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New Challenges for Quality Assurance of Manufacturing Processes in Industry

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Abstract – In any manufacturing systems, irrespective of the products, quality is the most fundamental concern of all manufacturers. Quality management consists of some relevant tools and processes that can improve the overall system performance of a manufacturing unit. With the rapidly changing business environment and stiff market competition, quality tools and continuous improvement (CI) have become important for sustainability and accepting challenges. The key to organizational success lies in satisfying customers with high quality, best prices, and timely delivery of the products. This paper mainly focuses on systematic review and introduction of QC tools and techniques, its importance and subsequent advantages.

These days, the flexibility in the manufacturing process and cost management has significant roles in the competitiveness of the organizations. We think that, in the process of intermittent manufacturing, the primary aim of the industry should remain in mass productivity at affordable prices. We think that while achieving this objective the manufacturing industries would adopt more complex manufacturing systems. With the increasing manufacturing complexities, quality assurance becomes a new and ever-changing challenge to the companies. We can accumulate new categories of data that could help in the improvement of the manufacturing process and product quality. This paper introduces the essence of Industry, as well as the new challenges for the quality assurance of manufacturing processes. Possible research directions for overcoming challenges are also presented.

Keywords: Manufacturing, quality assurance, industry, seven-qc tools and techniques, total quality management, quality control, decision making, PDCA, continuous improvement, customer satisfaction.

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I. INTRODUCTION

Total Quality Management (TQM) consists of some essential stages of the manufacturing process. Not all these stages are directly linked with the manufacturing process directly. These stages include strategy formulation, goal setting, and objective setting. The concept of quality management was first adopted by several industries in Japan, especially Toyota. Quality is not a matter of "by chance"; it is an outcome of proper strategy and skillful execution. It is also a way of offering the market wise choice of alternatives. Constant changes in the business environment induce companies to find new tools and techniques to improve their business performance and output capacities. Every organization keeps some objectives in focus which essentially includes world standard of products and classy organization in every sense. Due to this aim, the trend toward excellence has been increasing with time. The mechanism of Continuous Improvement (CI) is an essential part of management but its success depends on several factors such as leadership involvement, managerial efficiency, employee participation, and training. The target of total quality management is to achieve optimum efficiency in all process performance of the organization. So, focus on quality brings business growth and improves business performance.

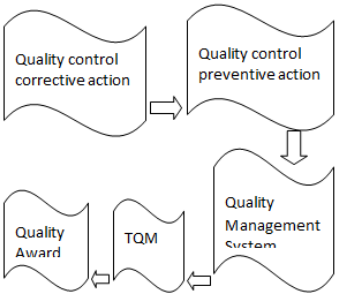

Figure 1: Development of Quality Management Concept

A. The Present Scenario of Quality Control across the industries

Customer satisfaction is directly related to the competitiveness of an organization. The fundamental objective of an industry is customer satisfaction by identifying customer needs and marketing quality products through the process of cost-effective mass production (Ahmed and Hassan, 2003). As the product types increase, the complexity of different manufacturing processes increases simultaneously. This involves elaboration in the fields of quality assurance and quality management. This aspect of business can be the source of several research topics (Antony and Taner, 2003). There are some futuristic attributes in this aspect but the business world can progress towards it through the constant development of technology. The virtual and real worlds along with the big data concept have new ways and more opportunities for the product and service quality improvement (Battikha, 2003). We can gather data related to a manufacturing process that has not been touched or explored yet. We can analyze the data and find the interlinks among different fields through this data for demand forecasting, determining the reasons for failure, understanding the requirement of technology, and fixing weaknesses in material handling or resource allocation process. Therefore, we have to find the types of data to be saved and all possible ways of data analysis and applications for quality improvement. This paper introduces the characteristics of the industrial Changes and covers the most important tools of the 4th industrial Changes (Dale, et. al., 2003). Later, the functional methods in manufacturing processes related to the field of quality assurance will be presented elaborately. We think that quality-centric tools can improve the working method and performance of the business world. This paper will explore these new possibilities.

It is obvious that any remarkable industrial change has its effects on the society, economy, and technology of a region or country as a whole. Suitable social and economic environments are necessary for the development and spread of new technologies. For instance, the invention of steam engines had a profound effect on the then industry and society. Basic features of industrial changes are shown in Table 1. These days, virtual and real worlds have been designed to perfectly work in tune to proceed with automation (Mahanti and Antony, 2005). This new aspect of technology has initiated Industry.

