Department	mechanical		Programme	BTech 5th	
Subject name	Machine Design I		Subject code	MEC502	
Semester	5th	Credits	4	Teacher incharge / mentor	Mr. M Shafi Charoo
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Lecture 1

Introduction to Machine Design

Links to the Resources: https://www.youtube.com/watch?v=mzWMdZZaHwI

Book to be consulted

1. Design of Machine Elements by VB Bhandari third edition. Page no. 1 to page no. 3

Topic: Introduction to Machine Design

Definition of Machine design

Machine design is defined as the use of scientific principles, technical information and imagination in the description of a machine or a mechanical system to perform specific functions with maximum economy and efficiency. The definition of machine design contains the following important features:

(i) A designer uses principles of basic and engineering sciences such as physics, mathematics, statics and dynamics, thermodynamics and heat transfer, vibrations and fluid mechanics. Some of the examples of these principles are

(a) Newton's laws of motion,
(b) D' Alambert's principle,
(c) Boyle's And Charle's laws of gases,
(d) Carnot cycle, and
(e) Bernoulli's principle.

(ii) The designer has technical information of the basic elements of a machine. These elements include fastening devices, chain, belt and gear drives, bearings, oil seals and gaskets, springs, shafts, keys and couplings and so on. A machine is a combination of these basic elements.

(iii) The designer uses his skill and imagination to produce a configuration, which is a combination, which is a combination of these basic elements. However, this combination is unique and different in different situations.

(iv) The final outcome of the design process consists of the design process consists of the description of the machine. The description is in the form of drawings of assembly and individual components.

(v) A design is created to satisfy a recognised need of customer. The need may be to perform a specific function with maximum economy and efficiency.

Basic procedure of a Machine Design

The basic procedure of machine design consists of step-by- step approach from given specifications about the functional requirements of a product to the complete description in the form of drawings of the final product. A logical sequence of steps, usuall common to all products is illustrated in fig 1.

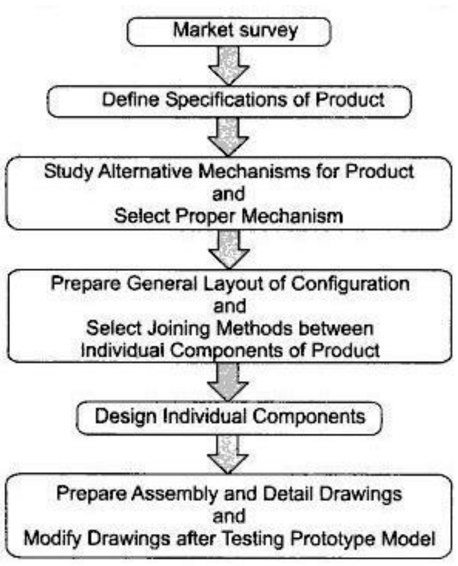


Fig. 1.1 Design process

The following steps are involved in the process of machine design.

Step 1: Product Specifications

The first step consists of preparing a complete list of the requirements of the product. The requirements include the output capacity of the machine and its service life, cost and reliability. In some cases, the overall dimensions and weight of the product are specified. For example, while designing a scooter, the lit of specifications will be as follows:

- (i) Fuel consumption = 40 km/l
- (ii) Maximum speed = 85 km/hr
- (iii) Carrying capacity =two persons with 10 kg luggage
- (iv) Overall dimensions
  Width = 700 mm
  Length = 1750 mm
  Height = 1000mm
- (v) Weight = 95 kg
- (vi) Cost = Rs 40000 to Rs 45000

In consumer products, external appearance, noiseless performance and simplicity in operation of controls are important requirements. Depending upon the type of product, various requirements are given weightages and a priority list of specifications is prepared.

Step 2: Selection of Mechanism

After careful study of the requirements, the designer prepars rough sketches of differnet possible mechanisms for the product. For example, while designing a blanking or piercing press, the following mechanisms are possible:

- (i) A mechanism involving the crank and connecting rod, converting the rotary motion of the electric motor into the reciprocating motion of the punch;
- (ii) A mechanism involving nut and screw, which is a simple and cheap configuration but having poor efficiency.

The alternative mechanisms are compared with each other and also with the mechanism of the products that are available in the market. An approximate estimation of the cost of each altenative configuration is made and compared with the cost of existing products. This will reveal the competitiveness of the product, depending upon the cost-competitiveness, availability of raw materials and manufacturing facility, the best possible mechanism should be selected for the product.

