Design methodology

Engineers Provide:

- Engineering Products: *Washing machines, food processors, trucks, weapons, tooth brush, etc*
- Engineering services: *operation, maintenance, etc*

Life of engineering product: *Design, manufacture, test, develop*

A product design must be:

- **Functional** **:** *the product must perform to fill its intended need*
- **Safe** **:** *the product is not hazardous to users*
- **Reliable** **:** *the product will perform its intended function satisfactory at a given age.*
- **Manufacturable:** *The product can be manufactured with the available technology with required quantities*
- **Marketable** **:** *the product can be bought and service, repair, is available*
- **Competitive** **:** the product is contender, challenger, in its market

What is Design

The word 'design' means different things to different people: a wallpaper pattern, a fashionable dress, the appearance of a racing car and so on are all sort of designs.

To engineers it means:

> ***Design is the application of creativity to planning the optimum solution of a given problem and the communication of that plan to others***.

The design process:

We can think of design as a ***process*** where a plan is to be prepared for the satisfaction of a ***human need,*** See fig.(1.1)

Recognition of need:

Design begins when somebody, may be an engineer recognize a need and decide to do something about it. The need may be a vague discontent, a feeling of uneasiness or sensing that something is not right, e.g. a need to do something about a packing machine, level of noise, variation in package weight or the quality of package or wrap

Definition of problem (*Design specifications*)

This includes all the specifications for the thing that is to be designed. It is the input and output quantities, the characteristics, dimensions of space available, and all limitations on these quantities

The specifications defines the cost, expected life the range, operating temperature, speeds feeds weight limitations etc.
Codes of practices and national and international specifications should be consulted when writing design specifications.

Synthesis :

It is the methods of obtaining alternative solution. It is sometimes called the *invention of the concept.* In this stage as many solutions or ideas as possible are required. Fig.(1.1) shows that synthesis and analysis and optimization are closely and iteratively related. Synthesis draws heavily on talent but factor which drives invention or creativity can list as:

