Journal of Economics and Technology Research
ISSN 2690-3695 (Print) ISSN 2690-3709 (Online)
Vol. 1, No. 1, 2020
www.scholink.org/ojs/index.php/jetr

Original Paper

Studies on New Japan Global Manufacturing Model: The innovation of manufacturing engineering

Kakuro Amasaka[1*]

[1] College of Science and Engineering, Aoyama Gakuin University, Tokyo, Japan

[*] Kakuro Amasaka, College of Science and Engineering, Aoyama Gakuin University, Tokyo, Japan

Received: April 29, 2020 Accepted: May 5, 2020 Online Published: May 9, 2020

doi:10.22158/jetr.v1n1p42 URL: http://dx.doi.org/10.22158/jetr.v1n1p42

Abstract

This study describes the "New Japan Global Manufacturing Model" (NJ-GMM) that contributes to strengthening of Japanese global manufacturing strategy. NJ-GMM is the innovation of manufacturing engineering fundamentals. Specifically, the foundation of NJ-GMM consists of the "Intellectual Working Value Improvement Management Model" (IWV-IMM), "Partnering Performance Measurement Model" (PPMM), "Strategic Stratified Task Team Model" (SSTTM), "Intelligence High-cycle System for Assembly Maker Production Process" (IHS-AMPP), "Strategic Quality Management using Performance Measurement Model" (SQM-PMM), and "Working Value Evaluation Model" (WVEM). The effectiveness of NJ-GMM was verified through the actual applications to automobile manufacturing in Toyota and suppliers.

Keywords

New Japan Global Manufacturing Model (NJ-GMM), manufacturing engineering, Toyota

1. Introduction

The Japanese-style production system represented by the current Toyota Production System (TPS), called JIT, has already been developed as an internationally shared system, and is no longer an exclusive corporate management technology in Japan (Amasaka, 2002, 2007a). Therefore, the pressing management issue particularly for Japanese manufacturers to survive in the global market is the uniform quality worldwide and production at optimum locations which is the prerequisite for successful corporate management strategy. To overcome this issue, it is essential to renovate not only TPS, which is the core principle of the production process (Amsaka, 2007a; Amasaka & Sakai, 2010, 2011). Because of that realization, the author has created the "New Japan Global Manufacturing Model" (NJ-GMM) which realizes the simultaneous achievement of Quality, Cost and Delivery (QCD) into effective global manufacturing. The aim of NJ-GMM is the innovation of manufacturing engineering fundamentals to strengthening of Japanese global manufacturing strategy with new hardware and software methodologies as next generation manufacturing.

Specifically, six core models of NJ-GMM foundation consists of the "Intellectual Working Value Improvement Management Model" (IWV-IMM) for the revolution of operating technology and skill in workplaces, "Partnering Performance Measurement Model" (PPMM) for assembly makers and suppliers" for the strengthening of SCM strategy, "Strategic Stratified Task Team Model" (SSTTM) for the driving force of Problem-Solving, "Intelligence High-cycle System of Assembly Maker Production Process" (IHS-AMPP) for the development of simultaneous achievement of QCD, "Strategic Quality

Management using Performance Measurement Model" (SQM-PMM) for QCD activity, and "Working Value Evaluation Model" (WVEM) for strengthening of manufacturing technology (Amasakka, 2004a, 2009a, 2017a; Yamaji et al., 2007a, 2008; Tsunoi et al., 2010; Amasakka & Sakai, 2010; Sakai et al., 2010; Kozaki et al., 2012; Uchida et al., 2012).

Concretely, the author has verified the effectiveness of NJ-GMM through the actual applications of automobile manufacturing by developing main sub-core models of Toyota and suppliers (Amasaka, 2004a, 2004b, 2008, 2018a; Ebioka et al., 2007, Yamaji & Amasaka, 2007a; Sakai & Amasaka, 2008; Kojima & Amasaka, 2011; Yanagisawa et al., 2013).

2. Needs for Advances in Global Manufacturing Engineering

2.1 Manufacturing Shifting to Global Production

The Japanese management technology that made the biggest impact on the world in the latter half of the 20th century was the Toyota Production System (TPS) called Just-in-Time (JIT) or Lean System (Ohno, 1977; Amasaka, 1988, 2000a, 2002). At present however, the TPS has been further developed and spread in the form of internationally shared in the the manufacturing industry and it is no longer a proprietary corporate management technology of Japan (Womack et al., 1990; Goto, 1999; Taylor & Brunt, 2001; Amasaka, 2002). The environmental changes that surround today's manufacturing industry are truly severe. The current task of today's manufacturing is to succeed in global production.

The urgent mission for Japanese manufacturers is to reconstruct world-leading, uniquely Japanese fundamentals of management technology, which is often referred to as a worldwide quality competition, the pressing corporate management issue is to realize the kind of global production that can achieve the simultaneous achievement of QCD—ahead of their competitors (Amasaka, 2004a, 2008; Amasaka et al., 2008; Ministry of Land, 2009). Therefore, in-depth study of the kind of management technology employing the advanced-manufacturing engineering that will be effective even for next-generation manufacturing operations is urgently needed as well. Specifically, advanced companies in the world are shifting to global production to realize the "*worldwide uniform quality and production at optimal locations*" (Amasaka, 2002, 2004b, 2004c, 2007a, 2007b).

2.2 Problems with Success in Global Manufacturing

The greatest concern of corporate managers is the success of "overseas production strategy—local production" as well as "to bring overseas manufacturing to Japan standards". Therefore, in order to increase the skills of production workers at local manufacturing sites (hereafter referred to as operators), the key to successful global manufacturing is necessary to realize manufacturing suited to the actual situation at manufacturing sites of various overseas production bases (Amasaka, 2007a, 2007b; Ebioka et al., 2007). However, it has been observed that, despite the fact that overseas plants have the relevant production systems, facilities, and materials equivalent to those that have made Japan the world leader in manufacturing, the "building up of quality—assuring of Process Capability (Cp)" has not reached a sufficient level due to the lack of skills of the operators at the manufacturing sites (Lagrosen, 2004; Ljungström, 2005; Yamaji and Amasaka, 2007a; Koren, 2010) and TQM (Burke et al., 2005; Hoogervorst et al., 2005; Amasaka et al., 2006).

As a countermeasure to such a problem, and in order not to lag behind the "evolution of digital engineering—the transition to advanced production systems at production plants", the Japanese manufacturers expect the production plants in Japan to serve as the "mother plants". They would welcome overseas operators to these plants, and promote "a local production program—transplanting the know—how of Japanese manufacturing" (Ebioka et al., 2007).

2.3 The Demand for Advances in Global Manufacturing Engineering

However, it is by no means easy to transfer the "know-how of Japanese manufacturing" directly to overseas production bases as mentioned above. In other words, there is always "an obstacle to overcome—a suitable production system for each production base", due to the difference in ability (level of skill and education) or national characteristics between the local manufacturing site and Japan (Amasaka, 2002; Sakai & Amasaka, 2006). Therefore, to cope with this situation, an environment in which the creation of labor values–ES (employee satisfaction), advanced skills, a sense of achievement, and self- development can be realized must be urgently considered (Amasaka et al., 2006; Yamaji et al., 2006, 2007b). To accomplish the above, the author surmises that it is necessary to develop a type of manufacturing which fits the local circumstances of various overseas production bases, and to advance from "Japanese mother plants" to "global mother plants" (Ebioka et al., 2007).

To be successful of global manufacturing in the near future, the Japanese manufacturing industry must develop an excellent manufacturing management technology employing the advances in manufacturing engineering that can continuously provide high value products in a timely manner surpassing "Kaizen" (improvement) of manufacture site symbolized by TPS based on the three actuals of the actual place, actual part and actual situation called "Sangen Shugi" (Toyota, 1987; Amasaka, 1988, 2000a, 2009b; Jeffrey, 2004). Furthermore, a key of global manufacturing is the systematic deployment of Supply Chain Management (SCM) on a global scale that encompasses cooperative manufacturing operations with overseas suppliers employing a newly global partnering model (Amasaka, 2000a, 2000b, 2004a, 2004b, 2008; Ebioka et al., 2007).

3. Creation of the New Global Japann Manufacturing Model (NJ-GMM)

To realize the world uniform quality-simultaneous model launches, the author has created the "New Japan Manufacturing Management Model" (NJ-GMM) by using six core models based on the structure of manufacturing engineering as shown in Figure 1. In NJ-GMM, the main characteristics of each core model contribute to the advancement of manufacturing management through actual QCD research by using statistical science, as follows.

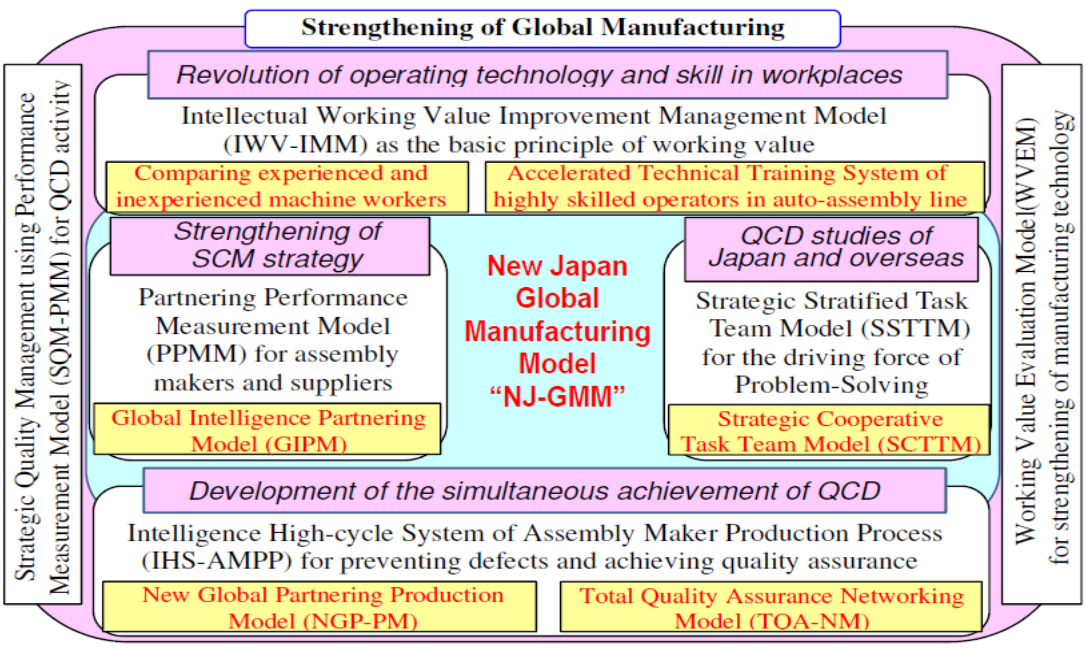


Figure 1. New Japan Global Manufacturing Model (NJ-GMM)

3.1 Intellectual Working Value Improvement Management Model (IWV-IMM) as the Basic Principle of Working Value

A priority issue in particular is the securing of working productivity at overseas plants deployed by advanced manufacturers promoting global manufacturing at a rapid rate. Against this background, the author has presented the “Basic Principle of Working Value Improvement” (BP-WVI) with the 5 layered levels of the (a) physical workload reduction, (b) mental workload reduction, (c) self-actualization, (d) contribute to an organization, (e) contribute to Social Satisfaction (SS) and (f) Customer Satisfaction (CS) by producing high quality products. As depicted in Figure 2, on the premise that a well-planned human resource development scheme aimed at improving worker motivation is a top issue from the standpoint of “Basic Principle of Working Value Improvement” (BP-WVI) (Tsunoi et al., 2010).