Industrial Changes 1	*Industrial Changes 2*
Beginning: 1760s Most important features: - steam engine, - mechanization of textile plants, - steamships, - steam railway, etc.	Beginning: 1870s Most important features: - electricity, - oil industry, - steel industry, - invention of internal combustion engine, - mass production, etc.
Industrial Changes 3	*Industrial Changes 4*
Beginning: 1930s Most important features: - nuclear power, - new technologies, - CAD/CAM systems, - CIM systems, processes, networks, etc.	Beginning: from today Most important features: - Internet of Things (IoT), - Cyber-physical systems, - logistics , manufacturing , hospital logistics ., etc.

Table 1: Industrial Changes (Mahanti and Antony, 2005)

II. LITERATURE REVIEW

The industry is an accumulation and coordination of different elements. The Internet of Things (LoT) is one of them. Two other important aspects are big data and the cyber-physical world. According to the experts, these three aspects of the industry are going to rule the world in near future (Mason and Antony, 2000). In this section, we will discuss these tools.

Important tools of the 4th generation of industrial changes are as follows:

- The Internet of Things (IoT): IOT is an IT-based technology that enables the access of different equipment through the internet (Motorcu and Gullu, 2004). In many situations, it establishes the essential communication among various equipment which is otherwise a manual job. In recent times, the majority of data created on the internet are recorded automatically. This has enabled us to access trillions of data in any field. For more professional use of logistics, we need to understand each of its components more closely. This is possible if we have sufficient data about the components like human resource, other resources, machinery, and products. IoT can make this data accumulation, analysis, and sharing easier and faster. For example, if we put a sensor on a certain part of a technological component that can immediately provide the status of that part. This is where IoT plays an important role.

- Cyber-physical system: If an electronic device possesses a network connection and an automated control system then it is called a cyber-physical system (Slattery, 2005). The development and improvement of information technology and automation have made cyber-physical systems more

industry-friendly. These systems are programmed to collect data from the environment, analyze them, and then act accordingly. Normally, the cyber-physical systems are connected through networks (wired/wireless). Their important parts are also connected with each other. As these systems can use cloud networks, they improve the overall performance remarkably.

- Big Data concept: The volume of data doubles in every two years (Thorpe, et. al., 1994). This means we could access huge data in almost every walk of life such as market condition, market demand, stock exchange, resource management, etc. We can develop new services by analyzing data and finding correlations among different sets of data. An example of such a service is estimating flight prices with the help of a software system that can analyze the historical data to predict future trends. The essence of Big Data lies in finding the probabilities through mathematical and statistical methods. According to the experts, Big Data has opened up a huge possibility in business research and analysis (Woo and Law, 2002). It is capable of changing the way we work today. With it, we can predict the future with much more accuracy.

The above-mentioned expressions are related to each other in some way or the other. It is not possible to establish a Big Data analysis system without IoT or an IoT system without a cyber-physical system.

A. Seven Basic QC Tools

The concept of QC tools was proposed by Xie and Goh (1999) [11]. He wrote the book "Gemba no QC Shuho" where he explained the importance of quality management and how that could be done through techniques and practices. He further explained how quality management can help an organization in problem-solving, process management, and decision making. Dr. Ishikawa opined that most of the quality related problems can be solved through QC tools. There are seven basic QC tools used for quality improvement process in product and service industries worldwide. The brief descriptions of these tools are given below:

1. Pareto Diagram: It is a tool used to find the problems and then prioritize those problems based on their effects on the organizational process. It was conceptualized by Velfredo Pareto. He noticed that 80% of wealth is actually in the hands of 20% of the total population of a country. Xie et al (1999) developed the Pareto Principle (Xie, et. al., 1999). Through this principle, he suggested a process of quality control for separating "vital few" problems from "trivial many". Pareto Principle shows the process of breaking a bigger problem in smaller ones and then identifies the most vital issues. Figure 1 indicates that there are 6 problems but the first three are causing maximum damage. Thus, the Pareto Principle helps to detect the critical problems at the earliest.

