International Journal of Industrial Engineering & Production Research

september 2012, Volume 23, Number 3
pp. 207-216

http://IJIEPR.iust.ac.ir/

ISSN: 2008-4889

Product Development in Production–Networks

Sujit Kumar Jha*

Sujit Kumar Jha, *Engineering Department, Ibra College of Technology, Ibra, Sultanate of Oman*

KEYWORDS

Product Development, Design, networks, Internet, data integration, Globalization and lead times

ABSTRACT

This paper presents an overview of new approaches in rapid product development in production networks from design points of view. The manufacturing industries are changing their focus to global sourcing as a means to improve performance and enhance competitiveness. Some partnerships created with this strategy improve product development through collaborative design. With the advent of e-Commerce, a new set of collaborative applications integrated to the firms' IT infrastructure allow a direct interaction between the firm and its suppliers, having an impact of negotiations. The globalization of the market necessitates the reduction of time-to-market, mainly due to shorter product life cycle. The computing and communication have become indispensable in every aspect of product development and design. The paper describes the network that directly links designer capabilities and with customers and manufacturing division. The networks focuses the three major forces that will affect the design community, namely, speed of decision, expansion of scope and degree of concurrency. Due to evolution of production networks, it has become possible to obtain the mass production within a key short time, using emerging technology that affect the speed and efficiency of product development using a pool of efficient designers and product managers.

© 2012 IUST Publication, IJIEPR, Vol. 23, No. 3, All Rights Reserved.

1. Introduction

Due to globalization, a new paradigm of product development has emerged whereby companies are utilizing skilled engineering teams dispersed around the world to develop products in a production network. The art of creativity, managing and controlling the product development depends on traditional trade-offs between four possible objectives in product development cycle: (1) development speed (2) product cost (3) performance of the product, and (4) expense on development program [1]. In today's competitive environment product development facing remarkable challenge due to frequent changes in technology, product variety and features according to the customer requirements. The change in technology calls for product modification and new development.

A business organization can thrive by reduction of "time to market" and "cost of designing and manufacturing" to have a cutting edge over the competitors. The high cost and long cycle time of development of products by traditional method can be overcome by development of the product on production networks**.** Organizations are under a pressure of improving quick responsiveness and

* **Corresponding author: Sujit Kumar Jha**
Email: *skj828 @gmail.com*
Paper first received Jan. 30, 2012, and in revised form May 21, 2012.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

effective utilization of technology and resources. The overall productivity improvement and cost reduction is the major objective of any business organization to remain in the market. Rapid development of right product at right time and at right cost emphasizes the evolution of the new concepts likewise virtual enterprise, rapid prototyping, rapid-manufacturing, supply chain management and design in production networks.

The selection of technologies to implement the product features has to be performed at an early stage of product development. Therefore, in the early phases of product development around 80% of the manufacturing costs of complex products are established. The constant advent of new technologies and new ways of configuring the systems require flexibility and fast cooperation during product development cycle. The design evaluation has to consider the system design capability to satisfy the customer needs as well as to reduce the cost.

The design and development of the products using networks extend the innovative capabilities of the firm. A reputed product maker relies on network of component suppliers and original design manufacturer (ODMs) to bring new product models to market and incorporates new technologies and features into those products. The industry is global, but product development and manufacturing are concentrated almost entirely in the U.S., Japan, Taiwan, China and India.

Product development in networks refers to cross-company cooperation, coordination, collaboration and sharing of tool, techniques, technology, team and information. The networks used for it go beyond customer-suppliers relationship. The main purpose of this network is the mutual use of resources and the joint planning of value added process [2].

The network used in this process provides intensive communication between the participating companies, exchanging detailed design data etc. Internet or Information Technology (IT) make a positive impact on productivity improvement, design works with customers and suppliers. The followings are most significant impacts of the internet to conceptual and engineering design:

i. ***Speed of Information:*** The use of internet in product development and design accelerate the exchange of requirements, information, drawings, data and test results which minimizes the Tim-to-market and inurn the cost of the product and reliability.

ii. ***Expansions of Scope:*** Internet breaks down the barriers among organization and that of time and geographical distances. Customers, suppliers, participating companies can participate in the product development process from anywhere in the world.

iii. ***Degree of Concurrency:*** Participants in the product development not only focused in design only but also share machines, technology, team and other resources at the same time. It eliminates the serial process and paves the way for simultaneous sharing of resources by different expertise and allows them to incorporate their instantaneous suggestions.

iv. ***Design Flexibility:*** Mutual Sharing of information and concepts among participating partners and ability of editing of digital data over network allows accommodating any proposed changes in the design and brings the design more flexible than conventional one.

