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Abstract: This paper discusses the organizational concepts for a successful implementation of concurrent engineering. It also present s a discussion about concurrent engineering application cases, as well as the new product development differences by using concurrent engineering and traditional methods.

Organizational Concepts of Concurrent Engineering

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Organizational Concepts of Concurrent Engineering

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Abstract

Concurrent Engineering is a concept that has been applied in Japan's industries for more than twenty years. However, this concept has not more than ten years in the U. S. At first , these ideas and principles have been embraced by large corporations. Nevertheless many smaller companies have been looking to adopt it into their design practices. The main topic of this paper is to discuss the organizational concepts for a successful implementation of concurrent engineering. Also presents a brief discussion about concurrent engineering application cases, as well as, the new product development differences by using concurrent engineering and traditional methods.

Contents

1.0 Introduction

Since World War II, the world has been shrinking. Advances in telecommunications have linked all parts of the world electronically and, to a lesser extent politically. Over the years a new economic infrastructure has also replaced the old one. As national companies serving primarily domestic markets expanded into the international marketplace, a global web of economic interconnectedness formed and is today dominant economic force shaping the American economic scene. The economy of the countries become fully integrated into a new and evolving global market [13].

Because more and more manufacturers are competing in global markets, engineers are under tremendous pressure to rapidly bring quality products to market on the fist try. This becomes more acute for near-term markets where rapid changes in consumer taste, style, and global technologies can make products obsolete in a very short period of time, even in their development stages. Companies could once take ample time to bring a product to market. Today, they cannot afford that luxury and, therefore, must abandon the time-consuming, iterative process of product design and manufacturing development in a sequential or serial mode [11].

The other factor forcing faster product development is simply the pace at which advances in technology drive new product introductions. For product incorporating solid-state electronics, the time spans within which new products can be successfully launched are growing shorter. Suppliers who fail to compress product development cycles will either miss opportunities or bring to market mere "me too". The reduction in the development cycle itself result in cost saving [17].

One of methodologies being touted as the key to survival for manufacturers is concurrent engineering. Concurrent Engineering is the systematic approach to integrated development of a product and its related processes, that emphasizes response to customer expectations and embodies team values of cooperation, trust, and sharing in such a manner that decision making proceeds with large intervals of parallel working by all life-cycle perspectives, synchronized by comparatively brief exchanges to produce consensus.

Concurrent engineering is a culture change for most organizations. Its thus has a big impact on the whole organization, but especially so on the designer. It is intended to cause designers, from the very beginning for a design activity to consider all elements of the product life cycle, from product concept through design, manufacture, service, disposal, quality, overall business costs, time to market and customer needs [16].

Shina's definition of concurrent engineering states that "Concurrent engineering is defined as the earliest possible integration of the overall company's knowledge, resources, and experience in design, development, marketing, manufacturing, and sales into creating successful new products with high quality and low cost , while meeting customer expectations." [18].

CE has many names which are synonyms:

- Simultaneous Engineering
- Parallel Engineering
- Integrated Product Development
- Design for Excellence

1.1 Sequential Engineering Practice

The traditional process of new product development can be seen in Figure 1. It starts out with market needs being identified. Once the market needs are understood the product specification is developed and engineering gets started in the design cycle. Next the product is defined, prototypes are made and the product is tested and modified depending on the test results. Once engineering is confident that it will pass testing without substantial change then manufacturing is brought into the picture. Manufacturing identifies the manufacturing process to be used, and the way in which the product will be tested. This normally results in some re-specification and redesign on the part of engineering. At this point additional prototypes are built and the complete cost estimate for the product is developed. The testing information and the product cost information are now reviewed to see if the cost objectives and functionality objectives are met. In many cases they are not and the cycle is partially repeated. Sometimes, over the period of the development cycle the market needs have changed, competitive products have been introduced, etc. These changes tend to be factored in at this point in the process oftentimes causing major redesign in the product. Thus, the historical process has many iterations of the design. A result, the initial business objectives of the product are often no achieved [24].