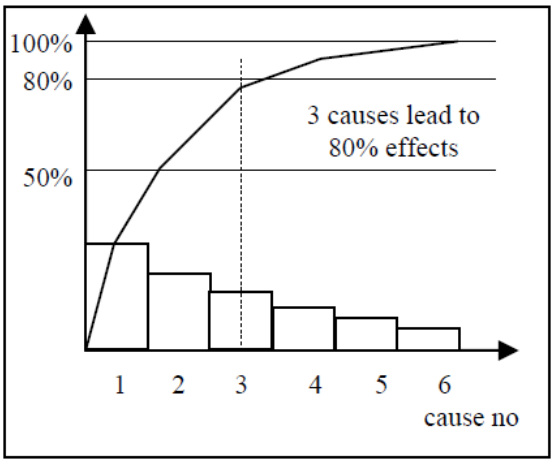

Figure: 2: Pareto Diagram

2. Cause and Effect Diagram: This is also known as the Ishikawa diagram. Its purpose is to identify various factors related to a potential problem. As there may be several causes related to a problem, Cause and Effect Diagram helps to understand the actual causes and develop ideas to solve them. It is also known as Fishbone Diagram as the diagram resembles the skeleton of a fish. The head of the diagram is the problem and bones depict different causes (Mahanti and Antony, 2005). The major bones can again branch off into smaller ones as we try to define the lower levels of cause-effect more aptly. When all the bones are drawn, the whole diagram provides a clear picture of cause-effect and probable solutions.

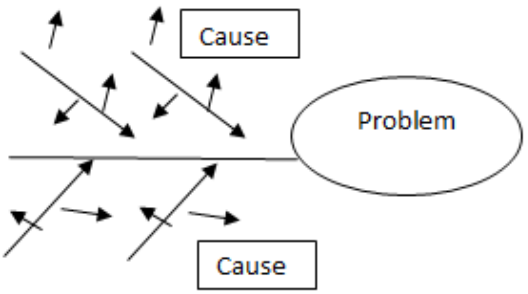

Figure 3: Cause and Effect Diagram

3. Control Chart: This is a graph to investigate the relevance of different

process performances. Its aim is to stop all kinds of system abnormalities and ensure stable condition. It also helps to differentiate common cause, exceptional cause, and special cause. It can evaluate the effectiveness of variations in process performances.

4. Checksheet: This provides a structured form to accumulate data and then analyze that data systematically. Through this planned activity different categories of data could be collected. Check sheet helps to know a problem from different aspects. There are different kinds of Checksheet such as defect location check sheet, defect cause check sheet, and tally check sheet.

5. Scatter Diagram: This is a tool used during a problem analysis to know clearly the relationship between two variables. Two variables are plotted on two axes of a scatter diagram. It finds the correlation between two variables such as Positive, Negative, and No correlations. Figure 4 shows a Scatter diagram.

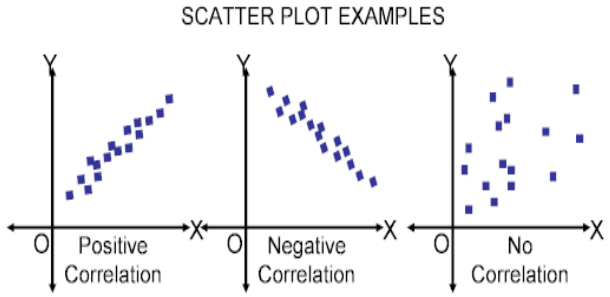

Figure 4: Scatter Diagram

6. Stratification: It is a method of collecting data from different groups after segregating the causes. A problem is an outcome of several causes. The prime cause or causes behind a problem is obtained by analyzing the data from different groups.

7. Histogram: It is the graphical representation of frequency distribution. It helps to compare a process before a problem is solved and after the problem is solved. We can come to a conclusion by studying the distribution pattern. It can efficiently summarize a large data in graphical form and compare different parameters. Therefore, decision making becomes easier. Figure 5 shows a histogram diagram.

