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Quality Control Implementation in Manufacturing Companies: Motivating Factors and Challenges

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1. Introduction

The pressure from globalisation has made manufacturing organisations moving towards three major competitive arenas: quality, cost, and responsiveness. Quality is a universal value and has become a global issue. In order to survive and be able to provide customers with good products, manufacturing organisations are required to ensure that their processes are continuously monitored and product quality are improved.

Manufacturing organisation applies various quality control techniques to improve the quality of the process by reducing its variability. A range of techniques are available to control product or process quality. These include seven statistical process control (SPC) tools, acceptance sampling, quality function deployment (QFD), failure mode and effects analysis (FMEA), six sigma, and design of experiments (DoE).

The purpose of this chapter is to present the implementation of quality control in four manufacturing companies and identify the factors that influence the selection of quality control techniques in these companies. The paper discusses the reasons for applying quality control techniques, the techniques used, and problems faced by them during the implementation. The paper begins with an overview of quality control and its implementation in organisations. This is followed by the description of four selected companies in this study including their products and company backgrounds. The application of quality control in each company is then presented. The motivating factors for the companies to apply quality control and challenges faced by companies in implementing quality control are discussed.

2. Quality control

Quality can be defined as fulfilling specification or customer requirement, without any defect. A product is said to be high in quality if it is functioning as expected and reliable. Quality control refers to activities to ensure that produced items are fulfilling the highest possible quality. Most of tools and techniques to control quality are statistical techniques. Quality control techniques can be classified into basic, intermediate, and advance level, but there is no consensus among researchers in the classification. For example, Xie and Goh (1999) consider

DoE as an intermediate level technique whereas Antony et al (1998) classified the technique as advanced. Nevertheless, the content is more important than the classification.

Among the basic techniques are SPC. SPC is a statistical approach for assisting operators, supervisors and managers to manage quality and to eliminate special causes of variability in a process (Oakland, 2003). The initial role of SPC is to prevent rather than identify product or process deterioration, but Xie and Goh (1999) suggest for its new role to actively identifying opportunities for process improvement. The main tools in SPC are control charts. The basic idea of control charts is to test the hypothesis that there are only common causes of variability versus the alternative that there are special causes. By continuously monitoring the process, the manufacturing organisation could prevent defect items to be processed in the next stage and to take immediate corrective action once a process is found to be out of control (Hairulliza et al., 2005).

DoE and Taguchi methods are powerful tools for product and process development. Taguchi methods, for instance, aim at making product or process that robust to undesirable disturbances such as environmental and manufacturing variations. However, the application of these two methods by industries is limited (Antony and Kaye, 1995). Antony et al (1998) explore the difficulties in the application including improper understanding and fear of statistical concepts in the methods, thus propose a methodology for the implementation.

Process capability study is an efficient method to examine the capability of a process to produce items that meet specifications. The method gains rapid growing interest due to increased use of quality system QS9000, where use of process capability studies is requested (Deleryd et al, 1999). The findings from capability study might require adjustment of process using other statistical technique such as SPC or DoE. Capability studies conducted by Motorcu and Gullu (2004) and Srikaeo et al (2005) show that the machine tool and process capability and production stability was evaluated and necessary steps to reduce poor quality production was carried out using other statistical techniques.

FMEA is a powerful method to detect where exactly problems can occur and to prioritise possible problems in the order of their severity (Dale et al., 2003). The tool is useful to identify problems in product, i.e. design FMEA, as well as to trouble shoot problems in process, i.e. process FMEA (Xie and Goh, 1999). Six sigma is also a statistical tool for ensuring defect free products through process continuous improvement. The term six sigma originated at Motorola and many inspired worldwide organizations have set goal towards a six sigma level of performance (Breyfogle and Cupello, 2001). The application of six sigma has been mainly used in manufacturing industry. An example of the use of six sigma in non-manufacturing industry is in software development (Mahanti and Antony, 2005).

Acceptance sampling is another statistical techniques to make a decision whether to accept or reject a lot based on the information from sample. The application of acceptance sampling allows industries to minimise product destruction during inspection and testing, and to increase the inspection quantity and effectiveness. The application of acceptance sampling has been mainly used in manufacturing industry. Similarly, its application in non-manufacturing industry is widely reported such as Thorpe et al. (1994), Gardiner and Mitra (1994) Bathika (2003) and Slattery (2005).