Based on the suggested BP-WVI, the author has created the “Intellectual Working Value Improvement Management Model” (IWV-IMM) for the revolution of operating technology and skill in workplaces as outlined in Figure 3 (Yamaji et al., 2007a). In Figure 3, the design, production, quality assurance, marketing, human resource development, and administration cooperate and must reform the technologies and skills of the workers. In particular, boosting morale, reduction of fatigue, development of physical strength, development of tools & devices, improvement of thermal environment and prevention of illness & injury are required for evolution. The deployment and validity of IW-IMM are detailed to the references of Amasaka (2015, 2017b, 2020).

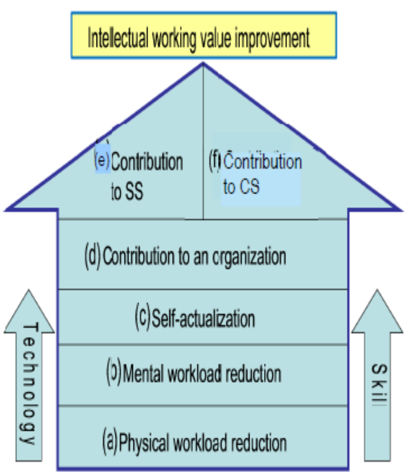


Figure 2. Basic Principle of Working Value Improvement (BP-WVI)

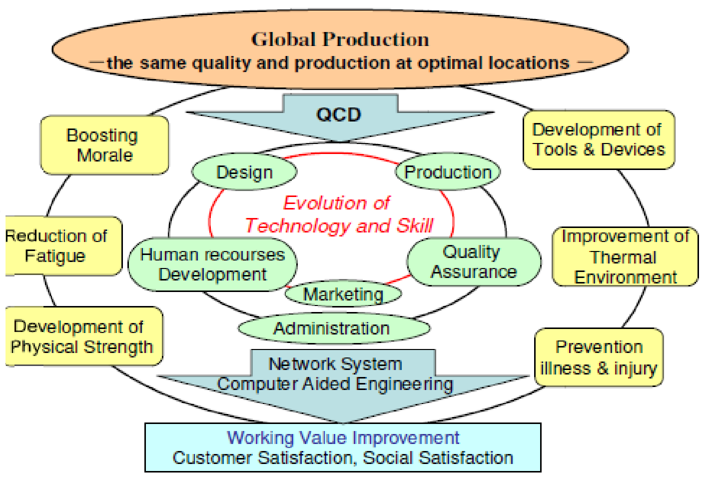


Figure 3. Intellectual Working Value Improvement Management Model (IWV-IMM)

3.2 Partnering Performance Measurement Model (PPMM) for assembly Makers and Suppliers

To strengthen of SCM strategy, it is vital to reinforce the global partnering through strategic collaboration with both domestic and foreign suppliers. In order to implement such reinforcements of product power, the author has created the “Partnering Performance Measurement Model” (PPMM) for assembly makers and suppliers (Yamaji et al., 2008). As a concrete instance, this model should serve as a formulation model using radar chart for visualization for evaluating the actual status of Japanese partnering between automobile assembly makers and parts suppliers, which has been somewhat implicitly carried out in the past. In connection with the PPMM development, the authors creates PPMM-A for assembly makers, PPM-S for suppliers, and PPM-AS for assembly makers and suppliers, as a comprehensive dual performance measurement to be shared by both.

Specifically, evaluators from related departments on both sides were given a survey using the evaluation sheet as shown in Table 1. The survey comprised of a total of nineteen evaluation factors (Factor X1 to X19 with evaluation contents) extracted from an affinity diagram based on meetings with assembly makers and suppliers. Concretely, evaluators of assembly makers and suppliers are Toyota (Sales 1, Production Preparation 2, TQM Promotion 1), Hino (Procurement 1, TQM Promotion 1), Fuji Heavy Industries (TQM Promotion 1, Procurement 2), Honda (Quality Assurance 1), Nissan (Procurement 1), GM (Procurement 1), Ford (TQM Promotion 1), Jatco (Quality Assurance 2), JFE (Quality Assurance 2), (Procurement 1), NHK Spring (Quality Control 1, SQC Promotion 1).

By using Table 1, the author attempted to derivate a formulation model that incorporated multivariable analysis. First, cause and effect relationships were extracted by conducting cluster analysis and principal component analysis using scoring of seven-steps. Next, using categorical canonical correlation analysis, formulation models were derived, while coefficients of each group's factors were calculated and a radar chart was designed for each group. One hundred was set as the highest score. Based on the above, evaluation factors could be categorized into five elements as shown in Figure 4: (a) supplier follow-up and (f) assembly maker follow-up (unity to sprit of mutual), (b, g) degree of quality inspection, (c, h) corporate capability, (d) supplier decisions and (i) sprit of corporation (unity to relationship with business partners) and (e, j) price setting as shown in derivation of PPM-A and PPM-S.

The evaluation example of Toyota and NHK Spring is further described in Figure 4. As the figure indicates, evaluations on both sides are generally high. There are no large differences between elements, but a slight gap can be observed in spirit of mutual support and price setting. Generally, from other same investigations, it can be generally confirmed that assembly makers' evaluations are higher than those from suppliers. However suppliers' evaluations are more severe than the assembly makers' evaluations assume. Deployment and validity of IW-IMM are detailed to Amasaka (Ed.) (2012) and Amasaka (2015, 2017b, 2020).

Table 1. Evaluation sheet

Factor	Contents
X_1	Corporate strategy
X_2	Bias in selection of Suppliers
X_3	Selection of affiliated Supplier
X_4	Weakening of group affiliation
X_5	Weight of Suppliers' opinion
X_6	Spirit of cooperation
X_7	Appropriate evaluation
X_8	Considerate relation
X_9	Demand on discounting
X_{10}	Methods of price setting
X_{11}	Price setting considering labor
X_{12}	Parts inspection standards
X_{13}	Parts inspection items
X_{14}	Response to recalls
X_{15}	Response to contractual failure
X_{16}	Ability to improve
X_{17}	Technical capabilities
X_{18}	Total satisfaction rate
X_{19}	Gained technology and know-how

Derivation of PPM-A

(a) Supplier Follow-up $= 5.24X_4 + 8.86X_7$

(b) Quality Inspection $= 2.28X_{12} + 12.01X_{13}$

(c) Corporate Capability $= 1.91X_1 + 2.44X_{16} + 1.85X_6 + 2.46X_{17} + 1.89X_5 + 1.81X_8 + 1.91X_{15}$

(d) Supplier Decisions $= 5.39X_2 + 7.23X_3 + 1.67X_{14}$

(e) Price Setting $= 6.80X_9 + 5.84X_{10} + 1.64X_{11}$

Derivation of PPM-S

(f) Assembly Maker Follow-up $= 5.83X_1 + 5.59X_4 + 2.75X_{14} + 0.12X_{15}$

(g) Quality Inspection $= 1.54X_{12} + 12.75X_{13}$

(h) Corporate Capability $= 5.23X_2 + 2.27X_3 + 1.34X_7 + 0.63X_{16} + 4.81X_{17}$

(i) Spirit of Cooperation $= 6.46X_5 + 3.26X_6 + 4.56X_8$

(j) Price Setting $= 4.17X_9 + 5.41X_{10} + 4.70X_{11}$

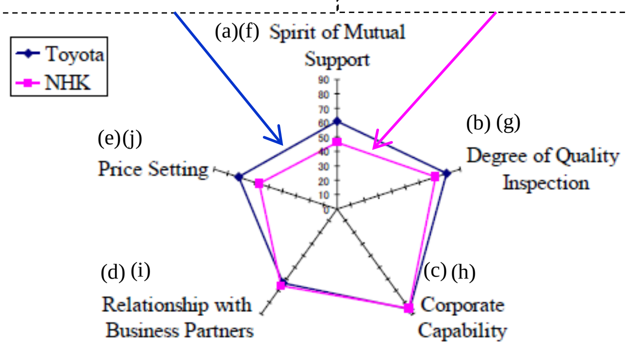


Figure 4. Rader chart of Toyota and NHK Spring using PPM-AS

3.3 Strategic Stratified Task Team Model (SSTTM) for the Driving Force of Problem-Solving

Generally, the automobile assembly makers and suppliers through QCD research activities develop an important role by the mutually disclosing their software and hardware techniques to each other. To perform PPMM mentioned above, the author has created the "Strategic Stratified Task Team Model"

(SSTTM) by using "SQC Technical Methods" called "Mountain-Climbing for Problem-Solving" as shown in Figure 5 (Amasaka, 2004a, 2004b, 2008, 2017a). As the driving force of *Japan Supply System* (Amasaka, 2000b; Amasaka et al., 2008), the expected role of SSTTM and the benefits it will provide are not limited only to cooperation among the departments inside the company. It will also contribute to the strengthening of the ties among group manufacturing companies, non-group companies, and even overseas manufacturers.

To realize this, the level of problem-solving technology rises in product development strategy I and II through joint task teams of intra-company departments and divisions (Task-1 to Task-5, Group Task team, Department task team, Division task management team, Field task management team and Total task management team) in proportion with the improvement of the stratified task level called "Internal Partnering". This technology is further expanded to quality management strategy I to II through the domestic affiliated company, domestic non-affiliated company, and overseas non-affiliated company (Task-6 to Task-8, Joint A to Joint C). Task 6 (Joint A) is aimed at establishing a collaboration with the group suppliers with whom domestic affiliated company has a capital tie-up, and Task 7 (Joint B) is aimed at a collaboration with suppliers that are not within its group, and Task 8 (Joint C) is to strengthen cooperation with overseas suppliers called "External Partnering." Deployment and validity of SSTTM are detailed to Amasaka (Ed.) (2012) and Amasaka (2015, 2017b, 2020).