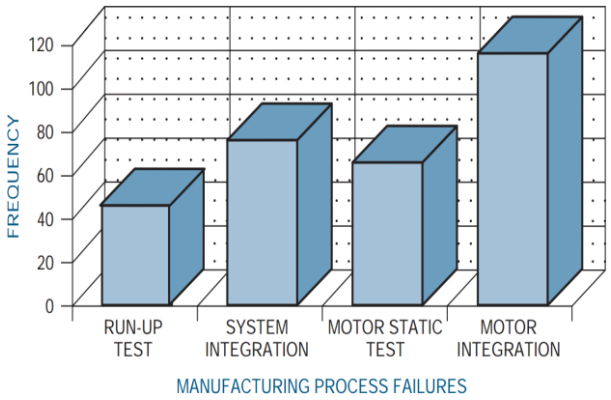

Figure 5: Histogram

B. Relationship of 7 QC Tools

The quality Control tools are used for the quality management system to analyze, improve, and control the manufacturing process of a product or maintain the service quality. The above-mentioned 7 QC tools have different roles to play in the overall improvement process. The inter-relationships among the QC tools are depicted in Figure 6. The purpose of the tools is to monitor the overall performance of a system. Thus, process analysis including process identification can be accomplished with these 7 QC tools (Motorcu and Gullu, 2004).

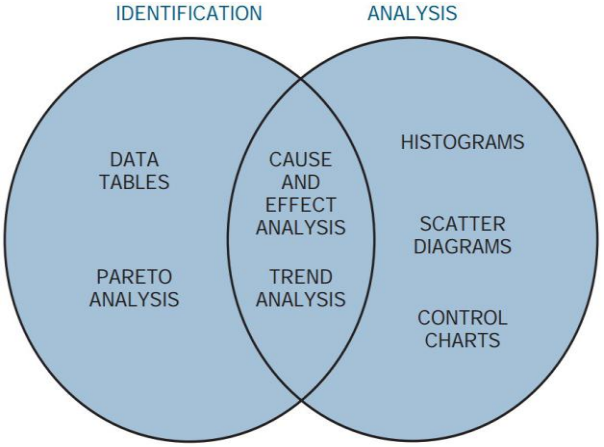

Figure 6: Relationship of 7 QC Tools

C. Process Improvement through PDCA Cycle

Continuous process improvement can provide satisfactory results when it is maintained within the PDCA framework. At first, the complex process needs to be simplified. Then, the entire focus should be given on improving the simplified processes. There needs to be a target of improvement through inexpensive techniques. PDCA framework was developed by Walter Shewhart in the 1920s. After that, it was modified by Dr. Edwards Deming. This is now also known as

Deming's wheel. PDCA cycle includes the following four phases:

- Plan: It is necessary to identify the areas that require improvement. Optimal solutions to be planned for them.
- Do: This phase is concerned about the implementation of the solutions.
- Check: This phase includes the evaluation and control of the process changes.
- Act: This phase asks to adopt the changes.

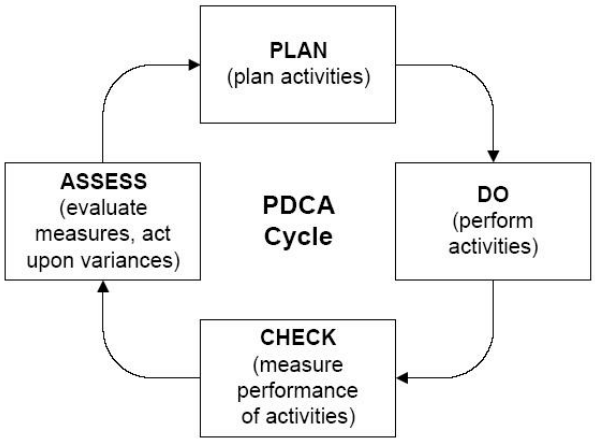

Figure 7: Process Improvement through PDCA Cycle

In PDCA, the four phases are integrated in a systematic manner. The current phase depends on the previous one. Different phases of PDCA cycle with corresponding activities are shown in Table 7. When cycle is completed, we say that one improvement took place. As such, PDCA is an incessant process. Figure 8 shows that as one cycle ends, another problem needs attention immediately which necessitates another PDCA cycle.

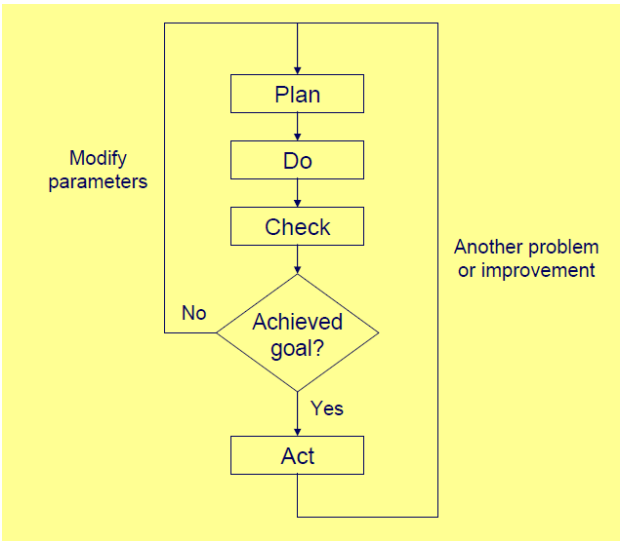

Figure 8: PDCA cycle

Table 2: PDCA cycle.

