A Study for Building a Comprehensive PLM System Based on Utilizing the Japanese Strength of Industry

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Abstract. Keeping “the Japanese Strength” in digitizing the process of product development is important for the Japanese industry to survive in the intensifying global competition of market. This paper researches about the way of building a comprehensive PLM system based on "the Engineering Process Integrated Architecture (EPIA)" to realize it by taking up actual cases. The system, based on integrated database, consistently integrates the whole process of product planning, development and design, manufacturing preparation, production, purchasing, sales, service and maintenance, and it enables the mutual cooperation of the information of PLM/SCM/CRM.

Keywords: Product Development Process, 3D Digitization, Design and Manufacturing, Product Design Architecture, Organizational Capability, Process Optimization, Product Globalization, CAD, CAE, PDM, BOM, PLM.

1 Introduction

Keeping “the Japanese Strength” in digitizing the process of product development is important when a PLM system is built. If you look at the characteristics of product development in terms of "product architecture", "manufacturing organizational capability" and "design and manufacturing process", it is necessary to connect them based on the "digital data standards" in the PLM system construction. Among them, the strength of Japan, in particular, is in a tight connection with the "manufacturing organizational capability" and "design and manufacturing process", and it has a feature that allows for flexible system operation. (Fig.1) [1], [2]

In this paper, based on taking up actual cases, we study a comprehensive PLM system construction which integrates consistently the whole process of product planning, development and

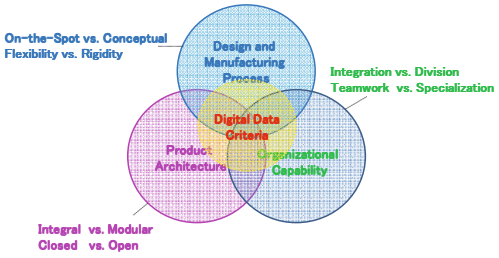

Fig. 1. Characteristics of the product development

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design, production preparation, production, procurement, sales, service and maintenance. The system will become important in the future, in the digitization of the product development process to utilize the Japanese strength of industry, in the intensifying global competition market.

2 Development History of the PLM System

2.1 To a Mutual Cooperation System from a Individual System

PLM systems that support the actual business of product development was first constructed in the individual work of each department. Then, it has been built consistently, from the design and development work of the upstream process, in turn manufacturing arrangements, production process, etc. Among these, the system is constructed as to allow cooperation between departments adjacent individually.

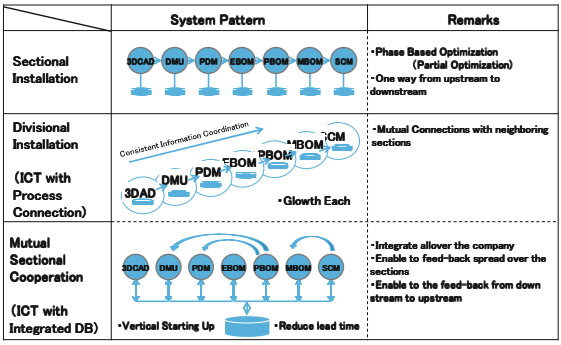

Fig. 2. Growth history of PLM system

At present, by globalization of manufacturing industry, localized production and purchasing has progressed, the needs to send the local information to upstream process is increasing. To respond to such needs, there has been seen such a case for feeding back information to the upstream process from the downstream process, by building a system of mutual cooperation between business, based on an integrated database. (Fig.2).

2.2 Design Concept of the Cooperative System

In the intensifying competitive global market, to take advantage of the strengths of product development of Japan, the spiral cooperation in the design development and manufacture is the key, that is made of not only a top-down approach from the upstream process of Western thought but also made of a bottom-up approach from the production site of Japan. In

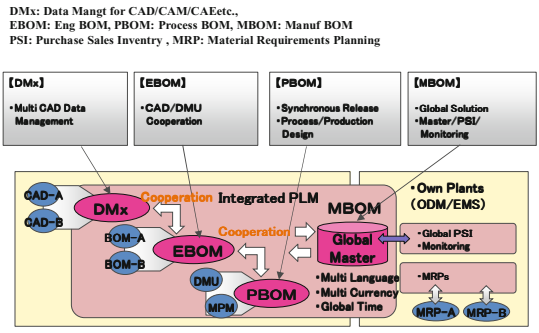

Fig. 3. Architecture of integrated PLM system

order to strengthen it, in the digital development of the Japanese manufacturing industry in the future, it should be aimed at to build a PLM system by an architecture that enables the consistent conjunction of information with assembly process BOM and manufacturing BOM in the downstream process along with the control of CAD, PDM and design BOM in the upstream process. (Fig.3)[3]

