Design of a Diving Bell

Perform a “quick” problem solving exercise to come up with a preliminary design.

Record your thoughts/questions.
What information does your group need?
From whom would you obtain it?
Basic Engineering Science
What we learn in engineering school --------------> Partial Design
First few years in industry

Partial Design - Concentration on creative concepts and feasibility, the assurance of a first-order compatibility with the laws of nature.

Things that might be missing:

- Responsiveness to customer needs
- Viability of the core concepts
- Producibility of the design
- Robustness of functional quality
- Economical precision of their production
- Success of integration
- Effective reusability
- Strategic impact

Traditional engineering - Serial development, the “throw-it-over-the-wall” style.

Basic Concurrent Engineering - Simultaneous engineering, integrated product and process development. Basic improvements
in clarity and unity.

1. Improve Process (Better Game Plan)
   a. Concurrent process
   b. Focus on quality, cost and delivery (QCD)
   c. Emphasis on customer satisfaction
   d. Emphasis on competitive benchmarking

2. Closer Cooperation (Better Teamwork)
   a. Integrated organization
   b. Employee involvement
   c. Strategic relations with suppliers

Critical Steps in New Product Design

1) Create the concept
2) Will it work?
3) Can it be made?
4) Does it satisfy the customer’s need?
5) Consistently?
6) Profitably?

Two Essential Characteristics of Basic Concurrent Engineering
1. It is a concurrent process.
2. It is carried out by a multi-functional product development team (PDT).

Basic Principles

1. Start all tasks as early as possible.
2. Utilize all relevant information as early as possible.
3. Empower individuals to define the objectives.
4. Operational understanding of all relevant information.
5. Adhere to decisions and utilize all relevant previous work.
6. Lasting decisions, not just quick and/or novel.
7. Trust
8. Consensus
9. Visibly concurrent process

In this approach design of the production and field support systems start early. This leads to good manufacturability and field support and an effective commitment to design success from those facets of the organization. It also leads to a more mature design at an earlier phase of development thereby reducing the total prototype iteration.

Paper Feeder Example
Solving problems versus preventing problems: A tale of two.

(1) Read one short of paper
(2) Do not read more than three of paper

Read one short of paper
Our fundamental requirement for the paper is:
- The development of a low-cost paper reader, such as used in a desktop computer
- The reader must be able to read the compact form of the paper

We place no strict limit on this feature.

In other words, there are some problems that are not easily solved by

To better understand some of the problems, let us look over the short

Paper 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.
The team reached the second sheet.

\[\begin{align*}
\text{(1:1) } & \quad x = \frac{b - \sqrt{b^2 - 4ac}}{2a} \quad \text{for quadratic equations}\]
al variations of parts and operating conditions. This is called robust design. The product has robust functionality; it functions well over the range of conditions that are likely to be met.

When the vice president of engineering and manufacturing (the traditional two jobs were combined into one) came to visit Team B, the team showed him Figures 1.5 and 1.6 and described how their design prevented all potential major failure modes over the anticipated range of production and field conditions. They pointed out that by being able to tolerate 9 mm of variation in the position of the stack top, an unusually tight tolerance on the sheet metal thickness had been avoided. This design was placed in production and was a big success.

Now, what should we conclude about the different styles of Teams A and B? The major conclusion is that solving problems is not good enough. Team A solved problems, but Team B prevented problems. Team A was constantly adjusting the design and could always solve any specific problem. However, Team A did not increase the variation of penetration that could be tolerated (Figure 1.5), nor did it reduce the variation that would occur in actual practice (Figure 1.6). Therefore, Team A was constantly adjusting away from one problem and into another problem. It did not develop robust functional quality. Therefore, Team A's paper feeding reliability was poor. Its design was expensive to produce, and its development time was excessive. In summary, Team A showed some of the inadequacies of partial design.

Team B did much better, but after it successfully completed the development of the flipper feeder, it recognized that its approach, although much faster than that of Team A, had taken longer than necessary. Team B initially emphasized the research approach of understanding all of the phenomena. When that proved too difficult to achieve in a time span that was compatible with the opening in the market window, the team found that the information provided in Figures 1.5 and 1.6 was sufficient for making the design decisions. Earlier use of a direct approach to design decisions would have resulted in capturing the problem-prevention advantages of Team B's approach in a much shorter time. Team B did well, but initially depended too much on a research style.

Team B used some of the main features of total quality development: a multifunctional team, undertaking simultaneous development for functionality and producibility: and an emphasis on functional robustness (the ability to work well over a wide range of conditions). Once this team becomes skilled at making disciplined decisions based on the existing understanding of nature, it will have a successful development style.

Team A dramatizes some of the shortcomings of the traditional process, which is little more than partial design. Team B initially tended toward another pitfall, a research style in development. The time frame for development work is much shorter than for research. Decisions must be based on the existing understanding of nature. We take needs for major advances in knowledge back into research, and unlock the secrets over a time period that is much too long for the typical development project. In other respects Team B did very well, skillfully benefiting from some of the key elements of total quality development.
Clark and Fujimoto’s (1991) Levels of Increasing Concurrence in Automotive Industry Product Development

(1.) Traditional Sequential Approach
(2.) High Bandwidth Technology Transfer (i.e., A High Rate and Large Total Amount of Information Exchange.)
(3.) Overlapping with Preliminary Information Transfer.
(4.) Overlapping with Mutual Adjustment.
(5.) Overlapping with Early Downstream Involvement.

Modes of Operation

(1) A Functional Structure
(2) A Lightweight Product Manager
(3) A Heavyweight Product Manager
(4) A Product Execution Team
(5) An Independent Product Development Team
Successful Product Development Teams

Qualities

1. Cohesive, mutual like and respect for expertise.
2. Specialists from all major functional areas.
3. Common vision of the concurrent process.
4. Controlled convergence to a solution everyone accepts and understands.
5. Vigilant information processing/active open-minded thinking/avoiding premature consensus.
6. Balance between individual and group work.
7. Systematic methods
8. Formal and informal communication
9. Member’s skills and inclinations match the task.
10. Principled leadership, empowerment.

Pitfalls
(1) “Group Think,” Convincing each other of the wrong answer.
(2) Learning is hindered within functional groups.
(3) PDT isolation, i.e., lessons are not easily passed to other PDTs.

Effective Product Leaders
1. Broad in scope responsibility.
2. Responsible for specifications, product concept, costs and schedule.
3. Responsible for product concept being translated into technical detail.
4. Frequent direct contact with PDT people at the working level.
5. Maintains direct contact with customers.
6. Knowledge/experience in many disciplines to communicate better.
7. Active in managing conflict/may initiate conflict to maintain the concept.
8. Has market imagination, knows the voice of the customer.
9. Circulates informally with the PDT, leads in achieving the winning product concept.