Step 3: Layout of Configuration

The next step is to prepare a block diagram showing the general layout of the selected configuration. For example, the layout of an Electrically- operated Overhead Travelling (EOT) crane will consist of following components:

(i) Electric motor for power supply;
(ii) Flexible coupling to connect the motor shaft to the clutch;
(iii) Clutch to connect or disconnect the electric motor at the will of the operator;
(iv) Gear box to reduce the speed from 1440 rpm to about 15 rpm.
(v) Rope drum to convert the rotary motion of the shaft to the linear motion of the wire rope;
(vi) Wire rope and pulley with the crank hook to attach the load; and
(vii) Brake to stop the motion.

In this step, the designer specifies the joining methods, such as riveting, bolting or welding to connect the individual components.

Step 4: Design of individual Components

The design of individual components or machine elements is an important step in a design process. It consists of the following stages:

(i) Determine the forces acting on the component.
(ii) Select proper material for the component depending upon the functional requirements such as strength, rigidity, hardness and wear resistance.
(iii) Determine the likely mode of failure for the component and depending upon it, select the criterion of failure, such as yield strength, ultimate tensile strength, endurance limit or permissible deflection.
(iv) Determine the geometric dimensions of the component using a suitable factor of safety and modify the dimension.

Lecture-02

Topic: Introduction to behaviour of mechanical systems

Link:

Book: The mechanical Design Process by David G. Ullman, fourth Edition, Page no. 28-30.

Lecture Note:

Behaviour of mechanical systems

In mechanical engineering, we commonly use the terms function, operation, and purpose to describe what a device does. A common way of classifying mechanical devices is by their function. In fact, some devices having only one main function are named for that function. For example, a screw driver has the function of enabling a person to insert or remove a screw. The terms drive, insert and remove are all verbs that tell what the screwdriver does. To discover how, we must have some information on the form of the device. The term form relates to any aspect of physical shape, geometry, construction, material, or size.

Many common devices are cataloged by their function. If we want to specify a bearing, for example, we can search a bearing catalog and find many different styles of bearings (plain, ball, or tapered roller, for example). Each "style" has a different geometry—a different form—though all have the same primary function, namely, to reduce friction between a shaft and another object. Cataloging is possible in mechanical design as long as the primary function is clearly defined by a single piece of hardware, either a single component or an assembly. In other words, the form and function are decomposed along the same boundaries. This is true of many mechanical devices, such as pumps, valves, heat exchangers, gearboxes, and fan blades, and is especially true of many electrical circuits and components, such as resistors, capacitors, and amplifier circuits.

Two other terms often related to function are behaviour and performance. Function and behaviour are often used synonymously. In fig. 2. there are two standard system blocks with an input represented by an arrow into the box, the system acted on by the input represented by the box, and the reaction of the system to the input represented by the arrow out of the box. The box in the upper part of the figure shows that function is the desired output from a system that is yet to be designed. When we begin to design a device, the device itself is unknown, but what we want it to do is known. If the system is known, as in the second part of the figure, then the behavior of the system can be found. Behavior is the actual output, the response of the system's physical properties to the input energy or control. Thus, the behavior can be simulated or measured, whereas function is only a desire.

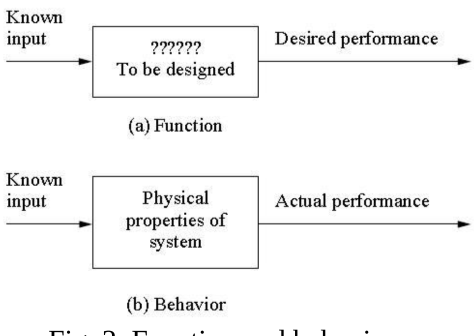


Fig. 2. Function and behaviour

<u>**Lecture-03**</u>

Topic: Design and Designer

Link:

Book: The mechanical Design Process by David G. Ullman, fourth Edition, page no. 48-55

Lecture Note:

Design and Designer

It is important to realize that design is the confluence of technical processes, cognitive processes, and social processes. We begin our discussion of how humans design mechanical objects by describing a cognitive model of how memory is structured in the individual designer. The types of information that are processed in this structure are explored, and the term knowledge is defined.

Once we understand the information flow in human memory, we develop the different types of operations that a designer must perform in memory during the design process, and we explore creativity. The study of human problem-solving abilities is called cognitive psychology.Although this science has not yet fully explained the problem-solving process, psychologists have developed models that give us a pretty good idea of what happens inside our heads during design activities. A simplification of a generally accepted model is shown in Fig. 3. This model, called the information-processing system and developed in the late 1950s, describes the mental system used in the solution of any type of problem. In discussing that system here, we give special emphasis to the solution of mechanical design problems.