3. Research method

The study aims at exploring the implementation of quality control in Malaysian organisations. Four industries were participating in the study. They will be identified as Company A, Company B, Company C, and Company D. These are among listed operating

manufacturing companies in the Bandar Baru Bangi Industrial Area. Initially, 10 companies were contacted to be invited to participate in this study. As a result, only four agree to cooperate. An appointment has been made with the Quality Manager of each company for an interview. The meeting enables the researchers to get as much information about quality control implementation in the company. A list of questions has been prepared prior to the company visit as a guidance for the researcher to get the information. The interview with the Quality Manager and factory visit take about two to three hours for each company.

4. Quality control implementation

This section will describe the application of quality control techniques in each company. The discussion will present some examples of quality control techniques in each company.

4.1 Company A

Company A is a subsidiary of locally-owned National Power Limited. It produces various cables ranging from low to high voltage capacity. This company is the only local producer of fiber optic. The mission of Company A is to become the main local producer and distributor of cable, and to enter the global market soon.

Company A is striving to be the main supplier of electric cable in the country and consequently in the region. One of the ways to achieve the company mission is by ensuring high quality cables produced by them. The produced cables need to be inspected in order to ensure only good cables will be delivered to customers.

Therefore, acceptance sampling is applied by selecting a random sample from a production lot of cables and checking for defect cables in the sample (if any) to later decide whether the whole lot should be delivered to customer or not. The information is also useful for management to make any adjustment in production to ensure the cable meet the specifications. Each cable type has a set of standards or specifications comprising of for example thickness diameter, breaking load etc.

For a big-size cable such as XXX cable, the thickness diameter is measured manually. About 5 or 6 cables are randomly selected from a production lot of for example 100 cables, and tested for their outer covering diameter, to ensure that they are within the specification. Caliper is used to measure the thickness diameter. If the measured diameter is within the minimum and maximum specification, the cable is considered passed for the inspection.

Each selected cable will be measured once, and the reading figure will be recorded in a Checksheet form. Usually 5 selected cables represent a production lot, therefore a checksheet will comprises of five measurement figures. If at least two measurements are beyond the maximum specification, improvement will be made in the manufacturing department. The measurement for selected cable is recorded in a checksheet as in Table 1.

There were seven quality variables recorded in the sheet and five measurements need to be taken for each variable. The specification readings are printed in the sheet as a guideline. The quality engineer will be able to make a suitable decision whether to allow cables for shipment or not. The record in Table 1 is useful for production planning. Analysis on those data enable planning unit to monitor the production performance weekly or monthly.

Company A seems to be satisfied with the applied quality control techniques. With enough trained workers and tools to perform quality control tasks, the Quality Manager in Company A agrees that the current quality control implementation is not facing much difficulties. The only problem that they experience for current implementation is regarding

setting up a new set of specifications that involves various measurements each time Company A get new customers. The procedure takes tremendous amount of time to prepare the new specifications due to various tests are needed to inspect the new cable required by new customers.

	Description	Unit	Measurment						Min	Ave	Spec
			M1	M2	M3	M4	M5	M6			
1	Aluminum H68 Condition	mm									Min:18.2 Max:18.6
2	Conductor screen R. Thickness	mm									Min. Spot 0.5
3	XLPE Insulation Diameter	mm									Min: 26.0 Max: 28.0
4	Core Diameter	mm									Min: 27.0 Max: 32.2
5	Min. Breaking Load	N									2708
6	Wrapping Test	-									No Crack
7	Black MDPE Sheath	mm									Min: 32.1 Max: 36.2

Table 1. Checksheet to inspect the selected cable

Company A has some planning to apply other quality control techniques and tools in future. The new techniques and tools are hoped to solve the current problems and to increase the efficiency and effectiveness in ensuring the products meet customer requirements.

4.2 Company B

Company B is a producer of soft drinks. This company produces drinks with a famous brand and other new brands. There are altogether about 10 branches under the parent company of Company B all over Malaysia. It produces drinks according to the specified standard that involves only mixing the specified ingredients and packing them.

