ELSEVIER

Int. J. Production Economics 80 (2002) 135–144

international journal of production economics

www.elsevier.com/locate/dsw

"New JIT": A new management technology principle at Toyota

Kakuro Amasaka*,[1]

Aoyama Gakuin University, 6-16-1, Chitosedai, Setagaya-ku, Tokyo 157-8572, Japan

Abstract

A future successful global marketer must develop an excellent quality management system that impresses users and continuously provides excellent, quality products in a timely manner through corporate management. The author proposes New JIT, a new management technology principle for manufacturing in the 21st century. New JIT contains hardware and software systems as next-generation technical principles for transforming management technology into the management strategy. The hardware system consists of the Toyota Marketing System (TMS), Toyota Development System (TDS) and Toyota Production System (TPS). These are the three core elements required for establishing new management technologies in the marketing, engineering and production divisions. To improve work process, quality of all divisions concerned with development, production and sales, the author proposes Toyota Total Quality Management utilizing Science SQC (TQM-S) as the software system. The author believes that New JIT's effectiveness has been demonstrated as described herein based on the author's experience at Toyota.

Keywords: New JIT; Three core elements (TMS, TDS, TPS); TQM-S; Science SQC

1. Introduction

The production technology principle Japan contributed to the world in the latter half of the 20th century was the Japanese-style production system typified by the Toyota Production System (TPS). This system was enhanced by the quality management technology principle generally referred to as Just In Time (JIT). Today, however, improvements in the quality of Japanese-style management technology principles are strongly desired in the face of unexpected quality-related recall problems breaking out among industrial leaders, while at the same time delays in technical development cause enterprises to experience crises of existence (see Goto, 1999). To realize manufacturing of the best quality for the customer in a rapidly changing technical environment, it is essential to create a core principle capable of changing the technical development work processes of development and design divisions.

Similarly, it is important for the production division to develop a new production technology principle and establish new process management principles to enable global production[2] (Hayes and Wheelwright, 1984).

*Tel.: +81-3-5384-3795; fax: +81-3-5384-6500.

E-mail address: kakuro_amasaka@aoyama.ac.jp (K. Amasaka).

[1] The author was TQM Promotion General Manager at Toyota and led the Toyota team during the course of this study.

[2] The model of high-performance manufacturing (HPM Model) proposed by Hayes and Wheelwright (1984) is well known as a preceding research.

0925-5273/02/$ - see front matter © 2002 Published by Elsevier Science B.V.
PII: S0925-5273(02)00313-4

Furthermore, new marketing activities independent from past experience are required for sales and service divisions to achieve firmer relationships with customers. In addition, a new quality management technology principle linked with overall activities for higher work process quality in all divisions is necessary for an enterprise to survive. In this need for improvements, Toyota is no exception. For this reason, the author, anticipating the manufacturing of the next generation, has developed a new management principle called "New JIT" as the next step in the evolution of conventional JIT. Its effectiveness is demonstrated in this paper.

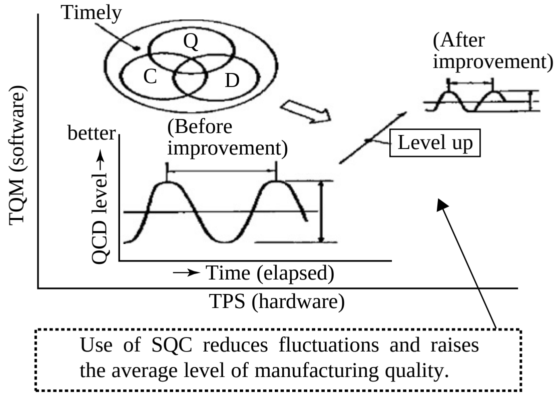

Fig. 1. Relation between TPS and TQM.

