UNIT B: The Engineering Design Process

Competency: D502.00

Explain the concepts and principles of the engineering design process.

Objective: D502.01

Explain the linear design process.

Introduction: The purpose of this unit is to show that the design process is a challenging effort, and the designer relies heavily on the use of graphics as a means to create, record, analyze and communicate to others. The engineering design process is used to solve society's needs, desires, and problems through the application of scientific principles, experience, and creativity. (R1 398-411, R2 49-53)

Explain the following:

C. Design is the conception of an idea and its development, through graphic communication, into a practical, producible, and usable product or process.

D. Functional design is the design of a product so that it operates successfully or accomplishes its purpose.

E. Aesthetic design is the form or overall physical appearance of the product. Aesthetics involves characteristics such as color, line, style, space, contrast, proportion and balance.

F. In the development of the any product, designers use knowledge, creativity, experience, and resources to create a new or improved product. The design must be functionally efficient, meet the design objective, and be aesthetically appealing.

G. In the linear design process, a designer takes the design of a product from the initial design problem or idea stage and carries it through, step by step, until it is turned over to the production division.

1. A design or idea starts with the recognition of a problem or the determination of a need or want. The designer carefully analyzes the idea to determine if it is practical and marketable.
2. Next, alternative designs are gathered to create possible product solutions. All notes and sketches are signed, dated, and retained for further work and possible patent proof.
3. At this point the best solution is evaluated in detail, and attempts are made to simplify the design so that it performs efficiently and is easily manufactured. Materials and costs are carefully considered. A design layout drawing is made to show basic proportions of parts and how they fit together in an assembly drawing.
4. After the most feasible solution is selected, a prototype is constructed to test the design. The prototype can be a physical model or a computer-generated model of the design.
5. Once the engineering team or a select group of consumers has evaluated the prototype, the feedback is used for changes to the design. The design process then loops back to previous stages for final consideration before the manufacturing of the product.

6. Finally, a set of working drawings are prepared, and the design is sent into production.

Linear Engineering Design Process

Stage 1 - Identification of Design Problem
- Problem identified
- Analysis of need, market research
- Costs (estimated cost limit)
- Design requirements (essential, important, desirable, or beneficial)
- Time-line, scheduling

Stage 2 - Problem-Solving Concepts and Ideas
- Concepts and ideas collected and recorded
- Legal requirements (patents)
- Material requirements
- Manufacturing requirements
- Overall size requirements

Stage 3 - Compromise Solutions
- Compromise solutions
- Initial design sketches are refined
- 3D modeling
- Inventions (starting from scratch) vs. Evolutionary Designs (the 2004 model)

Stage 4 - Models & Prototypes (Analysis)
- Creating a prototype (machined, rapid prototyping, electronic prototype, etc.)
- Kinematic/motion testing
- Life testing
- Finite element analysis (stress/strain)
- Thermal analysis

Stage 5 - Production or Working Drawings
- How is information passed to production?
- Working drawings
- Computer Numerical Control (CNC)
- Computer-Aided Manufacturing (CAM)

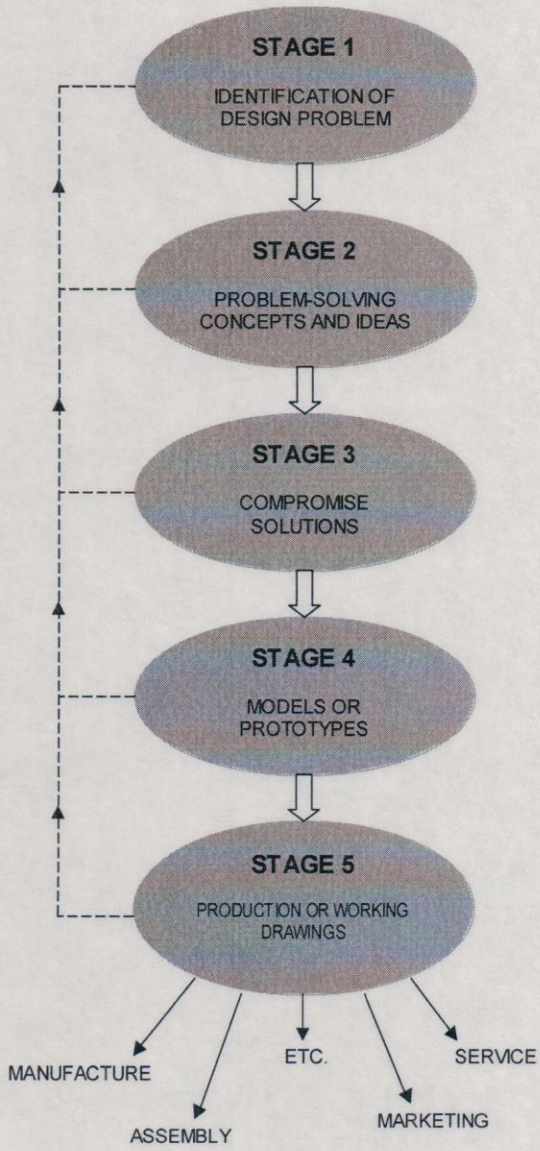

Figure 1. The Linear Design Process.

UNIT B: The Engineering Design Process

Competency: D502.00

Explain the concepts and principles of the engineering design process.

