Concurrent Engineering: An Integrated Approach for Product Life Cycle Design

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ABSTRACT

This paper discusses the definition of concurrent engineering as a systematic integrated approach for the development of products using life cycle concept. Concurrent engineering incorporates the various elements of product life cycle like manufacturability, assemblability, testability, serviceability, reliability, quality, cost, disposability, etc. during the product development phase. Need, principles and benefits of concurrent engineering have also been emphasized in this paper.

Key words: Concurrent Engineering, Product life cycle

1. Introduction

The term Concurrent Engineering (CE), also called simultaneous engineering was coined in the US in 1989. It means a way of work where the various engineering activities in the product development, production process development and field support development are integrated and performed as much as possible in parallel rather than in sequence (Soblenius 1992).

Concurrent Engineering is a systematic/management technique used for product development, which provides an integrated approach to the design of products and their related processes from concept to disposal. The various elements of product life cycle like manufacturability, assemblability, testability, serviceability, reliability, quality, cost, disposability, user requirements etc. are incorporated during the product design and development phase. Integration is usually accomplished through computerized technical tools and cross-functional teams consisting internal (e.g. manufacturing, assembly, R&D, Service, process planning) and external (e.g. customers, suppliers) members. The basic CE has two elements: improved process and closer cooperation. The improved process provides greater clarity to the activities and focus on: concurrent process, quality, cost & delivery (QCD), customer satisfaction and competitive benchmarking. The closer cooperation, which facilitates better communication and provides unity to the cross functional team focus on: integrating organization (multifunctional team) and strategic relationship with suppliers. Concurrent engineering helps to produce quickly better and cheaper products (Loureiro and Leaney 2003).

2. Sequential versus Concurrent Engineering

Traditionally, the marketing department of an organization identifies the need of a product, expected performance and the viable price range from the potential consumers/ customers. This department passes these loose specifications to the design department that works on these specifications to develop technical requirements (e.g. material/size, shape etc.) and detailed design. During the design no consideration was given to the available manufacturing facilities or techniques, the way product will be assembled, the serviceability methods once the product is in the field or the effect on environment etc. In other words the design department makes a design, which is usually best from the viewpoint of design department only. This design is passed to the manufacturing department to develop the manufacturing processes necessary to produce the design. If any changes or corrections (which are usual) are required then the design is passed back to the designers for necessary modifications or corrections. Only when the manufacturing department is fully satisfied with the design, it passes the design to next department in the progression as shown in the figure 1. This traditional sequential approach to the product design which is also known by the name of over the wall engineering encourages a large number of modifications and corrections in the later stages, when it is more expensive and difficult to do so and increases the product development lead time that organizations can not afford these days because of the prevailing market conditions as explained later in this section.
Fig. 1: Schematic figure showing sequential and concurrent process techniques

In CE, once the needs of the customers are identified, a multi-functional team is formed that will consider all the aspects of the product life-cycle like manufacturability, assemblability, testability, reliability, serviceability, cost, user requirements, disposability etc. at the time of the design itself. There is a close integration between the various departments during the design leading to a design that requires hardly any correction or modification. This way the product can be brought to the market quickly at a low cost and with an improved quality.

The traditional approach emphasizes specialized excellence, often at the expense of overall success. Inward looking technical specialists can be overwhelming competent at a specialized conference but the results in a product development program usually lack integration and often focuses on sub optimal objectives. Individual brilliant results are of little value if they do not lead to the overall optimal solution. Take an analogy. The Indian cricket team has many star players but India keep on losing most of the games. Why? The answer to most of us is simple: lack of game plan and teamwork. The same metaphor is true in product development also. Even if an organization has brilliant individual specialists, the result will be poor unless the organization has an improved process (better game plan) and closer cooperation (team work) i.e. concurrent engineering. Main characteristics of sequential engineering and concurrent engineering are shown in table 1 and table 2 respectively.

Table 1: Sequential Engineering Characteristics

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Sequential activities increase development cycle time thereby increasing time to market and consequential losses</td>
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<tr>
<td>2.</td>
<td>Weak commitment to previous decision</td>
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<td>3.</td>
<td>Design specifications (PDS) considered in isolation</td>
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<tr>
<td>4.</td>
<td>Divergent interpretation of the specifications</td>
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<td>5.</td>
<td>Redundant and obsolescent information</td>
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<td>6.</td>
<td>Authoritative management</td>
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<td>7.</td>
<td>Ineffective communication</td>
</tr>
<tr>
<td>8.</td>
<td>Focus on intermediate intestines</td>
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<td>9.</td>
<td>“Crisis management” style</td>
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<tr>
<td>10.</td>
<td>Wasted resources in making changes, firefighting etc.</td>
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<tr>
<td>11.</td>
<td>No role of customer and specialist vendors in product development</td>
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</table>
3. Need of Concurrent Engineering

There are many reasons that have influenced the need of CE, like: saving in lead-time, technology push, demanding customers and increased competition (Sangwan 2001).

**Lead-Time:** One of the prime motivations for concurrent engineering approach is the desire to decrease or shorten the product development time or lead-time or in other words developing the products faster (Duffy and Salvendy 1999). It is fully recognized that addressing all the problems of product life cycle in the design phase shortens the product lead-time. These days, for some products, average product lifetime is less than the average product development time. Therefore, for a company to survive and remain competitive, it has to decrease the product development time maintaining the high quality and low cost.

**Technology Push:** Newer technologies are being developed continuously. These newer technologies may bring down the costs, production time and even may improve the quality. But, such knowledge is often with the production engineer and not the design engineer. Therefore, to make the optimum use of newer manufacturing methods, close cooperation between design, production, and R&D departments is essential.