1-1. Design and Development Process

The product development cycle for a product consists of three major phases: design, development and production. These phases take around a year or more for an entirely new product, and less for upgrades of existing product. According to the principles of Wheelwright and Clark [3], product makers have organized new product development into specific activities and outputs, with gates to pass before proceeding to the next phase. The production of a new product can be organized into two design phases, three development phases and two production phases as shown in figure1.

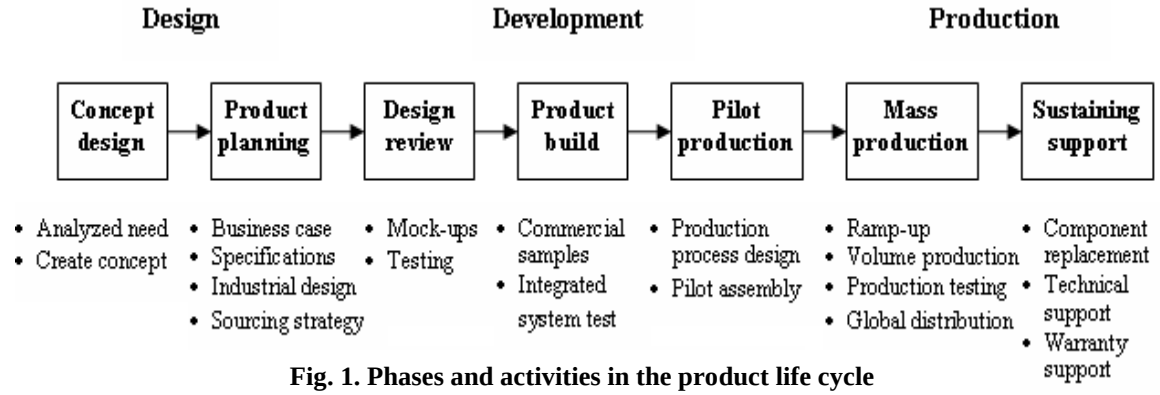

Fig. 1. Phases and activities in the product life cycle

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

Design Phases

During concept design on the based of market forecasts, technology roadmaps, and customer needs an effort is made to define a new product. Concept design is developed by a multidisciplinary team comprising from product marketing, market intelligence, industrial design and physical design disciplines. The output is usually a design requirement documents that identify the target market, desired features, industrial design language and resource required to develop the product. During planning phase, a planning team translates the market data, user requirements and product features into a business case for the product with estimates for costs, units, revenues and margins. The industrial design language is translated into mock-ups of the product through sketches and cardboard.

Development Phases

Design review is conducted to test whether the concept design can be built physically. The physical structure for the component is built from the industrial design with attention to mechanical issues. The gate for design review is a design verification test. The design review might result in new specifications for components, functionality, software and physical layouts because new technology becomes available or system integration problems require changes. In prototype build phase, all the components are assembled together into an integrated physical system and tested. This is when issues such as heat dissipation, power management, creep and fatigue are tested and the whole system is "stressed" under extreme operating-like conditions related to running time, vibration, shock. And pressure in test laboratories.

The prototype must pass reliability and quality criteria and the physical samples must meet criteria for fit and finish. Pilot production is the final product development phase involves preparation for mass production. The production process is designed and a pilot production line is set-up to produce around 500-1000 units that will enable a test of the process.

Production Phase

Mass production requires manufacturing engineers to plan and manage the production process and require test facilities and quality engineers to continually improve product and process quality. Sustaining support deals with changes that occur because of introduction of a new technology or methodology developed or improved products come to the market. The sustaining engineers also provide the highest level of technical support when problems occur during use over the product's 2-3 year warranty period.

The rest of the paper has been organized in the following manner. Section 2 presents a brief overview of production networks. Section 3 illustrates application of Information Technology in product development In section 4, the details of modes of networking have been described.. In section 5, the details of customers and suppliers participation have been described. Finally, this research concludes in section 6.

2. Production Network

Businesses are increasingly relying on production networks to support innovation and create competitive advantage. Production network means cooperation among partner companies to achieve a specific goal. Partner companies have capability to reconfigure themselves in this network [3]. The objective for production network is the mutual use of resources and combined planning of the value added process from product design to dispatch of the product to the end users.