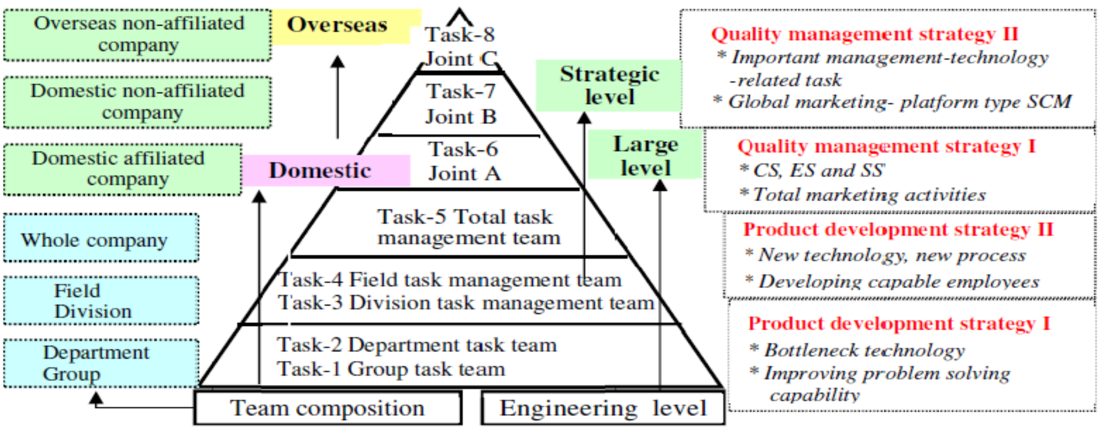


Figure 5. Strategic Stratified Task Team Model (SSTTM)

3.4 Intelligence High-cycle System of assembly Maker Production Process (IHS-AMPP) for Preventing Defects and Achieving Quality

Then, the author has created the "Intelligence High-cycle System of Assembly Maker Production Process" (IHS-AMPP) reflecting the deployment of PPMM and SSTTM mentioned above. The aim of IHS-AMPP is the realization of "development of the "simultaneous achievement of QCD" through strengthening of preventing defects and achieving quality as shown in Figure 6 (Amasaka et al., 2006, 2008; Amasaka & Sakai, 2010; Amasaka, 2018a). This system is effective management of the advanced production process in order to improve the intelligent productivity of production operators and to consolidate the information about highly cultivated skills and operating skills by using advanced facilities into commonly shared fore core systems (I-IV) as follows:

(I) The Highly Reliable Production System (HRPS) that enhances intelligent productivity with highly skilled workers aims to construct a global production network system utilizing the latest technologies, such as CAE, CAD, robots, and the use of CG (computer graphics).

(II) The Intelligent Quality Control System (IQCS) aims to achieve high quality assurance through digital engineering, reinforcement of quality incorporation focusing on intelligent control charts, and ensuring Cp and Cm through innovation of the operating and maintenance systems of production facilities.

(III) The Renovated Work Environment System (RWES) aims to improve the value of labor and bring about a comfortable workplace environment that can accommodate the increasing number of older and female workers in the labor force.

(IV) The Intelligent Operators Development System (IODS) aims to realize the early cultivation of highly skilled workers through utilization of visual manuals supported by the latest IT and virtual technology. Deployment and validity of HIS-AMPP are detailed to the references of Amasaka (2015, 2017b, 2020).

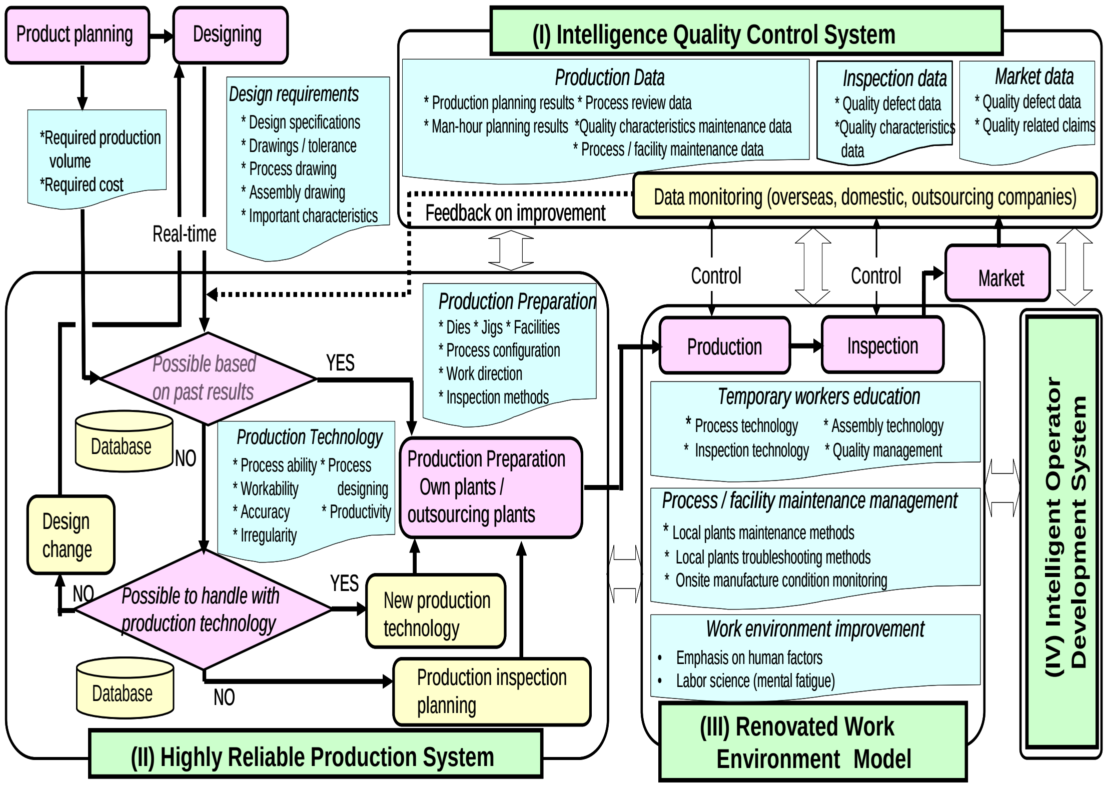


Figure 6. Intelligence High-cycle System of Assembly Maker Production Process (IHM-AMPP)

3.5 Strategic Quality Management Using Performance Measurement Model (SQM-PMM) for QCD activity

The author has created the “Strategic Quality Management using Performance Measurement Model” (SQM-PMM) for strategic development of NJ-GMM as shown in Figure 7 (Amasaka et al., 1999; Amasaka, 1999, 2004c, 2004d, 2009a; Kozaki et al., 2012). Specifically, a survey of top management at Japanese manufacturers was conducted in order to investigate the management achievements as a key to strategic global manufacturing (Survey targeted 898 companies and resulted in 354 valid responses for a rate of 39.4%).

First, the author conducted the graphical modeling method in SQM-PMM creation. Based on the correlations among the 28 practice items for corporate QCD activity (confirmed using a partial correlation coefficient), interrelation of the six categories—TQM methods for strategy and policy management (7 items), technological development (3 items) and CS (4 items), quality assurance (4 items), and corporate culture with creative workplace (5 items) and total participation activities (5 items)—and their contribution to management achievements was confirmed visually using the relation chart by evaluation of 5-point scale.

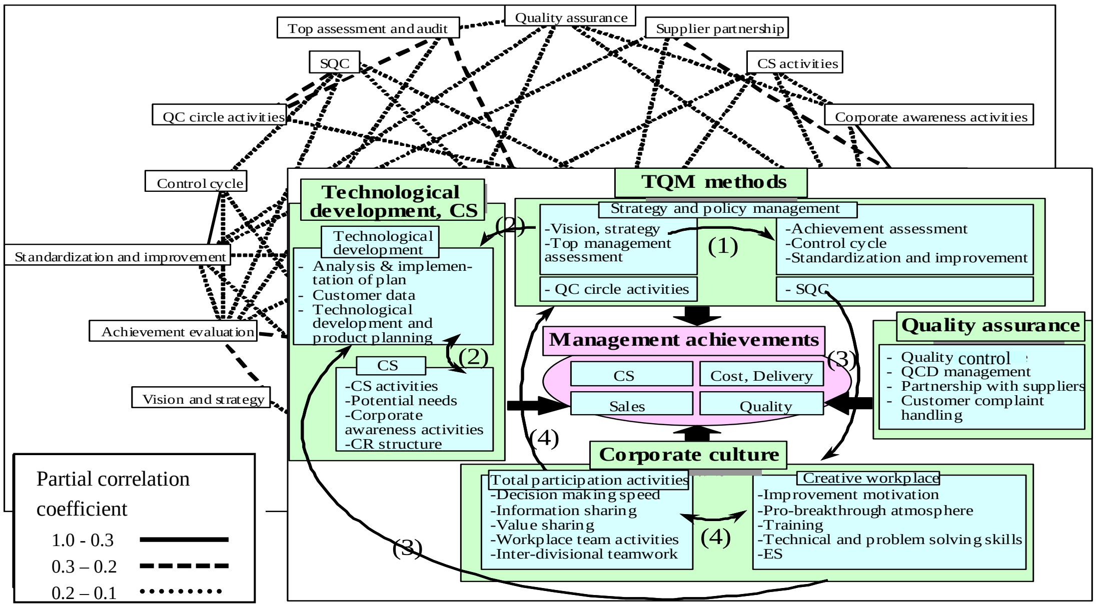


Figure 7. Strategic Quality Management –Performance Measurement Model (SQM-PMM)

From the analysis of graphical modeling method, for example, the relationship marked with arrow (1) marked with indicate that, for their vision/strategy and top management to function effectively, companies must enhance achievement assessment, control cycles, and standardization /improvement. The two arrows (2) marked with indicate that a correct vision/strategy is necessary for technological development and CS to effectively contribute to sales. The arrows (3) marked signify that a creative workplace, backed by SQC, is necessary as a foundation for effective technological development. The arrows (4) marked illustrate the relationship between total participation activities and a creative workplace, as well as the importance of QC circle activities as participation opportunities for all employees.

Second, the author performed the formulation of SQM-PMM through canonical correlation analysis. The first canonical variate (f_{11} to f_{16}) was divided into six categories, of which the relational expressions are indicated in (i) to (vi). Items x_1 to x_4 are quality assurance; x_5 to x_9 are CS; x_{10} to x_{12} are product and technological development; x_{13} to x_{17} are total participation activities; x_{18} to x_{22} are creative workshops, and x_{25} to x_{28} are conventional TQM methods. Then, the author developed the formulation of the SQM-PMM through canonical correlation analysis. Specifically, the first canonical variate f_1 (f_{11} to f_{16}) was divided into six categories, of which the relational expressions are indicated in formula (i) to (vi). Items x_1 to x_4 are quality assurance; x_5 to x_9 are CS; x_{10} to x_{12} are product and technological development; x_{13} to x_{17} are total participation activities; x_{18} to x_{22} are creative workplace, and x_{25} to x_{28} are conventional TQM methods.

$f_{11}=0.418x_1+0.232x_2+0.530x_3+0.160x_4$ (i)

$f_{12}=0.160x_5+0.878x_6+0.156x_7+0.494x_8+0.533x_9$ (ii)

$f_{13}=0.335x_{10}+0.712x_{11}+0.063x_{12}$ (iii)

$f_{14}=0.089x_{13}+0.477x_{14}+0.064x_{15}+0.058x_{16}+0.332x_1$ (iv)

$f_{15}=0.230x_{18}+0.316x_{19}+0.259x_{20}+0.052x_{21}+0.210x_{22}$ (v)

$f_{16}=0.105x_{23}+0.254x_{24}+0.254x_{25}+0.251x_{26}+0.119x_{27}+0.190x_{28}$ (vi)

Third, as a standardization of SQM-PMM, the author illustrated an example of "creative workplace at company B by evaluator B" as shown in Table 2. Moreover, as the verifying the validity of SQM-PMM, the author showed a radar chart sample-1 as shown in Figure 8. Deployment and validity of

SQM-PMM are detailed to Amasaka (Ed.) (2012) and Amasaka (2015, 2020).