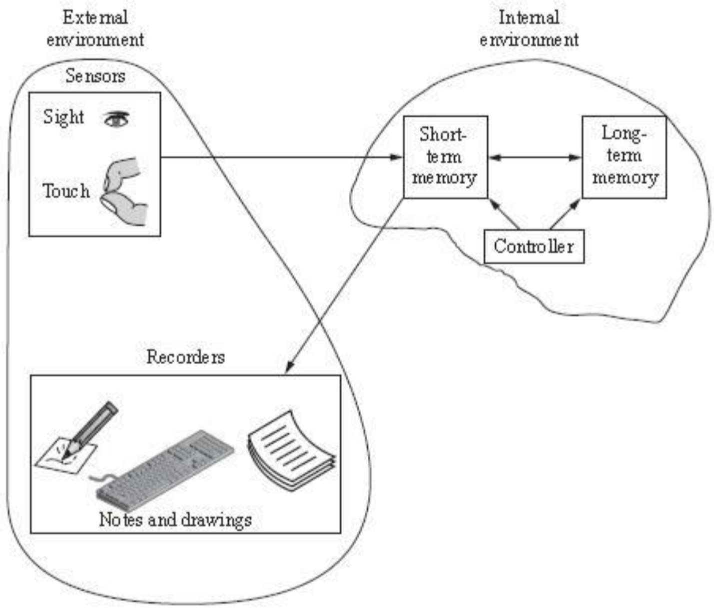


Fig. 3 Information processing takes place through the interaction of two environments.

The internal environment: Information storage and processing inside the brain. In the internal environment, i.e., within the human mind, there are two different types of memory; short-term memory, which is similar to a computer's operating memory and long term memory, which is like a computer's disk storage. Bringing information into this system is from the external environment are sensors, such as eyes, ears and hands. There is a controller that manages the information flow from the sensors to the short term memory and the means of output.

The external environment: it comprises of paper and pencil, catalogs, computer output, and whatever else is used outside the human body to extend the internal environment. The external environment plays a number of roles in the design process: it is a source of information; it is an analytical capability; it is a documentation/communication facility; and most importantly for designers it is an extension for the short term memory. Because the short term memory is a space limited central processor, human problem solvers utilize the external environment as a short term memory extension, much as a computer extends RAM by using cache memory. This is accomplished by making notes and sketches of ideas and other information needed in problem solving.

Control of the Information-Processing System

During problem solving, the controller (Fig. 3) enables us to encode outside information obtained through our senses or retrieve information from long-term memory for processing in the short-term memory. Some of the information in the short-term memory is allowed to fade, and new information is input as it is needed and becomes available. Additionally, the controller can help extend the short-term memory by making notes and sketches; these need to be done quickly so that they do not bog down the problem-solving process. When we have completed manipulating the information, the controller can store the results in long-term memory, or in the external environment by describing it in text, verbally, or in graphic images.

Implications of the model

One of the implications of the model of the information-processing model of human problem solving is that the size of the short-term memory is a major limiting factor in the ability to solve problems. To accommodate this limitation we break down problems into finer and finer sub problems until we can get our mind around it-in other words, manage the information in our short term memory. Typically, these fine-grained subproblems are worked on for about 1 minute before going to the next one. Thus, design of even a simple problem is the solution of many thousands of subproblems. Further, our thinking process has evolved so that, as we solve problems, our expertise about the constraints and potential solutions increases and our configuration of chunks becomes more efficient. This helps offset the “magic number” seven, but human designers are still quite limited. It would almost seem that these limitations would preclude our ability to solve complex problems.

Lecture 4

Topic: Objective of Design

Link:

Book: Design of Machine Elements by VB Bhandari third edition.

Lecture Notes

Objective of design

The primary objective of this course is to demonstrate how engineering design uses the many principles learned in previous engineering science courses and to show how these principles are practically applied. The emphasis in this course is on machine design: the design and creation of devices that consist of interrelated components used to modify force and/or motion. Along with traditional "one-answer" homework problems, the students will be presented with design challenges.

The type of design addressed in this course is that of detailed design, which is to define the shape, size and material of a particular machine element such that it will not fail under the expected load and operating conditions. The team design project for this semester was to design an ergonomic opener for vacuum sealed jars.

