and Indonesia automotive industries. It is believed that there is a need to understand commonalities and differences of critical success factors (CSFs) for successful QE practices in Malaysia and Indonesia context to gain insights into the status of these practices. The future research will be attempted to identify and to evaluate the CSFs for the successful implementation of QE. The analytic hierarchy process (AHP) approach is going to be employed to prioritize the critical factors for implementing QE.

The AHP approach is used in the future study to formulate an appropriate model to evaluate CSFs and develop strategies to implement QE tools and techniques in Malaysia and Indonesia automotive industries.

Reasons for QE Tools and Techniques Implementation Failures

Mc Quarter, Scull, Dale and Hillman [3] explore the common difficulties in using tools and techniques, including some practical steps to help with their application and use. The research was carried out in conjunction with 18 organizations in the UK, France and Germany. They noted that the common difficulties associated with the use and application of tools and techniques identified from their research include: poorly designed training and support, being able to apply what has been learnt, inappropriate use of tools and techniques, resistance to the use of tools and techniques, failure to lead by the example, poor measurement and data handling, and not sharing and communicating the benefits achieved.

Shamsuddin and Masjuki [30] noted that Quality management cannot be practiced effectively and objectively without using a set of tools and techniques. They also stated that the choice of any tool or method is not just automatic, rather situation specific. Tools are not to solve the existing or would be problems, but to use as means of identifying the problems or strengths in specific terms through systematic manners. Therefore, the users must understand the applicability of particular tools before being applied.

Some of the factors that indicate a group of companies that is not successful in applying quality tools adequately [24]:

1. Lack of confidence in potential benefits prevents some companies from trying to implement quality tools.
2. Problems in determining how to choose from the large amount of existing tools in various programs such as SPC, TPM, Taguchi or Six Sigma.
3. Problems in determining how to react to new developments in quality tools and programs.
4. Lack of ability to follow developments and apply tools that were applied successfully in other companies.

Schippers [24] also categorized and clustered the various factors causing poor success in applying quality tools that reported in many literatures. His research shows that an important part of the causes of problems in applying quality tools is clearly of an organizational culture. Examples of organizational factors influencing success mentioned by several authors are: lack of management commitment, lack of training, lack of support from an SPC facilitator, lack of involvement of operators, and poor ways of implementing and managing SPC. It also shows that a problem may have multiple causes and root causes. Differently, Mann and Kehoe [16] reported that the type of product and processes influence the implementation and success of SPC. Although the types of products and processes may vary between organizations, this does not seem to be an organizational problem.

Kwok and Tummala [13] noted that the root causes of failure in applying these quality tools are not due to the fact that they are ineffective, but due to lack of clear understanding by people regarding when, where and how to apply the tools. The appropriateness and effectiveness of applying a quality tool determines the success of the tool in company. Numerous failure cases and the cause of failures can be found in industries using these quality tools.

According to Noviyarsi and Yusof [33] most of Malaysian Automotive suppliers applied almost all seven basic tools in their everyday working, meanwhile the seven new tools is not highly applied as the seven basic tools. Besides seven basic tools, sampling, brainstorming, mind mapping, and ranking and rating are the other tools with high application in Malaysian automotive suppliers. They found that the five most applied techniques were: Failure Mode and Effect Analysis (FMEA), Process Capability Analysis, Statistical Process Control (SPC), benchmarking and cost of quality. In terms of degree of understanding, the results showed that the companies have a good understanding of the seven basic tools.

Noviyarsi and Yusof [33] noted that the reason why the seven new tools are not as well applicable as the seven basic tools is lack of understanding by the companies about the application of these tools. This means the companies did not have enough knowledge to apply these tools as a part of continuous process improvement.

Comparison of Quality Management Practices between Malaysia and Indonesia

There are some studies about quality in Malaysian but they are focused on TQM and implementation of ISO 9000 such as Sohail and Hong [39] and Thiagaragan, Zairi and Dale [40]. Muzalwana et al. [38] research attempts to investigate the general quality practices of Malaysian Automotive suppliers and the deployment of statistical approach as the quality improvement efforts and still in their early stage.

Meanwhile, there is a lack of study relating to the implementation of QE tools and techniques especially in Indonesia's automotive industries. The research conducted by Rianto [41] attempts to analyze the process of technological learning in SMEs, focusing in Indonesian auto parts industry. An in-depth analysis was carried out by case study in two-innovative SMEs, Nandya Karya Perkasa (NKP) Company and Karya Paduyasa (KP) Company, which

successfully developed their own technological capabilities, showed that there is technological learning inside the company proceedings. However, the research conducted by Rianto [41] does not focused on the field of QE implementation. His research just looked into analyzing the process of technological learning process in Indonesian SMEs auto part industry.