Table 2. Example of Creative workplace

Evaluation Item	5	4	3	2	1
Activities to maintain improvement motivation	Original activities implemented and are effective	Implemented generally	Implemented partially	Not implemented very much	Not implemented at all
Activities to create pro-innovation atmosphere	Original activities implemented and are effective	Implemented generally	Implemented occasionally	Not implemented very often	Not implemented at all
Training to enhance all employees' capabilities	Implemented regularly and is effective	Implemented generally	Implemented partially	Not implemented very much	Not implemented at all
Practice and accumulation of special skills and problem solving capabilities	Practiced and accumulated	Practiced and accumulated generally	Practiced and accumulated to some extent	Not practiced and accumulated very much	Not practiced and accumulated at all
Activities to enhance employee satisfaction (e.g. self realization, evaluation, treatment)	Implemented regularly and is effective	Implemented generally	Implemented partially	System exists but not implemented very much	Not practiced and accumulated at all

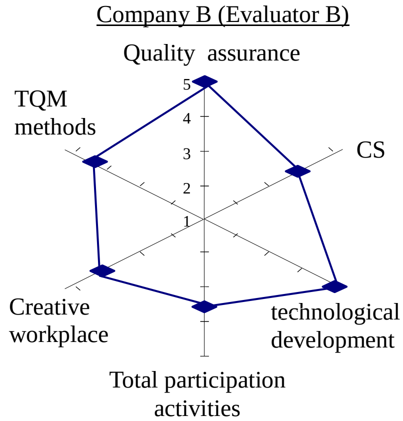


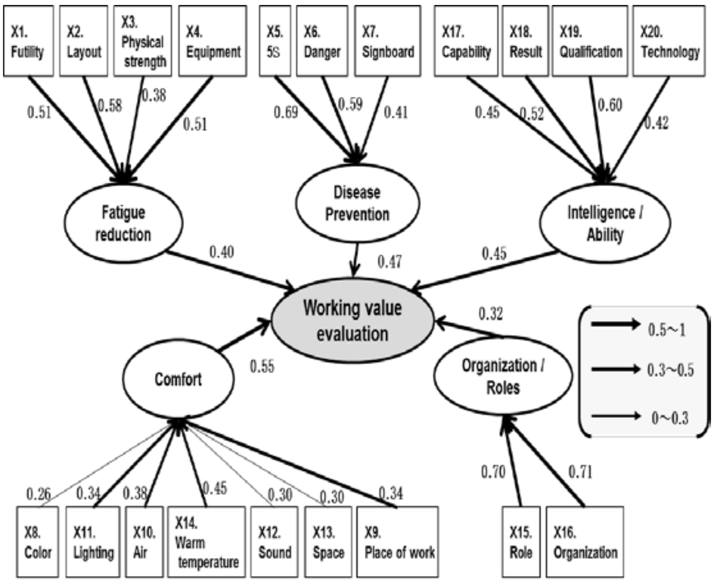
Figure 8. Rader chart sample 1

(using Amasaka New JIT Laboratory website: http://133.2.218.195/~amalab/H)

3.6 Working Value Evaluation Model (WVEM) for Strengthening of Manufacturing Technology

Then, the author originated "Working Value Evaluation Model" (WVEM) which makes the foundation of above-mentioned IW-IMM for strengthening of manufacturing technology. To improve the working value of workers from a comprehensive perspective, this model is a tactical element which makes the basic of "creative workplace" as moving power of above-mentioned SQM-PMM. WVEM evaluates the awareness of the working value of workers by statistically analyzing data collected through actual condition survey on Toyota, Nissan and other three companies as shown in Figure 9 (Uchida et al., 2012). Concretely, the author picked up 4 specific working processes (welding, painting, machining and assembling) that add a greater burden to human bodies, and surveyed by interviewing workers and taking videos of actual operations. This model systematically covers 20 key factors (items: X1 futility to X20 technology), and is made up of 5 axes: (1) Fatigue reduction (4 items), (2) Disease prevention (3 items), (3) Comfort (7 items), (4) Organizations and roles (2 items), (5) Intelligence ability (4 items) (see to Figure 9-1). Each item in the awareness survey was scored on a 1 to 7 scale, and the author received 25 sets of answers from workers in the manufacturing industry.

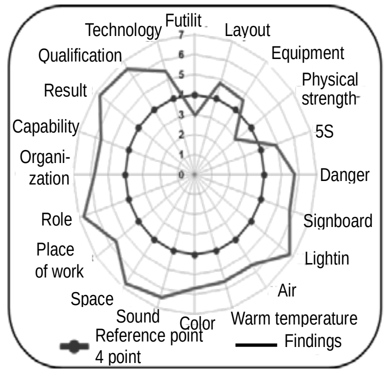
In Figure 9-1, first, the author analyzed their weightings using covariance structure analysis and used maximum likelihood estimation, which is the most widely used estimation method. The goodness of fit of this model is 0.623 and its interpretability exceeds 60%, which are fairly reliable values that indicate that this model can be trusted. In Figure 9-2, second, the author weighted the evaluation entered in the score sheet, and described a model formula used to display the output result. WVEM formulas are standardized so that 100 is the full score, thereby making it possible to easily compare each evaluation axis. Also, standardization of evaluation formulas made it possible to compare the strength of each working value evaluation axis. In Figure 9-3a and 9-3b, third, the author used radar charts to display the output result. The author created 2 radar charts. Radar chart for working value evaluation axes (Figure 9-3a) shows the calculation results of the model formulas on a scale of 100; Radar chart by working value item visualizes all evaluation scores (Figure 9-3b). Deployment and validity of WVEM are detailed to Amasaka (2017b, 2020).



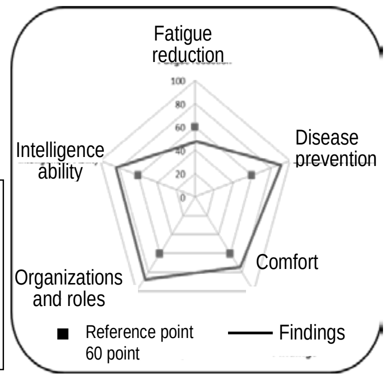
9-1: Weighting by covariance structure analysis

$L_1=(0.36X1+0.51X2+0.35X3)\times 11.7$ (i)
$L_2=(0.34X4+0.47X5+0.36X6)\times 12.2$ (ii)
$L_3=(0.25X7+0.30X8+0.28X9+0.27X10+0.27X11+0.23X12)\times 8.93$ (iii)
$L_4=(0.60X_{13}+0.50X_{14})\times 13.0$ (iv)
$L_5=(0.36X_{15}+0.35x_{16}+0.32x_{17})\times 11.0$ (v)
$L_6=0.105x_{23}+0.254x_{24}+0.254x_{25}+0.251x_{26}+0.119x_{27})\times 6.80$ (vi)

9-2: Formulations by weightings of the working value evaluation items



9-3a: Radar chart by working value item



9-3b: Radar chart for working value evaluation axe

Figure 9. Outline of the Working Value Evaluation Model (WVEM)

4. Application Examples

In this section, the author illustrates the pioneering research examples as applications of NJ-GMM, which has contributed to the advancement of manufacturing engineering by partnering Toyota and Amasaka New JIT Laboratory (Aoyama Gakuin University).

4.1 Comparing Experienced and Inexperienced Machine Workers

With the amount of production from the machining and assembly industries increasing year-on-year, machining technology is becoming increasingly important because machining is the fundamental process underpinning the industry. To developing IWV-IMM and WVEM, specifically, the author clarifies the factors involved in improving the skills of technicians by conducting a comparison of experienced and inexperienced workers engaged in typical lathe work with 6 processing stages of setup, rough cutting, semi finishing, making adjustments, finishing and completion by using S45C workpiece (Yanagisawa et al., 2013). During the initial setup stage, workers must visually and tactually check the workpiece and its characteristics in order to make decisions concerning the most suitable cutting speed and cutting tool for the workpiece, and also use the visual and other senses to determine whether the cutting work is satisfactory. For the comparison, videos were taken while working, and the time taken (seconds) for each processes' tasks was noted. Then, the physical and mechanical characteristics of a workpiece are those tensile strength, elongation, hardness, thermal conductivity, density, Young's modulus, shear elasticity modulus and yield strength, and the relative influence of these characteristics are clarified in accordance with the cutting conditions.

Concretely, first, a fact-finding survey concerning skill transfer in machining work was conducted to determine the kind of lathe work tasks undertaken by skilled workers. Second, a survey comparing worker's cognition was conducted using Electroencephalography (EEG) and statistical science to clarify differences in the cognition of experienced workers and inexperienced workers. Third, a decision-making criteria used by experienced workers was identified. Fourth, decisions related to the workpiece were visualized. The findings thus obtained were then used to clarify the necessary factors for efficiently and effectively improving the skills of inexperienced workers such as cutting tool selection. Through these investigations, the author clarified the important criteria for making decisions based on the chip color and chip shape. Moreover, the color of chips varies depending on the cutting temperature, and the shape of the chips also varies significantly. For example, chip color and chip shape—which are the keys to making appropriate decisions—are used as decision-making factors, while the tool type, cutting speed, feed rate, cutting depth, presence/absence of cutting oil, escape angle, and shear angle are the variable factors. Figure 10 illustrates an example of "chip color during finishing" using covariance structure analysis, and clarifies the influence these elements receive from each factor.

This research clarify points where inexperienced workers need guidance such as cutting tool selection, which is beneficial for both the person giving guidance and the person receiving guidance. Moreover, the author has investigated how intuition and knowhow make a difference between the skills of experienced and inexperienced workers based on the validity of this study (Kawahara et al., 2015). Deployment and validity of these studies are detailed to Amasaka (2015, 2017b).

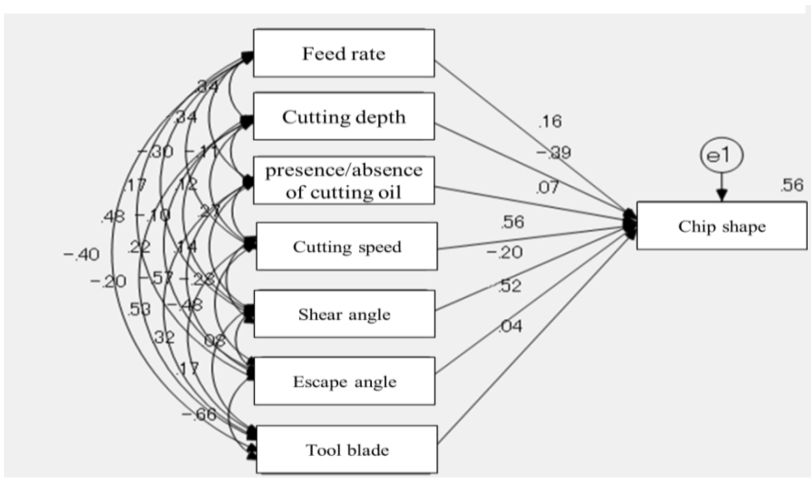


Figure 10. Outline of Chip Color during Finishing Using Covariance Structure Analysis

4.2 Accelerated Technical Training System of highly Skilled Operators in Auto-assembly Line

The author considers the need to make production operators achieve creation in addition to engineering capabilities and skills so as to become intelligence operator employing NJ-GMM. Therefore, the author illustrates the "Accelerated Technical Training System" (ATTS) called Toyota's "Human Integrated Assist System" (HIA) of highly skilled operators in auto-assembly line to developing IWV-IMM and WVEM (Sakai and Amasaka, 2008). To realize the shortened training, ATTS contains the combination of (I) Repetitive training using *Hyper Visual Manual* as the new communication tool, (2) *Intelligent IT System* using video for the self-study of operations and (3) *Assessment of Aptitude / Inaptitude Test* by *Aptitude Evaluation Sheets* of fundamental skills with eight categories (tightening, screw grommet, attachment, connector, hose, plug hole, tube and fitting) (Amasaka et al., 2008). This skill training for newly employed production operators in Japan and abroad is conducted for production operators so that they are able to operate correctly at the time of a new plant start-up or model change.

