Material selection-Cost and service requirement

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Goal And Objectives

The overall goal of this is to illustrate how systematic selection procedures can be used to select optimum materials and processes for a given component.

General Steps In Material Selection :

1. Analysis of the performance requirements.

2.Development of alternative solutions to the problem.

3. Evaluation of the different solutions.

4.Decision on the optimum solution.

Analysis Of Material Performance Requirements

The material performance requirements can be divided into 5 broad categories:

- Functional requirements
- Processability requirements
- Cost
- Reliability requirements
- Resistance to service conditions

Product Function Is

Interdependent



Creating Alternative Solutions

Aving specified the material requirements, the rest of the selection process involves the search for the material that would best meet those requirements.

The starting point is the entire range of engineering materials.

A steel may be the best material for one design concept while a plastic is best for a different concept, even though the two designs provide similar functions.

The importance of this phase is that it creates alternatives without much regard to their feasibility.

Property Profiles By Family

Characteristics	M etals	Metals Ceramics		
strength	strong	strong –C weak – T	weak	
elastic strength	very	som e	som e	
stiffness	very	very	flexible	
ductility	ductile	brittle		
hardness	medium	hard	so ft	
corrosion resistance	poor	good	excellent	
fatigue resistance	good			
conductivity (heat/electric)	conductor	insulator	insulator	
creep resistance	good		poor	
im pact resistance	good	poor	good	
density	heavy	medium	light	
tem perature tolerance	good	super	poor	

Screening: How Do We Choose A Material?

Product function depends upon... material, manufacturing process, geometry

We have to consider all three

Do we select a few feasible materials first... then select the specific mfg process?

OR

Do we select a few feasible mfg processes... then select the specific material?

Screening: Materials First Approach

Application Information

1. Applied loads magnitude cyclic nature (steady, fatigue) rate (slow, impact) duration (creep) 2. Ambient conditions temperature moisture sunlight chemical liquids/vapors 3.Safety 4.Cost

Screening: Manufacturing Process First Approach

Part Information

1.Production volume 2.Part size (overall) 3.Shape capability (features) boss/depression 1D boss/depression >1D holes undercuts (internal/external) uniform walls cross sections (uniform /regular) rotational symmetry captured cavities

Ashby's Method











3.

✤ Given the same cost/volume... which is stronger?

index = Strength/cost

✤ Given the same cost/volume... which is stiffer?

index = Young's modulus/cost

Comparing And Ranking Alternatives I Weighted Properties Method I

- In this method each material requirement is assigned a certain
- weight, depending on its importance.
- A weighted property value is obtained by multiplying the scaled value of the property by the weighting factor (α).
- B = scaled property = numerical value of property x 100 The weighted property values of each material are then summed to give a performance index (ψ) . The material with the highest performance index (γ) is optimum for the application.

Comparing And Ranking Alternatives I Weighted Properties Method II

✤For cost, corrosion loss, etc., a lower value is more desirable and the lowest value is rated as 100

n

B = scaled property = <u>minimum value in the list x 100</u> numerical value of property

Material performance index = $\gamma = \Sigma$ B_i α_i i=1

where i is summed over all the n relevant properties.

Reaching Final Decision

4. After ranking of alternatives, candidates that have the most promising performance indices can each now be used to develop a detail design.

 Each detail design will exploit the points of strength of the material, avoid the weak points, and reflect the requirements of the manufacturing processes needed for the material.

 After completing the different designs, solutions are then compared, taking the cost elements into consideration in order to arrive at the optimum design-material-process combination.

Case Study -Selecting A Beam Material For Minimum Cost

 A simply supported beam of rectangular cross section of length 1 meter, width 100 mm, and no restriction on the depth is subjected to a load of 20 kN in its middle.

The main design requirement is that the beam should not suffer plastic deformation as a result of load application.

Select the least expensive material for the beam.

Case Study -Selecting A Beam Material For Minimum Cost

Table Characteristics of candidate materials for the beam

Material	Workingstressa		Specific	Relative	Costof
	MPa	ksi	gravity	cost b	unit
					strength
SteelAISI1020, normalized	117	17	7.86	1	0.73
SteelAISI4140, normalized	222	32	7.86	1.38	0.73
Aluminum6061,T6temper	93	13.5	2.7	6	1.69
Epoxy+70% glassfibers	70	10.2	2.11	9	2.26

A The working stress is computed from yield strength using a FOS of 3.

b The relative cost per unit weight is based on AISI1020 steel as unity. Material and processing costs are included in the relative cost. considered for the selection of materials for design of machine elements?

- Following factors should be considered:
- 1. Availability :
- 2. Cost :
- 3. Mechanical Properties :
- 4. Manufacturing consideration :



Availability

Cost :

- For every application, there is limiting cost beyond which the designer cannot go.
- When the limit exceeded the designer has to consider an alternative material.
- In cost analysis, there are two factors namely cost of material and the cost of processing the material into finished goods.
- It is likely that the cost of material might be low but the processing may involve costly machining operations.



The important mechanical properties of material from the consideration design are strength, rigidity, toughness, resilience, shock resistance, wear resistance, creep characteristic, corrosion resistance, frictional properties and hardness.