The benefits of product development in production network includes greater engineering efficiency (by utilization of lower cost resources), access to technical expertise that is distributed internationally, design of product for more global market [2]. Designers within an organization can cooperate with other designers of the partner companies using the network.

Network among companies based on internet and intranet, wide area network (WAN) for the communication and transfer of design data and specifications. Production networks are global in scale, linking firms and individuals from around the world to create new knowledge and develop new products and services. This means an intensive flow of information between all participating partners in production network [4].

After globalization the development process has enabled a shift from in-house design and development to either outsourcing or joint development with ODMs. The competitive pressure to reduce costs, the growing capabilities of ODMs, and the perceived commoditization of products are the driving forces behind the shift to outsourcing.

The ODMs have developed specialized features in product design that only a few product makers can match or exceed. Some of the reputed product makers like Sony, Nokia, Ford and Maruti have used their internal design capabilities to differentiate their products and gain competitive advantage. There are three ways in which design and development are organized between product vendors and ODMs. First is in-house design, in which product maker uses its own design and development teams throughout the process. Second is joint design/development, in which the product maker develops product specifications, sometimes with, input from an ODM, then works with the ODM in the development, testing and production engineering processes. The third approach is when the ODM designs a generic product and the product maker simply selects the product off the shelf and sells it under its own name.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

The ODMs might prefer to design their own product and be able to sell to multiple customers, but this type of market is limited to smaller product makers who lack any design capabilities. ODMs are capable of architecture design, mechanical and electrical engineering, and component selection, but the product maker needs to protect its brand, product look and feel, and procurement leverage, which can be done by retaining industrial design, product management, high level architecture, and test monitoring.

2-1. Characteristics of Production Network

The production network is characterized by intensive communication between the participating companies even though they work on the same level of value adding. The intended duration of cooperation in a production network is larger than in a virtual enterprise, where partner's connection may break after completion of the project. In a production network partners cooperate over larger period since their integration is supported on the basis of the joint development of the product based on technological integration. Hence, it is more difficult and complicated for partners to withdraw. The traditional scope in design has been focused on direct mapping between the functional requirements to physical specifications of products [5].

On the other hand, the scope of design in production network is not only the development of the products but also include the business models that will sell the products and the enterprise process that serves the customer and provide customers with rewarding experiments.

The geographical location of new product development activities is influenced by the skill requirements associated with different stages of the process, the cost of those skills in different locations, and the benefits of having some activities located in close proximity to others. One effect of the need for proximity is that the shift of production to China is pulling that latter stages of development there, and may pull other processes as well.

2-2. Internal Coordination

The product and functional teams constitute the internal organization for features creation and deployment in ODM organizations. The product management team is the central coordinating structure across design, development and production. In matrix organization of design and development teams facilitates sharing of knowledge across development phases, engineering disciplines and product platforms. Product teams handle single products throughout the process, but coordinate with other product teams on things like selection of components to reduce procurement costs and simplify the task of supporting a number of product lines. Engineering teams coordinate across platforms and products on solutions to system integration issues.

Design teams meet with development engineers before, during and after handover, development teams meet with manufacturing engineers, and manufacturing teams meet with sustainability engineers. All product/process reviews are mechanisms for both formal and informal collaboration and information sharing.

2-3. Why Production Network

Over the past ten years, many industries have seen a rapid shift to global product development. In 2003 Deloitte Research Study of North American surveyed 48% of the companies have set up engineering operations outside of their home region. In fact 22% of the North American manufacturers already had located engineering functions in China. In 2005, Microsoft, Cisco and Intel each announced major investments in product development operations in India. There are two significant factors making viable a truly integrated distributed product development process. First, product design processes today are fully digital and completely networked. Second, many more business now have experience with global collaboration.

Throughout the 1980s and 1990s, many U.S., Western European and Japanese manufacturing companies located production operations in regions where labor cost much less than at home.

Most manufacturers today know how to collaborate across global supply chains and this experience applies directly to collaboration in production network [6, 7].

Companies are building their capabilities for any of four reasons:

1. **Lower cost:** There is a huge pool of engineering talent in low-cost regions such as China, India, Vietnam, etc.
2. **Improved Process:** Many engineering managers focused on co-locating development teams-particularly the design engineers with the manufacturing engineers – yielded both the cost benefit of design for manufacturing (DFM) and the agility benefit of time to market (TTM).
3. **Global Growth:** Due to dispersed engineering design team, companies can get access to critical information about markets in those regions.
4. **Technology Access:** Companies using production network to develop integrated product development process that include engineers in regions where critical new technology has been developed and where technical experts reside.

