EXPERIMENT No. 3

(To be performed by group of 4-5 students)

1.0 Title :

Select the material for given application using design data book.

2.0 Prior concepts:

Stress strain diagram for ductile and brittle materials

Mechanical properties of engineering materials

Knowledge of material science.

3.0 New concepts :

Proposition 1: MachineDesign

It is the use of scientific principles, technical information and imagination in the description of a machine or mechanical system to perform specific functions with maximum economy and efficiency. See figure 1.

Concept Structure

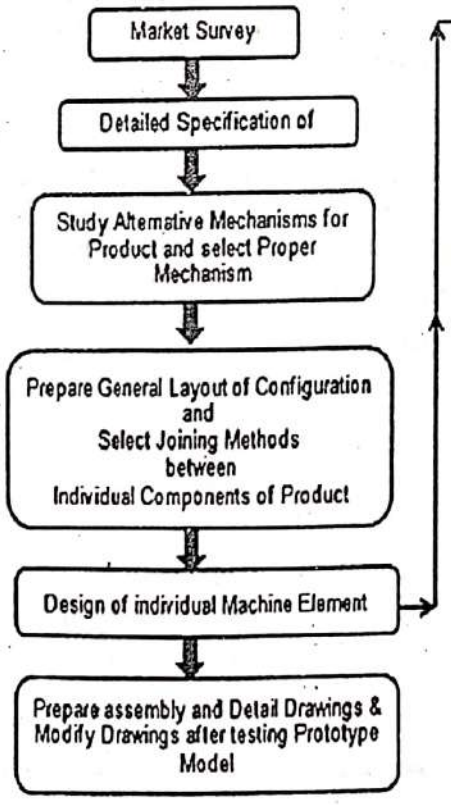


Figure 1: General Design Process

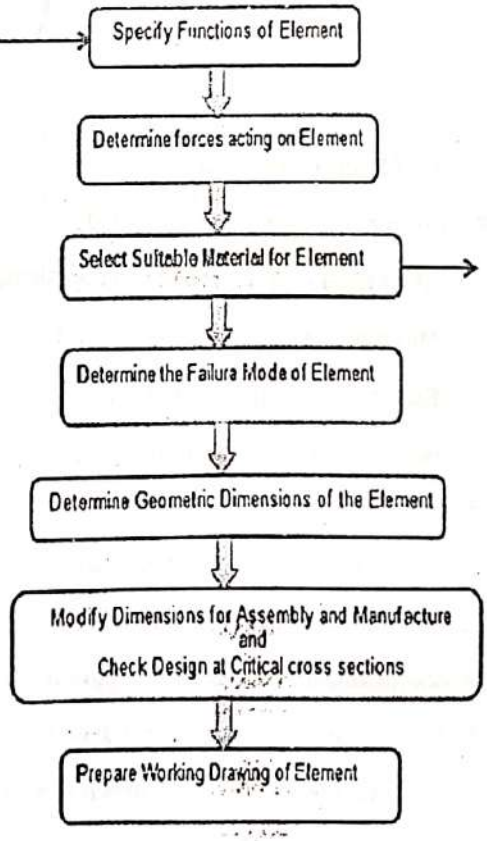


Figure 2: Basic Procedure of Design of Machine Element

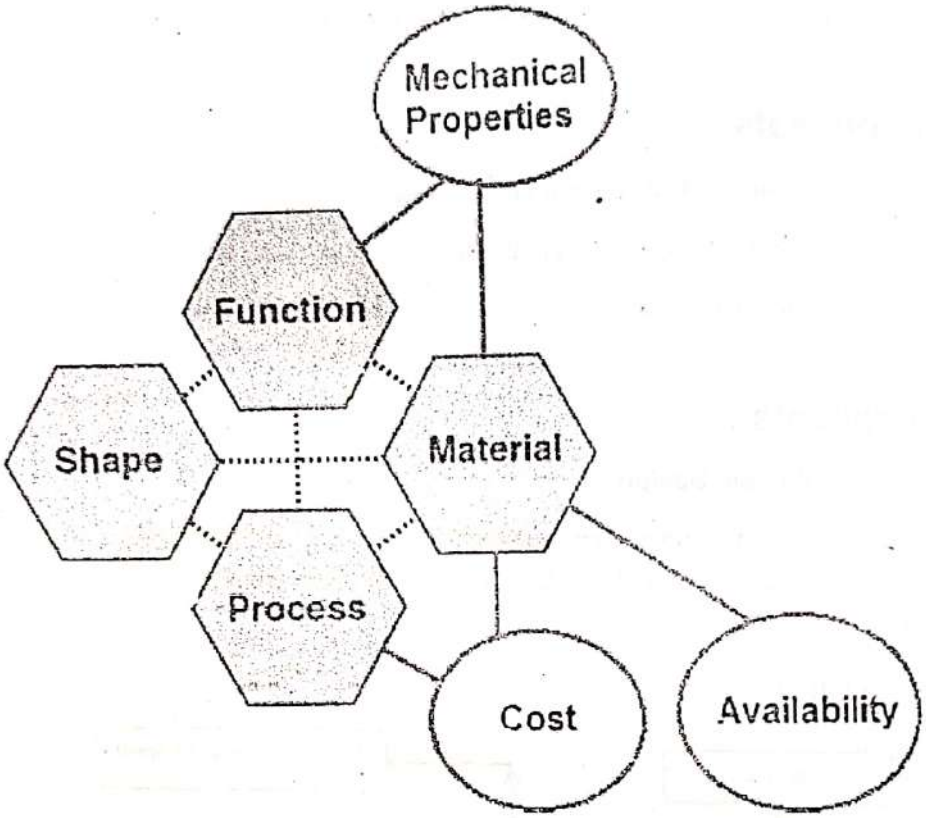
General Machine Design procedure incudes the Design of individual Machine Component as shown in figure 2.

Design of Machine Element includes selection of suitable Engineering Material.

Proposition 2: Selection of Material for engineering applications

It is a process of selecting the best material which will serve the desired purpose at minimum cost.

Concept Structure



Selection of Material Depends on

- **Function** of the Component: It include

  Structural support, protection,containment

  Mechanical movement and control

  Electrical operations and control,

  Requirements for **maintenance**etc.

  Note: Functions of the component need different properties of material.

  Properties of materials may be physical, chemical and Mechanical

- **Shape** and form can be important to a design's:

  Aesthetic qualities, ergonomics, strength, stability, rigidity, safety, aerodynamics.

