The Implementation of SPC in Malaysian Manufacturing Companies

Mohd Nizam Ab Rahman
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
E-mail: mnizam@vlsi.eng.ukm.my

Rosmaizura Mohd Zain
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Zulkifli Mohd Nopiah
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Jaharah A Ghani
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Baba Md Deros
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Nurhamidi Mohamad
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Ahmad Rasdan Ismail
Department of Mechanical and Materials Engineering, Faculty of Engineering
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Abstract

The importance of quality has been long recognised in the business environment in order to obtain or manufacture higher quality products. In a manufacturing environment, quality improves reliability, increases productivity and customer satisfaction. Quality in manufacturing requires the practices of Statistical Process Control (SPC). This paper addresses the case study on the implementation of SPC in eight manufacturing companies. The case study involves interviews and questionnaire surveys with the company representatives, as well as observations on their environment. This paper focuses on the result of the survey and its primary findings. The information gathered includes company background, applications and general information about SPC in the company, types and characteristics of SPC software and its development, problem and disadvantages of
software, as well as advantages and suggestion of improvement for the SPC software. Other key issues which were felt to be crucial to this study will also be discussed. The results of the case studies have shown that the implementation of quality SPC has encountered some barriers related to system and management, attitude, organizational culture, machine and equipments, facilities, cost and training issues.

Keywords: Quality, Barrier, Statistical Process Control (SPC), Case Study.

I. Introduction
Statistical Process Control has played a major role in controlling product’s quality, since Shewhart developed the technique of using control chart and applying statistical concepts in the manufacturing process [1]. SPC is one of the techniques used in quality assurance programs and/or total quality management (TQM), for controlling, monitoring and managing a process either manufacturing or service through the use of statistical methods [2]. The effective implementation of SPC can be achieved if organization/company has a good understanding of such strategy or method that will make the application successful. However, the development of SPC in Malaysian small and medium-sized enterprises (SMEs) is found lacking because some companies tend to delay installing SPC software to ‘save’ money. Generally, a SPC software and its hardware system can cost around RM4500 to RM6500 per site, not including training costs.

Traditional SPC are subjected to a certain limitations when they are applied in industrial sectors where only few quality faults occurred. The corrective actions by production/quality engineers and technicians are taken only after the occurrence of an out of control signal. In many cases, it is more effective to take a proactive approach to prevent the occurrence of out of control situations, allowing the process to be adjusted in preventive way so that fewer non-conforming items will be produced [3]. It is important to note that, the ability to assess quality data processes and make instant decisions is essential in competitive manufacturing environment which are supported and provided by the SPC applications.

This paper presents on the results of eight case studies performed as part of a research project in development of online SPC in Malaysian SMEs manufacturing companies. It proved difficult at times because the whole process involved seeking information, some of which are confidential and companies were not willing to cooperate with it. However, despite several difficulties faced, the case studies were successfully completed. The presentation of the case studies cover three main areas, which are the background of the company, general aspects of SPC implementation and SPC software employed by the company. Finally the case studies are discussed and concluded with directions for potential research. Knowledge gained from this study would be invaluable to the Malaysian government, especially the Ministry of Industry and Trade and it also serves a guide to the organizations that are planning to implement one of TQM philosophy that is known as SPC.

II. Small and Medium Enterprises (SMEs)
The terms ‘small and medium scale industries’ (SMIs) and ‘small and medium sized enterprises’ (SMEs) appear to have been used interchangeably, especially in Malaysian local newspapers and journals. The authors would like to note here that in economics perspective, an ‘industry’ addresses a group of organisations or companies producing the same type of products, whereas an ‘enterprise’ addresses a business company or an organisation. SMEs can be found in almost all industries. Therefore, the term ‘enterprises’ is the more accurate and suitable term to be applied in this paper.