Specifically, the author illustrates an application case of Toyota's shortened training for new overseas production operators as shown in Figure 11 (Amasaka, 2018a). The deployment of created ATTS for training newly employed production operators at domestic and overseas manufacturing plants reduced the conventional training period by more than half, from two weeks to five days, leading the full-scale production to a good start. In this case, the launch of an overseas production plant, the target operating rate was achieved in four months after the start-up as shown in Figure 12. Deployment and validity of these studies are detailed to Amasaka (2015, 2017b, 2020).

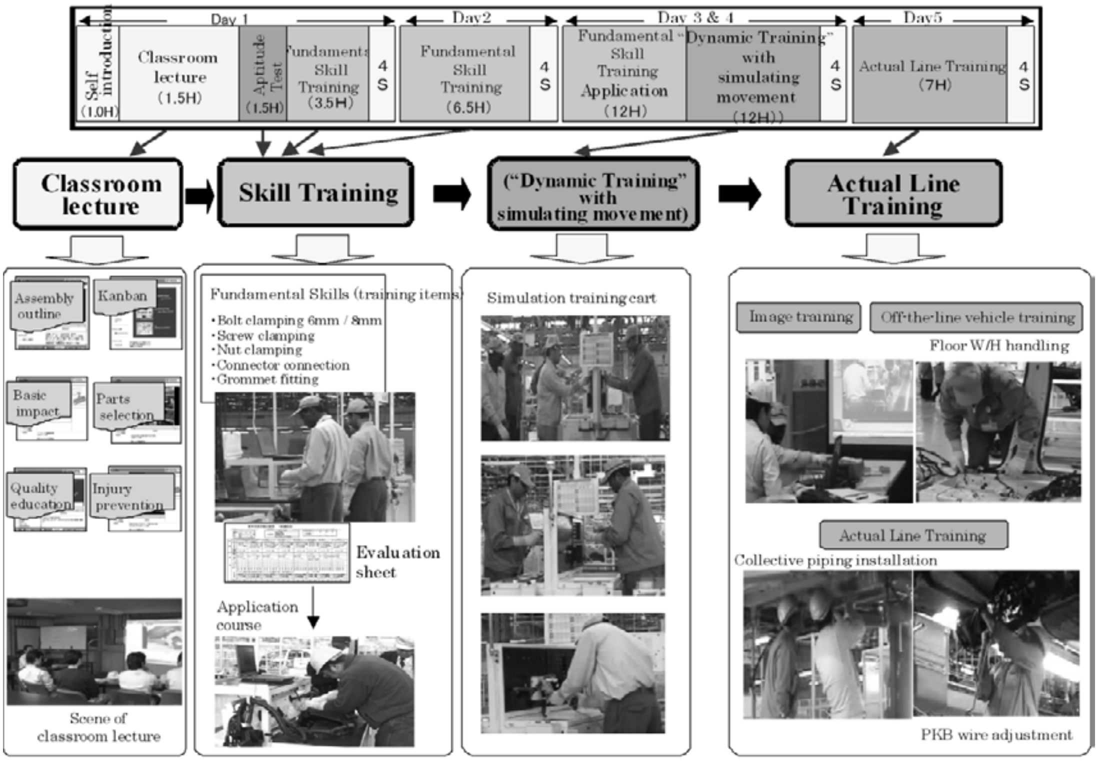


Figure 11. Skill Training Curriculum for New overseas Production Operators

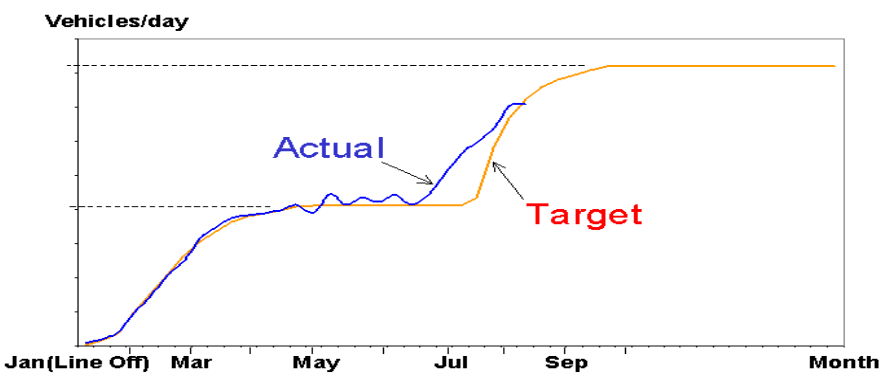


Figure 12. Transition of Operation Rate after Launch of Production Line

4.3 Global Intelligence Partnering Model (GIPM)

The key to success in "global manufacturing" lies in full functionalization of "partnering" in which forefront divisions of technology in a cooperative strategic scheme to realize global quality and optimal production based on NJ-GMM. To develop PPMM above, specifically, this actual research presents the "Global Intelligence Partnering Model" (GIPM) for automobile global manufacturing strategy which improves the intellectual productivity of the affairs and management sections as shown in Figure 13 (Yamaji & Amasaka, 2007b). In Figure 13, the following are the functions of the affairs and management sections as the corporate environment factors for succeeding in global marketing, customer-first, 1) CS, ES and SS, for 2) high quality product and as a strategic factor to realize it, in order to 3) product reliability (high quality assurance) and corporation reliability (excellent company), and success in 4) intellectual productivity and human resource development. Moreover, 5) global production is realized by these. So the same quality and production at optimal locations are achieved.

For that purpose, the highest priority was given to the "i) Intellectual information sharing" and "ii) strategic co-creative action" so that the "strategic intelligence application system" and "business process high linkage system" can effectively function. To actualize these, the author illustrates the strategic examples as the validity of GIPM as follows; The 1st research is the creation of "Automobile Exterior Design Model" (AEDM) for raising customers' worth of world's prestige car "Lexus" (Amasaka, 2018b). The 2nd is the "Solution of springback for stamping parts with longitudinal curvature" for the establishment of highly accuracy of auto-body manufacturing (Kusune et al., 1992; Amasaka, 2004b). The 3rd is the improvement in "Paint corrosion resistance" and "protect plating parts from corrosion" for raising auto-unit-axle reliability based on the "Toyota Supply System" (TSS) deployment to achieve simultaneous (Amasaka et al., 1993; Amasaka, 2004b; Yamaji and Amasaka, 2009).

Moreover, the 4th is the epoch-making improvement of QCD by development of "Mid-frequency tempering equipment using the heating coil of electromagnetic induction", "Automated straightening equipment" for the realizing high productivity of auto-unit-axle shaft, and "New ceramic materials to the welding nozzle and welding tip" for the improving high operational availability of auto-unitaxle housing (Amasaka, 2009b). Deployment and validity of these studies are detailed to Amasaka (2015, 2017b, 2020).

Figure 13. Outline of Global Intelligence Partnering Model (GIPM)

4.4 Strategic Corporative Task Team Model (SCTTM)

Today's corporate management challenge is to provide high QCD products ahead of competitors through "Market Creating" activities, with priority given to customers. To realize manufacturing that provides excellent quality to the customer, the author has created the "Strategic Corporative Task Team Model" (SCTTM) between the auto-maker and affiliated/non-affiliated suppliers employing SSTTM above based on NJ-GMM as shown in Figure 14 (Amasaka, 2008, 2017a; Yamaji and Amasaka, 2009).

To purchase the necessary parts, it will be important for the manufacturer to mutually cooperate with (a) Supplier I (in-house parts maker (own company)), (b) Supplier II, affiliated manufacturer (capital participation), (c) Supplier III, non-affiliated manufacturer, and (d) Supplier IV, manufacturer with foreign capital. In the stage of actual implementation, it is important to strategically organize the stratified task teams from the following viewpoints and by setting the objective to be continual improvement of management technologies: (i) Product strategy, (ii) Engineering strategy, (iii) Quality strategy, (iv) QCD effect, (v) Value of the task teams, and (vi) Human resource strategy. After solving the most important management technology challenges at the beginning, the important job for the manufacturer's general administrator is to select jointly from his own company and suppliers: (1) Generators gifted with a special capacity for creating ideas, (2) Mentors having the ability to give guidance and advice, (3) Producers with the capability to achieve and execute, and (4) Promoters capable of implementing things as an organization.

Then, as the key to successful SCTTM, the team leader (administrator) should select the members who have at least one of the capabilities for (a) to (d), commission authority and responsibilities to the members, and has himself/herself concentrate on risk management. As the leader, a person who has an experience of clearing business obstacles should be appointed, so that the leader is capable enough to lead the team overcoming difficulties. To actualize manufacturing of excellent quality for customer, the author presents the validity of SCTTM called Toyota's "Total Task Management Team Model" (TTMTM) for strengthening SCM strategy (Amasaka, 2004a, 2017b). To develop this, the author presents typical three case studies of how this model improved the bottleneck problems of worldwide automobile manufactures for realizing simultaneous QCD fulfilment as follows:

The first research is the establishment of "Brake pad quality assurance" using Total QA network (QAT) activity by Toyota, Aishin Seiki, Aishin Chemical, and Akebono Brake Industry. The main objective is to establish a technology for attaining satisfactory braking performance while minimizing squeal through exchange of the result of sensitivity analysis on the causes of squeal and braking performance. The result of QAT activity is remarkable effects as follows; (i) Estimated market claim ratio reduction to 1/6 (from 2.6% to 0.4%), (ii) In-process fraction defective: down 60% (from 0.5% to 0.2%), (iii) Short convergence of initial failures: (from 9 months to 3 months), and (iv) Cost reduction: 9.4% (156 Yen/unit). The second is the establishment of "High reliability assurance of the transaxle oil seal leakage" using "DOS-Q" (Drive-train Oil Seal-Quality Assurance Team) by Toyota and NOK. This team addressed the clarification of the cause and effect relationship between the oil seal design parameters and sealing performance with visualization of oil leakage mechanism by the fault analysis and factor analysis using various experiments, and oil seal simulator—"Optimal CAE Design Approach Model". As the result of the component analysis, it is confirmed that the fine foreign matter is the powder produced during engagement of gears inside the transaxle gear box. DOS-Q led to two measures to improve design quality (shape and materials), and ensured optimum lubrication of the oil seal lip where it rotates in contact with the drive shaft. The result of these countermeasures was a reduction in oil seal leaks (market complaints) to less than 1/20th their original incidence.