Table 1 illustrates the comparative study of product development in production network with traditional approach of product development.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

Tab. 1. Comparing the Product Development in production network with Conventional Approach

S. No.	Conventional Product Development	Product Development in Production Network
1	Mainly Focused on co-located teams	Globally distributed teams
2	Uses engineering technology located in the existing centers	Taking advantages of engineering technology in multiple geographic locations, including low, medium, and high-cost regions.
3	Uses a combination of digital product development tools and conventional paper-based processes for engineering.	Uses an entirely digital product development process to facilitate collaborative engineering.

Like software development companies, traditionally manufacturing industries like General Electric, Schneider Electric, General Motors, Hyundai Motor, Toyota and Siemens come into view on new development centers in China, India, Thailand, Mexico, Russia and other countries that have a plenty of engineering talent.

Hyundai Motor is an outstanding example, for doing most of its engineering work in Korea, but its product development work dispersed globally. The automaker has established operations in the United States for engine calibration and testing (Michigan), Vehicle Styling (Southern California) and high-temperature testing (California desert). Hyundai also operates research caters in Frankfurt (for diesel engine technology) and in Tokyo [8].

2-4. Selection of Partners

The selection of suitable partners is very important as all the partners get benefits from their participation in cooperation and each partner has an influence on decision within the network. Most important factors of the partners' selection are the analysis of their core competencies; their coherence with the network is strategy and the requirements.

Other criteria are their orientation towards customer satisfaction, their ability to communicate internally as well as externally, their flexibility and variability for adapting to changing environments their stability and reliability [9]. The joint development process is like a product makers' internal process. When using an ODM, a contract is executed with specifications, tests, timing and gates, and it becomes the framework for coordination. Vendors and ODMs agree that coordination is to be more formal and have formal meetings only 4-5 times over an 8-12 month design/development cycle. Usually one meeting occurs during design, whereas the others occur at the end of each stage of development. There may be many more face-to-face meeting between individual designers or engineers to work out specific problems. By being physically present of product managers, industrial designers, mechanical, electrical or software engineers any critical problems can be resolved much faster by joint effort.

Skill levels vary significantly in different locations. In the U.S., there are business skills such as market intelligence and product management. In Japan, there are industrial designers that are very good at designing for global market. In Taiwan mechanical and electrical engineers are available with strong hands-on experience. China has well-trained mechanical and electronic design engineers, but they are still developing the hands-on skills that come with experience. Relative costs vary greatly among the countries.

3. Application of Information Technology (IT)

Design, development and production occur in different geographical locations and information technology (IT) plays a key role in coordination. Communication may be synchronous and asynchronous forms, but the later is more frequent because of time differences. All forms of IT are used for coordination: fax, scanners, email, instant messaging, telephone, collaboration tools and design tools.

IT helps an organization to achieve a goal of meeting customer requirements better, quicker and cheaper. Customer participation in the product development and product realization has forced an enterprise to rethink about organizational structure and partnerships, and process. The product management databases are used throughout the design, development and early production phases, and passed on to the sustaining engineering team.

These databases contain documents, drawings, analyses and tests that are used on a daily and weekly basis throughout the process. They are the official record for confirming product specifications, engineering change requests, product review meetings and the stream of decisions that emerge from these activities. New product design must be done quickly in order to reach the market well ahead of the competitor. Application of IT in design phases has been described by [10] are:

a) **Architecture Support System:** Architecture design of the product, process and supply chain remains understanding and defining the problems and evaluating much different architectural alteration.

b) **Concurrency Enabler:** Provides an on-line multi media discussion, when a designer needs to

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

request and team approval to change a specification to resolve the problem. Changes in design automatically update relevant specifications and databases.

c) **Design Progress Monitor and Rescheduler:** Predict task completion times and predict bottlenecks. Initiate appropriate correcting action to avoid thesis slippages by rescheduling the tasks through automated negotiation with other teams. Recognizes design improvement opportunities feed back summary information and suggests potential redesign strategies.

d) **Overlapping Design Activity:** Process design need not be waiting for the completion of product design, and aspects of supply chain design such as identifying competent suppliers can begin well before product design is completed. Overlapping these stages reduces overall design time and provides feedback to prior stage. Overlapping incorporate automatic translation of CAD drawings to process plans and information integration across heterogeneous product, process and supply chain design system to reduce information transmission and avoid duplication.