2. Traditional TPS and TQM: JIT

Toyota Motor Corporation's production system, including JIT, is the manufacturing system Toyota developed in pursuit of optimum streamlining. It aims to "build quality in" using Total Quality Management (TQM) in the manufacturing process while following the principle of cost reduction. This is why Toyota often compared TPS and TQM to the two wheels of one vehicle (see Ohno, 1977; Toyota Motor Corp., 1987). To be able to manufacture vehicles that meet customer demands without fail, timely quality, cost and delivery (QCD) studies are important. To accomplish this, Toyota has positioned TPS and TQM as the two figurative pillars of our management technology principle (see Amasaka, 1989).

As Fig. 1 shows, these two elements combine to flatten extreme curves and constantly raise mean values by maintaining and improving QCD research with TPS as the hardware technology and TQM as the software technology. As is widely known, use of the rational technique of statistical quality control (SQC) reduces fluctuations in and raises the average level of manufacturing quality as represented in the figure. From such meaning as well, it could perhaps be said that SQC is the root of manufacturing and the historical origin of TQM. Improvements in engineering quality are an urgent necessity in order to emerge victorious from extreme global competition in the area of quality (see Amasaka, 1989).

The JIT (see Womack et al., 1991) concept and approach renovated vehicle production at Toyota. As a result of worldwide favorable evaluations of its effect, JIT became the core concept of manufacturing industries around the world in the 20th century (see Womack and Jones, 1994).

3. Today's management technology problem

In this section, the author touches upon the management technology problems which Toyota faces. Toyota's TPS has already been developed as an internationally shared system, known as a Lean System (see Taylor and Brunt, 2001) and is no longer an exclusive technology of Toyota in Japan. The success of TQM principles in the US resulting from the realization of the importance of quality management through studying Japanese TQM (also referred to as Total Quality Control or TQC) has diminished the superiority of Japanese product quality due to Japanese-style quality management (see Gabor, 1990; Joiner, 1994).

Because of these reasons, we conjecture that it is clearly impossible to lead the next generation by merely maintaining the two Toyota management technology principles, TPS and TQM. To overcome this issue, it is essential to renovate not only TPS, which is the core principle of the production process, but also establish core principles for sales, production planning, design, development, and other departments.

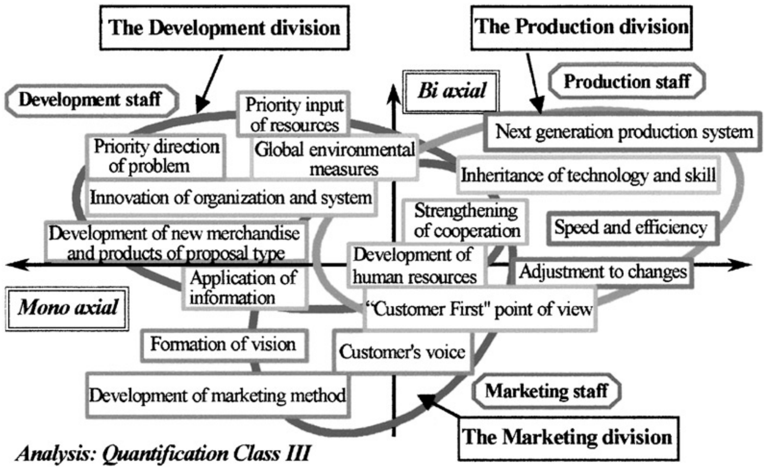

Fig. 2. Schematic drawing of Management Technology Problems throughout the Toyota Group (positioning of opinion).

In order to accomplish this, the author and others (Amasaka et al., 1999a) identified technological management problems from the management's point of view based on an awareness survey of 72 executives and general management personnel from 12 Toyota group companies (Toyota, Denso and others) as shown in Fig. 2. This figure depicts overall management technology problems by using Quantification Class III analysis (Amasaka et al., 1995; 1999a). The development division gives priority to the development of new products, the production division to next-generation production systems, and the marketing division to the development of new marketing methods. The common problem is revision of the organization or system through judicial sharing of information for better division-to-division coordination.

Such studies and analyses have clarified the core concepts necessary for the next-generation, new management technology principle, its roots, and the technical elements required for linking core concepts. As a result, it is considered strategically necessary to create a new management technology principle. This principle will be a new version of JIT with the new concept of linking the QCD research activities of all these departments. To facilitate excellent quality management that can contribute to engineering development worldwide, it is necessary to carry on precise and reasonable JIT activities so as to enhance the quality of work processes in all divisions.