Irianto [42] conducted his research which attempts to better understand quality management implementation in the Indonesian manufacturing situation, including the characteristics of quality management elements and the influence of internal and external factors; he then developed a strategy so that quality management implementation can realize the potential benefits of quality management. However, the framework developed by Irianto [42] was only appropriate for Indonesia's manufacturing firms, so this research will attempt to develop framework for successful implementation of QE tools and techniques that appropriate for Malaysia and Indonesia Automotive industries.

Amar and Zain [43] concluded that there are some impedance factors (mostly related to resources) in quality management in Indonesia, i.e. human resources, materials, and machinery or equipment. Amar and Zain [43] also noted that developing quality control tools, managing processes and resources to support improvement, and the attitude of people in decision making are some of difficulties in quality management implementation ranging from specific operational tasks to cultural issues.

Since there are no previous researches trying to investigate the critical factors for successful QE implementation in Malaysia and Indonesia automotive industries, it is therefore this research will attempt to identify and to evaluate the critical success factors for the successful implementation of QE. The Analytic Hierarchy Process (AHP) approach is going to be employed to prioritize the critical factors for implementing QE.

The Analytic Hierarchy Process (AHP) approach/methodology is used in this study to formulate an appropriate framework to evaluate critical success factors and develop strategies to implement quality engineering (QE) tools and techniques in Malaysia and Indonesia Automotive industries. The AHP devised by Saaty [44, 45] is a powerful technique in solving fuzzy and complex decision problems. The process can be used to make trade-off and determine priorities among factors and sub factors that are critical to making sound decisions with successful QE implementation.

Overview of ISO/TS 16949

ISO/TS 16949:2002 is a technical specification which forms the requirements or the application of ISO 9001 for automotive production and relevant service part organizations. It is required by the large automotive industry manufacturers such as Ford, General Motor (GM), and DaimlerChrysler, and others. It is essentially ISO 9001 with additional automotive specific requirements. ISO/TS 16949 is applicable to all suppliers of products and services for the automotive industry [46].

This standard is applicable to the quality system requirements for the design, development, production and installation and servicing of automotive related products. It is written in the format of ISO 9001:2000 and applies only to sites where automotive parts are in production. The standard has been accepted as a replacement for QS 9000, VDA 6.1 (Germany) AVSQ (Italy), EAQF (France).

Consistently satisfying customer expectations (the basis for determining strategy and objectives), improvement of processes worldwide, and measurement and overall improvement in a number of strategic areas are critical to the survival of the automobile industry. Not coincidentally, all of these issues happen to be critical ISO/TS 16949 factors.

Other key concepts being neglected include the management of key indicators from multiple operations worldwide, the management and integration of product and process design, and a particularly key value of system – knowledge management. In addition, the value of information technology in fulfilling and integrating these operations cannot be overstated.

ISO/TS 16949 will have an effect on the key movements in the automobile industry in this decade, namely [46]:

- Outsourcing of manufacturing and services to China and India and the need for strong systems for supplier development and monitoring.
- The need for the implementation of standards and management systems to be relevant to top management issues of cost reduction, lead time reduction, speed in new product design and development with first pass success, and the resulting healthy financial performance.
- The importance of customer expectations and requirements driving strategy, objectives, processes, measurement, and improvement in a company operating with management and factories worldwide and dependent upon a global supply chain.
- The importance of implementing an enterprise wide quality management software system.

ISO 9001:2000 advocates the use of other management disciplines to facilitate the achievement of quality objectives. Specifically, the 2000 revision advocates the use of eight quality management principles: customer focus, leadership, involvement of people, process approach, system approach to management, continual improvement, factual approach to decision making and mutually beneficial supplier relationships [46].

Overview of TQM framework

A framework or model is usually introduced to present a picture of what is required in introducing TQM. They are the means of presenting ideas, concepts, pointers and plans in a non-prescriptive manner and are usually not considered to be a "how-to" guide to TQM introduction and subsequent development. They are more concerned with the destination than the route to it [47].

Yusof [48] noted that some writers define framework as a set of principles or ideas used as a basis for one's judgment, decisions, while others portray the frameworks through diagrams, flowcharts, and graphical or pictorial representations.

A framework or model allows the user to choose their own starting point and course of action and build gradually on the individual features and parts at a pace which suit their business situation and available resources. The framework integrates the various aspects of TQM from "soft" approaches such as team work, employee development and human relations, to the use of "hard" techniques such as SPC and FMEA [47].