Bal Krishnan has shown in figure 2 to identify the impact of IT in the product development to achieve the business goal of profit maximization, time compression and empowerment.

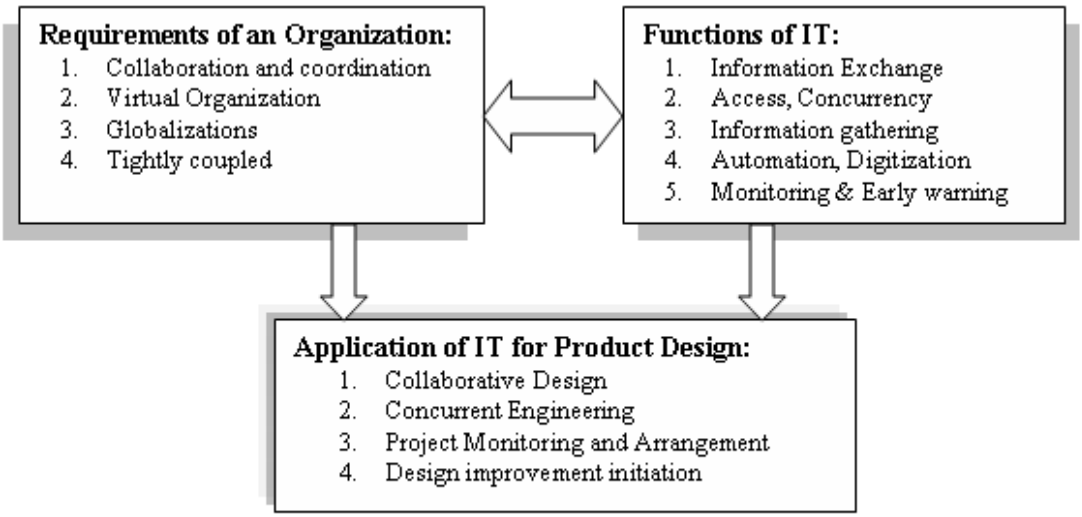

Fig. 2. Important of IT in product development

3-1. Internet Provides

- Global accessibility
- Remote Access to all Business
- Capacity & Resource planning integration between the factory floor and design center.
- Speed: time to market, product life cycles are significantly accelerated.
- Flexibility: implementing new technology shortens product life-cycle.

Many companies including automotive manufacturers developed comprehensive IT infrastructure for design of their specific products. Email is used on a daily basis both for messaging and for sharing files such as documents, open-issue lists, drawings, bill of materials, photographs, 3D images, etc. It includes digital model, which is used in design and production activities to reduce the lead time of product life cycle.

4. Modes of Networking

Networks and close cooperation among partners accelerates value adding process, adding innovative concepts, coherences among partners, team approach, creative and simulative ideas using the modern communication technologies like e-mail, voice mail, internet video conferencing, white boards etc. Before using the network, first design the network, develop the architecture of network on which it works, check the feasibility for fast communication of the network then coordination between participants are successfully executed. A central control of the network can be conducted by employees of companies or extended staff. The product development in the network is executed to reduce lead times considerable [11]. Product development in network using internet provides a collaborative process among designers, manufacturers and suppliers by breaking the restriction imposed by geographical locations [12]. For better satisfaction of the customers as well as designing new products, there must be a cohesive cooperation and active participation of customers and suppliers.

Cooperation in this context means the internal and external collaboration of all areas of know how

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

concerned with the product. The main goal of cooperation is to anticipate, collect, process and create information from all areas of activity throughout the product life-cycle [13].

The net partners may log into the server whenever they want and retrieve the information as shown in the figure 3.

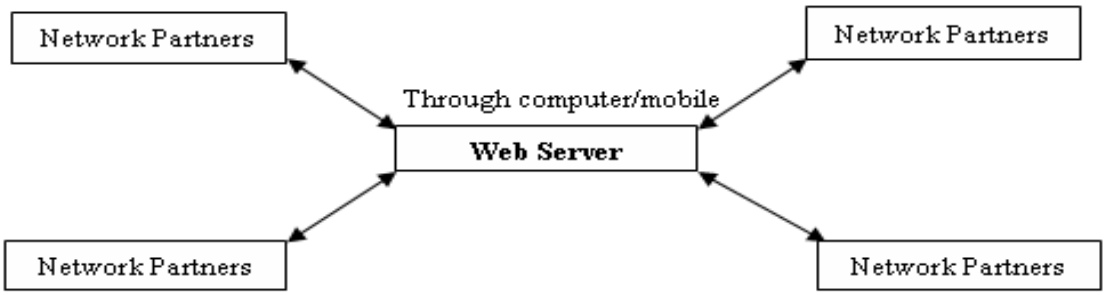

Fig. 3. Shows transfer of information among partners

Internet plays a vital role for the design of the product, where product information available on a server which can be accessed by network members involved in the development process.