4. Proposal of New JIT for renovating quality management

4.1. The concept of New JIT for renovating quality management

The creation of attractive products requires the implementation of "Customer Science" (refer to Appendix A.1) (Amasaka, 2000a) to scientifically grasp customers' tastes. To achieve this, the entire organization must be managed by each of the marketing, engineering and production divisions. All of these are organically combined by control divisions (Engineering Control, Production Control, Purchasing Control and Information Systems), the general administration division, and those in charge of motivating human resources and organizing the divisions as a whole. Therefore, a new organizational and systematic principle for the next-generation, new management technology principle, New JIT, for accelerating the optimization of work process cycles of all the divisions is necessary.

The author (Amasaka, 2000b) has developed a new management technology principle, New JIT, as shown in Fig. 3, which contains hardware and

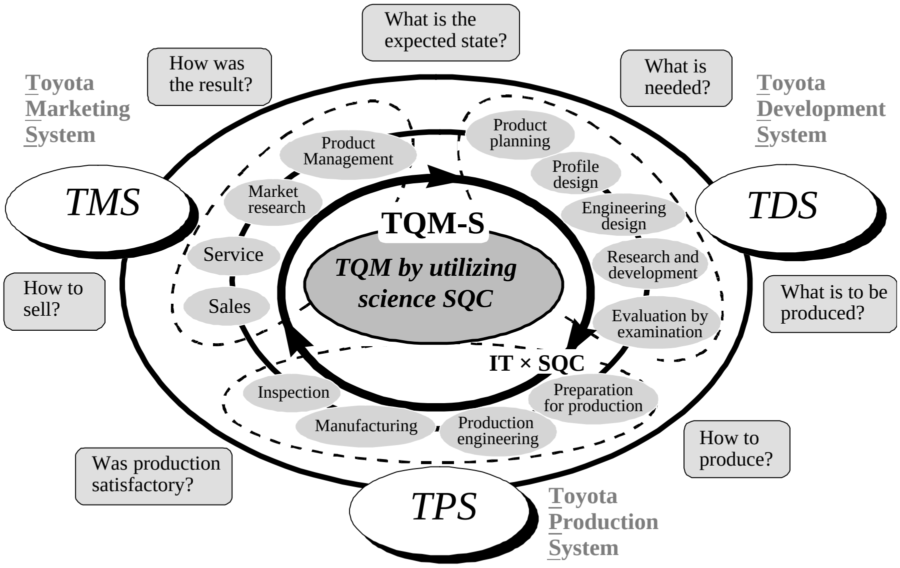

Fig. 3. New JIT, A new principle called TQM-S at Toyota.

software systems as the next-generation technical principles for transforming management technology into management strategy. The first item, the hardware system, consists of the TMS, TDS and TPS, which are the three core elements required for establishing new management technology principles for business planning, sales, R&D, design, engineering, and production, among others.

For the second item, software, the author (Amasaka, 2000a, b) has developed Toyota Total Quality Management utilizing "Science SQC" (TQM-S) as the system for improving work process quality of the 13 divisions shown in Fig. 3. In this concept, which was developed to make quality management more scientific, the quality management principle of "Science SQC" (refer to Appendix A.2) (Amasaka, 1997) was added to TQM activities. Its advantageous effect has been demonstrated. This systemizes and organically organizes the new SQC operation by combining information technology (IT) with SQC.

Thus, divisions are linked organically as shown in Fig. 3 below. We believe that this linkage contributes to further growth and development of the three core elements of New JIT, and general solutions have to be approached by clarifying the gaps that exist in theory, testing, calculation and actual application. For further details of "Science SQC" with four principles (Scientific SQC, SQC Technical Methods, Integrated SQC Network and Management SQC), refer to the references Amasaka and Osaki (1999) and Amasaka (1999, 2000a, b).

