High Linkage Model "*Advanced TDS, TPS & TMS*" for Strategic *New JIT*

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Abstract: - A study of a high-linkage model, "*Advanced TDS*, *TPS & TMS*" for the strategic development of management technology in advanced companies through the utilization of author's *New JIT.* This is the traditional *Just in Time* (JIT) system for not only manufacturing, but also for customer relations, business and sales, merchandise planning and engineering design, production engineering, administration and management for enhancing business process innovation and introduction of new concepts and procedures. The author believes that the proposal and effectiveness of a high linkage model, employing a structured "integrated triple management technologies system - *Advanced TDS*, *Advanced TPS and Advanced TMS"* for expanding "uniform quality worldwide and production at optimum locations" has been demonstrated as described herein based on the author's research at Toyota and others.

Key-words: - *New JIT,* High-Linkage Model, triple management technologies system, *Advanced TDS, Advanced TPS, Advanced TMS*, Customers' Sense of Value, High Quality Assurance Activity, Toyota

1 Introduction

At present, leading companies are promoting global production strategies to realize "same quality standards and simultaneous production startup worldwide". Advanced companies in particular are eagerly looking for a new quality management method to supply new attractive product models ahead of their competitors to ensure their survival in the worldwide market.

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. To realize manufacturing that places top priority on customers with a good QCD (Quality, Cost and Delivery) and in a rapidly changing technical environment, it is essential to create a new core principle capable of changing the work process quality of all divisions for reforming the super-short-term development production.

A high-linkage model of "*Advanced TDS*, *TPS & TMS*" for the strategic of development management technology in advanced companies that utilizes the author's *New JIT* [1]. This is the traditional *Just in Time* (*JIT*) system for not only manufacturing, but also for customer relations, business and sales, merchandise planning and engineering design, production engineering, administration and management for enhancing business process innovation and introduction of new concepts and procedures.

The author believes that the proposal and effectiveness of a high linkage model, employing a structured "triple management technology integrated system - *Advanced TDS*, *Advanced TPS and Advanced TMS"* for expanding "uniform quality worldwide and production at optimum locations" has been demonstrated as described herein based on the author's research at Toyota and others.

2 Background – Management Tasks of Advanced Companies

The Japanese production system represented by *Toyota Production System* was the most prominent business management technology contributed to the world in the latter half of the 20th century. *Toyota Production System* is a production system developed by Toyota [2]. It is called *JIT* in other countries. It is aimed at improving quality through pursuit of

maximum rationalization by applying TQM (Total Quality Management) to production processes with an eye on the cost reduction principle [2].

As the result of production innovation at Toyota and evaluation of its effects throughout the world, the concepts and approaches of the *Toyota Production System* have taken root as the core concept called "*JIT*", in the worldwide manufacturing industry [3]. The *Toyota Production System*, however, has already been developed into *JIT*, an internationally common system not monopolized by Toyota [4]. Moreover, the importance of quality control has been recognized anew in the United States through the study of TQM in Japan, resulting in the promotion of TQM activities that endanger the predominance of Japanese products in terms of quality [5].

Amidst severe global competition for survival in Japan and abroad, manufacturers must again recognize the "ideal of quality management in the manufacturing industry". This is especially true when they see numerous instances in which quality problems critically damage customer satisfaction. Increasing recalls by a number of advanced companies that should be leading the world in global production indicates the need for reinforcement of the "managerial engineering capabilities" of manufacturers in creating highly reliable products [6, 7].

For the reasons stated above, the author conducted a consciousness survey covering the directors and upper-class managers of eighteen advanced companies (225 subjects in total, including Toyota, Denso, Aishin-Seiki, Fuji Xerox, NEC, Daikin-Kogyo, JFE Steel, and others) [1, 8].

As shown in Fig. 1, general management technology problems have been pointed out utilizing Quantification Class III. The figure indicates that people engaged in development give top priority to "developing new merchandise and products of proposed type" based on the global merchandise strategy, production-related people establishing *next - generation production system* from the viewpoint of global production, and marketing/sales persons establishing *new marketing methods* for success in global marketing. The task common to all these tasks is adaptation to globalization.

To achieve these management tasks, it is important in the future to renovate the organization and systems, including career development through intellectual information sharing, and to create new management technology that would strengthen cooperation among divisions. Recent factorial analysis and other studies carried out by the authors [1, 8] have revealed insufficient engineering capability in business management to be addressed in particular by the Japanese manufacturing industry.