SMEs are an important sector for the growth of any country, as they are the life blood of modern economies [4]. Their survival will actually assist in improving the competitiveness of the large companies. Besides their flexibility and ability to innovate, SMEs play a significant role in providing
employment opportunities [5]. The important role of SMEs in the country’s economy can be summarised from the following quotes:

1) From the President of the USA in 1998 [6]:-

"First, SMEs are an integral part of the renewal process that pervades and defines market economies. New and small firms play a crucial role in experimentation and innovation that leads to technological change and productivity growth. Second, small firms are the essential mechanism by which millions enter the economic and social mainstream of American society. Small businesses enable millions, including women, minorities, and immigrants, to access the dream of economic growth, equal opportunity and upward mobility”

2) From the former Prime Minister, Mahathir Mohamed [7], in his speech ‘Malaysia: The Way Forward’, has stressed that:

"SMEs have an important role to play in generating employment opportunities, in strengthening industrial linkages, in penetrating markets and generating export earnings. They have a crucial role as a spawning ground for the birth of tomorrow’s entrepreneurs. The Government will devise appropriate assistance schemes and will seek to raise the level of management expertise, technological know-how and skills of the employees in this very important and in many ways neglected sector of our economy. The SMEs will be one of the primary foundations for our future industrial thrust. The Government is fully committed to its healthiest development."

Having discussed the importance of SMEs to the economy, it is necessary to further explain the SME characteristics in order to strengthen the basis for this research. SMEs are very different to large ones in many areas, such as management style, production process, available capital, purchasing practices, inventory systems and negotiating power [8]. There are various advantages and disadvantages that exist between large and SME companies on aspects such as structure, behaviour, process and people [4, 9, 10]. The main advantages that SMEs possess relative to larger companies are:

• their flat structure and short decision making process allows shorter and faster information flow which can improve communication, as well as easier to permeate new change initiatives.
• their flexible culture provides a good foundation for a change, for example the practices of quality initiatives.
• people dominated together with organic behaviour, rather than bureaucratic and system dominated, and this helps improve the chances of success for new initiatives.
• the high incidence of innovativeness can nurture a continuous improvement culture.

Meanwhile, the disadvantages faces by SMEs as compared to large business can be:

• Lack of skills and knowledge which can affect staff development and training.
• Lack of financial resources which can affect investment in new products or process.
• Owner not delegating, and trying to control every aspect of the business – can impede employees’ motivation, teamwork and involvement.
• Improper and inadequate systems and procedures can affect efficiency and will result in dissatisfaction from employees, for example, inconsistent industrial relations policies between different people.

These certain characteristics such as having limited resources which include money, time, expertise and manpower are the main concerns before attempting to introduce or adopt new quality activities such as SPC in local SMEs. Malaysian SMEs always complain about the problems they face, such as lack of time and finance [11]. However, with unique advantages of SMEs structure (flexible, versatile human resources, less bureaucracy [9] and, with better quality activity practiced, it is believed that they will be able to find better ways of doing things and achieve higher quality of products.
A. The Need for Quality Activity in SMEs

SMEs as a part of business sectors, are no different from any other business sectors. Quality performance plays an important role for many SME manufacturing companies in gaining competitive advantage and business survival. Emphasis on quality and managing the total quality transformation is part of company culture. Quality culture in a company should be properly managed and controlled to be an effective approach for integrating quality activity development, therefore, there is no excuse or option to them to continuously improve their process and compete in quality.

SMEs are often suppliers of products or services to larger organisations. There are two fundamental reasons why SPC should be implemented in SMEs. Firstly, it is necessary because large companies will demand ‘quality of product supplied’ from them, and secondly, it is the need for SME sector to be pro-active, and to be able to compete in quality in order to survive in today’s highly competitive business environment. The lack of product quality from SMEs normally affect the competitive ability of the larger companies.

However, it must be noted that in some instances, SPC programs is believed do not appear to be properly implemented by SMEs, or may not be fully applicable to SMEs environment. For example, those SMEs dealing with government projects, or those SMEs producing seasonal products, may normally see SPC as an inappropriate or unnecessary problem-solving activity. As SPC involves statistical analysis, many SMEs may not know how and where to begin, or how to really adopt the statistical approaches. However, SMEs should realise that to stay ahead in businesses mean that they have to adopt more effective quality control activities as their working practice.

In fact, SMEs have been shown to be less likely or hard to adopt the practices of SPC on their company [12] and they may see the practices of SPC (for example in the context of 7QC tools) as often involving difficulties, employee understanding, timescale and huge costs [13], which will compromise their business, flexibility and profit. SMEs are also often lack the expertise, funding and time availability which are necessary to assimilate and effectively utilise the practice of SPC [14]. In Malaysia, The barriers in SMEs from implementing quality activities including cost, lack of specialist knowledge, employee resistance to change and difficulty in releasing their employees for training [11]. However, the apparent success in the Japanese company or Japanese based-company outside Japan, suggest that with an appropriate understanding of the SPC concepts and the management commitment, can make effective use of the SPC.