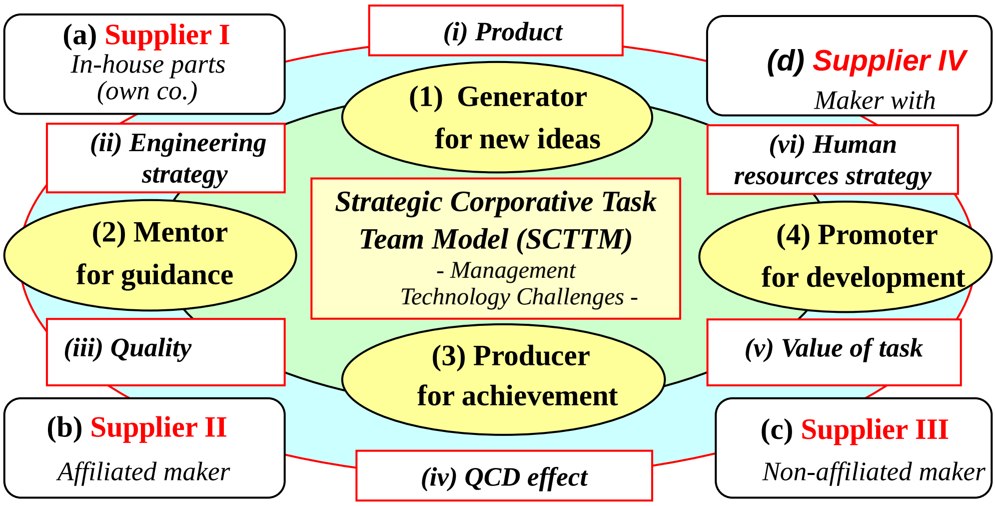


Figure 14. Outline of Strategic Corporative Task Team Model (SCTTM)

In other cases, furthermore, the author was able to apply the SCTTM to critical QCD studies of automobile manufacturing as follows; (i) Specific fuel consumption improvement of automobile engines, (ii) Rust preventive quality assurance of rod piston plating parts, (iii) Improving the reliability of body assembly line equipment, and (iv) Automobile bolt-nut loosening solution by developing "Automobile Optimal Product Design Model" (AOPDM) (Amasaka, 2004b, 2019a,b; Amasaka et al., 2012). Deployment and validity of these studies are detailed to Amasaka, Ed. (2012) and Amasaka (2015, 2017b, 2020).

4.5 New Global Partnering Production Model (NGP-PM)

In recent years, leading manufacturers in Japan have been deploying a new production strategy in order to get ahead in the worldwide quality competition. The key to successful global production is necessary to realize manufacturing suited to the actual situation at production sites of various overseas production bases based on the "New Japan Production Model" (NJ-PM) (Amasaka, 2007a). Against this background, the author has established a "New Global Partnering Production Model" (NGP-PM) employing "Advanced TPS" for Toyota's expanding overseas manufacturing strategy as shown in Figure 15 (Ebioka et al., 2007; Amasaka and Sakai, 2010, 2011; Sakai & Amasaka, 2005, 2008).

The mission of NGP-PM is the simultaneous achievement of QCD in order to realize high quality assurance. The essential strategic policies include the following three items: First of all, (A) the establishment of a foundation for global production, "realization of global mother plants-advancement of Japanese production sites"; Second, (B) achieving the "independence of local production sites" through the incorporation of the unique characteristics (production systems, facilities, and materials) of both developing countries (Asia) and industrialized countries (US, Europe); Third, (C) the necessity of "developing intelligence operators by mentioned-above 'ATTS' to promote knowledge sharing among the production operators in Japan and overseas as well as for the promotion of higher skills and enhanced intelligence".

To develop NGP-PM, it is essential to create a spiraling increase in the four core elements by increasing their comprehensiveness and high cycle-ization. Specifically, in "realizing global mother plants", if Japanese and overseas manufacturing sites are to share knowledge from their respective viewpoints, the core elements must be advanced. To achieve this, a necessary measure is to design

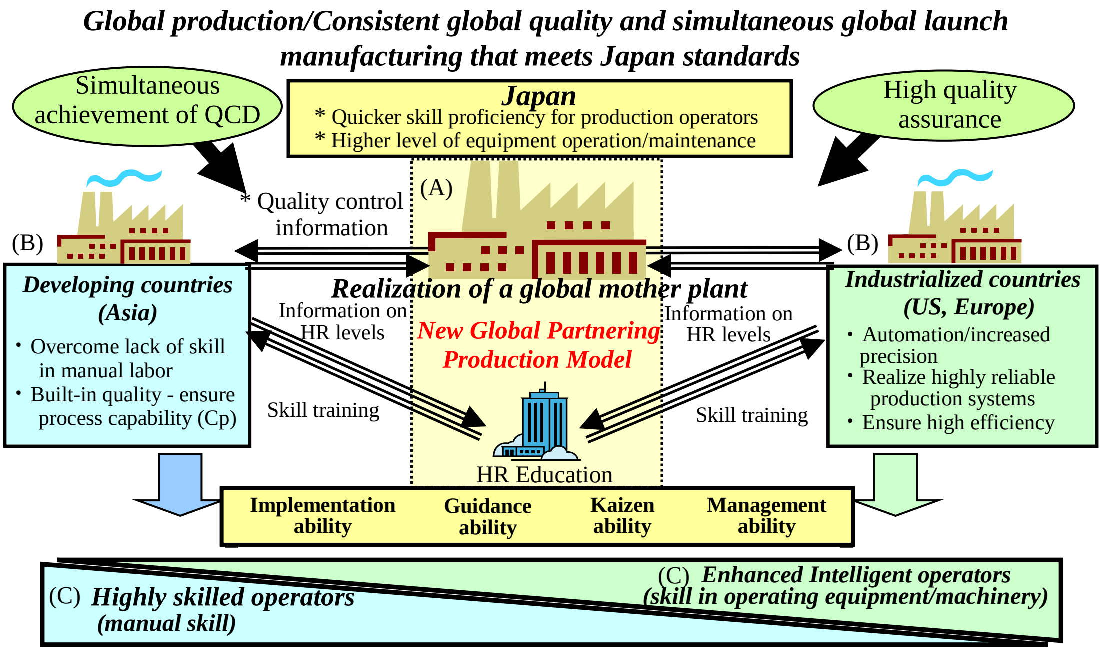


Figure 15. New Global Partnering Production Model (NGP-PM)

separate approaches suited to developing and industrialized countries. Concretely, in developing countries (1), the most important issue is increasing the autonomy of local manufacturing sites. At these sites, "training for highly skilled operators (focus on manual laborers)" that is suited to the manual-labor-based manufacturing sites is the key to excellent QCD studies. Similarly, in industrialized countries (2), where manufacturing sites are based on automatization and increasingly high-precision equipment, "training of intelligence operators" resulting in "realizing highly reliable production control systems and ensuring high efficiency" is the key to excellent QCD studies. Moreover, production operators trained at "global mother plants" (3) can cooperate with operators at overseas production bases, and in order to generate synergistic results, can work to "localize global mother plants" in a way that is suited to the overseas production bases.

As the concrete examples of NGP-PM deployment, furthermore, the author describes the typical case studies of new integrated local production by partnering Toyota and overseas as follows; (i) "New Turkish Production System" (NTPS), an integration and evolution of Japanese and Turkish Production System, (ii) "New Malaysia Production Model" (NMPM), a new integrated production system of Japan and Malaysia, (iii) "China Local Automobile Manufacturer's Production System", (iv) "New Vietnam Production Model", Developing hybrid production of Japan and Vietnam, and "Developing Advanced Toyota Production System at Toyota Manufacturing USA" (Amasaka, 2007c, 2016; Yeap et al., 2010; Shan, et al., 2011: Shan, 2012; Miyashita & Amasaka, 2014; Sakai, 2016). Deployment and validity of these studies are detailed to Amasaka (2015, 2017b, 2020).

4.6 Total Quality Assurance Networking Model (TQA-NM)

To survive globalization and worldwide quality competition, Japanese manufacturing must work in order to shorten development times, ensure high quality and lower production costs (Amasaka, 2007a). At the concrete stage of implementation until now, there are many tools, such as Quality Function Deployment (QFD) that can be used to ensure manufacturing Quality Assurance (QA), but they do not always produce sufficient results. In actual situation, there are three key technological components needed to take product quality assurance to the next level: (1) the experience and skill of technical personnel, (2) the combined use of methods that take a scientific approach, such as Failure Mode and

Effect Analysis (FMEA) and Fault Tree Analysis (FTA), and (3) partnerships—both internal partnerships that extend from design through production and external partnerships built with suppliers.

To develop the IHS-AMPP above, therefore, the author has created the "Total Quality Assurance Networking Model" (TQA-NM) includes the above key technological components as the new manufacturing management of product quality assurance and is introduced for the new defect prevention as shown in Figure 16 (Amasaka, 2004b; Kojima & Amasaka, 2011). This model is done through the prevention of defect occurrence and by supporting the simultaneous achievement of QCD that come from strategically deploying a high-level quality assurance process as follows;

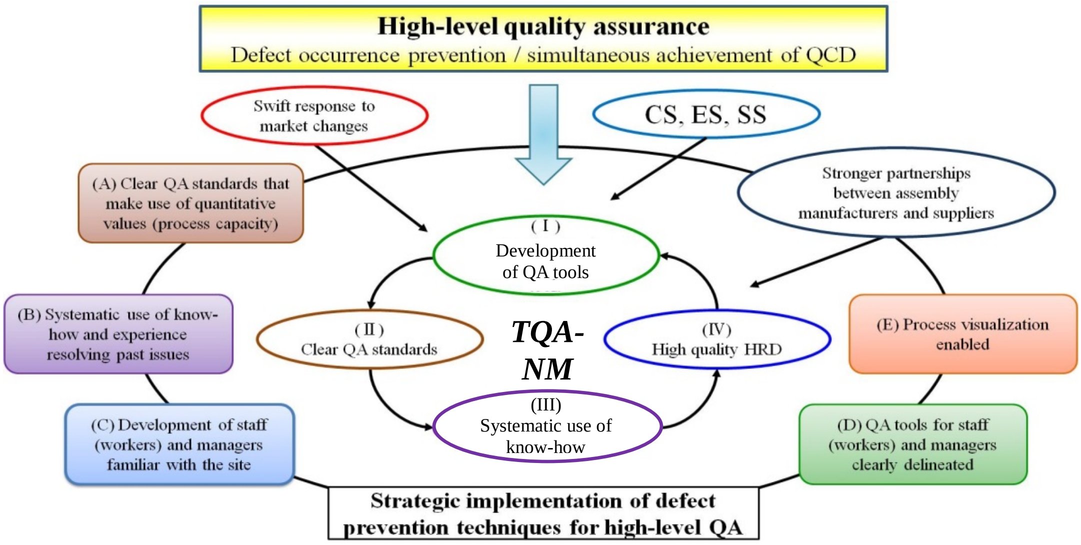


Figure 16. Total Quality Assurance Networking Model (TQA-NM)

(I) One of the technological components in achieving these goals is strengthening quality assurance networks by developing and deploying QA tools, (II) A second component is establishing clear quantitative QA standards (such as process capacity) that are not affected by worker experience, (III) A third component is creating a system that can make use of worker expertise and information on past defects in an organized manner, and (IV) A fourth component is the development of workers and frontline staff as the high quality HRD (Human Resource Development) who are familiar with the site.