More specifically, this consists of the following problems: (1) Insufficient workshop capability, (2) Insufficient reliability in the engineering, development and design fields, (3) Need for reasonable, innovative marketing activities in the service field, (4) Need to ascertain customer intentions in the general planning, merchandise planning and (5) Need to renovate business process quality in the clerical and administration fields in order to depart from traditional, reactive work processes to realize "simultaneous QCD attainment" in global production through proactive jobs as the core of corporate management activities.

3 Significance of *New JIT* Development

Customers today select products that fit their lifestyles and sense of values, and question *company*

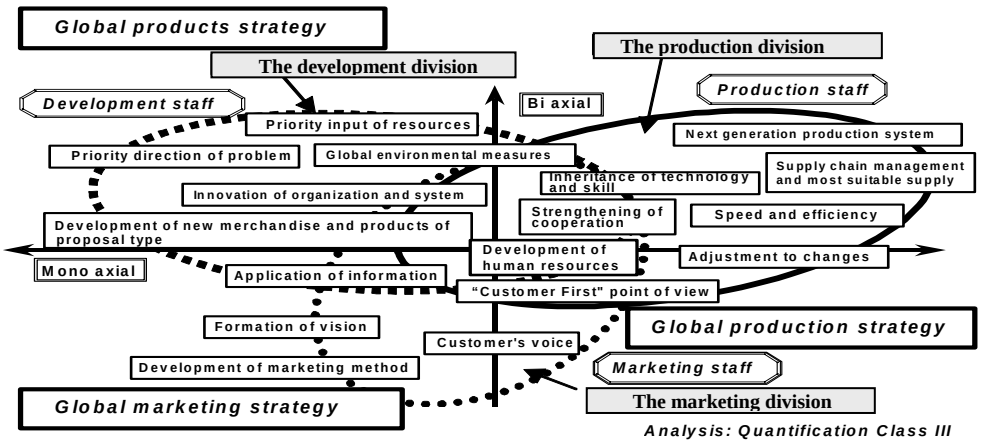

Fig. 1 Schematic Drawing of Management Technology Problems

reliability in terms of product reliability (quality and value for use). In order to manufacture attractive products as an advanced company, it is now necessary to establish a principle of new management technology for the next generation that will serve as a systematic and organizational behavioral principle to achieve a higher linkage of the business process cycles of all divisions, including not only sales, development and design and manufacturing, but also indirect divisions such as administrative/clerical, and suppliers.

Based on these needs, the author [1] proposed a new principle for next-generation management technologies - *New JIT,* as shown in Fig. 2. The hardware systems of *New JIT* are *TMS*, *TDS, and TPS*. These core systems are indispensable for establishing new management technologies. Further, the authors [7, 8, 9] have proposed a new principle of quality management "*Science TQM"* (Total Quality Management by Utilizing *Science SQC* called TQM-S) by using a principle of quality management, "*Science SQC"* (Statistical Quality Control), as a software system that improves the quality of all divisions' business processes in developing strategic quality management, important for survival in the current environment of worldwide quality competition.

Based on the matters cited above, the author [1] has been verifying the effectiveness of *New JIT* as a new management technology model to further develop traditional *JIT* practices at an advanced company in Japan. Thus the author has tested the effectiveness of the "strategic model of new management technologies" for further advancement of *JIT* at Toyota and others [6, 8].

4 The Needs for a New Global Management Technology Model for the *New JIT* Strategy

At present, advanced companies in the world, including Japan are shifting to "global production" to realize "uniform quality worldwide and production at optimum locations" for survival in fierce competition. To attain successful global production, technical administration, production control, purchasing control, sales administration, information system and other administrative departments should maintain close cooperation with clerical and indirect departments while establishing strategic cooperative and creative business linkages with individual development, production and sales departments, as well as with outside manufacturers (suppliers).

For a manufacturer to accurately grasp customer intentions in order to proceed with production that satisfies the demand of the times, it is important that all the departments play the leading role in company management with an advanced view of the world. Because realizing "production at optimum locations with the same quality worldwide" ahead of competitors is the key to successful global production, it is not too much to say that strategic partnering between engineering, production and sales operations as well as suppliers is essential [6].