4.2. Three subsystems of New JIT

4.2.1. TMS: The first principle

The expectations and role of the first principle, TMS, as shown in Fig. 4 include the following:

(a) Market creation through the gathering and use of customer information.
(b) Improvement of product value by understanding the elements essential to raising merchandize value.
(c) Establishment of hardware and software marketing systems to form ties with customers.
(d) Realization of the necessary elements for adopting a corporate attitude (behavioral norm) of enhancing customer value and developing customer satisfaction (CS),

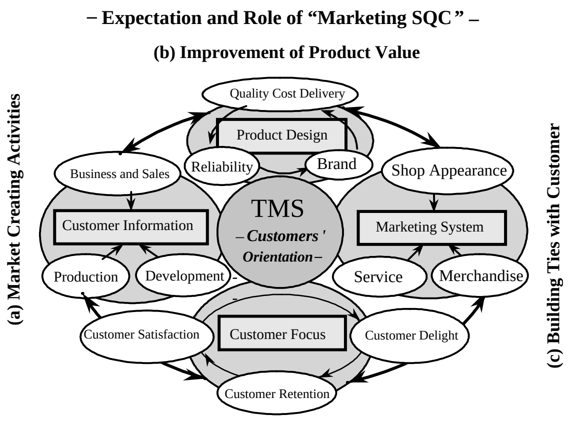

Fig. 4. Schematic drawing of TMS.

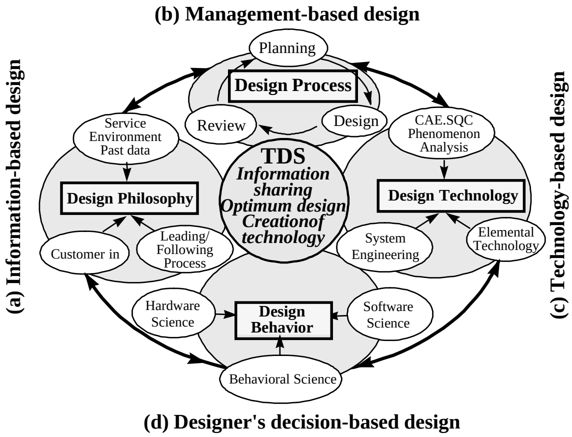

Fig. 5. Schematic drawing of TDS.

customer delight (CD), customer retention (CR), and networks.

The practical application of "Science SQC," the effectiveness (Amasaka, 2001) of which was demonstrated by the author in establishing TMS in the sales division as well as contributing to business through product planning departments, is termed "Marketing SQC". In order to scientifically conduct market surveys not confined only to readily apparent sales, recognize the importance of "Marketing SQC," which contributes to future development, and carry out customer-oriented global marketing, the implementation of "Customer Science" is becoming more and more important, not least in terms of properly linking TMS, TDS, and TPS.

4.2.2. TDS: The second principle

The expectations and role of the second principle, TDS, as shown in Fig. 5, is the systemization of a design management method which is capable of clarifying the following:

(a) Collection and analysis of updated internal and external information that emphasizes the importance of design philosophy.
(b) Development design process.
(c) Design method that incorporates enhanced design technology for obtaining general solutions.
(d) Design guidelines for designer development (theory, action, decision-making).

The application of "Science SQC" to improve the process quality of design work in order to realize these criteria is called "Design SQC" (Amasaka et al., 1998a). To create the latest technology in response to technological evolution, it is important to implement "Design SQC" so that it may contribute to the development of proprietary technology, its continuation, and its further advancement. The important thing is to establish general technological solutions, rather than particular solutions, by building up partial solutions. The true objective of establishing TDS is to create technologies through optimum design brought about by information sharing.

4.2.3. TPS: The third principle

The expectations and new role of the third principle, TPS, as shown in Fig. 6, comprise the following:

(a) Customer-oriented production control systems that place the first priority on internal and external quality information.
(b) Creation and management of a rational production process organization.
(c) QCD activities using advanced production technology.