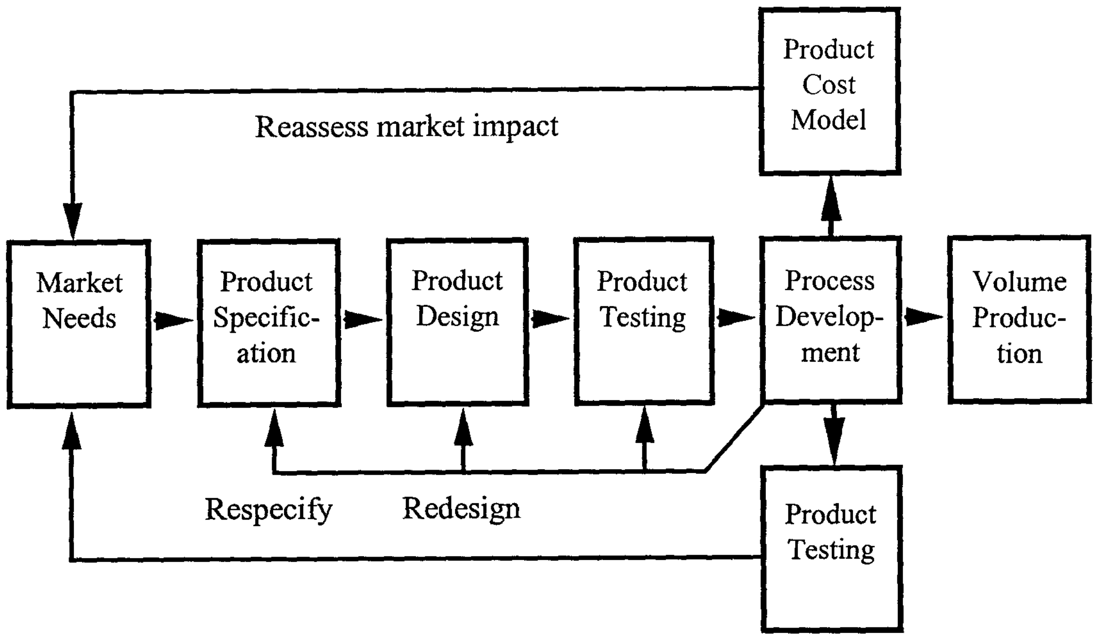

Figure 1: Traditional process of new product development

1.2 Concurrent Engineering Approach

One of the fundamental goals of concurrent engineering is to break down the barriers that exist between functional departments and to create interdisciplinary teams in order to facilitate communications. The major components of concurrent engineering are teamwork, communication, and an integrated design phase [11].

Concurrent engineering means asking each player from the organization to become part of the project right from the beginning. Here, each actor can at any time express his/her concerns, suggestions or constrains, and thus influence the development of the project in real time [6].

The development process using concurrent engineering is showed in Figure 2 [24]. Concurrent engineering is a methodology that brings together all relevant groups in the design phase, and their expertise is used in the initial design of the product. It promotes designing quality into the product, including customer requirements, manufacturability, reparability, maintenability, and supportability, prior to manufacturing rather than correcting problems during the production process. This reduce the number of iterations and increases the probability that quality is designed into the product. When implemented properly, concurrent engineering becomes synonymous with total quality management [11].

The concurrent engineering approach demands that more time is spent in defining the product than the linear process, planning too much more thorough in the early stages. In this way the majority of modifications are made at the design stage, well before prototype or production samples are produced. I might be expected that this would result in more time being needed to design the product. Far from it, it is in the later stages of conventional projects that most time is spent, as failures in prototypes, changes in engineer's thinking, or revised market projections make it necessary to redesign components. The more time spent in design phase is always less than when the changes are introduced in later stages [12].