In order to manufacture attractive products, it is necessary first for each of the marketing, sales, development design and manufacturing divisions to manage themselves with successful internal linkages and other divisions to organically link all of the foregoing divisions with administrative (technical administration, production control, purchasing

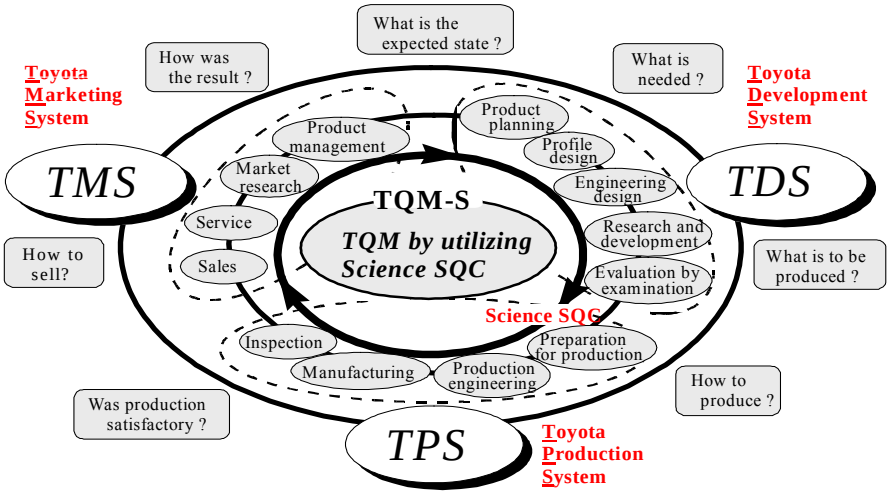

Fig.2 *New JIT*, a Management Technology Principle

administration, information system and quality assurance) and indirect clerical divisions through systematic, organizational activation of human resources in individual divisions. The author, therefore, requires the urgent establishment of a "new global management technology model" for the next generation.

5 Proposal of a High Linkage Model "*Advanced TDS, TPS & TMS*" for *New JIT Strategy*

So, in this chapter, the author proposes a high linkage model by structured "triple management technologies system - *Advanced TDS*, *Advanced TPS and Advanced TMS"* as shown in Fig. 3.

5.1 *Advanced TDS*, Total Development Design Model

Currently, to continuously offer attractive, customer-oriented products, it is important to establish a "*new development design model"* that predicts customer needs [8]. In order to do so, it is crucial to reform the business process for development design [10]. Manufacturing is a battle against irregularities, and it is imperative to renovate the business process in the development design system and to create a technology so that serious market quality problems can be prevented in advance by means of accurate prediction/control. For example, as a solution to technical problems, approaches taken by design engineers, who tend to unreasonably rely on their own past experience, must be clearly corrected.

In the business process from development design to production, the development cost is high and time period is prolonged due to the "scale-up effect" between the stages of experiments (tests and prototypes) and mass production. In order to tackle this problem, it is urgently necessary to reform the conventional development design process. Focusing on the successful case mentioned above, the authors [11] deem it a requisite for leading manufacturing corporations to balance high quality development design with lower cost and shorter development time by incorporating the latest simulation CAE and *Science SQC* [11, 12].

Against this background, it is vital not to stick to the conventional product development method, but to expedite the next generation development design business process in response to a movement toward digitizing design methods. Having said the above, the authors [11] propose "*Advanced TDS*, *Total*

