SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF AEROSPACE ENGINEERING

19AST101 – INTRODUCTION TO AEROSPACE ENGINEERING
I YEAR II SEM
UNIT-IV MATERIALS OF AIRCRAFT
TOPIC: Sandwich Structure

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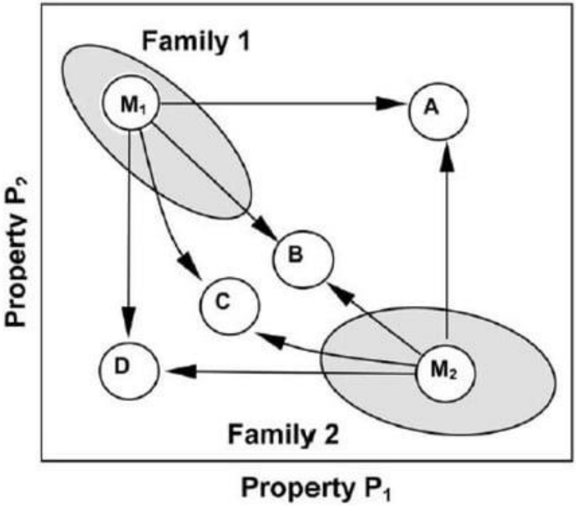
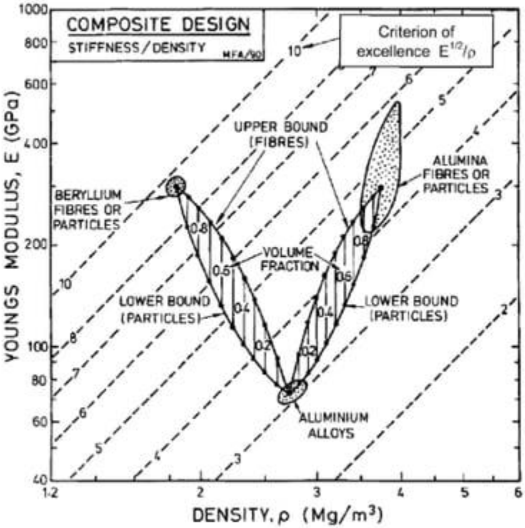
Hybrid Composites

- **Hybrid Composites, wherein one uses more than one type of fiber.**
- **Cost- performance effectiveness can be increased by judiciously using different reinforcement types and selectively placing them to get the highest strength in highly stressed locations and directions.**
- **For example, in a hybrid composite laminate, the cost can be minimized by reducing the carbon fiber content, while the performance is maximized by optimal placement and orientation of the fiber.**

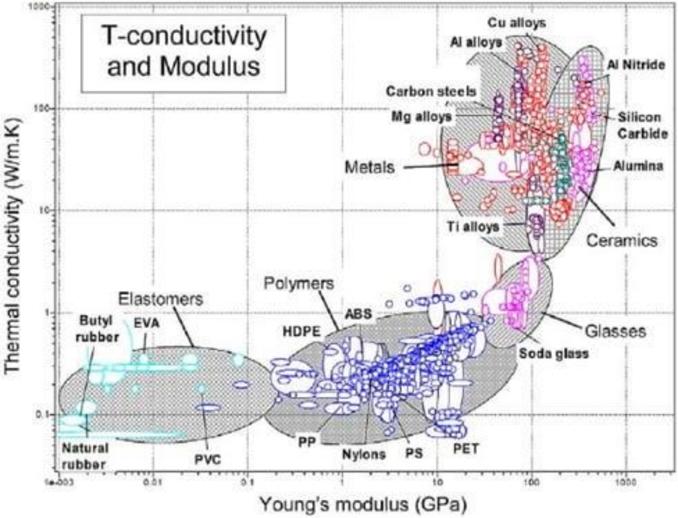
Possibilities of Hybridization



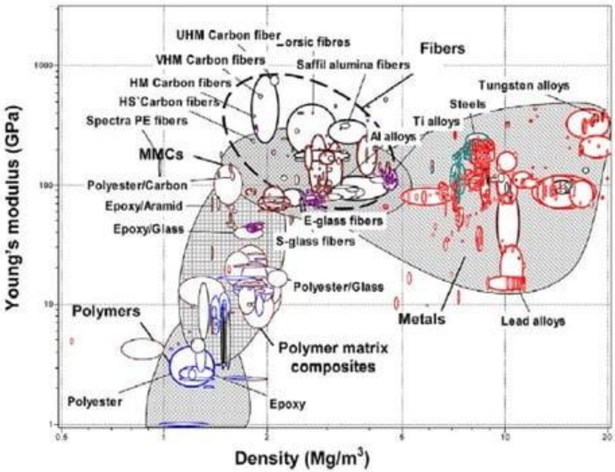
Part of the E–ρ property chart



Material-property chart of thermal conductivity and Young's modulus



Young's modulus and density



Classification of Hybrid Composites

- Hybridisation is commonly used for improving the properties and for lowering the cost of conventional composites. There are different types of hybrid composites classified according to the way in which the component materials are incorporated. Hybrids are designated as

  i) Sandwich   ii) Interply   iii) Intraply   iv) Intimately mixed

- **Sandwich:** one material is sandwiched between layers of another.
- **Interply:** alternate layers of two or more materials are stacked in regular manner.
- **Intraply:** Rows of two or more constituents are arranged in a regular or random manner.
- **Intimately mixed:** constituents are mixed as much as possible so that no concentration of either type is present in the composite material.