By the end of the course, each student should be able to:

- For a particular sub-set of machine elements and a given problem:
- Define failure,
- Decide on an appropriate failure model, and
- Design an appropriate machine element using:
- Allowable load (under the given operating conditions),
- Required element life,
- Manufacturing considerations, and
- Manage engineering projects.

<u>**Lecture 5**</u>

Topic: Design Process

Links:

Book: The Mechanical Design Process Fourth Edition By David G. Ullman, Page No. 8 To 12.

Shigley's Mechanical Engineering Design Ninth Edition, Page No. 5 to 7.

Lecture Notes

<u>Design Process</u>

The design process is the organization and management of people and the information they develop in the evolution of a product.

In simpler times, one person could design and manufacture an entire product. Even for a large project such as the design of a ship or a bridge, one person had sufficient knowledge of the physics, materials, and manufacturing processes to manage all aspects of the design and construction of the project.

By the middle of the twentieth century, products and manufacturing processes had become so complex that one person no longer had sufficient knowledge or time to focus on all the aspects of the evolving product. Different groups of people became responsible for marketing, design, manufacturing, and overall management. This evolution led to what is commonly known as the "over-thewall" design process (Fig. 4)

In the structure shown in Fig. 4, the engineering design process is walled off from the other product development functions. Basically, people in marketing communicate a perceived market need to engineering either as a simple, written request or, in many instances, orally. This is effectively a one-way communication and is thus represented as information that is "thrown over the wall."

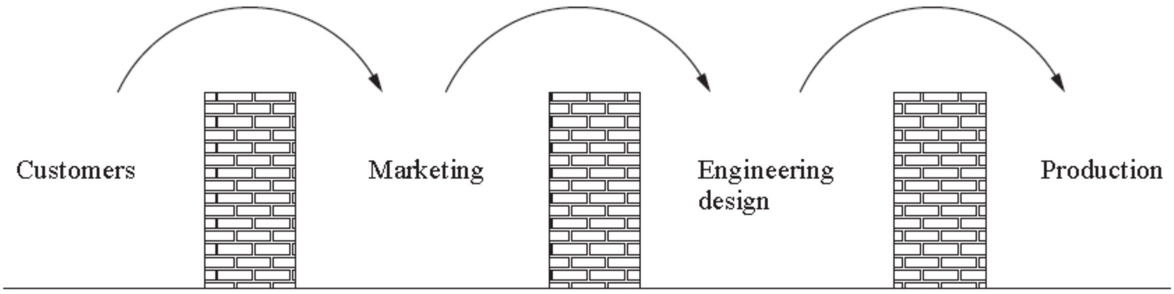


Figure 4 The over-the-wall design method.

Engineering interprets the request, develops concepts, and refines the best concept into manufacturing specifications (i.e., drawings, bills of materials, and assembly instructions). These manufacturing specifications are thrown over the wall to be produced. Manufacturing then interprets the information passed to it and builds what it thinks engineering wanted.

In the 1980s the simultaneous design philosophy was broadened and called concurrent engineering, which, in the 1990s, became Integrated Product and Process Design (IPPD). Although the terms simultaneous, concurrent, and integrated are basically synonymous, the change in terms implies a greater refinement in thought about what it takes to efficiently develop a product. Throughout the

rest of this text, the term concurrent engineering will be used to express this refinement.

In the 1990s the concepts of Lean and Six Sigma became popular in manufacturing and began to have an influence on design. Lean manufacturing concepts were based on studies of the Toyota manufacturing system and introduced in the United States in the early 1990s. Lean manufacturing

seeks to eliminate waste in all parts of the system, principally through teamwork. This means eliminating products nobody wants, unneeded steps, many different materials, and people waiting downstream because upstream activities haven't been delivered on time.
Six Sigma uses statistical methods to account for and manageproduct manufacturing uncertainty and variation. Key to Six Sigma methodology is the five-step DMAIC process (Define, Measure, Analyze, Improve, and Control). Six Sigma brought improved quality to manufactured products. However, quality begins in the design of products, and processes, not in their manufacture. Recognizing this, the Six Sigma community began to emphasize quality earlier in the product development cycle, evolving DFSS (Design for Six Sigma) in the late 1990s.

Design processes are:
Identify need. Design projects are initiated either by a market requirement, the development of a new technology, or the desire to improve an existing product.
Plan for the design process. Efficient product development requires planning for the process to be followed.
Develop engineering requirements. The importance of developing a good set of specifications has become one of the key points in concurrent engineering. It has recently been realized that the time spent evolving complete specifications prior to developing concepts saves time and money and improves quality.
Develop concepts. This is an important phase in the development of a product, as decisions made here affect all the downstream phases.
Develop product. Turning a concept into a manufacturable product is a major engineering challenge and is a more reliable process. This phase ends with manufacturing specifications and release to production.