3 Expansion into a Comprehensive PLM System

3.1 The Concept of a Comprehensive PLM System

Up to the previous section, a desirable PLM system has been shown from the globalization point of manufacturing preparation, production and procurement process. In the future, the system construction which hold the entire life cycle of a product as consistent process becomes important for promoting the "manufacturing innovation". The system includes not only the current process of design development, manufacturing preparation, production and procurement, but also the upstream process of the product planning, and the downstream process of sales, service and maintenance. A design concept in this system building, “Engineering Process Integrated Architecture (EPIA)” is shown in FIG 4.[2]

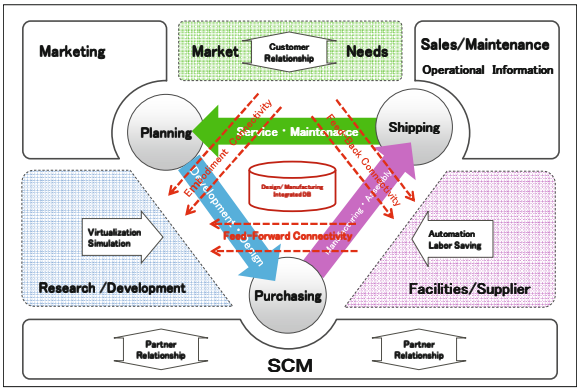

Fig. 4. Engineering Process Integrated Architecture

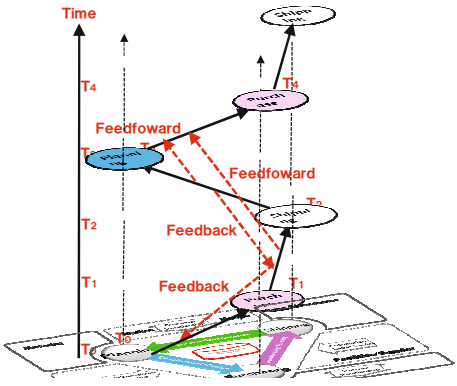

Fig. 5. Process Axes & Data linking of Each Process Axis

The representation put the time axis within each process axis is shown in Fig.5. In each process axes, depending on the progress of each process, data related to the product is stored and updated in the integrated database. Further, the data linkage performed by each arrow between each process axes is also performed through the integrated DB. The data is feed-forward between the virtual process and the

real process, and feed-back as the same. Similarly, the data is feed-forward between virtual process and field process, and feed-back as the same. In order to perform the close communication between organizations involved in each process, the Japanese "manufacturing organizational capability" is easily allow this data linkage. The following describes the concept by which in turn take up the actual cases.

3.2 Cooperation with the Manufacturing Site Information and Planning and Design Information (Data Linkage between the Virtual Process and the Real Process)

By using a digital mock-up, feed-forward and feed-back to the design by the production site information are performed by the design study of interference gap and operability etc. and by the productivity study of assembly and maintenance operation and the like. Further, by using a simulation, a similar function is performed by the performance study of design strength and heat resistance and so on.

In the product development of Japanese companies, this has been done through the teamwork of people at manufacturing sites and design, by sharing information with the drawings. Now, it came to be organized as (simultaneous) concurrent engineering, information cooperation by the system is carried out.

In recent years, the case that production site and design site is separated geographically is increasing. Originally, innovation of the product is realized based on awareness by trial and error in the site of production, by devising a new knowledge through teamwork of design and production. In terms of taking advantage of the strengths of Japan, cases such as the following are desirable.

3.2.1 A Case of the Automotive Industry

Toyota Motor Corporation says that new products and new technology are born from Japan with strong manufacturing site, high technology and a high-performance material. Therefore, competitive edge is in the domestic plant. In order to deploy the car of high quality into the factory of the world, to enhance the technology to produce low-cost in a short period of time, it is necessary to strengthen the mother plant in Japan (Iwate Prefecture, etc.). To do so, to carry out business as minimum, it is required domestic production of 3 million units in the maintenance of the pyramid structure of the domestic business.