The parent company of Company B produces a well-known soft drink brand and the drinks are marketed worldwide. It has a reputable name and makes every effort to maintain the status. Company B follows the quality control procedure as prescribed by the parent company. The drinks produced by Company B need to be monitored to ensure not only customers taste it good but also they will keep drink it.

Various variables are used to monitor the drink quality including mix amount, temperature, bottle condition, acid amount, etc. Among important ingredient in producing the drinks are a kind of sugar known as Brix or Soliber Solid and carbon dioxide (CO²). The specification for Brix amount is between 10.7° to 11.0°. At least 10 tests are conducted each day in this company to ensure that Brix amount is under control. As for carbon dioxide pressure, the specification value is between 29 to 30 Newton Pascal.

Control chart is used to monitor whether the ingredients are stable. A random sample is selected from the drink production for the analysis. With the help of a special QC machine, the measurement is conducted automatically from the connection to the big mixing machines. The QC machine is able to record, analyse, and produce graphical presentation

from the data. The presented control charts enable workers to take appropriate actions once the process is out of control. Among the improvement strategy is monitoring and examining the ingredient mixing process, adjusting the machine, monitoring the responsible worker for the ingredient mixing process.

Some of the graphical presentations of the analysis are as in Figure 1. The graphs show that the company needs to find out root causes that hinder them from achieving monthly and daily specification target.

Among the difficulties experienced by Company B in QC implementation is when the QC machine breaks down. Workers need to conduct control charting manually including taking the measurement reading for Brix and CO². Currently, the QC machine is connected to a few production machines. In future, the company intends to have an integrated system with a connection of QC machine to all production machines and monitoring computers. This enables an efficient data sharing and quality monitoring.

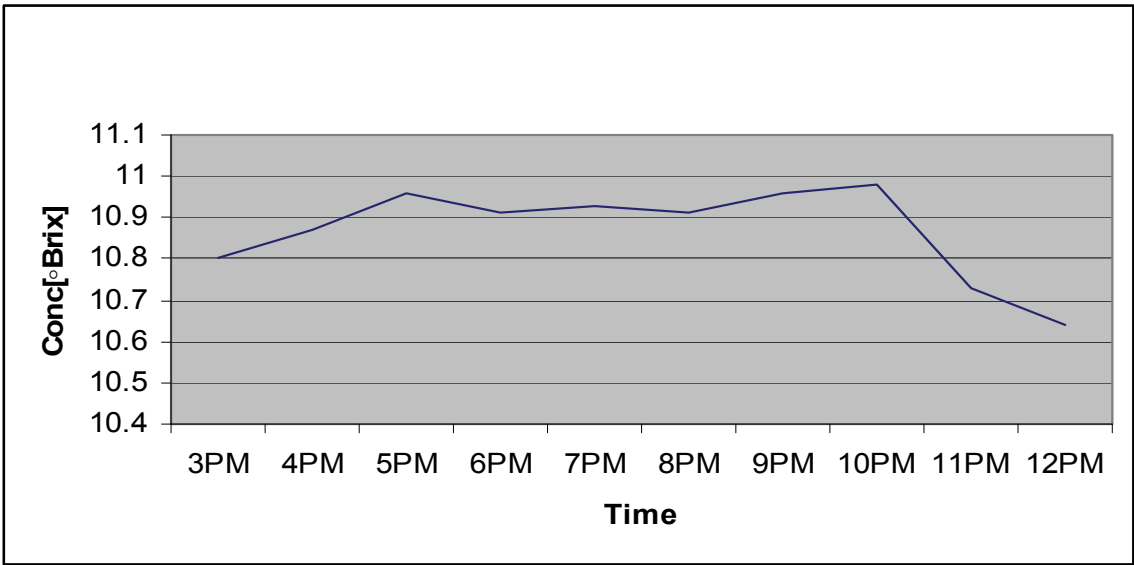


Fig. 1. Hourly Brix Amount

4.3 Company C

Company C produces plastic items. The production of items applies injection plastic mould. Among the produced plastic items are TV housing benzet and TV rear cover. Besides, the products are used as components in audio system, video frame, VCD frame, and air-conditioning frame. Company C produces plastic components for industrial usage. The company supplies raw material for many other big companies locally and abroad. This situation makes them give particular attention for quality control. The main reason for implementing quality in this company is due to customer requirement.