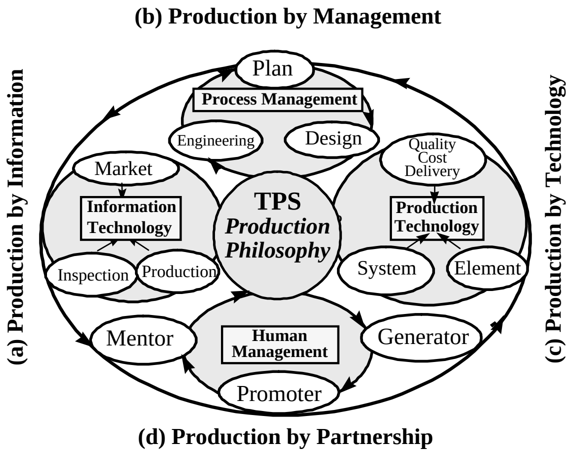

Fig. 6. Schematic drawing of TPS.

(d) Creation of active workshops capable of implementing partnerships.

The application of "Science SQC" to strengthen the overall production organization to achieve these objectives is called "Production SQC" (Amasaka et al., 1998b). One of the objectives of TPS implemented through the application of "Production SQC" is to solve bottleneck technical problems at the production engineering (preparation) and production stages. The second objective is to establish a rational, scientific process control method for achieving a highly reliable production system (Amasaka and Sakai, 1996; Amasaka et al., 1999b).

5. Implementation and effect of New JIT through TQM-S

The following are representative examples of research, as the basis for establishing TQM-S along with TMS, TDS, and TPS, which are core elements of New JIT.

5.1. Establishment of Toyota sales marketing system using TMS

The construction of a Toyota Sales Marketing System (Amasaka, 2001) that is capable of renewing established ties with customers is extremely important to strategic marketing, which is the basis for establishing global marketing and is one of the establishment targets of TMS. A "Netz"[3] Toyota dealer is introduced as a model case in which successfully vehicle sales market share increased largely through improvements in the CR ratio at vehicle replacement.

By using a new SQC method termed CAID (Categorical Automatic Interaction Detector) analysis based on "Marketing SQC," we were able to demonstrate the planning measures needed to improve the CR ratio of our products. Full-scale use of this strategic system began in mid-1998, contributing to the construction and development of the "Toyota Sales Marketing System" at Toyota dealers (see Nikkei Business, 1999).

5.2. Implementation of vehicle profile design using TDS

The main objective of establishing TDS is to provide creative products that highly impress customers ahead of the competition. Among many factors, vehicle styling is important in winning customers over. Designers have been groping for a method of supporting ideas for obtaining practical, distinctive solutions for many years. The author and others (Amasaka et al., 1998a, b) applied TDS by using Design SQC to develop the Aristo (Lexus GS400 in the US) and successfully achieved the objective (Motor Fan, 1997).

In this instance we applied the technical methods of SQC to visualize vehicle images that customers might desire followed by an analysis of the association between the degree of CS and elements of vehicle appearance based on appearance assessments. Using the knowledge thus acquired, the association between vehicle image and proportion data[4] of a vehicle was determined

[3] A "Netz" shop is one of the five sales affiliations of Toyota Motor Corp. A name changes from the usual "Auto" shop, and it is established in August, 1998, and there is "VITZ" (An European car name is "YARIS".) and so on in the sales main force car kind.

[4] The definition of the proportion data: two dimension ratios of main vehicles surveying. For examples, hood ratio is hood length/overall length and overall height ratio is overall height/overall length (see reference Joiner, 1994).

to help improve the design process. TDS has become the main vehicle design development method at Toyota and is contributing to the provision of high quality and highly reliable products to customers (Amasaka and Osaki, 1999, 2000).

5.3. Establishment of new TPS to meet challenges of globalization

In this section, the author discusses the establishment of a new Toyota Production System (New TPS) intended to meet the challenges posed by globalization. By implementing Inline–Online SQC, an integrated network system that utilizes IT and SQC, the next-generation, scientific process management principle New JIT can be achieved.

In specific terms, under New TPS, information originating on the line is gathered by computer and then transferred to other related divisions. Then anyone can carry out improvements promptly as needed by accessing the quality management information of a process anytime, anywhere and eventually improve the machine capacity (shown by the machine capacity index (C_m)) and process capability (shown by the process capability index (C_p)) through two network systems that contribute to the establishment of New JIT.