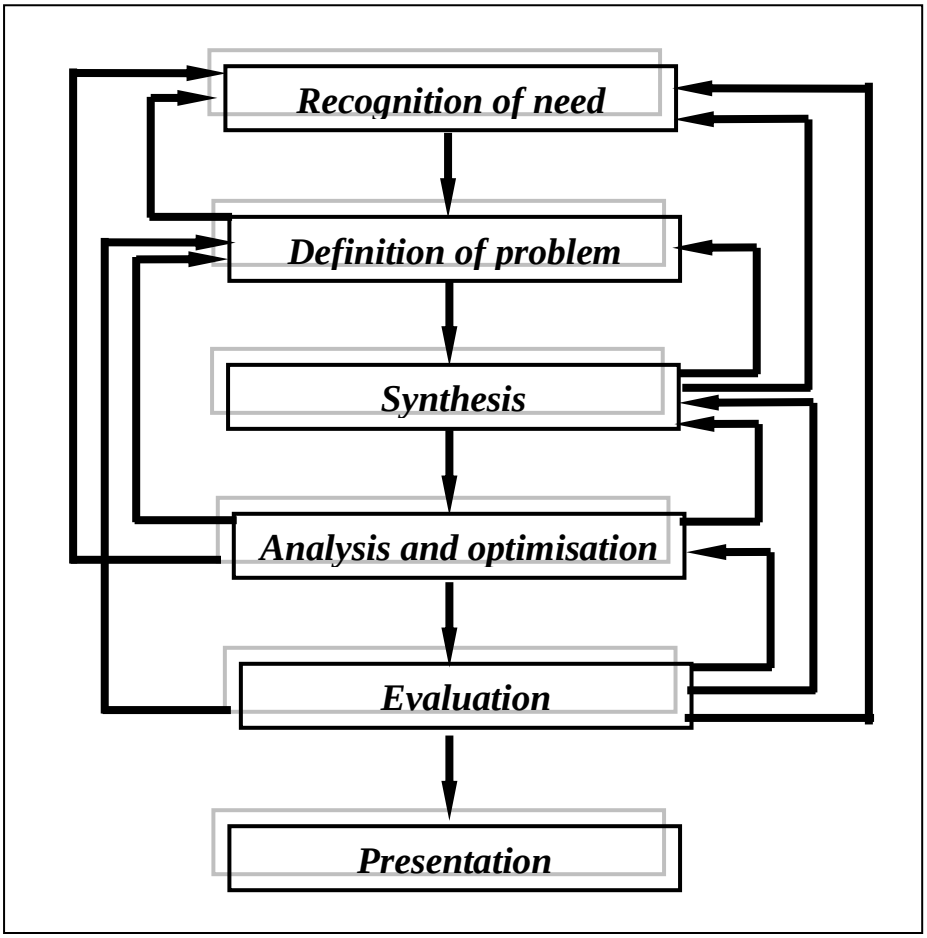

Figure 1.1: The phases of design

1. ***Inherited qualities ,talent***: we cannot all inherit Leonardo's genes, but each of us must have some talents qualities.
2. ***Thinking Methods:*** you can employ proven techniques to increase your inventive prowess
3. ***Attitude:*** you must be positive, you can invent!

4. ***Knowledge and experience:*** your understanding of how related problems are solved can be increased
5. ***Effort:*** Edison (inventor of the light bulb) put more effort to develop and improve his invention

Evaluation:

At the conclusion of the activity, we have a number of candidate solutions which meet all the constraints. These now have to be evaluated - that is compared with one another on the basis of the design spesifications in order to select the optimum solution.

Evaluation consists of three distinct steps, carried out by the designer:

1. The relative importance of the various criteria is defined
2. The degree to which each candidate satisfies each criterion is established
3. The degrees to which the candidates satisfy the overall problem are finally worked out.

Presentation:

Communicating the design to others is the final, vital step in the design process. There are three means of communication. These are:

- Written
- Oral
- Graphical form

From fig.(1.1) it can be noticed that design is an iterative process in which we proceed through several steps, evaluate the results, and then return to an earlier phase of the procedure

Design Communication

Reasons for communications

- Persuading people to follow your recommendations
- Convincing people to accept your ideas
- Records for further work

Communication could be:

1. Verbal
2. Written
3. Sketches and drawings
4. Models
   - Physical
   - Solid model
   - Analogue

- Symbolic

Reports have to be written describing:
What, when, where, why and how of the project

Types of written documentation:
- Design notebook
- Design portfolio: as an aid for gathering information (it is not used in industry)
- Final report

Guidelines for effective writing:
- ***Good idea of precisely what you want to communicate:***
  - Present information or
  - Persuading people to act or think in a certain way
- ***Go to the point:***
  - From the general to the specific
  - From conclusion to details
- ***Express your self clearly***
  - Do not allow misinterpretation (ambiguity, vagueness and lack of coherence or directness may leave a statement open to several interpretations)

    "Before accepting materials from new subcontractors, they should meet our requirements"

    Who is they:

    "Before we accept them, the materials from the new subcontractors should meet our requirements"
- ***Coherence***
  - Coherent sentences,
  - Coherent paragraphs,
  - Coherent report
- ***Aesthetics matters (Appearance) :***
  - Margin
  - Fonts, size and type
  - Headings (Bold, underline, shaded etc..)
  - Figures and tables

Methods of obtaining alternative solution

1. Standard parts:
- Copy an existing solution
- Change manual system into automatic one
- Change the system from batch to continuous production
- If the required system is very large and only part of it is available, use the available parts and fill the gap with new design
- Look for similar systems and modify to suit the required one

2. Method of Inversion

Inverse the characteristics of the system to get new ideas

- Change shape: *convex to concave etc.*
- Change motion: *rotary to linear, moving to stationary etc.*
- Change position: *front to rear, top to bottom, vertical to horizontal inside to outside etc.*

3. Solution at stages:

Divide the comlex system into stages and find alternative solution for each stage. Then combine the best and compatible solution from each stage