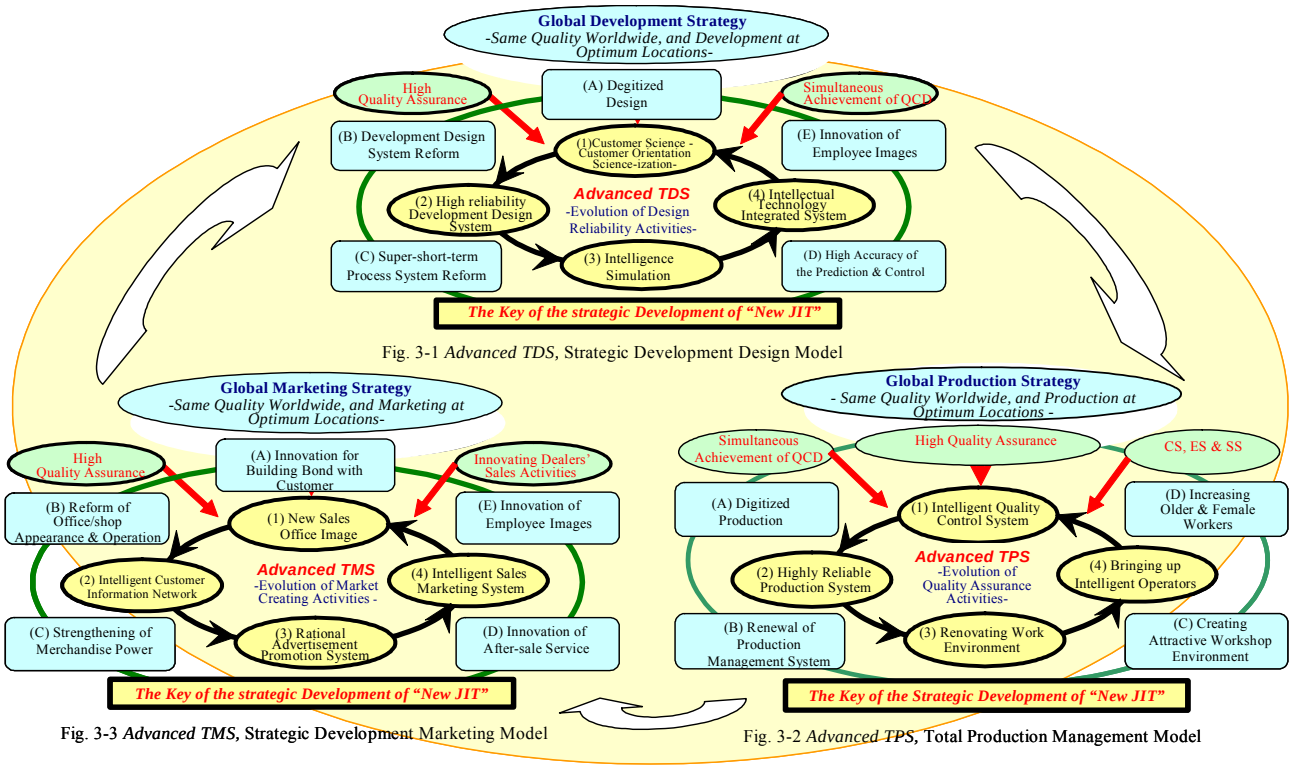

Fig. 3-1 *Advanced TDS*, Strategic Development Design Model

Fig. 3-3 *Advanced TMS*, Strategic Development Marketing Model

Fig. 3-2 *Advanced TPS*, Total Production Management Model

Fig. 3 High Linkage Model "*Advanced TDS, TPS & TMS" for* Strategic *New JIT*

Development Design Model" as described in Fig. 3-1, and further updates *TDS*, a core technology of *New JIT*. *New JIT* is aimed at the simultaneous achievement of QCD by high quality manufacturing which is essential to realize CS (Customer Satisfaction), ES (Employee Satisfaction), and SS (Social Satisfaction). For realization, (1) customers' orientation (subjective implicit information) must be scientifically interpreted by means of *Customer Science* [1, 13], namely, converting the implicit information to explicit information by objectifying the subjective information using *Science SQC* so as to (2) create *High reliable development design system*, thereby (3) eliminating prototypes with accurate prediction and control by means of *Intelligence Simulation.* To this end, it is important to (4) introduce the "*Intellectual Technology Integrated System"* which enables a sharing of knowledge and the latest technical information possessed by all related divisions.

5.2 *Advanced TPS,* Total Production Management Model

As digital engineering transforms manufacturing in workshops, a reduction in the engineering capability of members is often a result. This weakens the scientific production control that ensures that quality is incorporated in processes. Therefore, despite conventional success from the viewpoint of global production, it is an urgent task to strategically advance TPS (*Advanced TPS)* [10] in order to enable. The author, considering the necessity of including and organically integrating these four elements in the strategic application of *Advanced TPS* towards global production, has clarified the *"Total Production Management Model"* as shown in Fig. 3-2.

This model is an advanced production management principle designed to be applied as a global production technology and management model. The mission of *Advanced TPS* in the global deployment of *New JIT* is to realize CS, ES, and SS through production with high quality assurance. In implementing *New JIT* for uniform quality worldwide and production at optimal locations (concurrent production), the fundamental requirements are (i) the renewal of production management systems to accommodate digitized production (see (A) and (B) in Fig. 3-2) and (C) the creation of attractive workshop environments tailored to (D) the increasing number of older and female workers (see (C) and (D) in Fig. 3-2).