  Note: Functional requirement decides the shape and form of the component.

  Example: Shape of aeroplane is selected as aerodynamic (streamline) due to its functional requirement

- **Processes** include different manufacturing process (machining, casting, forming, joining, powder metallurgy etc.) which is function of shape and material to be selected.

Example: Intricate shape – manufacturing process needed is casting hence material selected shall be cast iron.

Note: Availability and properties of material decides the cost of material and cost of material decides the cost the processing of that material to make the required component of designed shape for the intended function.

Proposition 3: Designation of Engineering Materials

Designation is the process of coding the engineering materials which indicates the chemical composition of material / mechanical properties and heat treatment.

Designation of materials is the part of standardization.

B.I.S SYSTEM OF DESIGNATION OF STEEL

A large number of varieties of steel are used for machine components. Steels are designated by a group of latters or number indicating any one of the following three properties:

1. Tensile strength,
2. carbon content, and
3. composition of alloying element,

Steels which are standardized on the basis of their tensile strength without detailed chemical composition are specified by two ways – symbol Fe followed by the minimum tensile strength in N/mm^2 or symbol FeE followed by the yield stress in N/mm^2. For example, Fe 360 indicated a steel with a minimum tensile strength of 360 N/mm^{2}FeE 250 indicated a steel with minimum yield stress of 250N/mm^2.