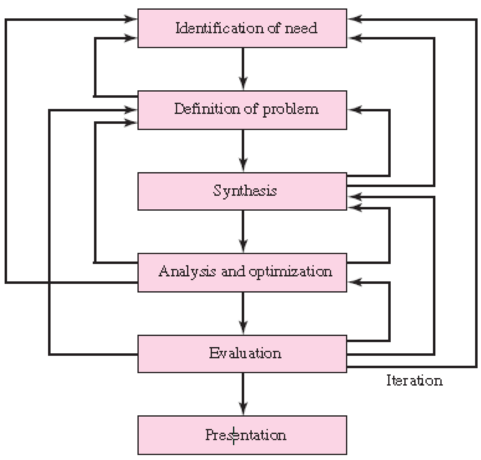


Fig.5 The phases in design

Lecture 6

Topic: Types of design

Link: http://www.amiestudy.com/studynotes/design/2.htm

https://www.youtube.com/watch?v=gM0Kp0BQUXU&list=PLHpC4_VH4uh0bIKMtFg0hXFckep6sBzwi&index=2

Book: Machine Elements in Mechanical Design by Mott R. L Fourth Edition

Lecture Notes

TYPES OF DESIGNS

2.1 The design can be classified in many ways. On the basis of knowledge, skill and creativity required in the designing process, the designs are broadly classified into three types

- Adaptive Design
- Variant Design
- Original Design

- **Adaptive Design**

In most design situations the designer's job is to make a slight modification of the existing design. These are called adaptive designs . This type of design needs no special knowledge or skill. E.g. converting mechanical watches into a new shape.

- **Variant Design**

This type of design demands considerable scientific training and design ability, in order to modify the existing designs into a new idea, by adopting a new material or a different method of manufacture. In this case, though the designer starts from the existing designs, the final product may be entirely different from the original product.

E.g. converting mechanical watches into quartz watches. Here a new technology is adopted.

- **Original Design**

Here the designer designs something that did not exist previously. Thus, it is also called new design or innovative design. For making original designs, a lot of research work, knowledge and creativity are essential. A company thinks of new design when there is a new technology available or when there is enough market push. Since this type of design demands maximum creativity from the part of the designer, these are also called creative designs.

2.2 On the basis of the nature of design problem, design may be classified as

- Selection design
- Configuration design
- Parametric design
- Original design
- Re-design

- **Selection Design**.

It involves choosing of one or more items from a list of similar items. We do this by using catalogues.

Eg. -Selection of a bearing from a bearing catalogue

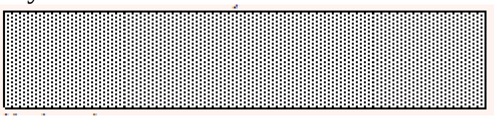
-Selection of a fan for cooling equipment

-Selecting a shaft.

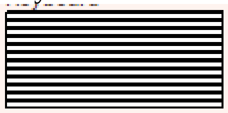
- **Configuration / Layout / Packaging Design**

In this type of problem, all the components have been designed and the problem is how to assemble them into the completed product. This type of design is similar to arranging furniture in a living room.

Consider the packing of electronic components in a laptop computer. A laptop computer has a keyboard, power supply, a main circuit board, a hard disk drive, a floppy disk drive and room for two extension boards. Each component is of known design and has certain constraints on its position. For example, the extension slots must be adjacent to the main circuit board and the keyboard must be in front of the machine.

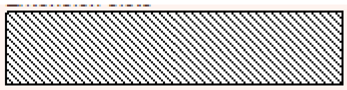


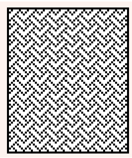
Keyboard



Main Circuit board

Extension slots

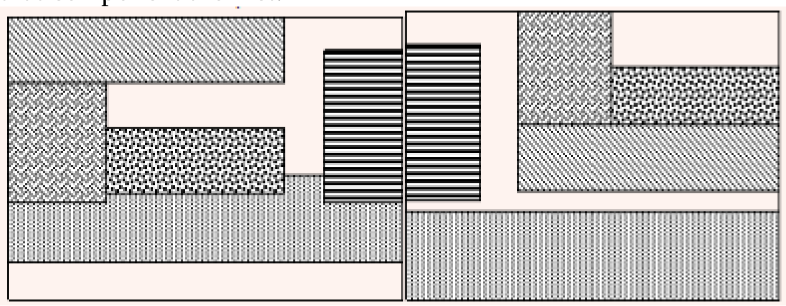




Floppy drive

Power supply

The different components are shown above. The designer's aim is to find, how to fit all the components in a case? Where do we put what? One method for solving such problems is to – select a component randomly from the list and position it in the case so that all the constraints on that component are met.



