Rewarding Learning

AS LEVEL Section A

FACT FILES

Technology & Design

For first teaching from September 2011

For first award in Summer 2012

New Materials Part 1

technology and design

FACT FILE

1.5 New Materials Part 1

Learning Outcomes

Students should be able to:

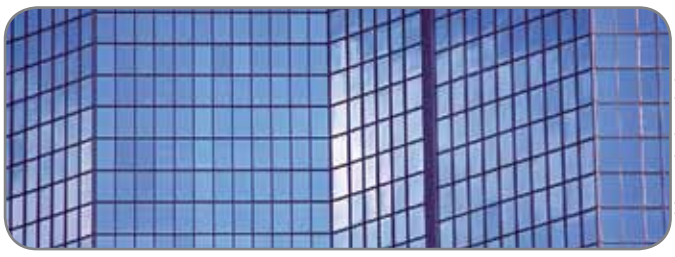
- Understand the difference between composites, alloys and combinations when creating new materials.

Course Content

What is a composite?

A composite is a material which is made up of two or more materials with significantly different properties. When they are combined they make a new material, with properties which are different to the original materials.

Composites are usually made up of resins, reinforcements, fillers and additives. A bulk or resin material - known as a 'matrix' - acts as the 'glue' which holds the composite together and will play an important role in defining the property and characteristic of the final composite.



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A reinforcing material, which is usually in a fibre form, adds strength and thickness to the bulk material, this is often known as the reinforcement. The reinforcing fibres give composites stiffness and excellent strength to weight ratios. Some composites use particles or sheet material for their matrix, these composites usually contain ceramics and/or metals.

- Thermosetting and thermoplastics are commonly used as the resin in polymer based composites.
- Glass is the most common fibre used in composite materials, but carbon fibre can be combined with glass to strengthen it.
- Additives are often used to improve appearance or provide fire retardance.
- Most composites can be divided into three groups:

Fibre Reinforced Polymers

1. Fibre Reinforced Polymers, use a polymer based resin - like epoxy resin - as the matrix and fibres - like glass and carbon - as the reinforcement.

   Examples include: Carbon fibre reinforced plastic (CFRP) used for high performance car bodies, tennis rackets and Glass reinforced plastic (GRP) used in a wide range of products like boats and wind turbine blades.

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Metal Matrix Composites

2. Metal Matrix Composites, use metals - like aluminium - as the matrix and carbon fibres as the reinforcing material. These types of composites are commonly used in the car industry primarily for their heat resistance.

   Examples include: Particulate reinforced (P) and Continuous Reinforced (CR) both used widely in the aircraft industry for aircraft components.

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Ceramic Composites

3. Ceramic Composites, use ceramic as the matrix and short fibres - like silicon carbide - to reinforce the matrix.

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Examples include: Silicon Carbide composite used in bullet proof vests and Carbon composite combined used in high performance car disk brakes.

Advantages of Composites	Disadvantages of Composites
• excellent strength to weight ratios compared with traditional materials. • resistant to corrosion. • allows a greater flexibility with designs. • low thermal expansion. • very uniform in it's structure, providing reliability in manufacture and use. • weather resistance. • directional strength. • non-magnetic	• expensive to manufacture. • as they are mostly produced with thermosetting polymers they cannot be reshaped. • when damaged they are difficult to repair due to the fibres being mixed in the matrix. • difficult to produce to required properties requiring extensive design and testing.

Composites can be formed from a wide variety of materials, each type of resin, reinforcement, filler and additive will influence the performance and property of the composite formed. Designers and manufacturers can therefore select the type of materials required for a specified performance and mechanical property. Factors which need to be considered before selecting materials to form a composite are:

- Amount of fibre used.
- Type of fibre reinforcement.
- Direction of fibre (0, 45, 90 or combinations)
- Cost of the product.

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Composites	Materials	Characteristics	Uses
Glass-reinforced plastic (GRP)	Thermo or thermosetting plastic, e.g. epoxy resin, polyester mixed with glass fibre.	Strong, good tension and compression properties. Requires a gel coat to give it a smooth finish.	Boat hulls, canoes and water tanks.
Carbon Fibre	Matrix of epoxy or polyester with carbon fibre to reinforce.	Strong, lightweight, flexible.	High performance cars, tennis rackets, fishing rods.
Kevlar	Para-aramid fibres interwoven.	High tensile strength and good strength to weight ratio.	Bullet proof vests, woven into rope for cable, run flat tyres, blades of wind turbines.
Tungsten Carbide	Tungsten carbide and cobalt.	Resistance to wear and able to withstand high temperatures.	Drill bits and cutting edges of saw blades.
Chipboard	Wood chips/sawdust and a synthetic resin.	Flexible, low cost and available in large sheets.	Furniture (when faced with a laminate), building construction.

Alloys and Composites – What's the difference?:

Alloys are made up of a combination of metals to produce a material with improved properties of each of the individual metals.

However, where the materials which make up composites still remain separate and distinct within the composite, the metals in alloys change physically into a new material with enhanced properties.

On their own, metals can often have a limited range of useful properties, but by combining them with other metals they can increase their range of improved properties therefore maximizing their usefulness.

Alloying permanently changes the physical characteristics of the metals and some of the advantages that can be achieved through alloying are:

- increasing resistance to corrosion and oxidization.
- changing the electrical properties.
- improved strength.
- a higher or lower melting point compared with the constituent metals.
- can often be easier to machine.

By combining metals to produce an alloy this often has the effect of making a metal which is more cost effective than some of the metals which make up the alloy.

Alloying steel with other metals allows varieties of steels with much improved characteristics and properties. As the alloying process involves heating the metals, this has the effect of producing alloys which are more ductile and not as hard.

Brass is a good example of how mixing metals can change their characteristics:

Mixing copper and zinc produces an alloy which is more malleable than zinc and less expensive than copper. Also the colour change to a dull yellow gold makes it more attractive to look at.

Revision questions

1. Give **two** examples of commonly used composites and give an example of how each composite is used? [2]

2. Briefly explain the difference between a composite and an alloy. [2]

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