Objective: D502.02

Explain the concurrent engineering design process.

Explain the following:

A. Concurrent engineering design is done in a comprehensive team environment. The team consists of designers, engineers, drafters, and others associated with the overall design, manufacturing, marketing, and servicing of the product.

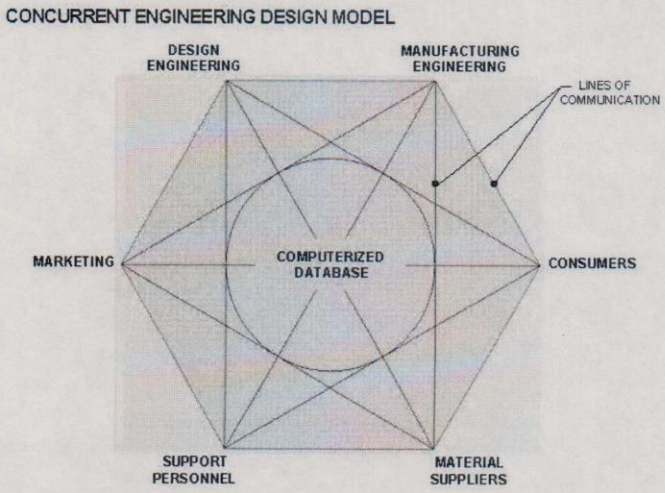

Figure 1. Lines of Communication within Concurrent Engineering Design.

H. In addition to the basic functional and aesthetic design concepts, the team considers important issues such as manufacturability, quality, life cycle, costs, and whether the finished product will meet the original design objectives.

I. In concurrent engineering design, a comprehensive 3D CAD and computerized engineering database serves as the nucleus for all aspects of design, manufacture, and marketing of the product.

1. The database can be accessed by anyone on the design team.
2. The team members do not have to be at the same location. They can be anywhere in the world.

J. Concurrent engineering is concerned with making better products in less time, so continuous quality improvement techniques are practiced throughout the product's life cycle.

1. The product's life cycle is its total life, from the conception of the idea to the recycling of the materials from which it is made.
2. The life cycle is considered as early as possible.

K. Ideation, refinement, and implementation are the three overlapped areas of concurrent engineering design.

1. **Ideation** is a structured approach to thinking for the purpose of solving a problem. Ideation is the beginning phase where the design problem is identified, preliminary solutions are developed and the preliminary design is agreed upon.
   a. *Problem Identification* includes activities such as:
      i. writing a problem statement
      ii. conducting research
      iii. gathering data
      iv. defining objectives for the project
      v. determining limitations of the design
      vi. outlining a reasonable schedule
   b. *Preliminary Ideas* includes activities such as:
      i. writing and collecting notes about the project
      ii. creating sketches and/or models of the design
      iii. brainstorming design ideas
      iv. synthesizing the design ideas
   c. *Preliminary Design* includes:
      i. evaluating preliminary ideas
      ii. selecting a design
2. **Refinement** follows the ideation process. It is a repetitive process used to test the preliminary design. It includes preparation of models and prototypes, thorough physical, production, and legal analysis of the design, and design visualization, or analysis of the aesthetics.
   a. *Modeling* – this includes geometric modeling, simulation, animation, and developing charts, graphs and diagrams.
   b. *Design Analysis* – this area includes material property analysis, mechanism analysis, functional analysis, and human factors analysis.
   c. *Design Visualization* – design visualization includes rapid prototyping, manufacturing visualization, and simulations.
3. **Implementation** is the final phase of concurrent engineering design. It involves careful analysis of production, financing, servicing, documenting, final planning, and life cycle issues.

L. Because the phases overlap and the entire team works on every element of the design, there is significant improvement in quality and a reduction in project time, cost and changes during production.

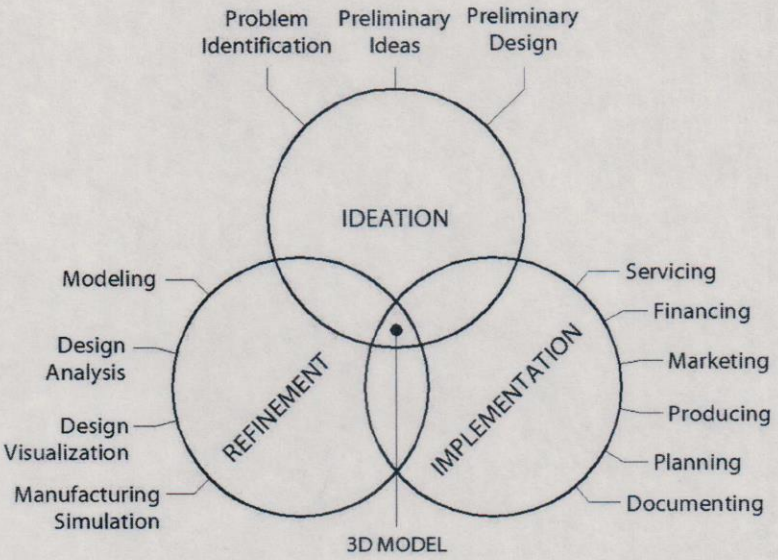

Figure 2. The Concurrent Engineering Design Process.