SPC tools are applied in various production stages. For example, workers collect data on product and process performance such as defect items and machine malfunctioning using checksheet. Suitable control chart such as np is used to identify whether the production process for video frame is stable. If there is any data above the upper control limit, corrective actions will be taken. Next, the root causes for the special variations will be identified using Cause-and-Effect diagram involving many workers in a brainstorming session.

Besides SPC, Company C also practices FMEA. The application enables Company C to identify, define and take preventive action in dealing with expected difficulties in the production process. The steps in FMEA application for producing video frame MRY are presented in Table 2. The purposes for the application are to identify the main cause for frame failure and to analytically classify the frame failure.

The application of FMEA results in systematic problem solving for various problems in the production process including Printing NG, Function NG, Cosmetic NG, Paint NG and Moulding Defects. The effectiveness of QC using FMEA was proven by analysing the performance prior to and after FMEA application. Tables 3 and 4 present these defect statistics.

No.	Step
1	Select MRY model and set the target index to be achieved.
2	Set target and date to achieve.
3	Identify problems, failures, and potential difficulties in the process.
4	Define and describe one of the failures experienced by the team.
5	Identify the known cause for the failures.
6	Identify the possible cause for the failures.
7	Identify the classification of failures model.
8	Identify preventive action to avoid failure causes.
9	Develop method for implementation.
10	Describe other failures or problems until all members satisfied.
11	Continue with identifying the cause for other problems.
12	Continue with identifying prevention action for other problems.

Table 2. Steps in FMEA application

Total Input	40070 Unit				
Defect Location	A	B	C	Total	Defect %
Printing NG	415	156	2	573	1.43
Function NG	138	53	1	192	0.48
Cosmetic NG	1520	570	7	2097	5.23
Paint NG	533	209	4	766	1.91
Moulding Defects	139	57	1	197	0.49

Table 3. Defect statistics prior to FMEA application

Total Input	53800Unit				
Defect Location	A	B	C	Total	Defect %
Printing NG	354	163	1	517	0.96
Function NG	119	53	0	172	0.32
Cosmetic NG	1296	596	2	1894	3.52
Paint NG	469	215	1	685	1.27
Moulding Defects	115	52	1	168	0.31

Table 4. Defect statistics after FMEA application

The analysis has shown that the defect rates have decreased for all defect types after applying the method. Consequently, about a thousand product items is secured from being defect items in Company C owing to FMEA application.

Among the difficulties experienced by Company C in quality control implementation is regarding the hardship for workers in working with SPC especially in using control charts. A training on basic statistics and quality concepts to conduct QC techniques is the critical action for the company.

4.4 Company D

Company D is a subsidiary of a conglomerate company in Japan. It offers an extensive range of room air conditioning units and compressors. The company is supported by over 1,000 employees and the latest technology. Company D grows to provide products, systems and services that fulfil their local and international customers, based on the latest advances in technology.

Company D also intends to be the catalyst for a changing society. This spirit has been disseminated among the workforce, and various trainings on quality and technical skills were conducted to ensure the workforce have the required knowledge and capability. In order to make sure that their products meet the high standards from customers, Company D applies rigorous quality control procedure. Company D aims that its air-conditioners offer these characteristics: comfort, energy saving, and silent.

The manufacturing process in Company D involves many stages, beginning with raw material until a complete item is produced. Each production line conducts its main function such as painting, machining, welding, and testing. One of the critical processes in Company D involves pump assembly that consists of various small processes including cuprum pipe pressing. The process takes place once the assembly of air-conditioner components completed, in which chlorofluorocarbon gas is filled into the item. The cuprum needs to be pressed so that the gas is not spreading out. If the process was not conducted properly, the cuprum pipe is leaking and the gas is released gradually from the components.

The emptiness of cuprum pipe from gas deteriorates the chilling effect thus users find it takes long time to cool down. Company D gives enough attention to the pressing process to maintain the comfort and cooling power of its air-conditioning items. To avoid this critical quality problem, ongoing monitoring of the process is conducted by taking at least five measurement of the pressed cuprum at one time, every regular hour. The readings are monitored by plotting an individual control chart to identify if the process is stable.