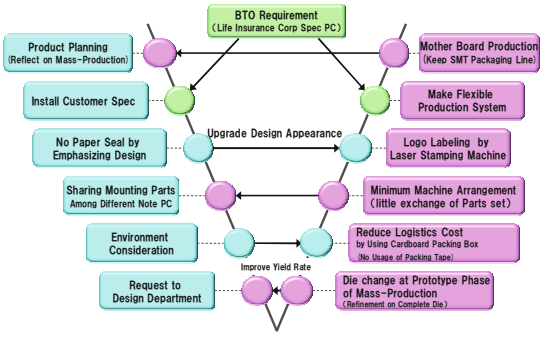

Fig. 6. Synergic Effects of Development and Manufacturing Dept

3.2.2 A Case of Electrical Precision Industry

In the production of notebook / Tablet PC, in order to suppress the domestic labor costs, Fujitsu limited promote automation (robotic) of the assembly process. Thereby, synergy to co-exist manufacturing and production operations, and design and development is prioritized. (Fig.6)

3.2.3 A Case of Heavy Machinery Industry

The characteristic of production and development system of Komatsu is coexistence of production and development department at all plants. Thereby a strong cooperation of both sectors is promoted. The key components that give a competitive advantage to competitors are developed and manufactured only in Japan. There is a mother plant in Japan in each product group, child factory carries out the production and development in a place close to the market. As a result, the building-cost and product quality, product development that meets the market needs are carried out.

3.3 Sophisticated Use of Information in Planning and Design of Upstream Process (Data Linkage between the Virtual Process and Field Process)

3.3.1 Sophisticated product planning method

In recent years, with the progress of globalization, the need of information required in the planning stage of product development is increasing to include production, purchasing and marketing from those around the product so far, i.e. where to buy, where to make, where to sell, where to make money, how to maintain? In this respect, feed-forward and feed-back of information of market and services and maintenance to the design and marketing has become more important. The following is one of the advanced cases of product planning.

3.3.1.1 A Case of Automotive Industry

A method for determining the procedure of product development incorporating tacit knowledge from the upstream planning

Technique to clarify the optimal product development logic has been developed by

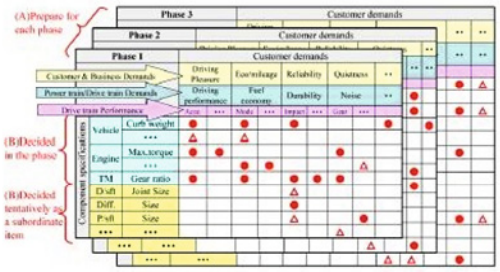

Figure 5. Simplified product architecture matrix (Image)
(A) Prepare a matrix linked to the development phases.
(B)Focus on key specifications and tentatively define the sub-set of items.

Quoted from reference[4]

Fig. 7. Method of Defining Product architecture for Each Dev. Phase

Nissan Motor Co., Ltd. The complexity of the product architecture is assessed multilaterally by architecture analysis from the upstream planning stage to downstream stage. And, implicit knowledge (know-how) of the design process that veteran designers have is transformed to explicit knowledge.[4]

As shown in Fig.7, the matrix of performance items and specification items (QFD matrix) that make up product architecture is prepared in size in accordance with the purpose of each development phase. In each phase, to determine the order in which they evaluate the degree of influence performance, specifications, and decide by priority of having a large impact. At this time, an efficient procedure is obtained by sorting of logical priority, and also by weaving know-how that is based on past experience. A consensus of the decision-making of each phase including especially difficult upstream processes is facilitated while incorporating the implicit intellectual approach of Japan.

3.3.1.2 A Case of Electrical Precision Industry

White Home Electric Appliances for Emerging Countries

In the Panasonic Corporation, volume segment products in the global, are positioned as strategic products in order to capture the emerging countries, and are classified into three categories. One is "leading global V" products intended to be sold to wealthy emerging countries, the value-added products that are popular in Japan and other developed countries. The second is products that fight head-to-head with other companies in the main battlefield of the global. Using a common base model, expand in multiple countries, it aims to increase market share in each country. The third is products developed by the idea of local market, in order to capture the middle layer of emerging countries.

Currently, Lifestyle Research Centers and equivalent organization are established in five countries, that is China, India, Brazil, Germany, and Vietnam. A mechanism has been built to create a product equipped with the functionality required for different countries by visiting to the country site actually to investigate the actual use.