The following are examples of the application of systematic development of quality assurance technologies to test the validity of New TPS at Toyota: (1) development of the Availability and Reliability Information Administration Monitor System in the Body Line (ARIM-BL) (Amasaka and Sakai, 1998) and (2) typical utilization of the Quality Assurance System by using TPS in the Unit-axle Line (TPS-QAS) (Amasaka et al., 1998b).

(1) ARIM-BL consists of the real-time management of trouble diagnosis of equipment using Weible analysis, contributing to the maintenance and improvement of machine capacity.
(2) TPS-QAS consists of the real-time management of process quality diagnosis using control charts, contributing to the maintenance and improvement of process capability.

With the adoption of New TPS, the expected effect can be attained (for details, see reference data Amasaka et al., 1998b and Motor Fan, 1997). In recent years, Toyota has been introducing New TPS in its domestic factories one after the other, resulting in attainment of the desired result. At present, a system applicable for Toyota group companies and overseas plants is being developed.

6. Conclusion

In this paper, the author has proposed "New JIT" as a new management technology principle for 21st century manufacturing. The proposed New JIT does not stop with "TPS" and "TQM", which are representative of the Japanese production system called JIT found in Toyota Motor Corporation and others. Rather, the author has strategically developed New JIT with a concept that goes beyond production.

New JIT renovates the business process of each division, which encompasses business sales, development and production, with the aim of "customer first" quality management. It includes hardware and software systems developed according to new principles to link all activities on a company wide basis.

The hardware system comprises three core elements: Toyota Marketing System (TMS), Toyota Development System (TDS) and Toyota Production System (TPS). The software system consists of the deployment of Total Quality Management utilizing Science SQC (TQM-S), which is a new principle for quality management. The objectives of TQM-S are to improve the quality of work processes in all divisions and to renovate quality management activities. TQM-S utilizes Science SQC, which has already been demonstrated to be effective.

The author and others believe that the effectiveness of New JIT has been demonstrated, as positive results in sales, design, development and production have been obtained from applying it within Toyota.

In the future, we will closely observe "next-generation manufacturing" and further develop "New JIT" applications for management technology from the viewpoint of management worldwide.

Acknowledgements

We are indebted to Dr. Jose A.D. Machuca, Editor of this Special Issue, to the referees of this article for their support and comments on the original draft that resulted in a much improved article. We would also like to thank the persons concerned at Toyota Motor Corporation for their comments and suggestions.

Appendix A

A.1. Customer science

The author (Amasaka, 2000b) considers that the next-generation New JIT should not remain mainly for production. It is essential to establish a methodology containing a new concept and core technology principle (core competence as the management technology principle) that permits corporate management based on it. Establishment of a methodology of corporate management adopting the concept and method of Customer Science proposed by the author (Amasaka, 2000a) and illustrated in Fig. 7 will become more and more important in the future. Customer demands (implicit knowledge) must be developed into images (lingual knowledge) using correlation technology. These images are then accurately converted into engineering language (explicit knowledge) and reliable drawings are developed that enhance process capability for prompt merchandizing. It is important that customer demands be converted scientifically into common language for use by all divisions.

A.2. Science SQC, a new quality control principle

It is important for all divisions to turn implicit knowledge of their business processes to explicit knowledge through integrated and collaborative activities by sharing objective awareness. To accomplish this, a new systematic and organized SQC propulsion cycle in the Toyota way, the so-called Science SQC, proposed by the author (Amasaka, 1997) was developed under a new concept using a new methodology that applied the four core principles as shown in Fig. 8 which enabled jobs to be scientifically performed. This conceptual diagram shows the nucleus of Toyota's and its group's TQM activities based on a new quality principle that are the secret of success for next-generation manufacturing.