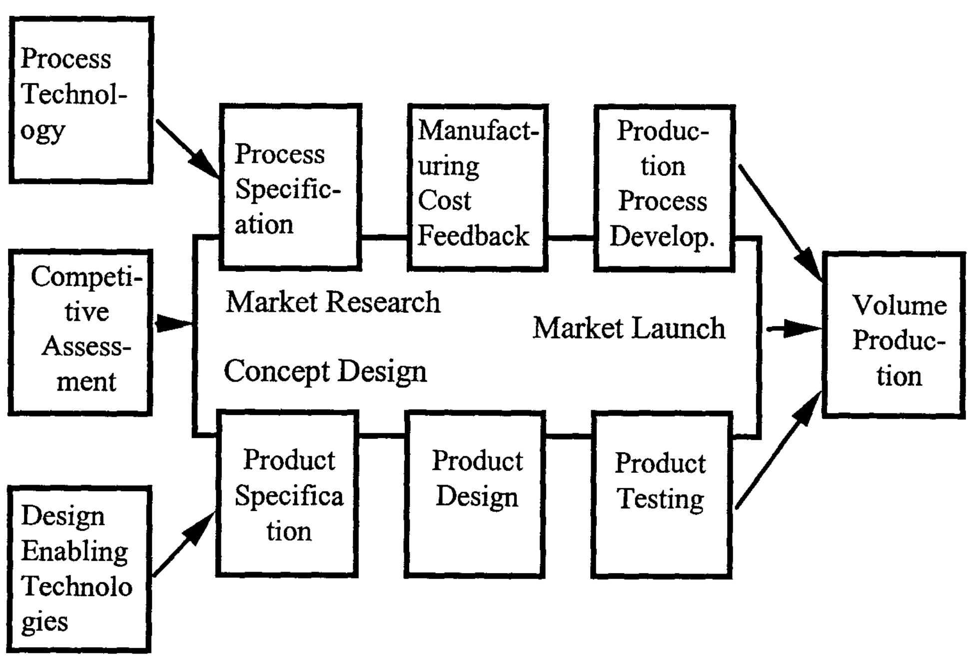

Figure 2: New product development process using concurrent engineering

2.0 Managing Concurrent Engineering: Organizational Aspects

Organizational aspects are key factors for a successful implementation of concurrent engineering. Lee (1992) suggests that to build the organizational aspects is important to take into account the next five critical components [18]:

1. The formation of a multi-functional team (or teams),
2. The adoption of innovative engineering and/or management techniques or methods,
3. The effective utilization of computer-based technologies,
4. The understanding of measurable and intangible goals stressing continuos improvements, and
5. The promotion of a supportive organizational environment.

2.1 The multi- functional team

The central concept of concurrent engineering is knowledge integration, therefore that people with different functional specialties must work together in a single team. Not is a team any group working together-committees, councils, and task forces are not necessarily teams. *"A team is a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable*". It is possible classify the groups of persons working together in both *teams* and *working groups*:

- A *working group's* performance is a function of what its members do as individuals.
- A *team's* performance includes both individual results and the called "collective work-products". A collective work product is what two or more members must work on together, such as interviews, surveys, or experiments. Table 1 shows the main differences between a team an a working group [15].

The technical community is typically not trained in academia to function as team members. Engineers are especially vulnerable to individual competition in undergraduate and even graduate level education. As a result, they can sometimes bring individualism into the workplace that disrupts common sense endeavor, such us concurrent engineering [30]. Therefore, to work effectively in concurrent engineering teams employees need team building, as well as training in soft skills like communication, conflict resolution and leadership [7].

2.1.1 Team Leader

The team leader is the person that chairs the meeting, manages the budget, and the project schedule, calls the team meeting, and holds the review meetings. This is management's contact with the product team. This person is chartered with resolving conflict, recruiting new members, developing the plans, organizing the team and coordinating the activities. The team leader, however, is not the boss of the team members. The leader does not have the sole responsibility for managing and facilitating all of the tasks. Each team member should play a part in both management and facilitation. The team leader is usually a member of engineering department [24].

Working Group	Team
☐ Strong, clearly focused leader	☒ Shared leaderships roles
☐ Individual accountability	☒ Individual and mutual accountability
☐ The group's purpose is the same as the broader organizational mission	☒ Specific team purpose that the team itself delivers
☐ Individual work products	☒ Collective work-products
☐ Runs efficient meetings	☒ Encourages open-ended discussion and active problem-solving meeting
☐ Measures its effectiveness indirectly by its influence on others (e.g. financial performance of the business)	☒ Measures performance directly by assessing collective work-products
☐ Discusses, decides, and delegates	☒ Discuses, decides, and does real work together

Table 1: Differences between a working group and a team [15]

2.1.2 Boundaries

If the new product teams are be able to fulfill their promise of shortening the product development cycle, they must develop the ability to obtain information and resources from diverse sources both inside and outside the organization. In addition to simply collecting information from diverse sources, team must also interact with others in the organization to negotiate delivery deadlines, coordinate or synchronize work flow, obtain support from upper levels of management, and smoothly transfer the "ownership" of the new product to manufacturing, marketing, and other groups. Boundary management is the process by which teams manage their interactions with other parts of the organization. Boundary management not only refers to communication or interactions that the team initiate but also to how the team responds to input from others [1].

Ancona and Caldwell found that the boundary management activities must differ across the product development cycle if the new product team is to be successful. They divided the development process into three phases: *creation, development* and *diffusion.*

The first phase, *creation*, is the early period of the product development cycle when the product idea is being formulated and the team organized. It is a time when the team consider technical possibilities, integrate marketing data into technical considerations, and development support for the product within the organization. During this time it in successful teams is observed: 1) high levels of team's protective attitudes from interference (called ambassador by the author), 2) the communications are laterally rather than up the organization (task coordinator), and 3) the team members go out from the team to bring back information about what is going on elsewhere in the organization (scout).