- Strength : The ability of material to withstand stress without fracture is called its strength.
- Ductility : The property of a material to undergo deformation under tension without fracture is called Ductility.
- Hardness: The ability of a material to withstand scratching, wear and abrasion or indentation (penetration) by harder bodies is known as hardness.

- Toughness : Toughness is the amount of energy that a material can absorb before it fractures.
- Resilience : It is the capacity of a material to absorb or store energy up to elastic limit, and to resist shock and impact.
- Creep
- : The slow and progressive deformation of a material with time at constant stress is called Creep.

Corrosion resistance : It is the deterioration of a material by chemical reaction with its environment.

- Brittleness : The property of a material by virtue of which it will be fractured without appreciable deformation is called brittleness.
- Weldability : It is defined as the ease with which a material can be welded under a given set of conditions.



It is important consideration in selection of materials.

Sometimes, expensive materials are more economical than low cost material, which difficult to machine.

<u>Q-2</u> : Most commonly used engineering material

- Cast Iron
- Alloy steel
- Plastic
- Aluminum alloy













- Lower melting point
- Low shrinkage and good fluidity and casting ability.
- Application:
- Car parts cylinder heads, blocks and gearbox cases.
- Foundation for big machines
- Cook wares Excellent heat retention





- Low Alloy (<10 wt%)
- Low Carbon (<0.25 wt%
 C)
- Medium Carbon (0.25 to 0.60wt%)
- High Carbon (0.6 to 1.4 wt%)



- High Alloy
- Stainless Steel (> 11 wt%
 Cr)

Low carbon

steel

- Properties:
- least expensive.
- Good Weldability and machinability.
- Application:
- Automobile panels, nails, and wire.
- Low temperature pressure vessels.





- Addition of Cr, Ni, Mo improves the heat treating capacity.
- Heat treated alloys are stronger but have lower ductility.
- Application:
- Railway whee gears, cranksh





High carbonsteel

- Properties:
- High C content provides high hardness and strength. Hardest and least ductile.
- Used in hardened and tempered conditi



- Application:
- Used as tool and die steels owing to the high hardness and wear resistance property.





- Thermo plastic rational can be neglected.
- Soften

<u>1C</u>

- Application:
- Self lubricating bearing, cams, valve seats, silent gears







<u>Aluminum</u> alloys

- Properties:
- Low specific gravity.
- Corrosion resistance.
- Easy to fabrication.
- High thermal conductivity.





- Application:
- Engine cylinder blocks, casting for valve body, connecting rod, fly wheel housing.
- Piston and cylinder head.



Q-3 : Select suitable material for following cases, indicating the reason.

a) A shaft subjected to variable torsional and bending load.

➤The material used are mild steel, such as Nickel, Nickel-Chromium and molybdenum steels.

➢It is used because it improve toughness, chromium improve hardness and resistance to wear and tear and molybdenum steel improve creep properties.

b) Spring used in spring loaded

safety valve.

- ➢ <u>Steel</u>:-
 - Great formability
 - Low density
 - Corrosion resistance
 - High yield strength
- Cast Iron:-



- Good compressible strength
- Easily machinable



►Bronze :-

d) Low speed line shaft coupling.

>The material used for making shaft coupling is cast iron.

>It is used because it is strong enough to transmit the torque from one shaft to the other shaft.

a) Turbine blade :-Q-4 : Select suitable material for following part stating special property

which makes it more suitable for use in manufacturing.

- Suitable material are super alloys of nickel based that in corporate chromium, cobalt and rhenium.
- Super alloy has key characteristics :-
- Excellent mechanical strength
- Resistance to thermal deformation
- Good surface stability
- b) <u>Diesel engine crank Shaft</u> :-
- Forged Steel :-
- Excellent mechanical strength
- High toughness





c) Heavy duty machine

tool blade :-Carbide tungsten :-

- High hardness
- High toughness
- Low thermal expansion
- d) Bush bearing :-
- Best material for bush bearing manufacturing is cast iron.
- Although bronze, graphite can be added reduce wear and tear.
- Characteristics :-
 - Good machinability
 - Good compressible strength
 - Good hardness





c) Noner bearing

oMost common material used is Chrome steel.

- ✤ <u>Characteristics</u> :-
 - High mechanical strength
 - Toughness is high
 - High resistance of wear and tear
 - Low thermal expansion
- f) <u>Dies</u> :-

oThe most common material is prehardened steel.

- Characteristics :-
 - High hardness
 - Good resistance of impact load.





g)Carburettor body :-

- It is a major part of an I.C engine.
- Three main characteristics component ma cast iron, zinc, aluminium.
- ♦ Characteristics :-
 - Low cost
 - High flowability
- h) Automobile cylinder block :-
- o Most new automobile engine use cast iron or grey iron and aluminium alloys.

Characteristics :-

- High strength
- Low thermal expansion
- Good machinability





) Tramway axle :-

oSteel is mostly used material in tramway axl

- Characteristics :-
 - High mechanical strength
 - High yield strength
 - High toughness
 - High resistance, wear and tear
- j) <u>Cam follower</u> :-



- Cam follower is used in I.C engine to operate the valve mechanism.
- The most common material is used in is stainless steel.
- Characteristics :-
 - Great formability
 - Low density
 - Corrosion resistance
 - High tensile yield strength.



THANK