**Demanding Customers:** These days, customers are becoming increasingly more demanding. Low costs and good quality they take for granted and then they demand products, which are more closely targeted to their needs. Companies, hence, have to be not only effective but also innovative too to fulfill the demand of customized products.

**Increased Competition:** With the opening of the global markets, the competition has increased manifolds. To survive in the market an organization has to develop and introduce innovative products well ahead of the competitors. Any delay in the introduction of the product in time causes losses to the profits of the organization. Carter and Baker (1992), introduced a simple method to measure the impact of delay in launching a product:

\[
\text{Losses in profit} = \frac{d(3w-d)}{2w^2}, \text{ where}
\]

- \(d\): delay in product launch
- \(2w\): product life cycle as shown in the figure 2

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**Table 2: Concurrent Engineering Characteristics**

- Use cross functional team
- Lasting decisions, utilize all previous work
- Decisions in a single trade-off space
- Effective and efficient communication
- Team is empowered
- Objectives & goals are defined by the team
- Team as a whole strive for consensus
- Design with open mind accommodating different viewpoints
- Focus on important aspects
- Utilize the relevant information as early as possible
- Continuous follow-up

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Because of the short lifetime of the products, no time is available to the companies for re-engineering or modifications and the only alternative left is to look forward to the philosophy of ‘right first time’. This can be possible by involving the people from manufacturing, finance, sales, services and specialist vendors etc. at the time of the product design itself. The impact is not limited to the design’s initial release. There is significant impact of the time at changes made during the development process. The cost of changes rapidly increases if the changes are made late as shown below for a major electronic product (Dataquest, Inc):

<table>
<thead>
<tr>
<th>Design changes made during</th>
<th>cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>1000</td>
</tr>
<tr>
<td>Design testing</td>
<td>10000</td>
</tr>
<tr>
<td>Process planning</td>
<td>100000</td>
</tr>
<tr>
<td>Test production</td>
<td>1000000</td>
</tr>
<tr>
<td>Final production</td>
<td>10000000</td>
</tr>
</tbody>
</table>

4. Basic Principles in CE (Sangwan 2001, Koufteros et al. 2001)

- Start all tasks as early as possible.
- Utilize all relevant information as early as possible.
- Work structuring: Systematically structure the work or work environment so that each task can be performed independently of each other either by a human being or a machine or a computer.
- Everyone participates in defining the objectives of their work.
- Operational understanding is achieved for all relevant information as team will work better if they know what other members are doing, e.g. what constraints a team member would encounter when certain parameters will be changed.
- A strong commitment is made to adhere to the decisions taken earlier.
- Decisions are made in a single trade-off space.
- Decisions are robust, overcoming a natural tendency to resort to quick, novel decisions.
- Trust among teammates. Trusting members, if they agree to accept responsibility for a task, prefer to work together rather than in isolation. This will also lead to better teamwork affinity.
- The team strives for consensus
- Team should be empowered to make decisions in product development and should be given “ownership” of what they produce.
- The team uses a visible concurrent process
- Constancy of purpose: This requires a change in thinking beyond the goals of one’s individual department or team to the company’s goals. Aiming toward constancy of purpose results in everyone contributing his/her best–working towards a common set of consistent goals.

These principles are simple and at first look seem to be unexceptionable, but in traditional process these principles have been frequently violated.
5. Benefits of Concurrent Engineering

Concurrent Engineering has been the focus of many industrial organizations for new product development, due to the ability of the cross-functional team to reduce the total time to design and manufacture or time to market. This reduction in the time to market is a major source of competitive advantage in the manufacturing environment we have today. Use of concurrent engineering should improve the performance of the organization in general but certain human and organizational characteristics may affect the degree to which improvement is felt in the organization. In literature, there are many companies showing benefits of concurrent engineering: Boeing reduced its product development cycle time by 40-60% AT&T reduced the process time for a new micro programmed digital switch by 46% Deere and Company reduced the product development time for construction equipments by 60% and cut manufacturing cost by 30-40%. McDonnel Douglas reduced rework costs 29%; reduced scrap cost 57%; and reduced nonconformance by 38%.

Typical benefits from concurrent engineering are (Sangwan 2001, Oliveto 2000):

- Reduction in time to market
- Improved product quality
- Increased customer satisfaction
- Reduced cost of production
- Reduction in engineering change requests
- Increased return on investment
- Increased level of group productivity
- Interdepartmental cooperation
- Increased employee satisfaction
- Reduction in development cycle time
- Increase in sales
- Reduction in life cycle costs
- Design rationalization
- Better communication
- Increased flexibility to accommodate changes
- Decreased occurrence of obsolescence
- Better use of scarce technical resources
- Other benefits: reduced lead time for creating bid proposals, reduced product development costs, parts reduction, lower inventories, fewer rework orders, less scrap.

Using CE, General Electric has cut its delivery time of customer made circuit breaker boxes from three weeks to three days. AT&T has reduced the product development time for telephones from two years to one. AT&T has also reported part counts down to one ninth of their previous levels and quality improvements up over one hundred times in surface defects. Motorola used to make electronic pagers in three weeks from order; it now produces them in two hours. The reported benefits from companies are large. In general products get to the market faster and at less cost. The quality is inherent in the product design rather than being an after thought. Employee morale and satisfaction is high as their voice is heard during the product development cycle. Projects run on time so suppliers & subcontractors too benefit and associate themselves with product success. Customers too are happy. So, who does not benefit from CE? None? Ponder.

6. Conclusions

This paper complements the previous studies by providing a clear definition of concurrent engineering and differentiating between the sequential engineering & concurrent engineering. This paper points out the need of concurrent engineering in today's competitive environment and also gives a comprehensive list of basic principles and benefits of concurrent engineering.

References