In more definite terms, what is needed is to (1) strengthen process capability maintenance and improvement by establishing an intelligent quality control system, (2) establish a highly reliable production system for high quality assurance, (3) reform the work environment in order to enhancement intelligent productivity, and (4) develop intelligent operators (skill level improvement) and establish an intelligent production operating system. Accomplishing these objectives will achieve higher-cycled next-generation business processes, enabling earlier implementation of uniform quality worldwide and production at optimum locations.

5.3 *Advanced TMS,* Strategic Development Marketing Model

When the author views recent changes in the marketing environment, what is needed now is to develop "Innovative business and sales activities" that are unconventional and correctly grasp the characteristics and changes of customers' tastes. "Contact with customers" has never called for more careful attention and practice and to offer an appealing, customer-oriented marketing strategy, it is important to evolve current market creation activities [1, 14]. Therefore, the author proposes "*Advanced TMS,* Strategic Development Marketing System" as described in Fig. 3-3, that further updates *TMS*. *Advanced TMS* is aimed at the implementation of a successful "Global Marketing Strategy" by developing "*Same Quality Worldwide, and Marketing at Optimum Locations*".

As shown in the figure, *Advanced TM*S aims to achieve" a high cycle rate for market creation activities" and is composed of four core elements (1)-(4) : Core element (1), a "new vehicle sales office image" to achieve a high cycle rate for market creation activities by, (A) innovative bond building with the customer and (B) shop appearance and operation, is particularly important, These constitute the basis for the innovation of (C) business talk, (D) after sale service, and (E) images of the employee image. At a certain stage of execution, for example, it is more important to construct and develop (2) an "Intelligent customer information network", (3) a "Rational advertisement promotion system" and a (4) an "Intelligent Sales Marketing System" that systematically improves "*Customer information software application know-how*" about users who

patronize vehicles of various makes.

This information network turns customer management and service into a science by utilizing "*TMS*" according to customers' involvement with their vehicles in daily life. The strategic new marketing model which applies the proposed "*Advanced TMS*" is presented in the next chapter.

5.4 *Advanced TDS, TPS & TMS* Driven by *Science SQC*

The further expansion of the *Advanced TDS, TPS & TMS*, "*Science SQC*" by utilizing the four core principles for *New JIT* strategy is a new principle for a next generation quality management technique for the manufacturing business, aiming at providing a universal "general solution" and thus creating a technology for problem solving [7-9].

The first of the four principles, "*Scientific SQC*" is a scientific approach, and the second principle, "*SQC Technical Methods*" is a methodology for problem solving. The third principle, SQC integrated network, "*TTIS*", is designed to turn management technologies that deal with proprietary technologies or business processes into owned assets. The fourth principle, "*Management SQC*", interprets the gap between the theory and reality of technical problems, as the problems existing between departments and organizations, and verbalizes the implicit understanding inherent in the business process, thus further presenting it as explicit knowledge and as a general solution for the technical problem.

6 Application of the High-Linkage Model "*Advanced TDS, TPS & TMS*"

6.1 Study on Customers' Sense of Value Using High-Linkage of *Advanced TMS* & *Advanced TDS:* Key to the Excellence Profile Design Vehicle "Lexus"

This study discussed the effectiveness of *Advanced TMS* and *Advanced TDS* as the key to *New JIT* Strategy and proposed the innovation of business process in developing and designing attractive product to develop idea for strategic product development. Today, growing companies both in Japan and abroad try to grasp the unprejudiced desires of their customers from the viewpoint of customer-oriented business management and to reflect these desires in future product development. However, the actual behavioral patterns (conception methods) of designers (new product planners and designers) in trying to grasp latent customer desires depend heavily on the designers' empirical skills.

It is, therefore, important to establish a scientific approach that improves powers of product conception (insight and foresight) or a "method for assisting the conception of strategic product development" and to test its validity. Upon designing a global strategic vehicle "Excellence Design Vehicle – *Toyota Lexus* design profile", the matter of primary concern for the designer is how to catch the target customers' heart. For the present time, the authors use collages created by the designer and search for