Seven QC Tools	Plan	Do	Check	Act
Pareto Diagram	✓		✓	
Cause and Effect Diagram	✓		✓	
Control Chart	✓		✓	
Check Sheet	✓		✓	
Scatter Diagram	✓		✓	✓
Graph	✓			✓
Histogram	✓			

D. PDCA and Value Addition

PDCA cycle is very effective in all kinds of organizations. Table 2 shows the application of PDCA cycle activities in different stages.

Table 3: Application of PDCA cycle activities in different stages

Plan	**Do**
• Create appropriate learns • Gather all available data • Understand customers' needs • Describe the process that surrounds the problem • Determine root cause(s) • Design action plan • Develop plant	• Implement Improvement • Collect appropriate date • Measure progress • Document resuls
Check	**Act**
• Summarize and analyze date • Evaluate results relative to targets & see differences • Review any problems/errors • Record what was learned • Specify any remaining issues or unintended costs	• Standardize desired improvements • Formalize "current best approach • Communicate results broadly • Identify next improvement

A great many successful companies across the world practice PDCA cycle for process improvement and quality control. It helps to understand various alternatives of process control and process improvement. It eases teamwork and establishes best organizational practices.

E. Currently Used Methods in the Quality Assurance of Production Processes

Achieving quality management and system is the goal of all companies. For this, most companies design their quality management system to ensure proper implementation of the quality policy. This is the quality goal which is the ultimate goal of every company. The quality goal could be realized through quality design, quality assurance, quality improvement, and quality control (Thorpe, et. al., 1994). Figure 1 shows a comprehensive list of

most effective tools and processes in quality control.

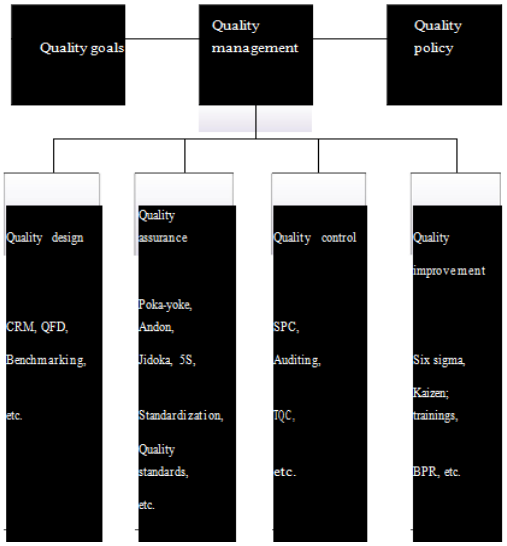

Figure 9: Classification of quality management tools and methods used in relation to manufacturing systems (Thorpe, et. al., 1994)

Quality Design: Quality design can be defined as the measures and activities that define the quality goal of a company (Woo and Law, 2002). On the basis of quality design, it is possible to develop a planning strategy for the appropriate use of company resources.

- Customer Relationship Management (CRM): This is a comprehensive process targeted at customer handling, this is largely dependent on specialized software systems and data analysis. It helps in understanding customer needs and expectations that in turn helps in quality management.

- Quality Function Deployment (QFD): It is a popular method used by many companies for the systematic transformation of customers' needs into quality parameters. Thus, the manufacturing process gets an integrated system of production.

- Benchmarking: The aim of benchmarking is to methodically develop and implement the best practices for quality management. The research or investigation can be conducted at a company (internal benchmarking) or in the industry (competitive benchmarking). Benchmarking can also be done by focusing on specific functionality (functional benchmarking) or on the entire issue (generating benchmarking).

Quality Assurance: This is the steps and activities undertaken with an aim to strengthen the confidence of the management that pre-determined quality assurance could be met (Motorcu and Gullu, 2004).