Network partner's computer system can be plugged into that database and able to perform several activities like downloading the product specifications, modifications to the database [12]. Hence, using Internet or Intranet is very easy to provide detailed information about products to network partners, for this a central web server contains the relevant information is used. Extensible Mark-up Language (XML) documents is used across different platforms and application for data exchange. It is widely accepted international standard for all kinds of Internet-based applications.

4-1. New Challenges in Design

In distributed product development, a division of engineers for product development is likely to be as follows: concept design and product planning in the U.S. and Japan, applied R&D and development of new platforms in Taiwan, and all production and sustaining engineering in China. Now a day, manufacturing industries follows new product lifecycle as "sell, design, make and deliver" instead of traditionally "design, make and sell". In traditional methodology, product design is at the initial point of product life cycle, where little information about customer's behavior and requirements are available. Any modifications made during the stages manufacturing causes heavy cost, as most of products are getting late for delivery to the end users, due to more time taken to product development. In today's competitive environment, design in networks can overcome the occurrence of long time of product development.

Time is reduced in such a manner that, after selling the product (on the basis of catalogue) specifications of the product design sent on shop floor quickly for manufacturing the product. In network design, organization has changed his focus from product design to designing the products as well as systems which provides value added delivery and services to end users.

During early stage of design, integration between CAD and Finite Element Method (FEM) analysis has been done considering manufacturing constraints to evaluate manufacturability. The design is analyzed using the FEM. Finite Element Analysis (FEA) system is used in design stage to provide various functions like automatic (re)meshing, graphical user interface for user friendliness, automatic parameter setting and changing. Using FEA system, the design can validate the proposed design and modify the design by examining the predicted mechanical properties and features. In the early design stages, it is necessary to obtain a prototype to validate the basic concepts. After the choice of material and technology for manufacturing it is also important to validate this technological strategy. Then, functional part has to be manufactured and tested for its efficiency. Product development in production networks follows the following procedure as shown in figure 4.

4-2. Case Study for Manufacturing World Car Project

After globalization, some companies focused on global view where as other focused on local product development system. But they have some common tendencies such as platform integration, reduction of R&D cost and reduction of development lead time by effective and efficient co-ordination in the R&D activities. Ford is developing a new car "world car" strategy, where global product development teams use a single platform to design for sale internationally. In Japan, Honda has benefitted from its global strategy, especially in North America compared to other Japanese companies. Most of the product development leaders were located in the U.S. and a few were located in Europe and Asia. Product development leaders producing the products design in one region and sold it to the other regions.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