One of the features that users associate the brand of Company D with is silent. This distinguish characteristic is designed in each air-conditioning item produced by Company D to ensure that users could enjoy the cool environment peacefully without any disturbance. The new twin turbo fan delivers powerful air flow while the streamlined, drag-reducing construction, the air-conditioning items reduce noise with great efficiency. Company D determines that only air-conditioners of the best possible quality produced by the factory. Thus, the practice of quality assurance is of the utmost importance.

All items should fulfill the strict requirements of the international certification. These items are subject to quality inspection to verify that they are free from defects. A number of products will be picked at random from the production line to be thoroughly inspected if any noise is produced by the item. Decision will be made whether to accept or reject the whole item and consequently whether or not distribute them to the markets.

Another characteristic that the users like the most about the brand produced by Company D is its capability to save energy and this means a lower electricity bills to them. To achieve a high performance in the market, Company D utilises various recent technologies that support energy conservation and cost reduction. Low energy consumption plays an important role in ensuring items produced by Company D is at highest possible quality and providing an environment that is sustainable for the future.

Techniques such as FMEA and six sigma are exploited to help the organisation identify, diagnose, and define difficulties and problems with the current products and consequently take tremendous action in improving and radically change them. Innovation such as air purification has made items produced by Company D exceed the needs of customers. With the innovation, the air-conditioners take in fresh air with sufficient oxygen thus keeping the same level with the outside atmosphere, so indoor air is balanced as in the natural environment.

A powerful ventilation system takes away foul odours and bacteria, scrubs out and expels pollutants such as carbon dioxide and formaldehyde. Bacteria and odours are promptly eliminated, as a result of the combination of the Nano Titanium catalyst with silver and zinc. In Company D, enough investment has been made on manufacturing technology such as the application of Scroll Involute Finish Cutting and 3-D Coordinate Measuring Machines. This ensures the fast and precise inspection of components of compressors with little tolerance for errors and high reliability.

Company D has set an example that to be dominant in a fierce global competition, quality must not be compromised. New idea must be identified to accommodate the unpredictable, turbulent, and ever-changing market, due to factors such as changing customer needs, technological advances, and shorter product life cycle.

5. Issues in quality control implementation

This section will discuss important issues in quality control implementation. These include motivating factors, challenges and future trends in QC implementation.

5.1 Motivating factors in QC implementation

The implementation of quality control in four Malaysian companies is reported in this study. As shown in the case study, the reasons for the implementation might come from the company itself, the parent company, or from customer. On the current world market, both manufacturers and consumers require guarantees for the quality of products and services. One of the ways to ensure that the required quality is obtained at appropriate cost and time is by applying quality control in the organisation. The aim of these companies is the same i.e. to produce high quality and reliable products, meet customer expectation, fulfill ISO condition and compete in the market.

Among various applied quality control techniques in the companies, SPC is the most popular applied techniques. Control chart, checklist, and cause and effect diagram were used in these companies to analyse and interpret the data related to product quality. SPC is not only easy and simple to be used, it provides a collection of powerful problem-solving techniques to achieve process stability and reduce variability, and can be used in any process (Montgomery, 2005). Consistent with previous research (Srikaeo et al, 2005; Mason and Antony, 2000; Antony and Taner, 2003; Xie and Goh, 1999), control chart is the most widely used SPC techniques in industries especially to monitor production process.

Acceptance sampling is also applied together with SPC in some companies to get better results of process and product improvement. The case study has shown that quality control implementation in Company A relies heavily on acceptance sampling. In company like this one, acceptance sampling plays an important roles to decide whether to accept or reject particular lot that contains tremendous amount of products. Conveniently, only small amount of products will be inspected to represent the whole lot. Though acceptance sampling technique receives many critics including using detection instead of prevention approach, expensive activity, provides unreliable information, acceptance sampling still has its function in industry. The finding supports Mital et al. (1998) that inspection remains an essential and critical activity for most companies even if there are some inspection-free companies due to their process stability and small process variability. Ahmed and Hassan (2003) also found that among the most used quality control techniques in the Malaysian SMIs was inspection-sampling.