- Poka-yoke: It is a technique of auto-detection of system errors and human negligence. It can be integrated with the system itself to detect the problems in real-time.

- Andon: This concept includes visual signaling devices. It helps to identify if any problem has occurred in the manufacturing process. Andon can stop the process until the issue is fixed.

- Quality Standards: There are different quality standards issued by the appropriate authority. The most popular quality standards are issues by ISO through their ISO 9000 series.

- Jidoka: This is related to a specific philosophy of automation. Its aim is to distinguish between manual and automated process. Jidoka can stop the process as soon as a problem is detected.

- 5S: This is based on 5 quality principles which are Seiri (sort), Seisho (shine), Seiton (set in order), Seiketsu (standardize), and Shitsuke (sustain).

- Standardization: Setting up standard methods that the company wants to follow in manufacturing or imparting services.

Quality Control: This includes the procedures and activities targeted at satisfying the quality requirements (Slattery, 2005).

- Statistical Process Control (SPC): SPC is one of the most fundamental tools in QC. It helps in accurate tracking of manufacturing processes and quality performance. It includes timing and sampling based control systems.

- Auditing: It inspects whether a process is complying with the industry norms and standards or not. It also inspects whether the process complying with the organization's own control system.

Total Quality Control (TQC): The essence of the concept of TQC (Total Quality Control) is that it extends the scope of quality control to the entire company, moreover to the entire product lifecycle. This is achieved through the involvement of all the departments of the organization, thereby exceeding the traditional boundaries of manufacturing.

F. 7 QC Tools Comes Under This!!

Quality Improvement: It is the measures and happenings targeted at the probable quality performance (Xie, et. al., 1999).

- Six Sigma: This is an effective quality improvement process. This largely depends on the SPC. The aim is to minimize the errors and failure rates. Thus, Six Sigma reduces performance variations (DMAIC method).
- Kaizen: "Kaizen" a Japanese term means "improvement". When used from an organizational perspective, it means continuous improvement of working life and performance. In this process, a broad system is segregated into several small sub-systems to investigate where improvement is possible.
- Training: The training of employees is important for the successful implementation of Six Sigma, Kaizen, or any other quality improvement methods and tools.
- Business Process Reengineering (BPR): This methodology put maximum attention on the radical redesign of older or traditional processes that are no longer so effective for the current market.

G. New Challenges for the Quality Assurance of Manufacturing Processes in Industry

In the modern context, collection and management of data is a challenge for the companies. Applying the tools and methods that the 4th generation of industrial changes have invented data accumulation and management has become easier and faster. This has created some new possibilities in the organizational processes, thus quality control and management. With time, these new opportunities will become even wider through the invention and implementation of new methods and technologies. Soon, industries will be able to develop near perfect error forecasting methods. This will enable better resource management and cost savings. The production system will be more flexible and comprehensive as Big Data, AI, and Cyber-physical systems implemented in the manufacturing processes (Battikha, 2003). These three new technological inventions related to information technology will help in the following ways:

- Reduce system failures remarkably
- Help to design optimal production planning
- Curtail material handling routes
- Design the best-integrated production systems
- Ensure prompt and hazardless communication systems

In this context, the fundamental questions are what kinds of data are required, how such data could be collected, where such data could be found. In the following section, we will show some examples of important data and how they could be used:

Material Handling Machines: The material handling machines are used with aims to minimize material handling routes, minimize time, and manage logistics.

The following information, which is new in this field, can fulfill the above purposes:

- A lifetime of the parts – It has a high impact on the maintenance planning of the system.
- Route temperature – Duct planning depends on it.
- Tire Atmosphere Pressure – Duct planning depends on it.
- Environment temperature and humidity – Duct planning depends on it.
- Moisture monitoring – Maintenance planning depends on it.

Technological equipment: All kinds of technological equipment used in quality control or process management should be planned for maximum utility. This is also true for all kinds of material handling equipment used in the system. Moreover, managing the operation at the optimum level should also remain in focus. New information, as depicted below can support all these activities:

- The ideal way of equipment handling and operation is influenced by current supply and atmospheric pressure and temperature.
- The ideal way of equipment handling depends on the humidity level.
- Product quality maintenance is important which depends on how much force a product could tolerate.
- Maintenance planning depends on moisture tolerance levels of different parts.

- Maintenance planning depends on the lifetime of technological equipment.