During the second phase, *development*, the high levels of ambassador and scout activities seen during the creation phase are reduced. Task coordination remains a dominant activity for these phase.

A change of boundary activities take place again during the third phase, *diffusion*. This phase encompass the transfer of new product from the team to other group in the organization, particularly sales, marketing and manufacturing. Here teams need to convince manufacturing that their product should take priority, and they must get marketing to have the documentation on time [1].

2.1.3 Physical Proximity

In many ways, organizations can be described as physical entities. They have offices, buildings and some degree of dispersion or concentration. These characteristics make up the physical structure of the organization. Physical structure can be defined as "the architectural design and physical placement of furnishing in a building that influence or regulate social interaction". Physical structure can influence the type of interactions, exchanges and communications that occur within and among groups in an organization. Pinto et al had demonstrated that the physical proximity (in feet) is a very important variable of successful in team working [21].

2.2 Adoption of Innovative Engineering Management Techniques

In most organizations, the multi-functional team work is a radical departure from the traditional way of conducting daily engineering activities. Diverse engineering techniques and innovative management practices have been reported in the literature for promoting concurrent engineering efforts. These include new design approaches such as Design for Manufacturing or Assembly and Quality management approaches such as Quality Function Deployment and Taguchi Methods [18].

2.2.1 Quality Function Deployment

An organization's motivations are very similar to an individual's motivations. This analogy between individuals and organizations is quite natural, since organizations are made up individuals. The individuals seek first to cover basic needs (survive), then the security aspect, and once do it they try to expand them. Figure 3 shows schematically the individual or organizational motivation: Increased ability to survive leads to increased security. Once an individual or an organization is secure, the possibility of expansion present itself. As the organization expand, survival becomes more certain.

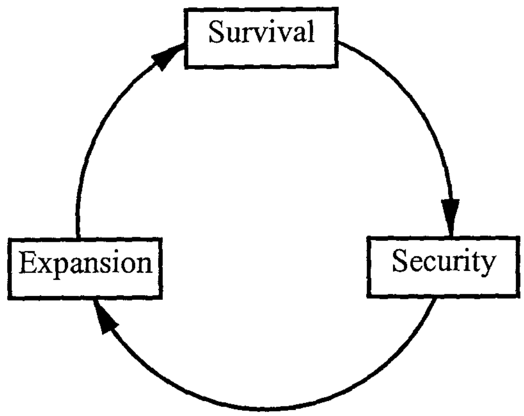

Figure 3: Organizational motivation

QFD can play an important role in helping organizations become stronger, and therefore more likely to survive, more secure, and more able to expand. QFD contribute:

- to decrease costs,
- to increase revenues,
- cycle time reduction, and
- to improve communications [3].

In QFD, the unstructured ideas come from the "words of the customers". It is possible to get these "word" by speaking with the customers in person or by phone, or by conducting surveys, or by recalling our personal experiences with customers, accumulated over the time. QFD allows us to relate our design decisions to the needs of the customers, originally expressed in the customer's own words, to the greatest extent possible [4].

The House of Quality is the central construct of QFD. It is a very complex matrix in sense consist of several matrices attached to each other. This matrix encompass different components (see Figure 4). The matrix should be filled the according to the next steps [3, 4]:

- ✓ *Step 1- Customer needs*: normally based on the "voice of the customers", and develop with the Affinity Diagram and Tree diagram.
- ✓ *Step 2- Planning matrix*: for recording the assessment of a variety of factors that combine to rank-order customer needs.
- ✓ *Step 3- Technical responses*: normally based on the designer's knowledge of the product and structured using the Affinity Diagram and Tree Diagram methods. These are tools to building an hierarchical structure from a set of unstructured ideas.
- ✓ *Step 4 - Correlation between customer needs and product features*: For each cell in this section, the team enters a value that reflects the extent to which the Substitutive Quality Characteristics contribute to meeting the customers need.
- ✓ *Step 5- Benchmarking*: It is a continuous process of measuring the product against the toughest competitors or those companies recognized as industry leaders [23].
- ✓ *Step 6- Technical Targets*: This is what technology we will use in the product.
- ✓ *Step 7- Technical correlation*: Each cell is related to a pair of product features of functions, identified by features at the end of the diagonal row and column that intersect at the cell.

The House of Quality matrix acts as a repository of marketing and product planning information. The key input to the matrix are customer wants and needs, product strategy information, and quality characteristics. Other information that can be placed in the matrix is product benchmarking and target values.