FMEA is applied in one of the companies to particularly help the company from financial loss due to product scraps and defects. Though the procedure is a bit complex, the production team in Company C works together to accomplish the FMEA activity that results in defect rates reduction. Workers knowledge about the process and products were harnessed throughout FMEA activities and their participation in QC activities has boosted the moral to contribute for company excellence. On the other hand, FMEA is utilised in Company D to innovate and radically change the current procedure of products are manufactured.

The four investigated industries show some pattern in the applied QC techniques. Company A relies only on acceptance sampling and checksheet to analyse and interpret the quality data. The Quality Manager seems to satisfy with the techniques since the workers are competent to conduct the related tests and the company shows capability to manufacture products that conform to specification. In the case of Company B, the selected quality control techniques and machines are recommended by the parent company, be able to monitor that the production process is stable. Company C and D takes a step forward from the other two companies in using FMEA to improve the productivity problem, besides using SPC.

The study concludes that the selection of quality control technique in these companies is influenced by three factors. First, ease of use of the technique. A simple but powerful technique will be easily adopted by workers. A more advance technique might require employee knowledge, and might risk employee acceptance to learn new methods. Second, technique that measures product specification fulfillment. Since customer and producer agree with product specification, the selected technique should provide some measurement of specification fulfillment. Third, technique that improves current critical quality and productivity problem. Quality and productivity measures the competitiveness of the company. If company is facing serious problems in these matters, certain quality control techniques will be applied to improve the situation.

The application of quality control technique shows similar pattern of usage in the production stage. Many industries report QC application in the post-production stage, meant for finished products. The application of combination of techniques as early in the process as possible will result in better product and process performance. Xie and Goh (1999) mention that companies will get maximum benefit by improving both the product and process if they can use the approach right from the design stage.

Some of QC techniques such as six sigma, DOE, Taguchi methods, and capability studies are left behind from being used in these four industries. The finding has proven Antony and Kaye's (1995) report that the application of DoE and Taguchi methods by industries is limited. One of the reasons is due to lack of knowledge in the technique. These industries might review the benefit of designing the product and process using DoE and Taguchi especially in Company C since it produced a wide variety of finished products. Capability study is also a useful technique these companies might consider to measure organization's ability to produce goods that fulfill tolerance limit. Some improvement in control chart (Xie et al, 1999) also need to be considered by these companies. The new technique based on the cumulative count of items produced before nonconforming ones are observed allows monitoring the process automatically.

The application of information technology and internet facilities in QC is among recent development in this field (Besterfield, 2004). Real-time QC would be a helpful solution for companies facing issues around lack of quality awareness, passive response, machine problem, unreliable incoming materials quality, and tight customer schedule (Chung et al., 2007). A computer collecting information in real time can detect very subtle changes in a process, and gives warning in time to prevent process errors before they occur (Woo and Law, 2002; Chin et al., 2004).

Research finding in this study shows that each company has shown capability or potential ability to practice QC effectively and efficiently using these facilities. Companies that use computer numerically controlled (CNC) machines enjoy automatic QC. The machine enables not only precise data reading but also controllable data error and efficient report preparation. The application of statistical packages and softwares to analyse data has been performed in these companies. It helps workers to analyse data and make graphical presentation to monitor process performance. Besides, some company is moving towards integrated QC system to allow all departments conduct an efficient QC.

5.2 Challenges and future trends in QC implementation

The study found that each company has its strengths and weaknesses in applying QC. For example, in Company A, though the applied method seems to be simple, it involves tedious procedure to conduct the inspection test. To overcome the complex measurement problem, Company A might consider using a more efficient technique to conduct the inspection test. This might involve using a better tool such as digital caliper, so that a precise and fast reading can be collected from the selected sample. Furthermore, the use of coordinated electronic inspection tools such as digital caliper allows Company A to integrate manual inspection with electronic inspection (Conci and Proenca, 2002).

Manual approach in conducting quality control could be found in some of these companies. For example, to monitor the cuprum pipe pressing process in Company D, individual control chart is used to detect the presence of specific variations in the process. The chart is produced by hand, thus require vast amount of time for its preparation. The workers seem to be comfortable with hard copy files and manual method in producing document for the produced items. The lack of confident in soft copy database was believed to be contributed by the fear that anyone might intrude and manipulate the data that could deteriorate the reputation of the company.