Understanding the concept and practice of SPC is a quite hard and complex task, as various principles and statistical practices that are not expressed in a language which SMEs readily understand, while the traditional culture and characteristics of the SME may not be conducive to SPC. It is difficult for SMEs with relatively limited management capabilities and financial resources to acquire new skills and knowledge by themselves. In most cases SMEs are not familiar with quality know-how, process thinking and management changing [15]. Huxtable [16] recognised that the SMEs manager may be at a loss as to where to start, especially considering the wide range of implementation strategies and formulas put forward by leading exponents or quality gurus of quality.

B. SPC & The Seven QC Tools

One of the best technical tools for improving product and process quality is through SPC [17, 18]. SPC is a problem-solving technique used for monitoring, controlling, analyzing, managing and improving the entire process using statistical methods. There are seven basic tools in SPC. The tools are: Pareto diagrams, cause & effect diagrams, stratification, check sheets, histograms, scatter diagrams, and graphs & control charts. The control chart is a powerful SPC tool developed by Walter Shewhart of Bell Laboratories in the 1920s [19], and it is one of the most widely discussed statistical techniques today [18]. Deming’s PDCA cycle [20] is a good technique in problem solving and continuous improvement where any good ideas of individuals or groups can be accommodated and can yield very significant benefits in the long run. The Deming Cycle is a continuous or repetitive cycle based on four activities: Plan, Do, Check and Action.
The collection of all interrelated activities and operations involved in producing goods and services is called a production system. Such activities are planning, purchasing, marketing, sales, product design, scheduling, packaging, shipping, warehousing etc. The Production Planning and Control activity is only part of a production system. Whilst, quality control at the production stage is related to the individual responsibility of the departments concerned with inspection, planning, machining, distribution etc. The production system also involves the quality tools and techniques, aimed at enhancing process capability and operational performance. In order to reach such a target, the use of statistical techniques (e.g. 7QC tools) becomes a daily practice, which greatly enables one to detect product nonconformities and to meet the customer services, inventory and costs [21]. However, the quality tools and activities highlighted above are common or fundamental to the improvement of company productivity. Most of quality activities have their roots in Japanese management approaches and have been proven in larger organisations such as Toyota, thus it should not be a barrier to the SMEs. Companies of any size or business can apply these quality improvement activities to realise the benefits.

III. Research Methodology

A case study can be used when attempting to understand complex organisation behaviours. The case study is especially appropriate when trying to answer the “how” and “why” questions in exploration of the research problems. The case study typically involves a small number of cases which are not necessarily represented of the larger population. Data collection for case studies may come from various sources such as interviews, surveys, company documents, archival records, observation and physical artifacts. The case studies need not always include direct and detailed examinations as a source of evidence as required in qualitative research [22].

In this study, fifteen companies were selected. However, only eight companies responded and indicated their willingness to provide information. Interviews with key personnel who were responsible in the SPC implementation were conducted. During interviews, a well design questionnaires were provided to key personnel for seeking further information concerning on SPC. Since this study focused on the production site, most of engineers or managers involved in this study were from production or quality department. The type of industries involved in this study includes automotives, electronics, medical disposal devices, computer components, plastics, chemicals and food. These questionnaires were designed into five parts. These are the background of the company, general information about the SPC implementation in the respective company, characteristics of SPC software; problem or errors in SPC software and methods of SPC software validation.

The first part was intended to gather general information about the company background including year of establishment, location of the company and nature of business. The aim of the second part was to determine the general information and comments, regarding on level of SPC adoption or practice in company. The third part includes type and characteristics of SPC software involved in SPC system. The fourth part of the questionnaire consisted of problem or errors while running the application and further actions to improve the problem. The final part was an explanation of the software validation including methods or tools for validation and person involved in this activity. On top of that, the key personnel were asked to give their comments on the future improvement, and overall suggestions for SPC system in company.