Let's take keyboard first. It is placed in the front. Then we select and place a second component. This procedure is continued until we reach a conflict, or all the components are in the case. If a conflict arises, we back up and try again. Two potential configurations are shown above.

- **Parametric Design**

Parametric design involves finding values for the features that characterize the object being studied.

Consider a simple example –

We want to design a cylindrical storage tank that must hold $4\ m^3$ of liquid.
The volume is given by
$V = \quad r^2 l$
The tank is described by the parameters, radius 'r', and length l .
Given $V = 4\ m^3 = \quad r^2 l$
$\quad r^2 l = 1.273$
We can see a number of values for the radius and length, that will satisfy this equation. Each combination-values of r and l gives a possible solution for the design problem.

- **Original Design**

An original design in the development of an assembly or component that did not exist before.

- **Redesign**

The redesign is a modification of an existing product to meet new requirements. It is same as adaptive design. Most design problems solved in industry are for the redesign of an existing product. Suppose a manufacturer of hydraulic cylinders makes a product that is 0.25m long. If the customer needs a cylinder 0.3m long, the manufacturer might lengthen the outer cylinder and the piston rod to meet this special need.

On the basis of the objective or strategy the designs are of following main types.

- Production Design
- Functional Design
- Optimum Design

- **Production Design**

In production design , the designer designs something in such a way that the cost of producing the product is minimum. That is, the first responsibility of the designer is reduction of production cost. Hence, a production designer is concerned with the ease with which something can be produced, and that at a minimum cost.

- **Functional Design**

In functional design , the aim is at designing a part or member so as to meet the expected performance level.
Functional design is a way of achieving given requirements.- but the same may the unproducible or costly to produce. A good designer, then, has to consider the production aspects also. A product designed without keeping all these aspects into account, wastes time, money and efforts.

- **Optimum Design**

It is the best design for given objective function, under the specified constraints.
On the basis of the field/ area or the domain of design, the following types are important.

- Mechanical Design
- Machine Design
- System Design
- Assembly/sub-assembly design
- Computer aided design

- **Mechanical Design**

It means use of scientific principles, technical information and imagination in the design of a structure,or machine to perform prescribed functions with maximum economy and efficiency.

- **Machine Design**

It is the process of achieving a plan for the construction of a machine.

- **System Design**

System Design is an iterative decision making process to conceive and implement optimum systems, to solve problems and needs of society.

- **Assembly/sub-assembly design**

In the design of Assembly/sub-assembly the major criterion is the fulfillment of functional requirements. The assembly has to be designed to meet broad technical parameters and purpose for which it was meant.
The characteristic features are:
• The total number of parts used in the design must be minimum.
• Sub-assemblies should be capable of being built separately in order to give maximum manufacturing flexibility.
• Standard parts may be used.
• Flexible parts should be avoided, as they are easily damaged during handling and assembly.
• Computer aided design [CAD]
It is a design methodology in which the designs take the advantages of digital computer to draw concepts, analyze and evaluate data etc. Computers are largely used in a design office for simulation and prototype study. In modern design, computers have become an indispensable tool.

Other types of designs are
Probabilistic Design
Industrial Design

Probabilistic Design
It is a design approach in which design decisions are made using statistical tools. Generally, the external load acting on a body, the properties of materials etc are liable to vary. In probabilistic design, the designer takes into account the variations of such parameters.

Industrial Design
It is the design made by considering aesthetes, ergonomics and production aspects.

Questions
1. What are the characteristics features of system design, assembly/sub-assembly design and component design? Explain briefly with the help of examples.
2. Distinguish between functional design and industrial design.
3. Discuss the meanings of conceptual design, creative design, adoptive design and variant design.
4. What are the three main types of design? Give a comparative analysis.
• Explain the difference between creative design, adoptive design and variant design.
• Designing for function involves the use and knowledge of ……………..
Ans. Eng. Sciences
8. Explain the meaning of
• Conceptual design, (ii) Functional design and (iii) production design. Give suitable example of each.