It can be summarized that a framework or model is a basic conceptual structure used to solve or address complex issues. A conceptual model is used in the future research to outline possible critical success factors for successful implementation of QE tools and techniques in Malaysian's and Indonesian's automotive industries.

II. DISCUSSIONS

This research will focus on the quality engineering tools and techniques implementation in Malaysian and Indonesia Automotive industries and concerned with the implementation of quality engineering tools and techniques that are commonly used from the time a product is conceived to the time that product is made and delivered to the customer.

Else, this research will give the depth analysis about critical success factors for the successful application of QE tools and techniques in ASEAN's automotive industry (Malaysia and Indonesia context) - using the Analytic Hierarchy Process for multi-criteria decision making.

The further research objectives are formulated as follows:

1. To identify and evaluate critical success factor for the successful application of QE tools and techniques in Malaysia and Indonesia automotive industries.
2. To identify the current status of QE tools and techniques awareness and adoption amongst automotive industries in Malaysian and Indonesia context.
3. To compare the CSFs between Malaysia and Indonesia relating to implementing QE tools and techniques.
4. To propose and develop an appropriate QE practices implementation model and systematic guidelines for automotive industries in Malaysia and Indonesia.

III. CONCLUSIONS AND FUTURE RESEARCH

There are a number of researches have been conducted to identify CSFs for implementation of quality tools in the areas of process control tools in production and improvement tools used to improve existing production processes such as SPC, Taguchi Method and Design of Experiment, however, no previous studies had tried to investigate CSFs for successful implementation of QE tools and techniques in automotive industries, especially in Malaysia and Indonesia

Furthermore, it is believed that the developing of conceptual model will need for successful QE practices in Malaysia and Indonesia automotive industries based on empirical research. To formulate an appropriate model, the authors are going to employ the AHP approach to evaluate CSFs for successful implementation of QE tools and techniques in Malaysian's and Indonesian's automotive industries. The critical success factors will review and analyze based on comprehensive literature review and ISO/TS 16949. The AHP approach is used in the future research because it is a very useful technique in solving complicated and unstructured problems that may have interactions and correlations among different objectives. The expected result for future research is a proposed conceptual model using AHP approach. The proposed AHP model developed in future research will hopefully discover how quality tools apply to automotive industries (both manufacturer and suppliers) in general, and Malaysia and Indonesia in particular; help automotive industries to identify the strengths and weaknesses between their current practices and best practices compare to their competitors.

ACKNOWLEDGEMENT

The authors would like to thank to the Ministry of Science, Technology and Innovation (MOSTI) E – Science Research Grant VOT 79120 (03-01-06-SF0381).

REFERENCEES

[1] Chin, K.-S., Pun, K.-F., Y. Xu, and Chan, J.S.F, "An AHP based study of critical factors for TQM implementation in Shanghai Manufacturing industries", *Technovation*, Vol. 22, pp. 707 – 715, 2002.

[2] Tari, Juan Jose, "Research and concepts: Components of successful TQM", *The TQM Magazine*, Vol. 17, No. 2, pp. 182 – 194, 2005.

[3] McQuater, R.E, Scull, C.H., Dale, B.G., and Hillman, P.G., "Using quality tools and techniques successfully", *The TQM Magazine*, Vol. 7, No. 6, pp 37 – 42, 1995.

[4] Bunney, H.S. and Dale, B.G., "The implementation of Quality Management Tools and Techniques: A Study", *The TQM Magazine*, Vol. 9, No. 3, pp 183 – 189, 1997.

[5] Yusof, Sha'ri Mohd. And Aspinwall, Elaine, "Critical success factors in Small and Medium Enterprises: A survey results", *Total Quality Management*, Vol. 11, No. 4/5 & 6, pp 448 – 462, 2000.

[6] Conca, Fransisco, Llopis, Juan, and Tari, Juan Jose, "Development of a measure to assess quality management in certified firms", *European Journal of Operational Research*, Vol. 156, pp 683 – 697, 2004.

[7] Antony, Jiju, Leung, Kevin, and Knowles, Graeme, "Critical success factors of TQM Implementation in Hong Kong industries", *International Journal of Quality and Reliability Management*, Vol. 19, No. 5, pp 551 – 566, 2002.

[8] Krishnamoorthi, K.S., "*A First course in quality engineering integrating statistical and management methods of quality*", Prentice Hall, Pearson, Upper Saddle River, New Jersey, 2006.