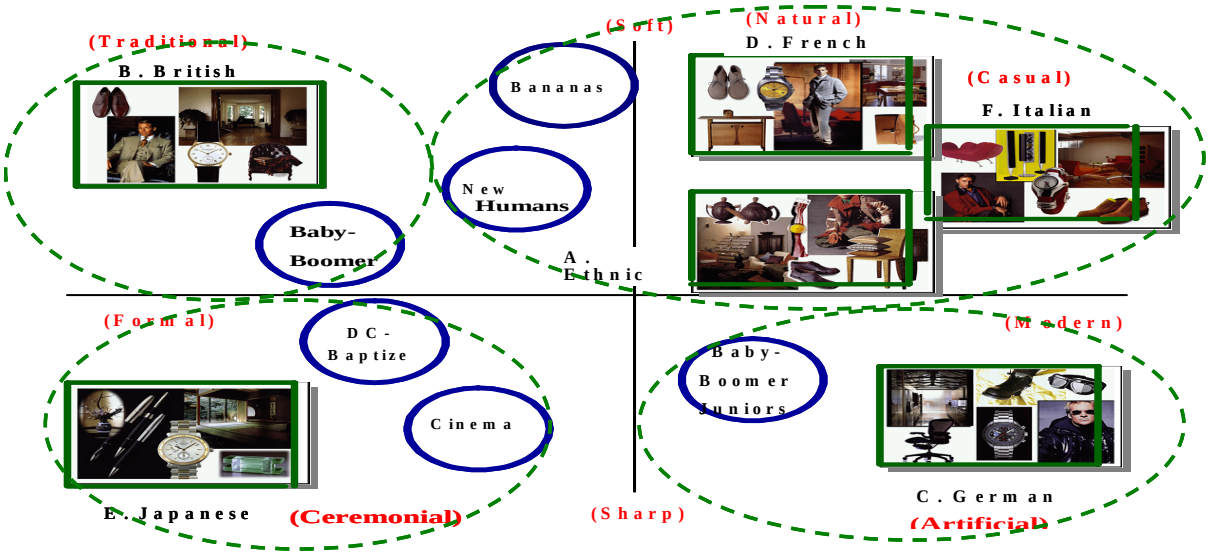

Fig. 4 Collage panel image analysis by generation
(Principal component analysis/correlation method: Scatter diagram of the principal ratings)

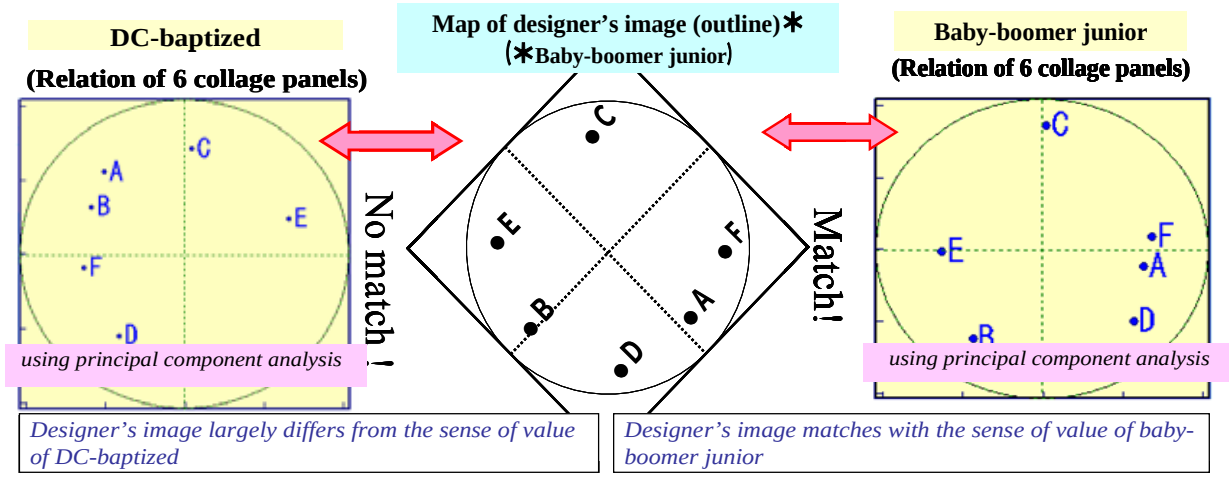

Fig. 5 Relation of Designer's Images and Customers' Preferences Using 6 Collages Panels

coincidence with the designer's images by investigating the customers' sense of values scientifically by utilizing *Scientific SQC and SQC Technical Methods called "Marketing SQC and Designing SQC"* [13-15]. As an analytical example of investigating customers' sense of values, Fig. 4 shows the result of analysis of the main component of the questionnaire (order of image word preference by generation). From the figure, the primary component axis is interpreted as modern/formal, the secondary axis as soft/sharp. A: ethnic, D: Italian, and F: French are positioned in the first quadrant, B: British in the second quadrant, E: Japanese in the third quadrant and C: German in the fourth quadrant.