The designation of plain carbon steel consists of the following three quantities:

1. A figure indicating 100 times the average percentage of carbon,
2. A letter C, and
3. A figure indicating 10 times the average percentage of manganese

As an, 55C4 indicates a plain carbon steel with 0.55% carbon and 0.4% manganese. A steel with 0.35-0.45% carbon and 0.7-0.9% manganese is designated as 40C8.

The designation of unalloyed free cutting steels consists of following quantities:

1. A figure indicating 100 times the average percentage of carbon
2. A letter c,
3. A figure indicated 10 times the average percentage of manganese,
4. A symbol 'S' , 'Se' , 'Te' or 'Pb' depending upon the element present which makes the steel free cutting and
5. A figure indicating 100 times the average percentage of the above element that makes the steel free cutting.

As an example, 25C12S14 indicates a free cutting steel with 0.25% carbon,1.2%manganese and 0.15% lead is designated as 20C12Pb15.

The term 'alloy' steel is used for low and medium alloy steels containing total alloying element not exceeding 10 per cent. The designation of alloy steels consists of following quantities.

1 A figure indicating 100 times the average percentage of carbon and

2 Chemical symbols for alloying elements each followed by the figure for its average percentage contain multiplied by factor the multiplying factor depends upon the alloying element. The values of this factor are given in table 2.3.

Table 2.3 multiplying factor for alloying elements in steel

Elements	Multiplying factor
Cr, Co, Ni, Si, and W	4
Al, Be, V Pb, Cu, Nb, Ti, Zr and Mo	10
P,S,N	100

In alloying steels, symbol 'Mn' for manganese is included only if the content of manganese is equal to or greater than 1 per cent The chemical symbols and their figure are arranged in descending order of their percentage content.

As an example, 25Cr4Mo2 is an alloy steel having average 0.25% carbon 1% chromium and 0.2% molybdenurn. Similarly 40Ni8Cr8V2 is an alloy steel containing average 0.4% carbon 2% nickel 2% chromium and 0.2% vanadium consider an alloy steel with the following composition.

carbon	0.12 to 0.18%
Silicon	0.15 to 0.0.35%
manganese	0.40 to 0.60%
chromium	0.50 to 0.80%

The average percentage of carbon is 0.15% which is denoted by the the number (0.15X100) or 15. Percentage content of silicon and manganese is negligible and they are deleted from the designation. The significant element is chromium and its average percentage is 0.65. The multiplying factor for chromium is 4 and (0.65X 4) is 2.6, which is rounded to 3. Therefore the complete designation of steel is 15Cr3. As a second example, consider a steel with the following chemical composition.

Carbon	0.12 – 0.20%
silicon	0.15 – 0.35%
manganese	0.60 – 1.00%
nickel	0.60 – 1.00%
chromium	0.40 – 0.80%

The average percentage of carbon is 0.16% and multiplying this value by 100 the first figure in designation of steel is 16 The average percentage of silicon and manganese is very small and the symbols Si and Mn are deleted. Average percentages of nickel and chromium are 0.8 and 0.6 respectively and the multiplying factor for both element is 4. Therefore,

Nickel : 0.8X4=3.2 rounded to 3 or Ni3

Chromium : 0.6X4= 2.4 rounded to 2 or cr2.

The complete designation of steel is 16NiCr2.

The term 'high alloy steel; is used for alloy steels containing more than 10 per cent of alloying elements The designation of alloy steels consists of following quantities;

1 A letter 'X'

2 A figure indicating 100 times the average percentage of carbon,

3 chemical symbol for alloying elements each followed by the figure for its Average percentage content rounded off to nearest integer, and

4 chemical symbol to indicate specially added element to attain desired properties, if any.

As an example X15Cr25Ni12 is high alloy steel with 0.15% carbon 25% chromium and 12% nickel As a second example, consider a steel with the followed chemical composition.

carbon	0.15 to 0.25%
silicon	0.10 to 0.50%
manganese	0.30 to 2.5%
chromium	16 to 20%

The average content of carbon is 0.20% which is denoted by a number (0.20X100) or 20. The major alloying elements are chromium (average 18%)and nickel (average 2%). Hence, the designation of steel is X20Cr18Ni2.