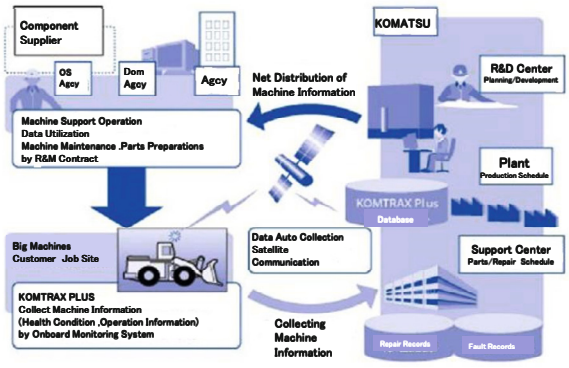

Fig. 8. Corresponding to the Market by Utilizing Field Information

3.3.2 Collaboration with Field Information

3.3.2.1 A Case of Heavy Machinery Industry

Meanwhile, In Komatsu Ltd., there is the case to enhance the more competitiveness of the product by utilizing market information, service and maintenance information, when the product is used in the market. By having a guideline of component replacement and maintenance time through the grasp of the actual usage in the market, they take advantage of the collaboration with production and parts procurement, and improve the quality of attractiveness by reflecting on the design specifications during product planning. (Fig.8)[5]

4 Manufacturing Organization Capability of Japan to Support the Comprehensive PLM System Construction

Here, the Japanese "manufacturing organizational capability" will be discussed. By performing a close communication between organizations, it allows in product development in Japan, the tight linkage of data between processes.

4.1 Characteristics of Design Information Management in Japan

An overview of the differences of Japanese-style and Western-type is shown in Fig.9 regarding the management method of design information in product development.

In the Western method, the information that is determined by the design is deployed by top-down in one direction to each relevant departments of the next step. In contrast, in the method of Japan, the information which is determined by the design, and is received feedback from each department, is deployed as the information that has been refined mutually in both directions.

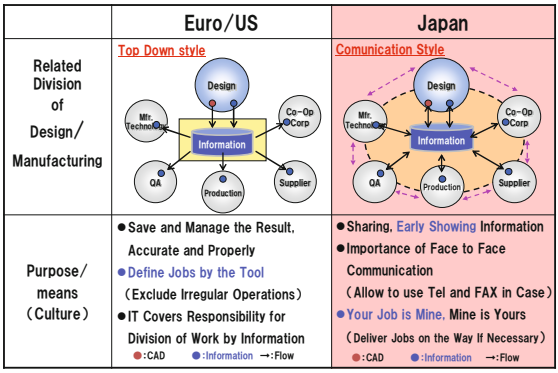

Fig. 9. Feature Comparison of Design Information Management

As shown in this figure, the management method of Japan has good compatibility with such as product development involving many technical elements, and especially with integrated products that require close cooperation of the data It is because it works by compromise, while allowing the ambiguity, and incorporating the diverse opinions of many stakeholders including the manufacturing site.

4.2 Characteristics of Organizational Culture of Japan

And also regarding the organizational culture, an overview of the differences of Japanese-type and Western-type is shown in Fig.10.

As shown in the table, it has the characteristics focusing on more bottom-up consensus in team play than personal top-down leadership. Hence, as mentioned above, tight linkage of data for managing the product development information is done naturally.

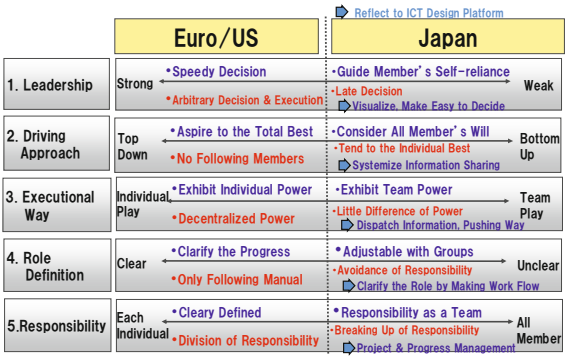

Fig. 10. Characteristics Comparison of Organizational Culture

Such as shown above, the characteristics of the Japanese "product development organizational capability" is considered to be intended to support the comprehensive PLM system construction. It should be noted that, at the time of comprehensive PLM construction, improving the weaknesses by emphasizing consensus is required, while following the strengths of Japan that has been demonstrated so far. For this purpose, the measures indicated by the arrow in Figure, is desirable to be reflected in the ICT design platform.