In addition, according to the data given in the same diagram, the mean value of each group implies the general characteristics of each group as follows: the "bananas" (90 people aged 31 to 36; this generation tends be sensible and prefer moderate personality. Sensuous characters in the work of the Japanese novelist, Banana Yoshimoto are typical of this generation) and "new humans" (52 people aged 37 to 42); when they were young, they were thought "eccentric" by an adult) tend to like panels A, B, D and F, the "baby-boomers" (30 people aged 50 to 55; their generation presents the maximum population in the post-war period) and "DC-baptized generation" (53 people aged 43 to 49; this generation is characterized by zeal for by wearing fashionable DC (designer and character) branded clothes) tend to like B and E, the "cinema generation" (19 people aged 56 to 65; when they were in the bloom of youth, the movie industry was also in the golden period and in the center of the youth cult) like E, and "baby-boomer juniors" (128 people aged 25 to 30); this generation is the children of baby boomers) like C.

As a new knowledge, the authors have found that the panel images of the designer coincide with the preferences of the customers of the generation the designer belongs to but do not necessary coincide fully with those of other generations as shown in Fig. 5. From these analytical results, it is possible to surmise that the idea for developing strategic products can be born in two ways, namely, by the royal road to designing by using a designer of the same generation as that of the target customers, or by using a designer of a different generation from the target to create an appealing design from a new point of view. Based on the observation above and through utilization of statistical science, the authors [13, 15] have ascertained the exterior automotive designs (design profiles) that customers in Japan and the West, irrespective of their age, are focusing on.

These include (i) which of the front, side, or rear they are mainly focusing on, and (ii) whether it is the overall balance or a specific location of the body that they are focusing on. Combining all these factors together, we have been able to devise the "proportional ratio" (For example, numerical conversion of height / length, hood length / total length, cabin length / total length, etc.) which reflects a (iv) "high-class look" and "freshness" that the customers value. These design approaches have been established as the "Design Profile Support System," the basis of Toyota's new model profile designing today. This study played the key role to develop "*Lexus GS400 / LS430*" (*Japan Name*: Aristo / *Celsior*) of which design profiles receive global popularity [16].

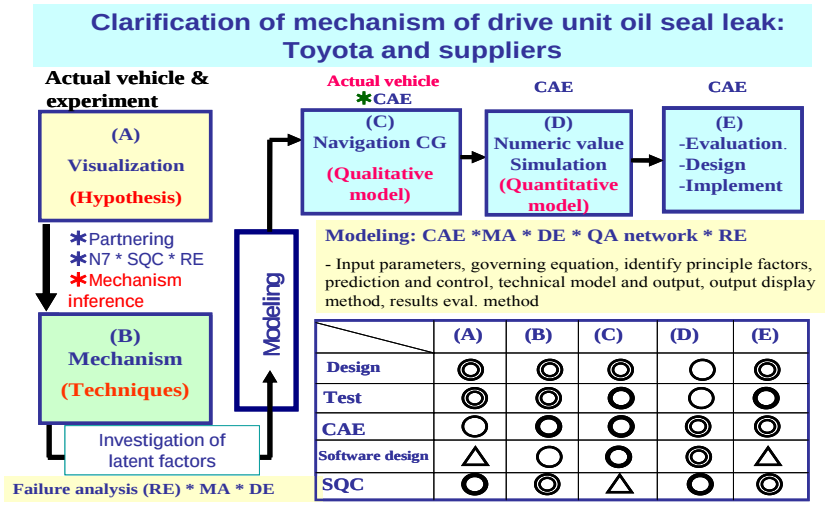

Fig. 6 *Intelligence CAE Management System Approach*

6.2 High Quality Assurance Activity Using the High-Linkage of *"Advanced TDS, TPS & TMS"*- Intelligence CAE Management System Approach – Oil Seal Leakage-

Recently, further shortening of the development production period of automobile development/ production (from planning to mass production) from 2year to one year, which includes the process of designing –prototyping–experimental evaluation– production preparation– mass production trial, is now anticipated by means of (i) evolution of CAD/CAM (2D→3D solid) and (ii) wider range of application for CAE [11].