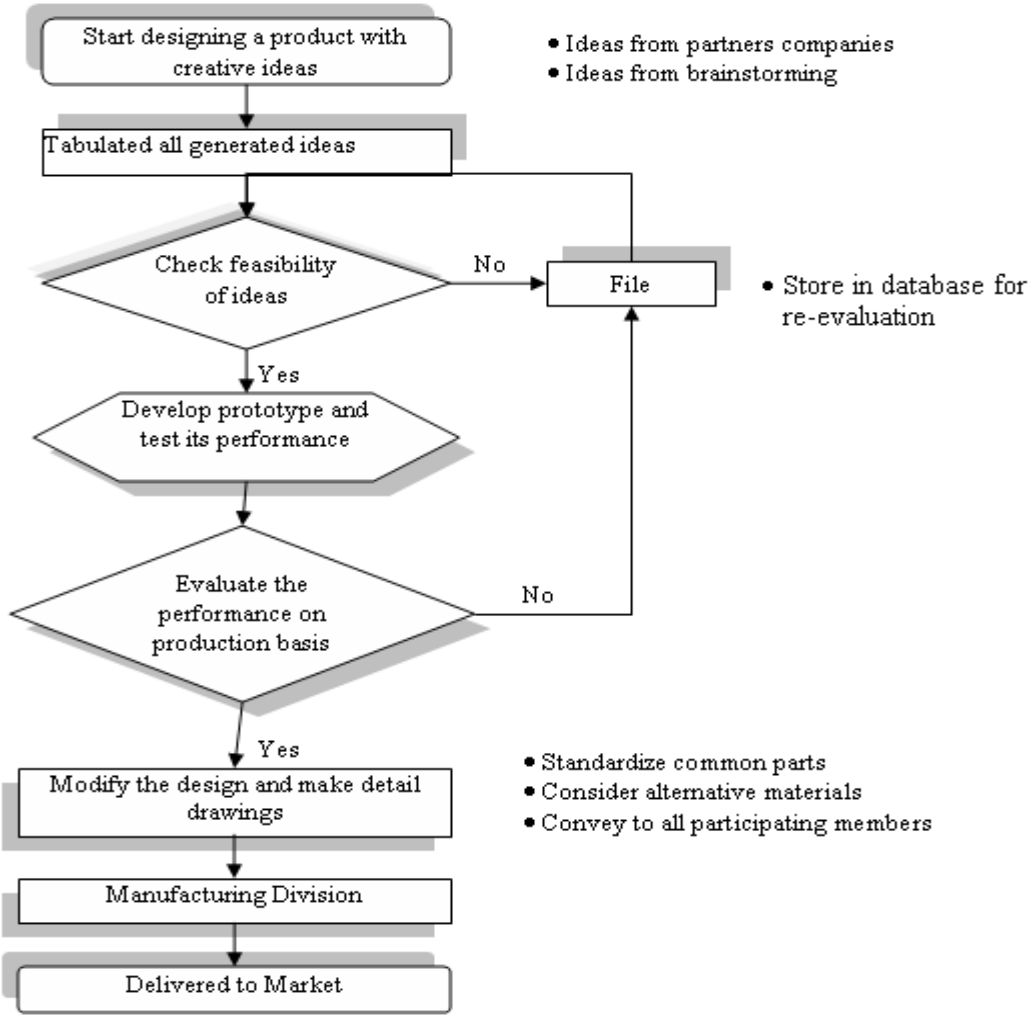

Fig. 4. Developing a new product – a systematic procedure

In early 1980s local production was appearing as a key of Japanese strategy. Instead of car, basic components such as the engine, transaxle, platform and so no were exported from Japan and assembled in each transplant. After 1985s, car categories would be available for either export or local production. Basic mass produced car were produced for local production and high priced luxury car exported to other countries. After 1990s, the globalizing R&D production, and parts procurement network, becomes more dominant as the new strategy to decrease car exports with increasing local production in the continuing restructuring of auto industry in Japan.

In North America, Japan's biggest car market and production base, Toyota, Nissan and Honda, enhanced their local contents ratio almost same as U.S. In North America Toyota uses its plant to produce Abaron. Honda is also expanding its plant capacity and operational ratio, with engine or assembly plants in Alliston, Ontario, Ohio and Anna. In the EU, Nissan is expanding more compare to other automakers. In U.S. their R&D system has developed further and launched Honda Accord, Toyota Camry, Toyota Abaron, Nissan Altima are exported to Japanese market, Europe or Latin America and other Asian countries. Japan – U.S. are moving towards increasing the number of overseas parts makers with whom they do business, while evaluating their capacities and the costs and quality of their products. From last five years, Japanese assemblers and suppliers are increasing investment in the ASEAN area, concentrated in Thailand, Malaysia, and Indonesia and after that Philippines and Taiwan. Japanese automakers are now going for communize the platform of low-priced world car and modify it to the needs of Asian Customers for example Toyota corolla, Honda Civic, and Nissan Sanny [14].

5. Customer and Suppliers Participation

An organization can survive in this global competitive environment by direct approach to the customers without going through the intermediaries,

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

which require a dramatic change in designing and manufacturing the products. Concurrent engineering works as parallel between design and manufacturing enable to eliminate the iterative processes and errors between two departments.

With the application of internet, suppliers, customers and even competitors the entire product life-cycle can be understood as a holistic product life-cycle, which originates from customers need identification to customers need fulfillment. In traditional way of product development the focus of technology were on Computer-aided "X" (CAX), where X being several stages of the process like CAE, CAD, CAM, CAPP etc. In the concurrent engineering approach to product development the technology focuses are on design-for "X" (DFX), where X being various product life cycle concerns like manufacturability, serviceability, etc. In networks design, the technology focuses has changed from DFX to DWX where W represent with and X is stakeholders.

Hence, designers must work collaboratively with all stakeholders via Internet.

In distributed manufacturing system with the emergence of e-manufacturing system, all professionals, plant and equipments become more computerized and Internet-ready.