IV. Results and Discussions

Based on this research, a total of eight SMEs were selected. These discussions are mainly focus on company background and parts of SPC implementation in manufacturing industries. Table 1 summarises for case studies on the implementation of SPC in Malaysian SMEs.
**Company A** produces high quality components for the automotive engine, transmission, brake and steering. It has successfully commenced the mass production and the delivery for CAMPRO engine parts for PROTON, PERODUA and FORDS. The company has 282 employees, and the company paid up per capital is RM15 billion. The basic SPC tools such as Pareto diagrams, control charts, check sheets, Ishikawa diagrams are found useful in this company. According to key personnel, the company has a good understanding about the SPC. However, its implementation takes a long time to adopt and practice. It uses MINITAB 13.2 version for conducting analysis, which is used extensively in business and higher education. In future, this company plan to upgrade to MINITAB 14.0, since the previous version unable to offer a facility for constructing either a bar or pie chart. The company also plans to provide education training to supervisor, engineer and manager in order to increase their knowledge and skills concerning SPC application.

**Company B** produces medical disposable devices such as extension tubes, scalp vein sets, infusion sets and urinary bags. Raw materials used in the production process include Polyethylene (PE), Polypropylene (PP), Polyvinyl chloride (PVC) and Nylon. Its main production processes are injection molding, extrusion molding and assembly. The company sales are for the export market such as Japan, India, Singapore, Philippine, Hong Kong and Taiwan. According to key personnel, SPC is implemented effectively in this company. As the result, SPC able to maintain the process stability, identify the critical parameters on machines and able to monitor the process timely. It prefers to use SPC XL2000 as SPC software for conducting analysis. However, the company has faced some problems with a variety of products, as such the data collected is extremely big. As the result, the company experienced shortage of workers to complete this task. To overcome this situation, the company have identified a few counter measures for future improvement such as to develop SPC online with technology enhancement, provide more facilities like allocating specific place to develop the system, and to display control chart on the machine automatically during process running.

**Company C** is a specialist in high quality and technologically advanced automotive components. It was established in the year of 1989. This company becomes a major automotive components supplier to national car projects including car air conditioning, spark plugs, wipers blade and truck freezer. The company uses manual SPC. Data on the control charts are plotting using graph paper. As the result, the company required more workers because the charting process is very time consuming. By using manual SPC, the number of fault that can be traced is limited. However, this company is still able to collect relevant data consistently over time plots it and examine the plot carefully. Furthermore, according to production manager, most workers had a very limited background in SPC and less understanding about this concept. They were not properly trained on SPC. Some improvements have been suggested by manager, such as providing SPC training and establish an SPC implementation team. In future, the company plan to develop the comprehensive SPC software which enables it to support the problem solving. It main features contains lists for cause, corrective actions, comments, tools, and anything that relevant to the operation.

**Company D** was established in the year of 1989. This company manufactures plastic parts for television, housing cabinet, rear cover, audio-video equipment, air-condition equipment, washing machine, compatible keyboard, display monitor and other plastic parts of computers. The company obtained certification of the International Organization for Standardization (ISO) 9001 and the environmental management standard, ISO 14001. The company has applied a very basic SPC concept by utilizing Microsoft Excel to calculate data and plot the graphs. Few engineers and managers understand the application of SPC. They claimed that the business is already quite successful even though they use basic SPC. In addition, they are not culturally ready for SPC. Other statistical tools such fishbone diagram and check sheet and are found useful in this company. In future, if the company plans to fully implement SPC, a very strong understanding and support from top management is needed.

**Company E** was established on 3rd of July, 1974. Its manufactures core products such as integrated circuits, transistors and diodes for application in high performance industrial and consumer products. This company is one of the core semiconductors assembly plants. Its mission is to achieve
customer satisfaction and to ensure profitability by supplying exceptional products in terms of quality, cost, and delivery. From the company perspective, the use of SPC is considered as a good practice. Adequate training is provided for the managers, engineers and operators. Quality control department is the department which is responsible to take action timely and find out causes and counter measure when out of control condition occurs. Their duties also include overall coordination and implementation of statistical techniques. Manufacturing department is assigned to identify process parameters for SPC, review and calculate control limits according to schedule. It uses e-SPC software to collect data, monthly review data, make evaluation of new coming products and machines. The system is developed for multiple users, as such it can be accessed by production and management site. This system also supports full security of the underlying database. In addition, password setting is available to protect confidential data. The main limitation of e-SPC is that the system does not provide intelligent device (alarm) to flag the point out of control data. For further improvement, the company plan to upgrade it system to SPC online and provide advance training for workers.