Lecture 7

Topics: Transformation of customer requirements into design artefacts

Links:

Book: Machine Elements in Mechanical Design by Mott R. L Fourth Edition page no. 9 to 14

Lecture Notes:

Transformation of Customer requirements into design artefacts

The ultimate objective of mechanical design is to produce a useful product that satisfies the Needs of a customer and that is safe, efficient, reliable, economical, and practical to manufacture. Think broadly when answering the question. "Who is the customer for the product or system I am about to design?" Consider the following scenarios:

• You are designing a can opener for the home market. The ultimate customer is the person who will purchase the can opener and use it in the kitchen of a home. Other customers may include the designer of the packaging for the opener, the manufacturing staff who must produce the opener economically, and service personnel who repair the unit.

• You are designing a piece of production machinery for a manufacturing operation. The customers include the manufacturing engineer who is responsible for the production operation, the operator of the machine, the staff who install the machine, and the maintenance personnel who must service the machine to keep it in good running order.

• You are designing a powered system to open a large door on a passenger aircraft. The customers include the person who must operate the door in normal service or in emergencies, the people who must pass through the door during use. the personnel who manufacture the opener, the installers, the aircraft structure designers who must accommodate the loads produced by the opener during flight and during operation, the service technicians who maintain the system, and the interior designers who must shield the opener during use while allowing access for installation and maintenance.

It is essential that you know the desires and expectations of all customers before beginning product design. Marketing professionals are often employed to manage the definition of customer expectations, but designers will likely work with them as a part of a product development team.

Many methods are used to determine what the customer wants. One popular method, called quality function deployment or QFD, seeks to identify all of the features and performance factors that customers desire and to assess the relative importance of these factors. The result of the QFD process is a detailed set of functions and design requirements for the product. It is also important to consider how the design process fits with all functions that must happen to deliver a satisfactory product to the customer and to service the product throughout its life cycle. In fact, it is important to consider how the product will be disposed of after it has served its useful life. The total of all such functions that affect the product is sometimes called the product realization process or PRP. Some of the factors included in PRP are as follows:

- Marketing functions to assess customer requirements
- Research to determine the available technology that can reasonably be used in the
- product
- Availability of materials and components that can be incorporated into the product
- Product design and development
- Performance testing
- Documentation of the design
- Vendor relationships and purchasing functions
- Consideration of global sourcing of materials and global marketing
- Work-force skills
- Physical plant and facilities available

- Capability of manufacturing systems
- Production planning and control of production systems
- Production support systems and personnel
- Quality systems requirements
- Operation and maintenance of the physical plant
- Distribution systems to get products to the customer
- Sales operations and time schedules
- Cost targets and other competitive issues
- Customer service requirements
- Environmental concerns during manufacture, operation, and disposal of the product
- Legal requirements
- Availability of financial capital

You should be able to see that the design of a product is but one part of a comprehensive process. In this book, we will focus more carefully on the design process itself, but the producibility of your designs must always be considered. This simultaneous consideration of product design and manufacturing process design is often called concurrent engineering. Note that this process is a subset of the larger list given previously for the product

realization process.

SKILLS NEEDED IN MECHANICAL DESIGN

Product engineers and mechanical designers use a wide range of skills and knowledge in their daily work, including the following:

1. Sketching, technical drawing, and computer-aided design
2. Properties of materials, materials processing, and manufacturing processes
3. Applications of chemistry such as corrosion protection, plating, and painting
4. Statics, dynamics, .strength of materials, kinematics, and mechanisms
5. Oral communication, listening, technical writing, and teamwork skills
6. Fluid mechanics, thermodynamics, and heat transfer
7. Fluid power, the fundamentals of electrical phenomena, and industrial controls
8. Experimental design and performance testing of materials and mechanical systems
9. Creativity, problem solving, and project management
10. Stress analysis
11. Specialized knowledge of the behavior of machine elements such as gears, belt drives, chain drives, shafts, bearings, keys, splines, couplings, seals, springs, connections (bolted, riveted, welded, adhesive), electric motors, linear motion devices, clutches, and brakes.

Lecture 8

Topic: Functional and Structural hierarchies

Link: http://www.amiestudy.com/studynotes/design/9.htm

Book: The Mechanical Design Process by Ullman Page no. 177 to 189

Lecture Notes:

A functional organizational structure is a structure that consists of activities such as coordination, supervision and task allocation. The organizational structure determines how the organization performs or operates. The term organizational structure refers to how the people in an organization are grouped and to whom they report. One traditional way of organizing people is by function. Some common functions within an organization include production, marketing, human resources, and accounting.