As determined from viewing Fig. 8, the four core principles in this figure are incorporated into

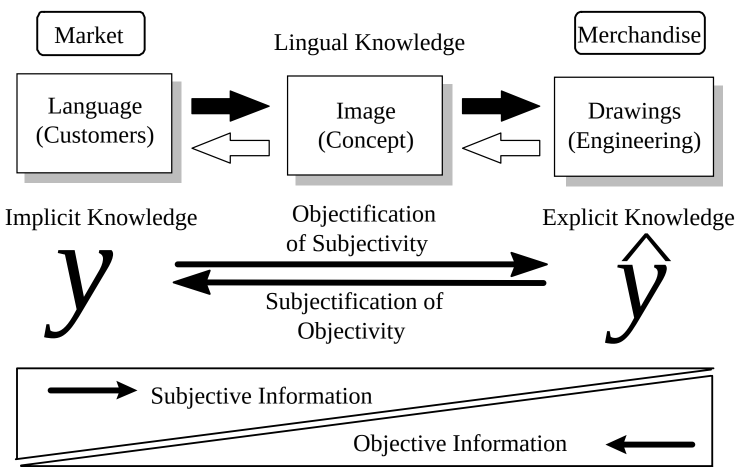

Fig. 7. Conceptual diagram of "Customer Science".

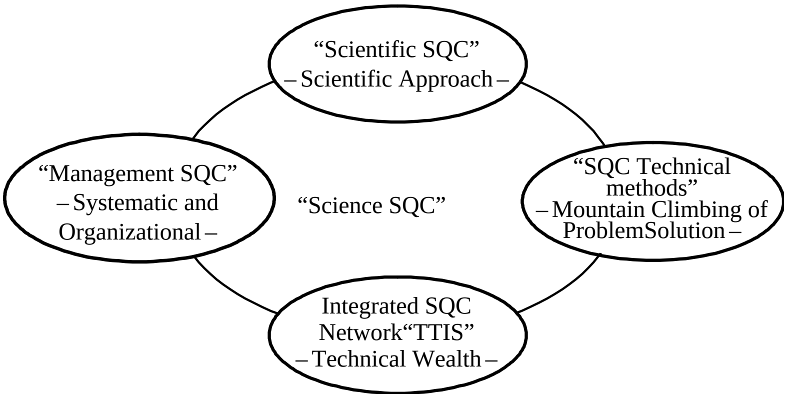

Fig. 8. Schematic drawing of "Science SQC".

a new SQC application system where they are closely linked to each other. The first principle of Scientific SQC refers to scientific approaches at every stage of the process ranging from determination of problem to accomplishment of objectives. The second principle of SQC Technical Methods by using the seven new tools for TQM (N7), multivariate analysis and design of experiment refers to the mountain-climbing methodology for solving problems. The third principle of SQC, total network Toyota SQC Technical Intelligence System (TTIS) represents the networking of SQC software application by using the four sub-core principles. It can turn proprietary data inheritance and development into a science. The fourth principle of Management SQC is to support prompt solution of deep-rooted engineering problems.

Particularly in the practical application, the gaps between principles and rules have to be clarified scientifically as engineering problems, and general solutions have to be approached by clarifying the gaps that exist in theory, testing, calculation and actual application. For further details on Science SQC with four principles, refer to references Amasaka and Osakai (1999) and Amasaka (1999, 2000a, b, c).

References

Amasaka, K., 1989. TQC AT TOYOTA, actual state of quality control activities in Japan. The 19th quality control study team of Europe. Union of Japanese Scientists and Engineers 39, 107–112.

Amasaka, K., 1997. A study on "Science SQC" by utilizing "Management SQC". Journal of Production Economics 60–61, 591–598.

Amasaka, K., 1999. Proposal and implementation of the "Science SQC" quality control principle. Proceedings of the First Western Pacific/Third Australia–Japan Work Shop on Stochastic Models, Christchurch, New Zealand, September 24, 1999, pp. 7–16.

Amasaka, K., 2000a. "TQM-S" a new principle for TQM activities—a new demonstrative study on "Science SQC". Proceedings of the International Conference on Production Research, Bangkok, Thailand August 3, 2000, pp. 1–6 (CD-ROM).

Amasaka, K., 2000b. New JIT, a new principle for management technology 21^{C}. Proceedings of the World Conference on Production and Operations Management, Sevilla, Spain, August 31, 2000, pp. 15–27.