**Company F** is a subsidiary to the Japan based plating company specializing in plating of various products and other precision plating. The company was established in the year of 1998. It provides surface treatment technology of semiconductor products to Asia market. The main activity are strip to strip solder plating for semi-finished integrated circuit (IC) product and reel-to-reel solder plating for semi-finished minimold transistor stamping and plating of lead frames for semiconductor components, and precision electroplating. According to the key personnel, SPC is implemented partially in this company due to lack of resources and understanding of SPC concepts. It uses Microsoft Excel to calculate data and plotting graph. In future, the company plan to provide training and instill positive commitment to all workers to ensure full implementation of SPC.

**Company G,** their headquarter is in Kashiwazaki and Tokyo, Japan. It was established in the year of 1989 and located at Bandar Baru Bangi Industrial Estate, Selangor, Malaysia. The company produces die-casting and precision machining parts for electronics, computer peripherals, camera equipments, automobile and industrial parts. Its vision is to be the world’s best manufacturer in die-casting and precision machining of electronic components. The company prefers to use SPC online compare to manual SPC because it able to reduce paper consumption, time utilization and less of workers involved. The system is linked directly from Computer Numerical Control machine to check dimension of products (X, Y and Z axis). Color code application is used to facilitate the users, red color indicates out of specs value while yellow color indicates out of control value. In future, the company plan to educate and train all workers to ensure continuous successful implementation of SPC.

**Company H** was established 6th of March, 1990 and started as an automotive parts manufacturer and diversified into the semiconductor, plastics, precision metal and information technology industries. It was listed on the Second Board of the Bursa Malaysia Berhad (Bursa Securities) on December 14, 1994. The company obtained certification of the ISO 9002 and the environmental management standard, ISO 14001. Quality control department is responsible to take action, find out causes and counter measure when out of control condition occurs. According to key personnel, SPC is implemented effectively in this company. As the result, it could reduce customer complaints. Advanced formula of statistics is programmed into Microsoft Excel to develop SPC system. All data are collected and plotted by graphs. For the future, the company plan to develop SPC online to improve the process performance and to provide adequate education training to all workers.
Table 1: Summarises for case studies on the implementation of SPC in Malaysian SMEs