2.2.2 Design for "X"

Customer needs and product specifications are useful for guiding the concept phase of product development; however, during the later development activities teams often have difficulty linking needs and specifications to the specific design issues they face. For this reason, many teams practice "design for X" [27]. Design for "X" is an approach to design products and processes for cost-effective, high-quality downstream operations from manufacture (including fabrication, assembly, and test) through end-customer usage [8]. "X" correspond to about one dozen of quality criteria, such as reliability, robustness, serviceability, environmental impact, manufacturability and assembling, soldering (for electronics industry), etc. [28, 8].

The most popular "X" is Manufacturing and Assembling.

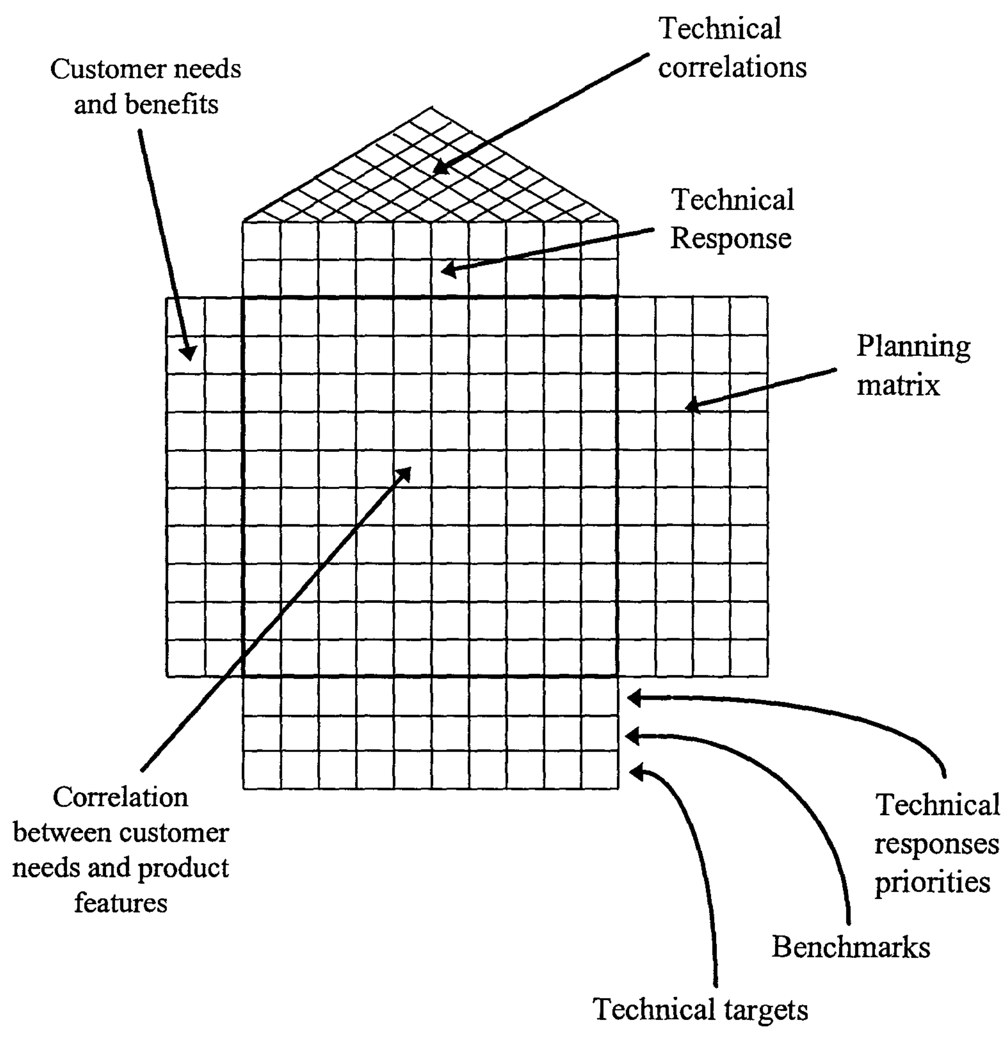

Figure 4: The QFD House of Quality

2.2.2.1 Design for Manufacturing and Assembling

Manufacturability is the measure of a design's ability to consistently satisfy product goals while being profitable. Product goals can be broken down into several categories: technical, performance, quality, reliability, availability, and cost. Traditionally, design engineers have focused on the technical performance of products and not on other manufacturability considerations. The use of design guidelines for manufacturability can change this focus and permit significant product improvements [10].