This organizing of specialization leads to operational efficiency where employees become specialists within their own realm of expertise. The most typical problem with a functional organizational structure is however that communication within the company can be rather rigid, making the organization slow and inflexible. Therefore, lateral communication between functions become very important, so that information is disseminated, not only vertically, but also horizontally within the organization. Communication in organizations with functional organizational structures can be rigid because of the standardized ways of operation and the high degree of formalization.

As a whole, a functional organization is best suited as a producer of standardized goods and services at large volume and low cost. Coordination and specialization of tasks are centralized in a functional structure, which makes producing a limited amount of products or services efficient and predictable. Moreover, efficiencies can further be realized as functional organizations integrate their activities vertically so that products are sold and distributed quickly and at low cost. For instance, a small business could make components used in production of its products instead of buying them.

Even though functional units often perform with a high level of efficiency, their level of cooperation with each other is sometimes compromised. Such groups may have difficulty working well with each other as they may be territorial and unwilling to cooperate. The occurrence of infighting among units may cause delays, reduced commitment due to competing interests, and wasted time, making projects fall behind schedule. This ultimately can bring down production levels overall, and the company-wide employee commitment toward meeting organizational goals.

Since a design project requires individuals with different fields of expertise, they can be organised into different structures. Listed below are the five organisational structures. The number in the bracket shows the percentage of design projects that use that particular organisation structure.

1. Project matrix, (28%)

It is an organisation structure having the features of project and matrix organisations.

2. Functional matrix (26%)

It is another organisational structure obtained by combining functional as well as matrix organisations.

3. Balanced Matrix (16%)

Here the project manager and functional manager work together. A project manager is assigned to oversee the project, and the responsibility and authority for completing the project rests with functional managers.

4. Project Team (16%)

A project manager is put in charge of a project team composed of a core group of personnels from several functional areas or groups assigned on a full time basis.

5. Functional Organisation (13%)

Each project is assigned to a relevant functional area or group within a functional area. A functional area focuses on a single discipline.

5.7. Task Clarification

A project plan is a document that defines the tasks necessary to be completed during a design process. A project plan is used to keep the project under control. It helps the design team and management to know how the project is actually progressing.

There are five steps to establish a plan. They are,

- Identify the task
- State the objective of each task
- Estimate Personnel's, time, resources required.
- Develop a sequence for these tasks.
- Estimate product development cost.

Step 1 Identify the tasks

In the first step of the planning of the design project, the different tasks needed to bring the problem from its initial state to the final products are identified. The tasks are the activities to be performed during the design process. Given below is a list of tasks drafted by a design team, for the development of a certain product.

a. Collect and evaluate customer requirements and competition scenario.
b. Establish two concepts for product development.
c. Develop final prototype.
d. Test prototype No1 and select one design for finalisation.
e. Redesign and produce proto type No2.
f. Field test prototype No2.
g. Complete production documentation.
h. Develop marketing plan.
i. Develop quality control procedures.
j. Prepare patent applications.
k. Establish product appearance.
l. Develop packaging.

Step .2. State the objective for each task.

Even though the tasks are initially identified, they need to be refined to ensure that the results of the activities are the stated objectives. For example, for the task No. (a) above, the objective is to collect information required for developing specification.

Step 3: Estimate the Personnel, Time & other Resources Required.

Completion of each of the tasks listed above will consume resources such as personnel, time etc. An estimate of the requirement of resources may look like:

Task Personnel/time
Collecting data Two market surveyors, two months
Concept generation Two designers, two week.

Step 4 Develop a Sequence for the tasks

The next step is scheduling of tasks-the purpose is to ensure that each task is completed, before its result is needed. CPM is the best method to accomplish this.

Step 5 Estimate Product Development Cost

On the basis of the above steps, the costs for developing the product can be estimated. Normally design cost is only about 5% of manufacturing cost.

The above plan developed in the early stage of the design has to be refined as the project progresses.

<u>Lecture-09</u>

Questions:

1. **Define machine design.**
2. **Discuss the basic requirements for machine elements and amchines.**
3. **What are the steps involved in design of machine elements?**
4. **Write the design procedure of design of machine elements.**
5. **What are the types of machine design?**
6. **Discuss in detail about adaptive design or redesign.**
7. **Define and discuss optimum design.**
8. **What are the functional hierarchies of machine design?**
9. **Discuss the design processes.**
10. **Discuss the following: (a) Developed design (b) Functional design (c) Initial and final design.**
11. **Discuss transformation of customer into design artefacts.**