<table>
<thead>
<tr>
<th>Company</th>
<th>General Information of SPC</th>
<th>Type and Characteristics of SPC Software</th>
<th>Deficiencies or Problems</th>
<th>Advantages and Guide to Process Improvement</th>
<th>Software Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1991)</td>
<td>SPC improves the process performance. However, it takes a long time to implement in this company.</td>
<td>Minitab13</td>
<td>-Operator errors would exist in the data entry. -Unable to construct either pie or bar chart. -Operator delay entering data into system.</td>
<td>-Timely notify out of specification data. -To improve SPC, company should be willing to provide a long term SPC education. -Upgrade to new version for attribute data.</td>
<td>-Compare with manual calculation by engineer and verified by management site.</td>
</tr>
<tr>
<td>B (1990)</td>
<td>SPC improves the process performance and able to check the critical parameters.</td>
<td>SPC XL 2000</td>
<td>-Operator errors would exist in the data entry. -This system unable to supports multiple users. -Unable to signal to other workers, if out-of-spec value occurs.</td>
<td>-Allows analysts to quickly create data collection. -Timely notify out of specification data. -The company must provide multiple users system.</td>
<td>-Compare with manual calculation by engineer and verified by management site.</td>
</tr>
<tr>
<td>C (1980)</td>
<td>SPC able to detect abnormality in the processes.</td>
<td>SPC system is manual application. -Plot the data on control charts using graph paper.</td>
<td>-Time consuming to plot the data. -Use a lot of graph paper. -Time consuming to determine a root cause of the problem when the data are not plotted correctly.</td>
<td>-Cost of the SPC is low. -Company must provide training and education to workers.</td>
<td>-Not applicable, data computed manually.</td>
</tr>
<tr>
<td>D (1989)</td>
<td>SPC techniques are used to control the processes and reduce variations, but effectiveness is not 100%.</td>
<td>-Compute data and creates charts by Microsoft Excel. -Provide a basic graphic facility. -Only engineers and management site understand the SPC’s concept. -Provide a basic graphic facility.</td>
<td>-Error would exist during data entry and no warning signal in this system to notify that error. -Data integrity by operator.</td>
<td>-Cost of the SPC is low. -Workers need little training in computers. -Company should provide SPC software packages in order to analysis of data timely, and upgrade the quality of presentation. -Provides training for workers on the SPC.</td>
<td>-Not applicable.</td>
</tr>
<tr>
<td>E (1976)</td>
<td>SPC improves the process performance because organisation provides awareness of statistical thinking from the top management to co-workers.</td>
<td>Used e-SPC to collect data, review monthly, evaluation for new machine or products introduction. -Easier to storage and retrieval of data.</td>
<td>-Error would exist during data entry and no warning signal in this system to notify that error. -Data integrity by operator.</td>
<td>-Timely notify out of specification data. -This system can be accessed by engineer and management site -For suggestion: Implement SPC online in order to monitor process timely.</td>
<td>-User Acceptance Test (UAT) by the engineer during initial system purchase, all inaccurate calculation or formula is corrected.</td>
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<tr>
<td>F (1984)</td>
<td>SPC improves the process performance. However, it takes a long time to implement in the company.</td>
<td>-Analysis data via Microsoft Excel. Only focuses for critical parts of product.</td>
<td>-Provide a basic graphic facility. -Operator error would exist in the data entry into system.</td>
<td>-Cost of the SPC is low. -Management should provide adequate resources and training which lead to continuous improvement of product/process quality.</td>
<td>-Not applicable.</td>
</tr>
<tr>
<td>Year</td>
<td>Description</td>
<td>Issues</td>
<td>Solutions</td>
<td>Remarks</td>
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<tr>
<td>1989</td>
<td>SPC improved the process performance and reduce the customer complaints.</td>
<td>Unable to upload the data from CMM machine when the server down. However, this situation is rarely occurs. Involved high cost.</td>
<td>SPC online can greatly reduce time and paper consumptions. Operators does not require to measure and record data manually. Upload data timely. Deduction of manpower. Display real time data. For improvement, provide comprehensive training for workers.</td>
<td>User Acceptance Test (UAT) by the engineer during initial system purchase, all inaccurate calculation or formula is corrected.</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>SPC able to maintain the process stability and reduced customer complaints.</td>
<td>Inadequate data to provide good reading or proper trends in graph analysis.</td>
<td>SPC system can greatly reduce customer complaints. For improvement, provide advance training for workers on SPC and upgrade the system.</td>
<td>Compare with manual calculation by engineer and verified by management site.</td>
<td></td>
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</table>
V. Conclusion

This paper has presented the case studies conducted in eight companies, of which only four companies fully implemented SPC system (company A, B, E, and G). Out of those companies that fully implemented SPC, only Company E and G implement web-based SPC system for conducting the process control. Company C prefers to use manual system (plot on the graph paper), while company D, F and H developed SPC system via Excel. From the study, certain companies were unable to provide complete information regarding SPC software because of the confidential information. The case study performed was able to differentiate between the case companies as to the level of SPC adoption, types of SPC software, problems and advantages of its application. For overall observation, almost all companies in this study have found that SPC is very useful to improve their quality process. For example, they are able to detect abnormality in process timely; check the critical parameters; reduce variations and maintain the stability of process. As the result, they managed to reduce the customer complaint, improve productivity and increase profitability.

From this study it was found that, implementation of SPC system is more difficult in SMEs, because smaller companies unable to afford high technology system (hardware, software, networking and security) and involved high cost. Some companies prefer to operate simple control charts and manual system using paper and pencil. Furthermore, any company which is seeking to implement a comprehensive SPC system will require having good levels of internal expertise and a good source of external advice. Large companies that using SPC has fewer problems in recruiting or educating workers. Other problem or barrier in the implementation of SPC system is due to the lack of commitment and support from top management. They also lacked awareness of SPC as a powerful problem solving technique. On top of that, lack of training and education in SPC also contribute as one of the major issue for the SPC implementation. The purpose of training and education in SPC is to encourage the workers to understand, manage and reduce variation due to implementation causes and to support continuous improvement. Training and education can enhance the level of knowledge and understanding of workers regarding when, where, and how to apply the tools and techniques of SPC. The primary findings from this paper will be used as the basis for the guideline of the further research in developing online SPC in manufacturing industry, which will be the subject of future paper.
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