Amasaka, K., 2000c. A demonstrative study of a New SQC concept and procedure in the manufacturing industry. The Journal of Mathematical and Computer Modeling 31, 1–10.

Amasaka, K., 2001. Proposal of "Marketing SQC" for innovating dealers' sales activities—a demonstrative study on "Customer Science" by utilizing "Science SQC". Proceedings of the 16th International Conference on Production Research ICPR16, Praha, Czech Republic, July 31, 2001.

Amasaka, K., Osaki, S., 1999. The promotion of new statistical quality control internal education in Toyota. The European Journal of Engineering Education on Maintenance, Reliability, Risk Analysis and Safety 24 (3), 259–276.

Amasaka, K., Osaki, S., 2000. Reliability of Oil Seal for Transaxle—A Science SQC Approach at Toyota, Case Study in Reliability and Maintenance. Wiley, New York, to be published.

Amasaka, K., Sakai, H., 1996. Improving the reliability of body assembly line equipment. International Journal of Reliability, Quality and Safety Engineering 3 (1), 11–24.

Amasaka, K., Sakai, H., 1998. Availability and Reliability Information Administration System "ARIM-BL" by methodology in "Inline–Online SQC". The International Journal of Reliability and Safety Engineering 5 (1), 55–63.

Amasaka, K. et al., 1995. A study of questionnaire analysis of the free opinion—the analysis of information expressed in words using new Seven QC Tools and Multivariate Analysis together. Journal of the Japanese Society for Quality Control; The 50th Technical Conference, 43–46 (in Japanese).

Amasaka, K., et al., 1998a. Studies on "Design SQC" with the application of "Science SQC". Japanese Journal of Sensory Evaluations 3 (1), 21–29.

Amasaka, K. et al., 1998b. Proposal of "TPS-QAS" by utilizing "Science SQC". Journal of the Japanese Society for Production Management; The 8th Annual Technical Conference, pp. 75–78 (in Japanese).

Amasaka, K. et al., 1999a. The development of "Science SQC" for industrial management—"TQM-S" in Toyota Group. Journal of the Japanese Society for Quality Control; The 61st Technical Conference, pp. 105–108 (in Japanese).

Amasaka, K., et al., 1999b. Development of working environment for older workers in final assembly process-AWD6 task management team activities at Toyota. Proceedings of the Second Asia Pacific Conference on International Engineering and Management Systems, Kanazawa, Japan, October 30, 1999, pp. 129–132.

Gabor, A., 1990. The Man who Discovered Quality; How Deming W.E. Brought the Quality Revolution to America. Random House, Inc.

Goto, T., 1999. Forgotten Management Origin—Management Quality Taught by GHQ. Seisansei Shuppan (in Japanese).

Hayes, R.H., Wheelwright, S.C., 1984. Restoring our Competitive Edge: Competing Through Manufacturing. Wiley, New York.

Joiner, B.L., 1994. Forth Generation Management: The New Business Consciousness. Joiner Associates, Inc., New York.

Motor Fan, 1997. The Whole Aspect of New "Aristo". A Prompt Report of New Model Car, A Separate Volume, 213, pp. 24–30 (in Japanese).

Nikkei Business, 1999. Renovation of shop, product and sales method targeting young customers by "Netz". No. March 15, 46–50 (in Japanese).

Ohno, T., 1977. Toyota production system. Diamond–Sha and Toyota Motor Corp, 1987 (in Japanese).

Taylor, D., Brunt, D., 2001. Manufacturing Operations and Supply Chain Management—Lean Approach, 1st edition. Thomson Learning, Florence, KY.

Toyota Motor Corp., 1987. The Toyota Production System and A Glossary of Special Terms Used at Production Job-sites at Toyota (in Japanese).

Womack, J.P., Jones, D.T., 1994. From lean production to the lean enterprise. Harvard Business Review, 93–103.

Womack, J.P., Jones, D.T., Doos, D., 1991. The Machine that change the World—The Story of Lean Production. Rawson/Harper Perennial, New York.