Organizations are focus to improve their specialties to provide services competitive to customers anywhere around the world. Product developments in this environment provide robust design, shorten product life cycle, and transferred the design specification on shop floor quickly, which provide economical product to end users.

Collaborative deign is a team design over production network, which facilitates information sharing, improving decision capability, process sharing and resource sharing. Collaborative designs include the suppliers in production management, which reduce inventory level without compromising service levels. Customers needs have been considered as the initial point of any design methodology. Nowadays, customers before making a final purchase decision, compare the available options. The low switching cost and increasing customers bargaining capacity focus the enterprise to seek active participation of customers in design process. Customers' participation enhances the product quality [15] and the shortening of product development time to market.

6. Conclusions

In this paper, we have presented our vision of the production network to expand the traditional scopes of design from designing products to designing product as well as systems, which provide products and services. Furthermore, we expand roles of customers and suppliers in developing the product as a stakeholder. We reviewed the significant change of traditional design process from "design-make-sell" to that of "sell-make-design".

It is due the high cost and long cycle time of developing the product in traditional method, which is overcome on networks by reducing product development time by joint efforts of different networks partners. Product developments in networks generate a variety of new environments to design and manufacture products to fulfill customer needs.

Although much research has been done on the requirements for networkable businesses, there is still a lack of descriptions regarding production networks. It required intensified research on the operation of networks as well as how internal data of a company can be separated from network partners.

References

[1] Flemings, M.C., Proc. Japan-US Joint Seminar on *Solidification of Metals and Alloys*,1. 1977.

[2] Frayret, J.M., D'Amours, S., Montreuil, B., Cloutier, L., *"A Network Approach to Operate Agile Manufacturing Systems",* Intl. J. Production Economics 74: 2001, pp. 239 – 259.

[3] Wheelwright, Steven C., Kim, B., Clark, *"Revolutionizing Product Development: Quantum Leaps in Speed*", Efficiency, and Quality, New York: Free Press. 1992.

[4] Lutz, S., Wiendahl, H.P., *"Concept for Production-Management in Networks, in: Renchu Gan (Eds)":* Proc. Of 16th IFIP World Computer Congress, Beijing (China) , 2000, pp. 424 – 431.

[5] Suh, N.P., *"Axiomatic Design, Advances and Applications"*, Oxford University Press, US, 2001.

[6] Bajpai, N., Sachs, J., Arora, R., Khurana, H., *"Global Services Sourcing: Issues of Cost and Quality,"* CGSD working paper no. 16, The Earth Institute at Columbia University, Center on Globalization and Sustainable Development, New York, June 2004.

[7] *Mastering Complexity in Global Manufacturing: Powering Profits and Growth Through Value Chain Synchronization,"* Deloitte Research, 2003.

[8] Moenaert, R.K., Caeldries, F., Lievens, A., Wauters, E., *Communication Flows in International Product Innovation Teams*. Journal of Product Innovation Management, 17: 2000, pp. 360-377.

[9] Engelbrecht, A., *"Biokybernetische Modellierung Adaptive Unternehmensnetzwerke*", VDI-Verlag, Dusseldorf, 2001.

[10] Balakrishnan, A., Sounder, R.T.K., Sunderesan, S., *"e-Manufacturing: Exploiting IT in Design and Supply Chains, e-Business Research Center Working Paper*", http:/www.ebrc.psu.edu/. October 1999.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

[11] Bullinger, H.J., Cebulla, T., Potinecke, T., *"Kooperative, Virtuelle Produktentwicklung*", wt Werkstattstechnik 91/2: 2001, pp. 63 – 67.

[12] Cheng, K., Pan., Harrison, D., *"The Internet as a Tool with Application to agile Manufacturing: a Web-Based Engineering Approach and its Implementation Issues*", International Journal of Production Research 38/12: 2000, pp. 2743 – 2759.

[13] Tonshoff, H.K., Schmidt, B.C., Seidemann, H., *"Co-Operative Product Engineering (CPR) – A New Approach to Simultaneous Engineering"*, Proc. ICME, Capri. Italy, 2000.

[14] Abo Tetsuo, ed: Japanese Management, Production System and America, in Japanese, Mineruba shobou, 1994.

[15] Maropoulos, P.G., *"Digital Enterprise Technology – Defining Perspectives and Research Properties*", Proceedings of the 1st CIRP International Seminar on Digital Enterprise Technology, Durham, UK, 16-17 September 2002, pp. 3-12.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]