5 Direction of the Comprehensive PLM System Construction in the Globalization of Industry

In the preceding description, in the industrial globalization, comprehensive PLM system construction to utilize the strengths of product development of Japanese companies is essential. Here, a direction of it is shown based on actual cases of PLM construction in the electric precision industry and the automotive industry in Japan.

5.1 A Case of Automotive Industry

In the automotive industry, according to the vertically integrated production structure, an industry pyramid is created in each region, and the core functionality of development and manufacturing, is located in Japan. The Planning, development and design by the OEM at the pyramid top is done in cooperation with other countries and Japan headquarters, and Teir1 below also has cooperation with local site and head office.

In this case, with respect to PLM tool, it is necessary to use a system of the same type as the OEM, or to use a system that does not have a problem on data distribution. Feedback to the design of information from production preparation, procurement and production is carried out in each layer of the Tier; a smooth cooperation with the Japanese headquarters of each layer is one of the most important issues.

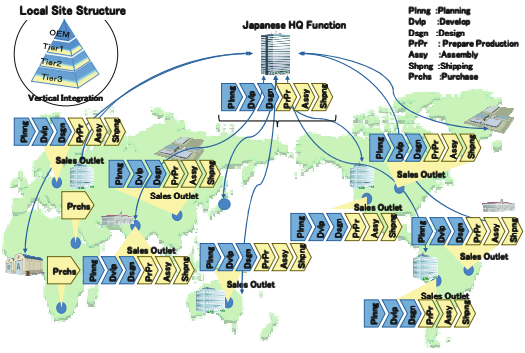

Fig. 11. Globalization Style of Automobile Industry

Hereafter, along with the development of the modular design of an automobile, global procurement of general-purpose products is carried out. For the PLM tool, a product of an open architecture having a higher degree of freedom increases the more importance in the product development of each company.

5.2 A Case of Electrical Precision Industry

Unlike the automobile, there is no pyramid structure of Tier; there is a horizontal specialization structure in which headquarters make procurement of general-purpose goods. The core functionality of development and manufacturing is located in Japan. Although production bases are deployed globally, the sourcing is concentrated in Japan headquarters. In that sense, in response to the globalization of product markets, production bases are located globally, planning and development functions does not moved, and each research site is placed in each market. (Fig.12).

In this case, PLM tool is a separate product for each part of each company. If necessary, assembly products manufacturer make design consideration by preparing data of the components for their own system. Feedback to the design of information from production preparation, procurement, and production is needed to be carried out direct and quickly to the headquarters. But the size of the spatial-temporal distance is increasing the difficulty of cooperation.

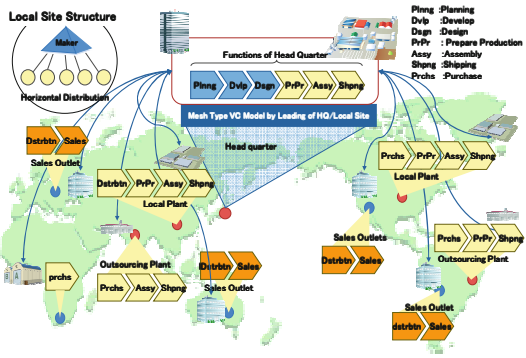

Fig. 12. Globalization Style of Elec./Prec. Industry

Future, since production bases movement, and speed up needs of procurement and production information F / B, the domestic production by returning to Japan is also considered. PLM system is required to have flexibility against such base movement.

Such as described above, electric precision industry and automotive industry place the mother plant in Japan, and has developed globally, while retaining the technology of the product development and grasping the local market needs. The direction of the comprehensive PLM system construction can be understood for carrying out product development to meet the market needs, in the two-way information cooperation of production site and development and taking advantage of the product development of Japan.

6 Conclusion

In this paper, for the sake of global expansion of Japanese industry, as a mechanism of information utilization to take advantage of the product development of Japan, a comprehensive PLM system based on a system architecture named as “Engineering Process Integrated Architecture(EPIA) is discussed by taking up the actual cases. The system, based on the integrated data base, consistently integrates the whole process of product planning, development and design, manufacturing preparation, production, purchasing, sales, service and maintenance. And also it enables the mutual cooperation of the information of PLM/SCM/CRM.

When the manufacturing industry of Japan performs the process reform to build a system based on this idea, it is possible to perform global deployment by leveraging the strengths of product development in Japan, drawing a line from the global expansion of Western industry.

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