Sandwich Structure

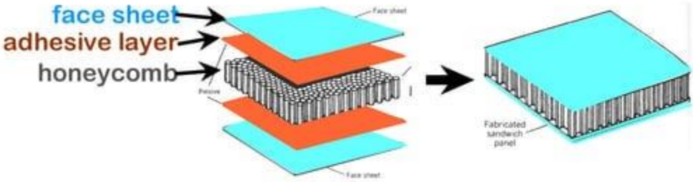
- Sandwich composites involve two or more layers of the same or different materials.
- Fibrous form results mainly in fiber reinforcement direction.
- Of course one can arrange fibers in two dimensional or even three dimensional arrays, but this still does not gainsay the fact that one is not getting the full reinforcement effect in directions other than the fiber axis.
- If a less anisotropic behavior is the objective, then perhaps sandwich composites made of, say two different materials would be more effective.

Sandwich Structure

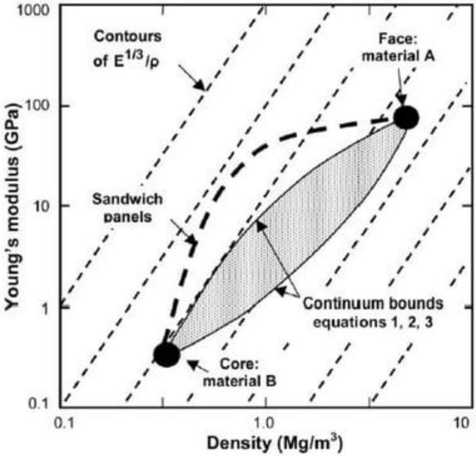
- Sandwich structure, consists of high strength facings or skins, being adhesively bonded to the low density core.
- **Core:** A centrally located layer of a sandwich construction, usually low density, which separates and stabilizes the facings and transmits shear between the facings and provides most of the shear rigidity of the construction.
- **Facing (skin/face/face sheet):** The outermost layer, generally thin and of high density, which resists of most of the edgewise loads and flatwise bending moments.
- **Adhesives:** The adhesives are used to bind the Core and Facing.

Sandwich Structure

- **Sandwich panels are used in bending and compression dominated components.**
- **The face sheets carry the applied in-plane and bending loads.**
- **The core resist the transverse shear and transverse normal loads, as well as keep the facings supported and working as a single unit.**



Sandwich panels (broken line) extend the range of flexural modulus



Selection of Materials for High Temperature Applications (T >700^{0}c)

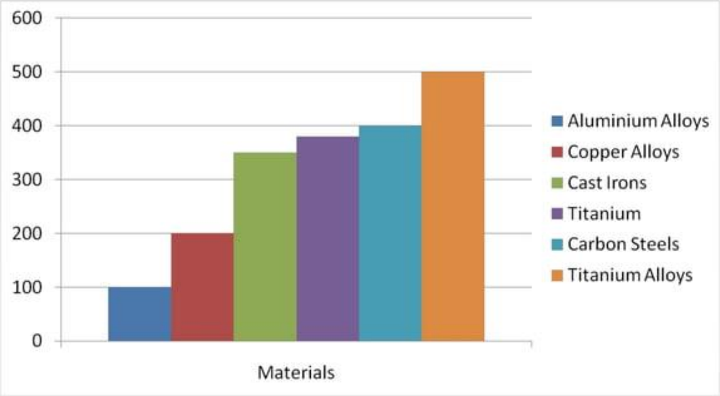
Materials for selection

- Metallic materials
- Polymeric materials
- Ceramic materials
- Composite materials

Properties for selection

- Thermal expansion coefficient
- Electrical conductivity
- Oxidation resistance
- Corrosion resistance
- Yield strength
- Elastic modulus
- Joinability
- Formability
- Cost
- Others, including resistance to hydrogen embrittlement, and machinability