- Maintenance planning depends on the forces put on the operating tools (Xie and Goh, 1999).

Human Resources: The most vital part of the human resource is ensuring timely availability of skilled human resources and accomplishes the jobs according to the plan. Following new information can make a huge difference in human resource management:

- Work efficiency depends a lot on the light, temperature, and humidity of the workplace.

- Checking whether the operational standards are adhered to.

- Work efficiency depends on the pulses, speed, and acceleration of machinery.

For collecting the data as discussed here, which were not known before, necessitates integration of new data collection device with the machinery or human carrying the operations.

Some important aspects of data collection equipment:

- The devices need to be damage proof.

- Attachment process should not hinder the workflow or slow down the process.

- Best, if the devices could be recycled.

- There need to be built-in charges with every device.

- Data transfer system needs to be easy and unhindered.

- Data transfer over a long distance or wireless data collection station will increase flexibility.

CONCLUSION

Quality issues could be attended efficiently through the systematic use of quality control tools. TQM needs utmost attention through an appropriate strategy. Implementation of TQM roadmap provides an integrated theory of quality management. Any manufacturing process consists of several sub-processes; QC tools can be implemented to any sub-process. These QC tools ease quality management. PDCA cycle is a simple yet very effective tool which makes it possible to detect and fix problems instantly thereby ameliorating the process. There are various other tools and techniques available for process improvement and quality management. However, the implementation of these tools and techniques require utmost commitment from the management and proper employee training. In a modern production process, the integrated quality management system is required. It is clear that in absence of a proper process improvement technique, no organization will be able to design a full-proof process management system.

This paper has paid maximum attention to different aspects of quality assurance amidst 4th industrial changes. It is obvious that the problems in the production process and product quality can be improved with the help of. So-far-not-collected data generation and through the application of artificial intelligence and Big Data concept. More research works in this field will enable understand what kinds of data can assist in more result-oriented operation systems, help to develop industry-appropriate technologies, and help to implement cyber-physical systems for optimum use of resources. In connection with these, we have described some of the important data types that need to be collected and also their application possibilities.

REFERENCES

1. Ahmed, S. and Hassan, M. (2003). Survey and case investigations on application of quality management tools and techniques in SMIs. *International Journal of Quality and Reliability Management,* 20(7), pp. 795-826.

2. Antony, J. and Taner, T. (2003). A conceptual framework for the effective implementation of statistical process control. *Business Process Management Journal,* 9(4), pp. 473-489.

3. Battikha, M. G. (2003). Quality management practice in highway construction. *International Journal of Quality and Reliability Management,* 20(5), pp. 532-550.

4. Dale, B. G., Bunney, H. S. and Shaw, P. (2003). Quality management tools and techniques: an overview. In Dale, B. G. (Ed): Managing Quality (4th Edition). Blackwell, Oxford.

5. Mahanti, R. and Antony, J. (2005). Confluence of six sigma, simulation and software development. *Managerial Auditing Journal,* 20, pp. 739-762.

6. Mason, B. and Antony, J. (2000). Statistical process control: an essential ingredient for improving service and manufacturing

quality. *Managing Service Quality,* 10(4), pp. 233-238.

7. Motorcu, A. R. and Gullu, A. K. (2004). Statistical process control in machining, a case study for machine tool capability and process capability. *Materials and Design,* 27, pp. 364- 372

8. Slattery, J. (2005). Sampling for quality assurance of grading decisions in diabetic retinopathy screening: Designing the system to detect errors. *International Journal of Health Care Quality Assurance,* 18(2), pp. 113-122.

9. Thorpe, C. D., Torrence, W. D. and Schniederjans, M. (1994). Quality assurance in human resource management for Computer-Integrated Manufacturing. *International Journal of Quality and Reliability Management,* 14(2), pp. 18-30.

10. Woo, T. M. and Law, H. W. (2002). Modeling of a quality control information system for small to medium-sized enterprise. *Integrated Manufacturing Systems,* 13(4), pp. 222-236.

11. Xie, M. and Goh, T. N. (1999). Statistical techniques for quality. *The TQM Magazine,* 11(4), pp. 238-241.

12. Xie, M., Lu, X. S., Goh, T. N. and Chan, L.Y. (1999). A quality monitoring and decision-making scheme for automated production processes. *International Journal of Quality and Reliability Management,* 16(2), pp. 148-157.

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