[9] Taguchi, Genichi, *"Introduction to Quality Engineering"*, Asian Productivity Organization, Tokyo, Japan, 1986.

[10] Taguchi, Genichi, Elsayed, Elsayed A., and Hsiang, Thomas, *"Quality Engineering in Production Systems"*, McGraw – Hill series in Industrial Engineering and Management Science, USA, 1989.

[11] Gasperz, Vincent, "*Total Quality Management*", PT Gramedia Pustaka Utama, Jakarta, 2001.

[12] Zin, Ahmad Rais Mat., Rohani, Jafri Mohd., and Yusof, Sha'ri Mohd., "A Survey on the Implementation of quality engineering tools in Malaysia Manufacturing industries", *Proceedings of the third International Conference on Advanced Manufacturing Technology (3rd ICAMT 2004), Kuala Lumpur: 11 – 13 May 2004*, pp 535 – 551, 2004.

[13] Kwok, Ka Yin and Tummala, V.M.Rao, "A quality control and improvement system based on the total control methodology (TCM)", *International journal of quality and reliability management*, Vol. 15, No. 1, pp 13 – 48, 1998.

[14] Spring, M., McQuater, R., Swift, K., Dale, B., and Booker, J., "The use of quality tools and techniques in product introduction: an assessment methodology", *The TQM Magazine*, Vol. 10, No.1, pp 45 – 50, 1998.

[15] Rahman, Shams-Ur, "Product development stages and associated quality management approaches", *The TQM Magazine*, Vol. 7, No. 6, pp 25 – 30, 1995.

[16] Mann, R.S. and Kehoe, D., "Factors implementing the implementation and success of TQM", *International journal of quality and reliability management*, Vol. 12, No. 1, pp 11 – 23, 1995.

[17] Scheuermann, Larry, Zhu, Zhiwei, Scheuermann, Sandra B., "TQM success efforts: use more quantitative or qualitative tools?", *Industrial Management and Data Systems* 97/7, pp 264 – 270, 1997.

[18] Does, R. J. M. M., Schippers, W.A.J, and Trip, A., "A framework for implementation of SPC", *International Journal of Quality Science*, Vol. 2, No. 3, 1997.

[19] Deleryd, Mats, "On the gap between theory and practice of process capability studies", *International journal of quality and reliability management*, Vol. 15, No. 2, pp 178 – 191, 1998.

[20] Deleryd, Mats, Rickard, Garvare, and Bengt Klesjo, "Case studies: experiences of implementing statistical methods in small enterprises", *The TQM Magazine*, Vol. 11, No. 5, pp 341 – 350, 1999.

[21] Husband, Stuart and Mandal, Purnendu, "A conceptual model for quality integrated management in Small and Medium size enterprises", *International journal of quality and reliability management*, Vol. 16, No. 7, pp 699 – 713, 1999.

[22] Xie, M. and Goh, T. N., "Statistical techniques for quality", *The TQM Magazine,* Vol. 11, No. 4, pp 238 – 241, 1999.

[23] Antony, Jiju, Balbontin, Alejandro, and Taner, Tolga, "Key ingredients for the effective implementation of SPC, *Work Study*, Vol. 49, No. 6, pp 242 – 247, 2000.

[24] Schippers, Werner Andreas J., *"Structure and applicability of Quality tools: Decision support for the application of process control and improvement techniques"*, Technische Universiteit Eindhoven, Eindhoven, 2000.

[25] Mason, Ben and Antony, Jiju, "Statistical Process control: an essential ingredient for improving service and manufacturing quality", *Managing Service Quality*, Vol. 10, No. 4, pp 233 – 238, 2000.

[26] Rungasamy, Selvan, Antony, Jiju, and Ghosh, Sid, "Critical success factors for SPC implementation in UK Small and Medium Enterprises: some key findings from a survey", *The TQM Magazine*, Vol. 14, No. 4, pp 217 – 224, 2002.

[27] Ozgur, Ceyhun, Meek, Gary E., and Toker, Aysegul, "The impact of ISO certification on the levels of awareness and usage of quality tools and concepts: A survey of Turkish Manufacturing Companies", *Quality Management Journal*, Vol 9, No. 2, 2002.

[28] Antony, Jiju and Taner, Tolga, "A conceptual framework for the effective implementation of SPC", *Business Process Management Journal*, Vol. 9, No. 4, pp 473 – 489, 2003

[29] Miguel, Paulo A. Cauchick,, "The state of the art of the Brazilian QFD applications at the top 500 companies, *International journal of quality and reliability management*, Vol. 20, No. 1, pp 74 – 89, 2003.