Maximum service temperature of common Engineering Materials



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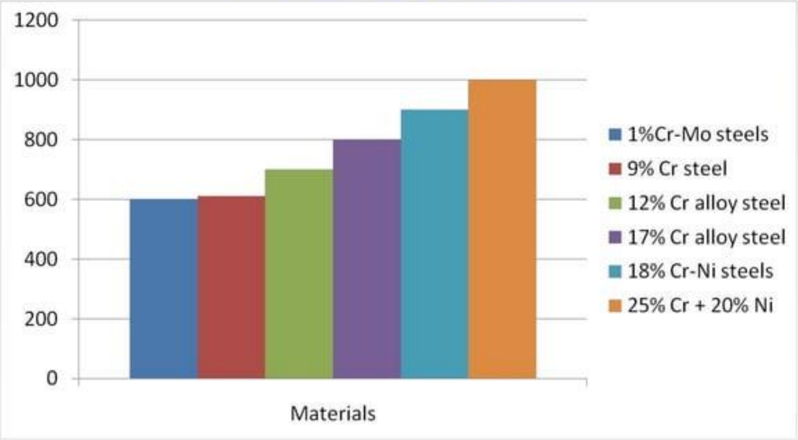
Maximum service temperature of common Engineering Materials



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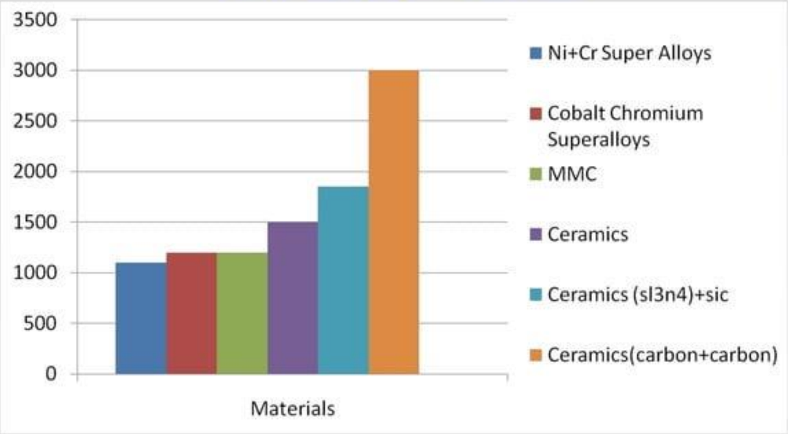
Maximum service temperature of common Engineering Materials



T < 700°C

- Plain carbon steels (%C < 0.08 to 1.03) Normalizing
  - Increase in carbon % improves the creep strength
  - Aluminium used as deoxidizer produce fine grain and reduces creep strength
  - Aluminium effects reduced by presence of Manganese and molybdenum
- Low alloy steels (Alloy %< 10)
  - Molybdenum and vanadium raise the creep resistance
  - %C<0.15 + 0.5% Mo~600°C (super heater tubes)
  - Above this temperature spheroidization and graphitization takes place and reduces creep strength
  - %Cr=1 increases the resistance to graphitization
  - Used for 750°c in boiler tubes

$T > 700^oC$

- Chromium + molybdenum + vanadium + C% upto 0.5
  - High yield strength and creep strength
  - Bolts, steam turbine rotors operating at 750°c
  - Chromium content will increase the resistance to corrosion and oxidation

Cr. Steels	Comp. (%)	Operat. Temp.	Applications
410		750°C	Steam valve, bolts, pump shaft
422		900°C	Steam valve, bolts, pump shaft
430	16% Cr.	1250°C	Heat-exchange equipment, condensers, piping and furnace parts
446	25% Cr.	1700°C	Heat-exchange equipment, condensers, piping and furnace parts

Austenitic stainless steels

- Chromium+nickel+carbon
  - Better creep properties than chromium steels

Austen. Steels	Comp. (%)	Operat. Temp.	Applications
310	25% Cr +20% Ni	1200°C	Furnace linings, boiler baffles, thermocouple wells, aircraft-cabin heaters and jet-engine burner liners
347	18% Cr +11% Ni +Cb& Ta	1350°C	steam liners, super heater tubes, gas turbines and exhaust systems in reciprocating engines

Chromium-nickel-molybdenum-iron alloys

- **Small amount of titanium and aluminium added**

Trade Name	Comp. (%)	Operat. Temp.	Applications
A-286 Discaloy Incoloy		950°C to 1150°C	Forgings for Turbine Wheels, Gas turbines, sheet-metal casings, housings and exhaust equipments

Nickel alloys

- 50 to 70% nickel
- 20% chromium
- 10% molybedenum or tungsten
- upto 20% cobalt
- titanium and aluminium

- **Applications**
  - Manifold, collector rings, exhaust valves of reciprocating engines, sheet form for combustion liners, tail pipes, casings of gas turbines and jet engines

Cobalt+chromium+nickel alloys have lower strength

used for wheels and buckets of gas turbines

Conclusion

- Commercial Alloys lose their strength rapidly when heated above 1700⁰C
- Allowable operating temperature can be raised by suitable base elements

- MOLYBDENUM-4730⁰F
- TUNGSTEN-6170⁰F

THANK YOU