Design for manufacturability (DFM) has other names, including design for assembly, design for automation, design for robotics, and design for production. Regardless the terms used, the objective of DFM is to design a product so that it can be produced in an extremely efficient manner at the highest levels of quality [22]. DFM process aims at optimization of product and process concepts during the design phase of a product in order to ensure ease of manufacture. The optimization is followed by product features to process compatibility. Product simplification is achieved through design of components for ease of assembly and handling to facilitate ease of manufacture, improved quality, and reduced manufacturing cost [28].

A study of British Aerospace conclude that 85 percent of a product's manufacturing cost is determined in the early stages of design. Experts estimate that a similar percentage of a product's quality is also determined early in its design. Because excellent production cannot usually compensate for poor design, a company must have well-designed products before it can attain competitive manufacturing cost, quality, and market responsiveness. Although each company interested in achieving manufacturable designs must develop its own specific design characteristics, the following rules can be applied at several products [29]:

- Reduce the number of parts
- Make assembly foolproof
- Simplify assembly process
- Make product easy to test
- Use common components across product families
- Avoid excessively tight tolerances

- Use modular product options
- Concurrent product and process development
- Early management involvement

Activity-based costing (ABC) is a very powerful tool that can be used to drive the DFM process [20]. ABC is an accounting system that assigns costs to products based on the resources they consume. The costs of all activities are traced to the product for which they are performed. Overhead costs are also traced to a particular product rather than spread arbitrarily across all product lines. The true cost of a product can be determined with much more fidelity than was previously available with a traditional accounting system. An ABC system gives visibility to how effectively resources are being used and how all activities contribute to the cost of a product activity [5].

2.2.3 Taguchi's Robust Design Approach

The Robust Design approach is a powerful approach with its own terminology. Taguchi views design as a system, with *inputs, outputs, control factors* and *noise factors* (see Figure 5). The goal of Robust Design is to use the control factors so that the noise factors do no change the response (or output). Control factors are defined as those factors which the designer can control and use to obtain the desired output. Noise factors are those which are not wanted and are not easily controllable. The noise factors can change the output. Some examples of the noise factors are the operating environment, the manufacturing process variations and material variations [24].

Another term used by Taguchi is the notion of Quality Loss. This is considered any deviation from the desired output. It can include losses to manufacturing, to the user of the product and to society in general. Under Taguchi's principles the idea is to minimize quality loss and in this way minimize the total cost [24]. He defined the quality of a product as "the loss imparted by the product to the society from the time the product is shipped". In other words, any requirement for maintenance, or any fault that either inconveniences the user or requires rectification reduce the quality of the product. The ideal product would be one that never required any attention, continued to perform adequately when worn, and was recycled when completely worn out [12].

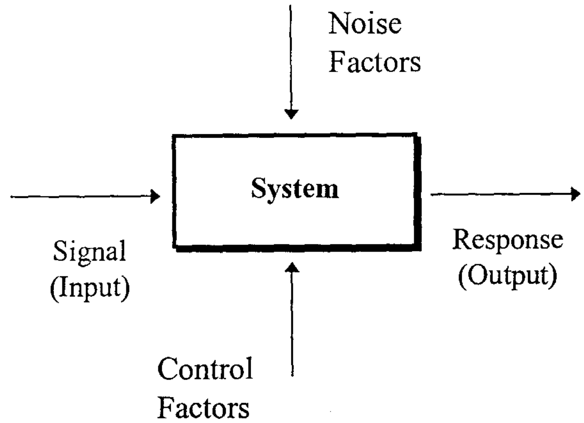

Figure 5: Taguchi's Terms

2.3 Role of Computer-Based Technologies

2.3.1 CAD/CAM

To maximize the benefits of concurrent engineering, the current trend toward increased computer-aided design and manufacturing (CAD/CAM) must be exploited. With the right combination of hardware and software, design and stress engineers can work in parallel, far fewer prototypes need to be built and lead times can be cut dramatically. Even without an integrated system, the use of CAD allows manufacturing engineers and the suppliers of machines and components to see the real product, whether it is still at the concept stage or is a finalized design. Without CAD, there is too much margin for error, virtually every two-dimensional paper drawing leaves the person studying it some areas for interpretation, especially where compound curves are involved. With a three-dimensional computerized image, the dimensions of the product are complete [12].