4. Black-box concept

Consider the system as consisting of black boxes without investigating the details of each box

5. Brain storming

- Brainstorming is essentially a free association of ideas where each idea is recorded when first thought of, and actively encouraged to initiate further ideas
- A group of people with different backgrounds and interests
- A leader
- Any hint of criticism during ideation is strictly forbidden, *If you think that an idea is unworkable or laughable, then the thought **MUST** be suppressed*
- Any idea which gives birth to other ideas cannot be wholly daft, and as this offspring is not weighed up until post-ideation criticism, there cannot be any justification during ideation for concluding that the idea is crazy or not. There is plenty of scope for criticism after the ideation activity has ceased.

General guidelines for writing design specification

Title

The title should be very specific and does not mix with other or previous specifications. Words should give specific meaning and can be easily translated to other languages

Role of equipment

The role of equipment is very important for the designer as well as the user. Also it helps the manufacturer in understanding the required specifications.

Inputs

The characteristics, nature and quantity, should be described carefully (*e.g. electric current, gas pressure, mechanical movement etc*.) The rate of change as well as the shape of change can be very useful. (*sine wave, constant, arbitrary etc)*

Outputs

Similarly the output from the system should be described without mentioning the relation between the inputs and outputs unless the customer insists in a certain way of transforming the inputs to ouputs

Environment and location

What is meant by environment here, is all factors which may influence the design and has not been mentioned in previous paragraphs. And what is meant by location is the relative position of the system to other systems and equipment. This information can be provided in terms of engineering drawings, photos or even models. There are two aspects in this context should be given more attention:

- ✓ **Human**

  Most of equipment are in direct or indirect relation with humans. Man has a role in their design, manufacture, assembly, use, or maintenance. Therefore great attention should be given to the following factors at the stage of design:

  - *Dimensions of human body*
  - *Natural abilities of human body* (power of muscles, range of hearing and sight etc.)
  - *Temperatures which a human body can stand*
  - *Comfort.*

- ✓ ***Auxiliary services***

  This includes all services needed for the functioning of the system(e.g. compressed air, water supply, electricity, hydraulic power etc..)

In addition to the above factors the following are very important to consider and include in the design specifications:

- Environment temperature and moisture
- Pressure due to wind or water waves
- Dust
- Rain and snow
- Light and other types of rays
- Noise and vibrations
- Centrifugal forces and inertia forces
- Heat

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Measures of value

Measures of value are the most difficult part of the specifications specially when converting technical values into numerical values that can be calculated and weighed. Measure of value may includes:

a. Performance
b. Initial cost
c. Operation cost
d. Maintenance cosy
e. Equipment rent cost
f. Total life
g. Comfort and ease of use
h. Appearance
i. Safety
j. Training
k. Reliability

Finally it is important to emphasize that referring to national and international standards(*British Standards, ASTM, AGMA etc*), and consulting governmental bodies are very useful in writing design specifications. .

Exercises

Prepare a complete report with neat sketches and comments which explains:

- A brief design specification.
- Alternative solutions.

for each of the following projects.:

a. Portable, small, cement mixture
b. Black board eraser
c. Foldable bicycle.
d. Semi-automatic wood turning machine.
e. A device for punching three digits on a flat surface of a workpiece
f. A reception chair
g. Pipe cutting and necking (swaging) machine See fig (1.2)
h. Desk lamp.
i. Jar opener
j. Arial work platform
k. Profile cutting machine
l. Nano car
m. Small hovercraft

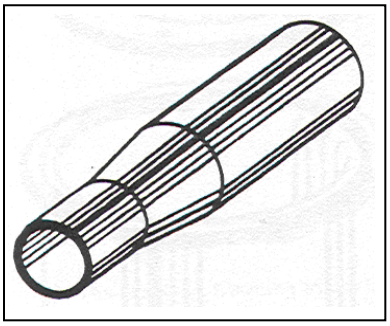

Fig.(1.2) swaging