In this section, the author will established *Toyota's Intelligence CAE Management System Approach* that supports *Advanced TDS* for high quality assurance of the drive train oil seal, a bottleneck technology for worldwide automobile manufacturers [11]. In order to solve unwanted technical problems, the authors organized a *Total Task Management Team* to pursue root causes at the internal organizations of Toyota Motor Corporation and NOK Corporation. Then, the authors investigated the oil seal leakage mechanism by bringing together Toyota, an automobile assembly manufacture, and NOK, a supplier. Based on the acquired knowledge, the CAE analysis precision by utilizing *"Intelligence CAE Management System Approach"* as shown in Fig. 6 has been significantly improved and the simultaneous achievement of QCD has become possible by utilizing *Management SQC and SQC Technical Methods called "Developing SQC and Manufacturing SQC"* [10, 11]

As seen in the figure, first, the (A) actual vehicle and experiment (meaning bench evaluation tests using actual vehicles and parts) visualizes the dynamic behavior (tricky mechanism) of the oil leakage. Next, by means of the (B) factorial analysis in which the unique technology and empirical technology are combined together with N7 (New seven tolls), RE (Reliability), MA (Multivariate analysis), and DE (Design of experiment), the latent factors which induce oil leakage are investigated using actual vehicles and experiment procedures in an effort to clarify the oil leakage mechanism.

Based on the knowledge obtained through the above steps, as well as the navigation process using CG (Computer Graphics) created by a combination of (C) experiments and CAE as shown in Fig. 7, qualitative modeling of oil leakage was conducted. Furthermore, for the purpose of accurately reproducing the oil leakage mechanism, which has been grasped by an inductive approach of visualization experiments, quantitative modeling is conducted by means of (D) numeric value simulation. In the final stage, the (E) differential (gap) between the evaluation results of actual vehicles and experiment procedures (absolute value) and those of the CAE analysis (simulation value) was confirmed.

Up until now, the differential ratio (gap ratio) of the CAE analysis precision against the evaluation value using actual vehicles and experiment procedures (absolute value) has been approximately 10%. The target of the differential ratio of analysis precision is between 1% and 2%. To achieve such a target, an all-out, collective partnering is indispensable among the chief engineers (□), collaborating engineers (○), and assistants (△) who are involved in the design, testing, CAE analysis,

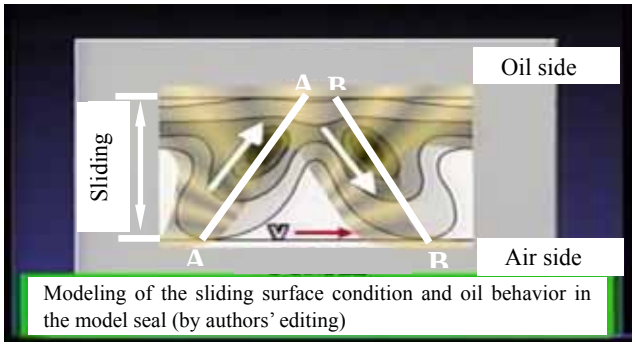

Fig. 7 CG Navigation and CG Software

CAE software development, and SQC throughout the process stages from (A) to (E) indicated in the figure.

The authors tackled the design changes and specific process control. Based on the above mentioned Weibull analysis and the visualization tests, as well as the knowledge obtained through planning (L27), etc, the influence of five dominant factorial analysis by means of the orthogonal test wear-causing factors (period of use, mileage, margin of tightening, hardness of rubber and lip average wear width) was studied through discriminant analysis using oil-leaking and non-oil-leaking parts collected in the past, and the contributing ratio was calculated. This required the operators to prevent such material being introduced into the transaxle so as to reduce early failures of the oil seal. As a result, the cumulative number of claims by production month decreased to one twentieth [11]. The final outcome was achieving longer life, as initially planned. As demonstrated in the study results cited above, the authors [8] have implemented the "High-Linkage Model, *Advanced TDS, TPS & TMS"* into the manufacturing operations conducted by some of the most advanced corporations (Toyota Group Companies, Fuji Xerox, NEC and others) and the desired results have been achieved.

7 Conclusion

This study discussed the proposal and effectiveness of a high linkage model employing a structured "integrated triple management technology integrated model - *Advanced TDS*, *Advanced TPS and Advanced TMS"* for expanding "uniform quality worldwide and has been demonstrated as described herein based on the author's research at Toyota and others.

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