Previous researches that have been conducted show similar problems in implementing quality control among local manufacturing organisations. Among the critical problems are

regarding poor process monitoring, inability to perform data analysis and the implementation of control chart only on the finished products and not in real-time manner (Hairulliza and Teoh, 2007; Hanida et al., 2009).

With the ability of computers to accept information that were typed in manually, read from scanners or manufacturing machines, or imported from other computer databases, the resulting control charts can be examined in greater detail, incorporated into reports, or sent to users across the internet. Real-time SPC would be a helpful solution for companies in facing issues such as lack of quality awareness, passive response, machine problem, unreliable incoming materials quality, and tight customer schedule (Anthony et al., 1998). Real-time quality control also provides great efficiency to the management as it takes time to prepare manual control charts and the time allowed to perform meaningful data analysis is limited (Hairulliza et al., 2010).

Among the reported benefits from real-time SPC were the ability of the production to provide all the charts they needed and responded flexibly to the demands of its employees, and the corporate staff in quality uses it to analyze monthly reports sent electronically by several divisions (Anthony et al., 1998). SPC tools serve not only in their technical aspects, but build an environment in an organization in which all individuals seek continuous improvement in quality and productivity.

Mohd Nizam et al (2009a, 2009b) and Rosmaizura et al (2008) study the barriers in developing an online SPC system, the findings show that factors related to top management support, costs to develop the system, inter-departmental relationship, education and training on SPC are impeding manufacturing organisations from conducting real-time process monitoring. Strong commitment from top management is crucial for a successful implementation of SPC (Jafri and Chan, 2001; Putri and Yusof, 2008; 2009).

The research found that worker training need to be given particular attention by management especially in Company B, C and D. The expected stumbling blocks in implementing quality control come from the technical aspect of the tools (Grigg dan Walls, 1999). Therefore the application of quality control techniques requires knowledge and training. Sufficient exposure to quality concepts and technical abilities need to be considered to ensure that QC activities are really efficient. This is particularly important if the industry intends to try new QC or implement a quite complex and tedious QC. The training does not only give important information and knowledge to workers but also build confidence and acceptance from them.

Support from management in funding the programme is necessary to ensure its effectiveness. However, one of the constraints faced by local companies in implementing quality control is limited investment to improve current techniques. The management might consider partnership with local agencies in enhancing quality and productivity in their company, for instances National Productivity Corporation (NPC) and Standard and Industrial Research Institute of Malaysia (SIRIM). Various training and seminar series were organized by these institutions particularly involving small and medium enterprises (SMEs) to help many organisations to enhance their competencies in market through quality and productivity achievement.

In future, manufacturers are expected to face an increasingly uncertain external environment with a cumulative effect of changes in customer requirements, global competition, and technological advancement. Quality, flexibility, cost and time are regarded as among the most important competitive weapons, in order for manufacturing companies

to survive. Manufacturers face the challenge of improving efficiency and lowering costs. QC techniques would be continuously exploited to help organizations to improve and innovate their products and process in order to be accepted by customers.

Because of the escalating concern on sustainable place and resource for future generation, manufacturers are expected to give more consideration on the environmental effect from their operations. Hence, implementation of environment conservation, atmosphere friendly manufacturing practices, and green technology appear to be dominant. The QC technique will integrate these environmental issues as its important elements. Simplicity and readiness for use would be the expectation for QC techniques of the future. New research is under way to design new QC approach that combine the conventional and model-free system to keep up with the advancing technology, expanding manufacturing process and growing product varieties.

6. Conclusion

The study finds that the motivating factors for these companies to apply quality control come internally from the management and parent company or externally from customer. SPC and acceptance sampling are used widely by the companies. Six sigma, DOE, Taguchi methods, and capability studies are left behind from being used in these four industries, due to lack of knowledge in the technique. The selection of quality control technique in these companies is influenced by three factors: ease of use of the technique; ability to measure product specification fulfillment; and ability to improve critical quality and productivity problem.

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The rich palette of topics set out in this book provides a sufficiently broad overview of the developments in the field of quality control. By providing detailed information on various aspects of quality control, this book can serve as a basis for starting interdisciplinary cooperation, which has increasingly become an integral part of scientific and applied research.

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