Note: Student shall refer and study the designation of different materials from design data book or IS codes.

4.0 Learning Objectives :

Intellectual Skills:

- Understand the basic philosophy and fundamentals of machine design
- Apply and use the basic knowledge of earlier subjects like mechanical engineering materials, Strength of materials and theory of machines
- Understand the concept of standards and standardization.

Motor Skills:

- Ability to identify the material required for the given application of a mechanical component.
- Ability to select standard material using design data book and different IS codes.

5.0 Learning Aids:

- Design data book published by PSG College of Technology Coimbatore.
- International Standard Codes specified as percurriculum.
- Material selection charts provided in book of "Material Selection in Mechanical Design, Michael Ashby published by Elsevier Publications.
- Working models of mechanical assemblies, components of machine tools from workshop, toys etc.

6.0 Stepwise Procedure :

1. Teacher shall introduce students to new concepts like design Procedure, basic procedure of design of machine element,
2. Teacher shall introduce students about selection of materials and designation of materials.
3. Teacher shall provide the information about the selection of materials by functional requirement of the mechanical component with suitable examples.

   Teacher shall explain the interrelationship of function, shape, process, mechanical properties cost and availability of material with the selection of material.

   Teacher shall use simple examples of like components of toys, simple mechanical tools like pliers, hammers to explain the section of material.
4. Teacher shall ask students to find out the chemical composition and mechanical properties of materials using design data book by giving some material designations and note under the observations.
5. Teacher can also ask the students to observe the applications of the materials from design data book and note under the observations.
6. Students in group will identify theappropriate engineering material for given mechanical component using International Standard Code/Design Data Book and note under the observations.

7.0 Observations :

Write the missing information in the observations given below.

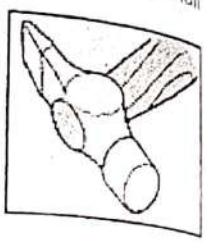
Fill in' the empty boxes (and also add to the other boxes if you canon a new page.)

Some of the information you require can be found from the experiment itself. For more detailed information you will need to use a more specialist book.

Material	Ferr-ous	Non-ferrous	Composition	Colour	Properties	Common uses
Mild steel	√		Iron+0.1% to 0.3 carbon		Fairly high tensile strength heavy metal(density=7.8g/km^3 High melting point (1600c)corrodes by rusting	
		√			Soft and ductile low tensile strengih lightweight(density = 2.7g/km^3) Melting point 660c	Milk bottle tops cooking foil ladders door and window frames
			Iron+0.3 to 0.7% carbon	Silver-grey		
			Pure metal	Reddish-brown	Heavy metal(density=8.9g/ cm^3) good conductor of electricity and heat cannot be magnetised	
	√				Properties vary depending upon percentage of chromium	
	√				Brittle high compressive strength low tensile strength corrodes by rusting	Machine bases manhole covers motor car engine blocks
			Copper-zinc	yellow		

8.0 Questions for confirmation of learning:

(Students shall writeanswers to the questions at the time of practicalindependently before completing the experiment to have self-feedback. He/ She may refer to the notes, etc. Teacher shall supervise.)



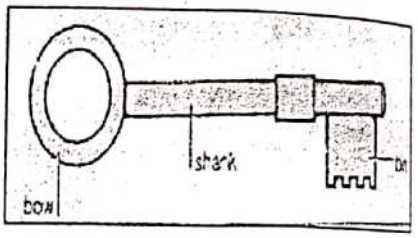
1. State the two essential properties of material required for hammer head?

   .....

2. Define any two physical properties of engineering materials.

   .....

3. State the essential material properties and manufacturing process proposed for manufacturing of different parts of key as shown in figure.



   .....

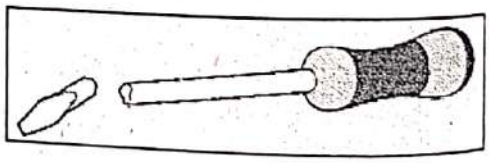
   .....