Computer-aided design (CAD) can be defined as the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. The computer systems consist of the hardware and software to perform the specialized design functions required by the particular user firm. Computer-aided manufacturing (CAM) can be defined as the use of computer systems to plan, manage, and control the operations of a manufacturing plant, through, either direct of indirect computer interface with the plant's production resources. As indicated by the definition, the applications of computer-aided manufacturing fall into two broad categories [9].

1. *Computer monitoring and control.* These are the direct applications in which the computer is connected directly to the manufacturing process for the purpose of monitoring or controlling the process.

2. *Manufacturing support applications.* These are the indirect applications in which the computer is used in support of the production operations in the plant, but there is no direct interface between the computer and the manufacturing process.

2.3.2 Simulation

Because of concurrent engineering emphasize the design process, simulation become in powerful tools to validate the design before prototyping. Use of the right types of simulation products early and often during the course of a design can significantly lower unit costs, provide reduced time to market due to reduced prototyping, improve product quality and minimize risks associated with the introduction of new technologies. Accurate simulation enables designers to evaluate each new piece of the design and each change, early enough to minimize negative impacts on other areas of the design. There are tree crucial requirements that must be addressed to allow simulation to become an effective alternative to prototyping throughout the product development cycle. Simulation tolls must be: accurate, easy to use by non-experts, and efficient enough to communicate information among the design and manufacturing groups involved in the production process [25].

2.3.3 Common Data Base

A common data base should be available to all departments in the form that they require, and for automated processing of these data as required. The data should be available as:

- design data for product engineering and component suppliers,
- functional design specifications for specialist suppliers,
- manufacturing data for manufacturing engineers,

- full specifications for cost analysis, and
- specifications in product terms for marketing [12].

2.4 Understanding of Measurable and Intangible Goals

Researches on implementation of technological innovations has found that projects that have set specific and challenging goals tend to be more successful than projects that do not have motivating goals [18].

The best teams translate their common purpose into specific performance goals. If a team fails to establish specific performance goals or if those goals do not relate directly to the team's overall purpose, team members become confused, and revert to mediocre performance. By contrast, when purpose and goals build on one another and are combined with team commitment, they become a powerful engine of performance. Specific team performance goals are helpful for several reasons [15]:

- facilitate clear communication and constructive conflict within the team,
- help teams maintain their focus on getting results,
- allow a team to achieve small wins as it pursues its broader purpose.

Pinto et al demonstrated that superordinate goals are useful to solve conflicts in the team and they are an important predictor of cross-functional cooperation. A superordinate goal refer to "goals that are urgent and compelling for all groups involved but whose attainment requires the resources and efforts of more than one group" [21].

The true test of success for concurrent engineering is the evolution of an integrated knowledge base that would take a holistic view of the product development process, hence allowing its team members to learn and improve continuously [18].

2.5 Role of a Supportive Organizational Environment

A concurrent engineering team does not operate in a vacuum but must function within an organizational environment. The top management support is a requisite for implementing concurrent engineering. However, top management support alone is not enough without also changing the reward structure, measurement system, and eventually the career path options of the organization [18].

Honeywell discovered the importance of recognition and support for its teams. The philosophy of this company is each team must feel that possesses decision-making power. If the company evisions a sizeable project that has the potential to be a tradition-breaker, upper management assigns a senior executive to be the champion of the team. This person attends occasionally team meetings to assure the team members that they have company support. The company always recognizes major milestones in a project by sponsoring dinners, awarding plaques, and expressing recognition in other ways. This practice motivate team members toward continued diligence in pursuit of the project goals [2].

The successful implementation of concurrent engineering will require the breakdown of its old functional structure, the restructuring of management control and authority from top executives to line and support staff, the design of new performance measurement systems, and the availability of new career advancement path in the organization [18].

3.0 Cases of Concurrent Engineering Application

During the late of 1980's and early 1990's, US companies began to migrate to concurrent engineering as a product development process methodology. Most were driven to the change because of the time to market pressure and the necessity of higher quality products. Many companies have reported between 30% to 70% reductions in total development time as a result of this conversion [24]. Automobile industry - Chrysler, Ford, General Motors- were the first companies that adopted this method to face the Japanese competency. The next were the electronic companies- Intel, Texas Instrument- and then aerospace firms such as Northrop and Boeing. However, concurrent engineering is not only a big-company's concept but it is applied also in small corporations [19].