[30] Shamsuddin, Ahmed and Masjuki, Hassan, "Survey and case investigations on application of

Quality Management tools and techniques in Small-Medium Industries", *International journal of quality and reliability management*, Vol. 20, No. 7, pp 795 – 825, 2003.

[31] Antony, Jiju, Somasundarum, V., and Blecharz, Craig Fergusson Pavel, "Applications of Taguchi approach to statistical Design of Experiment in Czech Republican Industries", *International Journal of Productivity and Performance Management*, Vol 53, No. 5, pp 447 – 457, 2004.

[32] Lin, Chin ho, Madu, Christian, N. and Kuei, Chua-Hua, and Lu, Min H., "The relative efficiency of quality management practices: A comparison study on American-, Japanese-, and Taiwanese-owned firms in Taiwan", *International journal of quality and reliability management*, Vol. 21, No. 5, pp 564 – 577, 2004.

[33] Noviyarsi and Yusof, Sha'ri Mohd, "Quality Engineering implementation in Malaysian Automotive supplier: A survey results", *Proceedings of the 35th International conference on computers and industrial engineering 2005 (ICCIE 2005), 19th – 22nd June 2005, Istanbul, Turkey*, pp 1445 – 1450, 2005.

[34] Thia, C. W., Chai, Kah-Hin, Bauly. John and Xin, Yan, "An exploratory study of the use of quality tools and techniques in product development", *The TQM Magazine*, Vol. 17, No. 5, pp 406 – 424, 2005.

[35] Costa, Nuno R. P. and Pires, Antonio R., Celma O. Ribeiro, "Guidelines to help practitioners of Design of Experiments", *The TQM Magazine*, Vol. 18, No. 4, pp 386 – 399, 2006.

[36] Hermann, Andreas, Huber, Frank, and Algerheime, Rene, "An empirical study of QFD on company performance", *International journal of quality and reliability management*, Vol. 23, No. 4, pp 345 – 366, 2006.

[37] Hagemeyer, Catherine and Gershenson, John K., "Classification and application of problem solving quality tools: A manufacturing case study, The TQM Magazine, Vol. 18, No. 5, pp 456 – 483, 2006.

[38] Muzalwana, Abdul Mutalib, Shamsuddin, Ahmed, Susila Munisamy, "The importance of statistical orientation for quality improvement in Automotive parts manufacturing and supply in Malaysia, *2nd International conference on Mathematical Science 2007 (ICoMS – 2007),* UTM, 2007.

[39] Sohail, M. Sadiq and Hoong, Teo Boon, "TQM practices and organizational performances of SMEs in Malaysia: some empirical observation", *Benchmarking an International Journal*, Vol. 10, No. 1, pp 37 – 53, 2003.

[40] Thiaragagan, T., Zairi, M., and Dale, B. G., "A proposed model of TQM implementation based on an empirical study of Malaysian industry", *International journal of quality and reliability management*, Vol. 18, No. 3, pp 289 – 306, 2001.

[41] Rianto, Yan, Laksani, Chichi Shintia, Triyono, Budi and Kardoyo, Hadi, "Technological learning in Indonesia's Autoparts SMEs", IEEE *International Conference on Management of Innovation and Technology*, 2006.

[42] Irianto, Dradjad, "*Quality Management Implementation: A multiple case study in Indonesian Manufacturing Firms*", University of Twente, The Netherlands, Dissertation, 2005.

[43] Amar, Kifayah and Zain, Mohd. Zuraidah, "Barriers to Implementing TQM in Indonesia Manufacturing Organizations", the TQM Magazine, Vol. 14, No. 6, pp 367 – 372, 2002.

[44] Saaty, T.L., *"The Analytical Hierarchy Process"*, 2nd ed. McGraw – Hill, New York, 1994.

[45] Saaty, T.L., *"Multi criteria decision making"*, RWS publications, Pittsburgh, PA, 1996.

[46] Kymal, Chad, Watkins, David K., and Cheek, Andy, "The ISO/TS 16949 implementation guide: gaining value from your ISO/TS 16949 implementation", Paton Press LLC, Chico, California, 2004.

[47] Dale, Barrie G., *"Managing Quality"*, 4th edition, Malden, MA: Blackwell Publishers, 2003.

[48] Yusof, Sha'ri Mohd., *"Development of a framework for TQM implementation in small businesses"*, dissertation, School of Manufacturing and Mechanical engineering, University of Birmingham, 2000.