4. State the name of mechanical property required to form i) steel wires ii) tin sheet

   .....

9.0 Conclusion:

1. 7C4 designation denotes means .....(Alloy steel/ high carbon steel/ plain carbon steel)
2. The screwdriver snapped during the use as shown, the material of screw driver is .....(ductile/ brittle)



3. Stiffness is the property of material to resist .....deformation.(tensile, compressive/ bending)

10.0 Student Activity (Field Visit)

(Teacher shall form a group of 4-5 students each. Each group shall perform only one allotted activity from the following. Teacher shall supervise these activities.)

1. Observe equipment available in different laboratories used for practical of mechanical engineering and find the stresses developed in different components of equipment. Draw the table and note the different names of at least ten components.

   Write the function of each component, select the suitable material enlisting the required mechanical properties, shape and manufacturing process. Provide the designation of material selected along with its chemical composition. (Applied Mechanics/ Strength of Materials/ Power Engineering/ Workshop/ Theory of machines and mechanisms, etc)

2. Observe the household appliances like mixer grinder, refrigerator, washing machine, LPG gas stove with Glass top. Write the function of each component, select the suitable material enlisting the required mechanical properties, shape and manufacturing process. Provide the designation of material selected along with its chemical composition.

3. Observe the mechanism of bicycle and identify the mechanical components.Draw the table and note the different names of at least ten components.

   Write the function of each component, select the suitable material enlisting the required mechanical properties, shape and manufacturing process. Provide the designation of material selected along with its chemical composition.

(Space for answer. Add page if required)

.....

.....

.....

.....

.....

.....

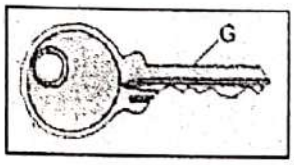
.....

11.0 Questions:

Write answers to Q....Q....Q....Q.... (Teacher shall allot the question)

1. State any five differences between physical properties and mechanical properties of engineering materials.

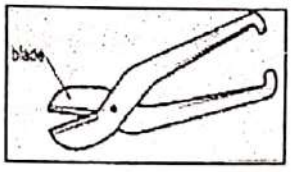
2. State the properties which are deficient if



   I. Old car shows rust spots.

   II. Cylindrical latch lock key shown in figure is broken during use.

   III. Blades of tinsnips shown in figure, loose sharpness very soon



3. Draw the stress –strain diagram for mild steel and cast iron and compare them.

4. How the proof stress and proof load can be determined by using stress strain diagram?

5. Why percent elongation is considered as an index of quality of the material.

6. Define the following mechanical properties of materials.

i)	Strength	ii)	Elasticity	iii)	Plasticity	iv)	Stiffness
v)	Resilience	vi)	Toughness	vii)	Malleability	viii)	Ductility
ix)	hardness	x)	brittleness				

7. Indicate the above properties on stress strain curve whichever is possible. State at least two applications each where the above properties are essential for design.

8. Distinguish between

   i) Elasticity and plasticity & ii) Malleability and ductility.

9. Distinguish between

   i) Resilience and toughness & ii) Brittleness and ductility.

10. Distinguish between mild steel, machinery steel, and tool steel

11. Give two applications of free cutting steels.

12. Compare cast steel with cast iron.

13. Compare cast steel with wrought steel.

14. State the meaning of the following material designations

   i) 40 C 8 ii) SG 700/2 iii) WM 320 iv) 30Ni16Cr5

15. State the meaning of the following material designations

   i) Fe 320 ii) FeE200 iii) X15Cr25Ni12 iv) CS 1030

16. Suggest suitable material for following machine parts stating the reason

   i) Casing of centrifugal pump ii) High strength bolt

   iii) Tie rod iv) Spring of I.C. Engine valve

17. Suggest suitable material for following machine parts stating the reason

   i) Engine cylinder ii) Pressure plate of clutch

   iii) Lathe bed iv) Brake drum.

(Space for Answers)