In the mid-1980s Cadillac position, which had the number-one luxury car distinction for more than 40 consecutive years, was in jeopardy. In response to a pending fuel crisis, Cadillac ad designed a new product lineup. The public's response to this lineup was less positive than anticipated and Cadillac's market began to decline. To revert the situation Cadillac needed to design and produce new vehicles that would recapture the Cadillac image and accomplish this in less than the normal time required for product development. To achieve this turnaround Cadilliac applied concurrent engineering. The new methodology permitted a time reduction in the development - from 80 to 55 months, as well as, a high level of customer satisfaction [14].

However, the benefit achieved by the car industry is not only the development time reduction but also profits in operations. Such as the case of GM power train division which could make significant gains due to the better design of an automatic transmission for GM truck. With this changes, GM:

- reduced material cost by 50 percent
- reduce scrap by 60 percent
- reduce the number of tools required in machining by 30 percent

This is typical of the gains that can be made, and shows how North Americans are regaining their ability to cut costs and introduce models as quickly as the Japanese [12].

Boeing applies concurrent engineering to develop the 777 aircraft incorporating new technologies such as lightweight materials and digital avionics. This design makes the operating costs 25% less than 747 family. Boeing faced significant product cost challenges on the 777 project due to stiff competition from Airbus and the deregulation of the airlines industry. To produce a high quality design, the Boeing new product development process encouraged cross-functional integration and communication. Communication was a priority not only between internal groups, but also with customers and suppliers. Representatives from the first four major airlines to purchase the 777 participate as members of the development team. In addition Boeing's teams included representatives from many of the project's approximately 100 major suppliers. Boeing also made a major investment in computerized design tools to help its designers produce high quality designs. The 777 was designed entirely using three-dimensional digital technology. A common data base allowed 777 designers around the world to access up-to-date designs for any of the 700,000 numbered parts in the aircraft. The design system included 1700 computer workstations in Seattle, more than 500 elsewhere in the US, and 220 in Japan [26].

In general the literature mention successful cases of concurrent engineering implementation. However, for some companies concurrent engineering has been a traumatic experience. A good example is the Hatch Company which had difficulties converting its old method of new product development into one by applying concurrent engineering [31].

In South America the industrialized countries have had closed economies for a long time, therefore the companies did not compete. World globalization economy put most industries in jeopardy. Argentina is a good example, of what happened when economy rules changes without transitions. For more than 30 years Argentinean industries enjoyed market protection by high importation taxes. At the beginning of 1990, the economical model changed, and many industries -except multinational companies- went bankrupt. In past decades, the products cycle time in the market was long, therefore the companies had not need to apply time reduction and costs methods. The new product development process was totally liner. Today, the companies are changing their cultures toward the team work, which is, the first step in the direction of concurrent engineering. This was mainly caused by some companies' need improving their quality by applying Total Quality Management concepts and ISO 9000 rules.

The team work approach has changed the criteria of personnel selection. Ten years ago, an employee was selected taking into account the personal curricula and the university grades. However, at present, the person's capacity of work in a team is the most important characteristic.

4.0 Conclusions

Concurrent engineering is defined by literature as a method. But it can be better called "a process" because it is a cultural change for most organizations. One of the key success factors is the team work, which in most cases, the companies have not a culture around it.

The decision to shift to concurrent engineering in almost all companies is based on the urgency to reduce the development cycle time, reduce costs and improve quality. But in most cases, the companies are not prepared to implement it. Difficulties for implementation of concurrent engineering depend on the culture of the company. Some of them have been working with team approach for a long time. However, there are a large number of companies that have individualistic work methods which are difficult to change.

Japanese companies have a long culture of team work. Therefore, concurrent engineering in this country has been successfully applied.

Concurrent engineering is a preventive method instead of reactive one that provides better communication between engineering specialists. This is involving experts in all phases of the product's life-cycle in the design phase. This assures feedback that can be given as early as possible during design.

The heart of concurrent engineering is teamwork. The closer company is from this it , the easier will be the implementation of concurrent engineering.

Although team work is the main requisite to successfully implement concurrent engineering, several tools have to be applied to facilitate the process. Concurrent Engineering increases the system complexity because the new product development is shared by different people or teams. Thus, auxiliary methods of documentation must be used to guarantee the availability of information by all members of the team or teams.

To maximize the benefits of concurrent engineering , the current trend toward increased computed-aided design and manufacturing must be exploited. Concurrent engineering is wasted without this methods.

In the United States concurrent engineering has been applying for ten years or more. In other countries, like South America these concepts have begun to awake.

Finally, the companies choose concurrent engineering because is the only way to survive in a competitive world. If they want to give customers products with high quality levels and a competitive price, the best way is optimizing the use of resources. Concurrent engineering provide the way to do it.

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