Specifically, the "Total QA Networking Chart" shown in Figure 17 was created in order to deploy the TQA-NM example. The chart is a defect occurrence prevention technique featuring a combination of QA tools. It also uses FMEA and matrix diagrams to deploy partnerships. The vertical axis of the chart identifies joint processes by suppliers and assembly manufacturers, from the arrival of goods to shipment. This creates a QA network that eliminates gaps in QA. The horizontal axis lists individual defects. The degree of QA is indicated where the two axes intersect, which allows a quantitative value indicating the importance of process management tasks to be assigned to each. Each process is comprehensively evaluated on the basis of what the defect occurrence prevention tasks are for that process and how highly they are ranked in terms of the level of QA using the Toyota's QA matrix called "Level-based application chart." The tasks of this chart is ensured based on the "Ranking Occurrence and Outflow prevention," and established a high-level QA system (refer to Amasaka (2004b) and Kojima and Amasaka (2011)).

As the pioneering examples of TQA-NM deployment in Toyota, the author presents as follows; (i) Establishment of optimum casting conditions for compact DOHC cylinder head (Miyamoto and Ishimoto, 1991), (ii) Development of ferrite heat resistant cast steel (Genma & Suzuki, 1992), (iii) Measures to be taken for difficulties in the manufacture of aluminum die-casted head cover (Keishima & Okada, 1992) and others. Moreover, as the examples of the technical forefront of Toyota's SCM strategy, the author presents as follows; (v) Rust prevention auto-quality assurance using QA network (Amasaka et al., 1995), (vi) Improving the automobile quality of brake pads (Amasaka et al., 1997), and (vii) CAE analysis for oil leakage mechanism of transaxle oil seal (Amasaka et al., 2012) and others. Deployment and validity of these studies are detailed to Amasaka (2015, 2017b, 2020).

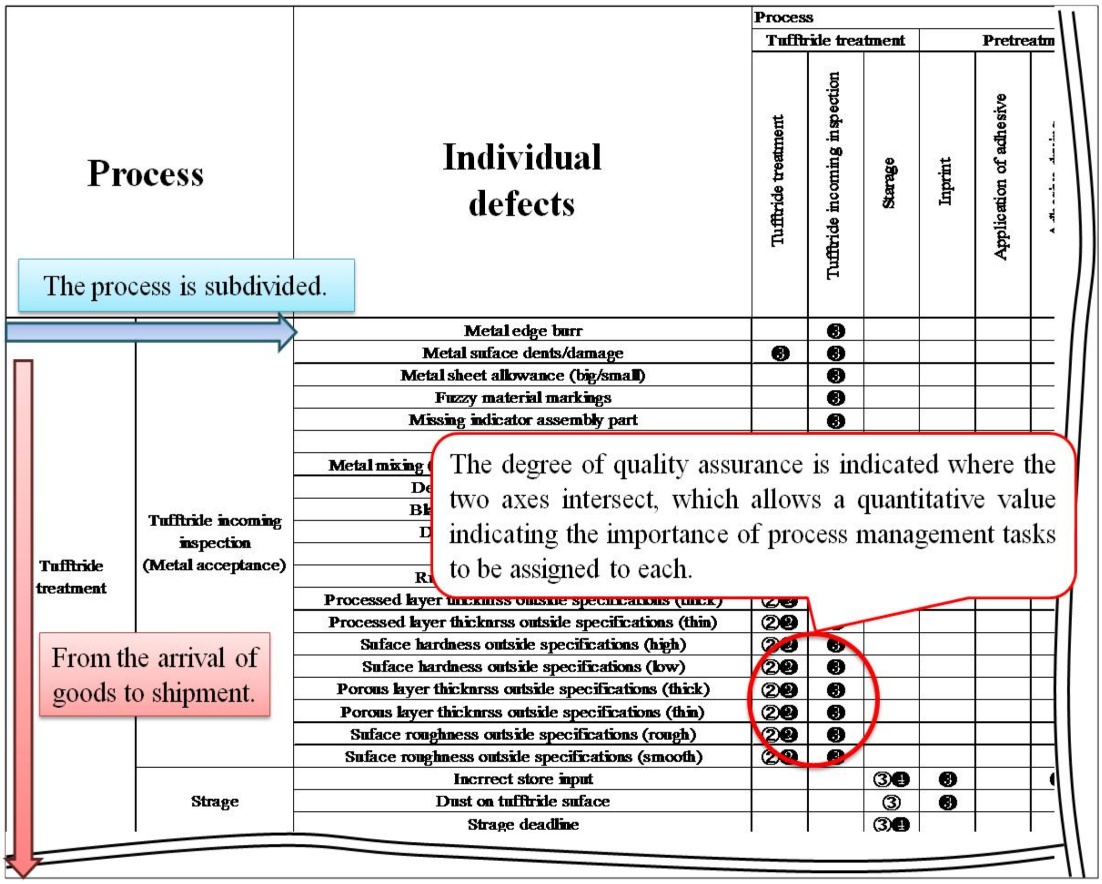


Figure 17. Example of the Total QA Networking Chart

5. Conclusion

Recently, the typical Japanese-style production system by the current TPS, has already been developed aa an internationally shared the manufacturing industry such as JIT, and is no longer a proprietary technology of Japan. From this point of view, therefore, the author has created the NJ-GMM (New Japan Global Manufacturing Model) for the innovation of manufacturing engineering. The core models of NJ-GMM foundation consists of the IWV-IMM (Intellectual Working Value Improvement Management Model), PPMM (Partnering Performance Measurement Model), SSTTM (Strategic Stratified Task Team Model), IHS-AMPP (Intelligence High-cycle System for Assembly Maker Production Process), SQM-PMM (Strategic Quality Management using Performance Measurement Model), and WVEM (Working Value Evaluation Model). The effectiveness of NJ-GMM was verified through the actual applications to automobile manufacturing in Toyota and various suppliers.

6. Acknowledgement

The author would like to acknowledge the generous support received from the following researchers: all those at the Study group of the "68QCS-Questionnaire analysis team of Toyota Group" in JUSE (Union of Japanese Scientists and Engineers), Study group of the Ideal Situation the Quality Management of Manufacturing Industry called Amasaka's Forum in JUSE, Toyota and other advanced assembly makers, many affiliated / nonaffiliated suppliers, and those connected with the Amasaka New JIT laboratory at Aoyama Gakuin University that assisted with author's research.

References

Amasaka, K. (1988). Concept and progress of Toyota Production System (Plenary lecture), *The Japan Society of Precision Engineering, and Hachinohe Regional Advance Technology Promotion Center Foundation, Hachinohe, Aomori-ken, Japan* (in Japanese).

Amasaka, K. (1999). The TQM responsibilities for industrial management in Japan (Special Lecture). *Journal of the Japanese Society for Production Management, The 10th Annual Technical Conference, Kyushu Sangyo University, Japan*, 48-54 (in Japanese).

Amasaka, K. (2000a). Basic Principles of JIT—Concept and progress of Toyota Production System (Plenary lecture). *The Operations Research Society of Japan, Strategic research group-1, Tokyo* (in Japanese).

Amasaka, K. (2000b). Partnering chains as the platform for quality management in Toyota. *Proceedings of the 1st World Conference on Production and Operations Management, Sevilla, Spain*, 1-13.

Amasaka, K. (2002). New JIT, a new management technology principle at Toyota. *International Journal of Production Economics*, *80*, 135-144.

Amasaka, K. (2004a). Development of Science TQM, A New Principle of Quality Management: Effectiveness of Strategic Stratified Task Team at Toyota. *International Journal of Production Research*, *42*(17), 3691- 3706. https://doi.org/10.1080/0020754042000203867

Amasaka, K. (2004b). *Science SQC, New Quality Control Principle: The quality strategy of Toyota*. Tokyo: Springer-Verlag. https://doi.org/10.1007/978-4-431-53969-8

Amasaka, K. (2004c). Establishment of performance measurement toward strategic quality management: Key to successful implementation of new management principle, Science TQM. *Proceedings of the fourth International Conference on Theory and Practice in Performance Measurement, The Edinburgh International Conference Centre, UK*, 515-522.

Amasaka, K. (2004d). Establishment of strategic quality management—Performance Measurement Model: Key to successful implementation of Science TQM (Part 6). *The Japan Society for Production Management, The 20th Annual Technical Conference, Nagoya Technical College, Japan*, 95-98 (in Japanese).

Amasaka, K. (2007a). *New Japan Production Model*, An Advanced Production Management Principle: Key to Strategic Implementation of *New JIT*. *The International Business & Economics Research Journal*, *6*(7), 67-79. https://doi.org/10.19030/iber.v6i7.3387

Amasaka, K. (2007b). High Linkage Model "Advanced TDS, TPS & TMS": Strategic development of "New JIT" at Toyota. *International Journal of Operations and Quantitative Management*, *13*(3), 101-121.

Amasaka, K. (2007c). Applying New JIT—Toyota's global production strategy: Epoch-making innovation in the work environment. *Robotics and Computer—Integrated Manufacturing*, *23*(3), 285-293. https://doi.org/10.1016/j.rcim.2006.02.001

Amasaka, K. (2008). Strategic QCD studies with affiliated and non-affiliated suppliers utilizing New

JIT. *Encyclopedia of Networked and Virtual Organizations*, *III*(PU-Z), 1516-1527. https://doi.org/10.4018/978-1-59904-885-7.ch201

Amasaka, K. (2009a). Establishment of Strategic Quality Management—Performance Measurement Model "SQM-PPM": Key to successful implementation of Science TQM. *China-USA Business Review*, *8*(12), 1-11.

Amasaka, K. (2009b). The Foundation for Advancing the Toyota Production System Utilizing New JIT. *Journal of Advanced Manufacturing Systems*, *80*(1), 5-26. https://doi.org/10.1142/S0219686709001614

Amasaka, K. (2015). *New JIT, New Management Technology Principle*. Boca Raton, London, New York: Taylor & Francis, CRC Press. https://doi.org/10.1201/b17755

Amasaka, K. (2016). Innovation of automobile manufacturing fundamentals employing New JIT: Developing Advance Toyota Production System at Toyota Manufacturing USA. *Proceedings of the 5th Conference on Production and Operations Management, Habana International Conference Center*, *Cuba*, 1-10.

Amasaka, K. (2017a). Strategic Stratified Task Team Model for Realizing Simultaneous QCD Fulfilment: Two Case Studies. *Journal of Japanese Operations Management and Strategy*, *7*(1),14-35.

Amasaka, K. (2017b). *Toyota: Production system, safety analysis and future directions*. New York: NOVA Publishers.

Amasaka, K. (2018a). Innovation of automobile manufacturing fundamentals employing New JIT: Developing Advanced Toyota Production System. *International Journal of Research in Business, Economics and Management*, *2*(1), 1-15.

Amasaka, K. (2018b). Automobile Exterior Design Model: Framework development and supporting case studies. *Journal of Japanese Operations Management and Strategy*, *8*(1), 67-89.

Amasaka, K. (2019a). Establishment of an Automobile Optimal Product Design Model: Application to study on bolt-nut loosening mechanism. *Noble International Journal of Scientific Research*, *3*(9), 79-102.

Amasaka, K. (2019b). Studies on New Manufacturing Theory. *Noble International Journal of Scientific Research*, *3*(1), 1-20.

Amasaka, K. (2020). *New Manufacturing Theory: Surpassing JIT*. Riga, Latvia, European Union: LAP Lambert Academic Publishing.

Amasaka, K., Baba, J., Kanuma, Y., Sakai, H., & Okada, S. (2006). The evolution of technology and skill the key to success—Latest implementation of new Japan model "Science TQM". *The Japan Society for Production Management, The 23th Annual Technical Conference*, *Osaka City University, Osaka, Japan*, 81-84 (in Japanese).

Amasaka, K. (Ed.). (2012). *Science TQM, New Quality Management Principle: The quality management strategy of Toyota*. UAE, USA, THE NETHERLANDS: Bemtham Science Publishers. https://doi.org/10.2174/97816080528201120101

Amasaka, K. et al. (1999). The preliminary survey in 68QCS: The questionnaire result of "TQM which creates Japan (1st report) (Special Lecture). *Union of Japanese Scientists and Engineers, 68QCS symposium, Hakone, Kanagawa-ken, Japan* (in Japanese).

Amasaka, K., Igarashi, M., Yamamura, N., Soeda, S., & Nomasa, H. (1995). The QA Network activity for prevent rusting of vehicle by using SQC. *The Japanese Society for Quality Control*, *The 50th Annual Technical Conference, Nagoya, Japan*, 35-38 (in Japanese).

Amasaka, K., Ito, T., & Nozawa, Y. (2012). A New Development Design CAE Employment Model. *The Journal of Japanese Operations Management and Strategy*, *3*(1), 18-37.

Amasaka, K., Kurosu, S., & Morita, M. (2008). *New Manufacturing Theory: Surpassing JIT—The* *evolution of Just-In-Time*. Tokyo: Maruzen (in Japanese).

Amasaka, K., Mitani, Y., & Tsukamoto, H. (1993). Study of quality assurance to protect plating parts from corrosion by SQC—Improvement of grinding roughness for rod piston by centerless grinding. *Journal of the Japanese Society for Control, Quality*, *23*(1), 72-98 (in Japanese).

Amasaka, K., & Sakai, H. (2010). Evolution of TPS fundamentals utilizing New JIT strategy: Proposal and validity of Advanced TPS at Toyota. *Journal of Advanced Manufacturing Systems*, *9*(2), 85-99.

Amasaka, K., & Sakai, H. (2011). The New Japan Global Production Model "NJ-GPM": Strategic development of Advanced TPS. *The Journal of Japanese Operations Management and Strategy*, 2(1), 1-15.

Amasaka, K., Shirasawa, H., & Misawa, N. (1997). The Development of Total QA Network by utillizing Management SQC—Example of Brake Pad's Qiality Assurance Activity (Part2). *The Japanese Society for Quality Control, The 55th Annual Technical Conference, Tokyo*, 17-20 (in Japanese).

Burke, R. J., Graham, J., & Smith, F. (2005). Effects of reengineering on the employee satisfaction—customer satisfaction relationship. *The TQM Magazine*, *17*(4), 358-363. https://doi.org/10.1108/09544780510603198

Ebioka, K., Sakai, H., Yamaji, M., & Amasaka, K. (2007). A New Global Partnering Production Model "NGP-PM" utilizing Advanced TPS. *Journal of Business & Economics Research*, *5*(9), 1-8. https://doi.org/10.19030/jber.v5i9.2576

Genma, Y., & Suzuki, M. (1992). Development of ferrite heat resistant cast steel: Optimization of material contents by multivariate analysis. *Quality Control*, *43*(5), 28-31 (in Japanese).

Goto, T. (1999). *Forgotten origin of management—Management quality taught by G.H.Q: CSS management lecture*. Tokyo: Productivity Publications (in Japanese).

Hoogervorst, J. A. P., Koopman, P. L., & Flier, H. (2005). Total quality management: The need for an employee-centered coherent approach. *The TQM Magazine*, *17*(1), 92-106. https://doi.org/10.1108/09544780510573084

Jeffrey, K. L. (2004). *The Toyota Way, 14 Management Principles from the world's greatest manufacture*. New York: McGraw-Hill.

Kawahara, F., Kogane, Y., Amasaka, K., & Ouchi, N. (2016). A skill map based on an analysis of experienced workers' intuition and knowhow. *Journals International Organization of Scientific Research (IOSR), Journal of Business and Management*, *18*(12). 80-85.

Keishima, K., & Okada, M. (1992). Measures to be taken for difficulties in the manufacture of aluminum die-casted head cover: Establishment of casting difficulty index and execution examples. *Quality Control*, *43*(5), 86-89 (in Japanese).

Kusune, K., Suzuki, Y., & Amasaka, K. (1992). The statistical analysis of the springback for stamping parts with longitudinal curvature. *Journal of the Japanese Society for Control*, *22*(4), 24-30 (in Japanese).

Kojima, T., & Amasaka, K. (2011). The Total Quality Assurance Networking Model For preventing defects: Building an effective quality assurance system using a Total QA Network. *International Journal of Management & Information Sytems*, *15*(3), 1-10. https://doi.org/10.19030/ijmis.v15i3.4637

Koren, Y. (2010). *The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems*. Hoboken, State of New Jersey: John Wiley & Sons. https://doi.org/10.1002/9780470618813

Kozaki, T., Oura, A., & Amasaka, K. (2012). Establishment of TQM Promotion Diagnosis Model "TQM-PDM" for strategic quality management. *China-USA Business Review*, *10*(11), 811-819.

https://doi.org/10.17265/1537-1514/2012.06.008

Lagrosen, S. (2004). Quality management in global firms. *The TQM Magazine*, *16*(6), 396-402. https://doi.org/10.1108/09544780410563310

Ljungström, M. (2005). A model for starting up and implementing continuous improvements and work development in practice. *The TQM Magazine*, *17*(5), 385-405. https://doi.org/10.1108/09544780510615915

Ministry of Land, Infrastructure, Transport and Tourism. (2015). Retrieved from htttp://www.mlit.go.jp/jidosha/ carinf/ rcl/ data.html

Miyamoto, M., & Ishimoto, Y. (1991). Establishment of optimum casting condition for compact DOHC cylinder head. *Quality Control*, *42*(5), 183-189 (in Japanese).

Miyashita, S., & Amasa, K. (2014). Proposal of a "New Vietnam Production Model" (NVPM), a new integrated production system of Japan and Vietnam. *IOSR Journal of Business and Management*, *16*(12), 18-25. https://doi.org/10.9790/487X-161211825

Ohno. T. (1977). *Toyota Production System*. Tokyo: Diamond-Sha (in Japanese).

Sakai, H. (2016). Toyota Motor Manufacturing, Texas: Highly Reliable Production System for expanding global production: Total linkage of planning, preparation and production. *Proceedings of The 5th Conference on Production and Operations Management, Habana International Conference Center, Cuba*, 1-10.

Sakai, H., & Amasaka, K. (2005). V-MICS, Advanced TPS for strategic production administration: Innovative maintenance combining DB and CG. *Journal of Advanced Manufacturing Systems*, *4(*6), 5-20. https://doi.org/10.1142/S0219686705000540

Sakai, H., & Amasaka, K. (2006). Strategic HI-POS, Intelligence Production Operating System: Applying Advanced TPS to Toyota's global production strategy. *WSEAS Transactions on Advances in Engineering Educatio*n, *3*(3), 223-230.

Sakai, H., & Amasaka, K. (2008). Human-Integrated Assist Systems for intelligence operators, *Encyclopedia of Networked and Virtual Iorganizations*, *II*(G-Pr), 678-687. https://doi.org/10.4018/978-1-59904-885-7.ch089

Sakai, H., Tsunoi, M., Yamaji, M., & Amasaka, K. (2010). A study of building an Intellectual Working Value Improvement Model, IWV-IM. *International Business & Economics Research Journal*, *9*(11), 79-84. https://doi.org/10.19030/iber.v9i11.33

Shan, H., Yeap, Y. S., & Amasaka, K. (2011). Proposal of a New Malaysia Production Model "NMPM": A new integrated production system of Japan and Malaysia. *Proceedings of International Conference on Business Management, Miyazaki Sangyo-Keiei University, Japan*, 235-246.

Shan, H. (2012). The proposal of China Local Automobile Manufacturer's Production System. *Graduate School of Science and Engineering, Aoyama Gakin University, Amasaka New JIT Laboratory*, 1-135 (in Japanese).

Taylor, D., & Brunt, D. (2001). *Manufacturing operations and supply chain management—The Lean Approach*. London: Thomson Leaning.

Toyota. (1987). *The Toyota Production System and A Glossary of Special Terms Used at Production Job-sites at Toyota*. Toyota-City, Aichi-ken, Japan: Toyota Motor Corporation.

Tsunoi, M., Yamaji., & Amasaka, K. (2010). A study of building an Intellectual Working Value. Improvement Model "IWV-IM". *International Business & Economics Research Journal*, *9*(11), 79-84. https://doi.org/10.19030/iber.v9i11.33

Uchida, K., Tsunoi, M., & Amasaka, K. (2012). Creating Working Value Evaluation Model "WVEM". *International Journal of Management & Information Systems*, *16*(4), 299-306. https://doi.org/10.19030/ijmis.v16i4.7306

Womack, J. P., Jones, D., & Roos. D. (1990). *The machine that change the world—The story of Lean Production*. New York: Rawson/Harper Perennial.

Yamaji, M., Sakai, H., & Amasaka, K. (2006). Intellectual Working Value Improvement Model utilizing Advanced TPS: Applying New JIT, Toyota's global production strategy. *Proceedings of the International Applied Business Research Conference, Cancun, Mexico*, 1-10.

Yamaji, M., Sakai, H., & Amasaka, K. (2007a). Evolution of technology and skill in production workplaces utilizing Advanced TPS. *The Journal of Business & Economics Research*, *5*(6), 61-68. https://doi.org/10.19030/jber.v5i6.2555

Yamaji, M., & Amasaka, K. (2007b). Proposal and validity of Global Intelligence Partnering Model for Corporate Strategy, "GIPM-CS". *Advances in Production Management Systems, International IFIP TC 5.7 Conference on Advanced in Production Management System, Linkoping, Sweden, Springer*, 59-67. https://doi.org/10.1007/978-0-387-74157-4_8

Yamaji, M., Sakatoku, T., & Amasaka, K., Partnering Performance Measurement "PPM-AS" to strengthen corporate management of Japanese automobile assembly makers and suppliers. *International Journal of Electronic Business Management*, *6*(3), 139-145.

Yamaji, M., & Amasaka, K. (2009). Strategic Productivity Improvement Model for white-collar workers employing Science TQM. *The Journal of Japanese Operations Management and Strategy*, *1*(1), 30-43.

Yanagisawa, K., Yamazaki, M., Yoshioka, K., & Amasaka, K. (2013). Comparison of experienced and inexperienced machine workers. *International Journal of Operations and Quantitative Management, 19*(4), 259-274.

Yeap, Y, S., Murat. M. S., & Amasaka. K. (2010). Proposal of New Turkish Production System, NTPS, Integration and Evolution of Japanese and Turkish Production System. *Journal of Business Case Study*, *6*, 69-76. https://doi.org/10.19030/jbcs.v6i6.260