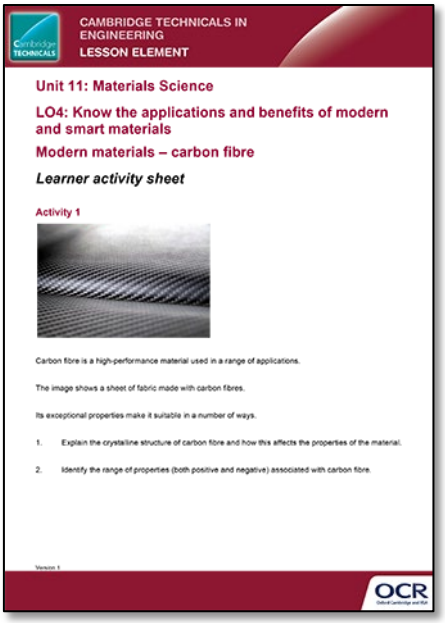
Unit 11: Materials Science

LO4: Know the applications and benefits of modern and smart materials

Modern materials – carbon fibre

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Modern materials – carbon fibre' *activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 11: Materials Science

LO4: Know the applications and benefits of modern and smart materials

Modern materials – carbon fibre

Learner activity sheet

Activity 1

Carbon fibre is a high-performance material used in a range of applications.

The image shows a sheet of fabric made with carbon fibres.

Its exceptional properties make it suitable in a number of ways.

1. Explain the crystalline structure of carbon fibre and how this affects the properties of the material.
2. Identify the range of properties (both positive and negative) associated with carbon fibre.

OCR

The Activity:

In Activity 1, learners have been tasked to investigate the crystalline structure of Carbon Fibre, and how this affects its properties. They have also been tasked to identify the properties of Carbon Fibre (both positive and negative). Indicative solutions are given below.

In Activity 2 learners have been tasked to investigate and summarise the processes by which carbon fibre is made into a composite material. An indicative solution is given below, although learners may provide alternatives.

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Suggested timings:

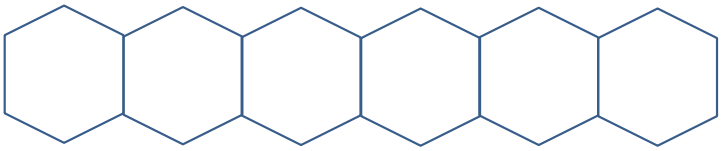
1 hour

Activity 1

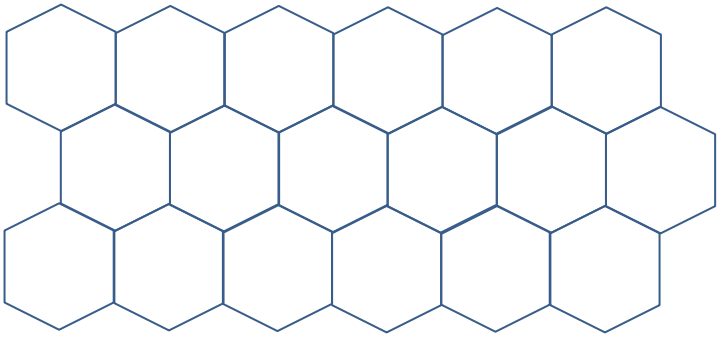
In Activity 1, learners have been tasked to investigate the crystalline structure of Carbon Fibre, and how this affects its properties. They have also been tasked to identify the properties of Carbon Fibre (both positive and negative). Indicative solutions are given below.

1. Carbon Fibre crystalline structure:

Carbon Fibre is made of carbon crystals aligned in a long axis. Typical crystal structure is shown below.



When heated and subject to other processing (controlled oxidation and carbonization) these honeycomb shaped crystals organize themselves in long flattened ribbons.



This crystal alignment makes the fibre strong. In turn these ribbons align themselves within long fibres.

Various precursors suitable for commercial manufacturing of carbon fibre include:

- Viscose rayon
- Mesophase pitch, and
- Polyacrylonitrile (PAN) fibres

Fibres (containing flat ribbons of carbon crystals) in turn are bundled in large numbers and are twisted into thread and woven. They are then used for reinforcing other materials.

2. Carbon fibres have the following properties. Learners may find alternatives.

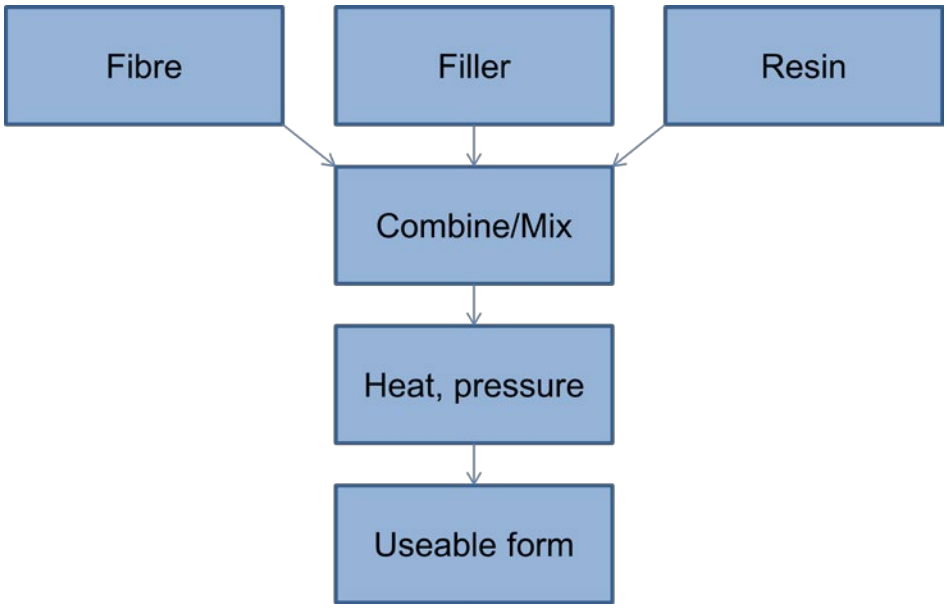
Carbon fibre properties:	
High strength to weight ratio Good rigidity Corrosion resistant Electrically conductive Fatigue resistant Good tensile strength but brittle Self lubricating Fire resistance/Not flammable High thermal conductivity in some forms	Low coefficient of thermal expansion Non poisonous Biologically inert X-Ray permeable Excellent EMI (Electromagnetic Interference) shielding property Relatively expensive Requires specialized experience and equipment to use.

Teachers might extend Activity 2 with learners providing a more detailed explanation against each property.

Activity 2

In Activity 2 learners have been tasked to investigate and summarise the processes by which carbon fibre is made into a composite material. An indicative solution is given below, although learners may provide alternatives.

Carbon Fibre composites are typically fabricated using the following process:



Carbon fibre reinforced polymer (CFRP) is one example of a composite material, consisting of various carbon fibres and thermosetting resins.

CFRP manufacturing processes can include moulding, vacuum bagging, injection moulding and extrusion moulding. Processing might also include sheet material manufacturing (e.g. rolling).

Carbon fibres can be taken as single twisted threads or as woven sheet material and combined with resin. A mould or former may be used to form the shape required, or the composite might be made as a sheet. Alternate layers of woven carbon fibre material and resin are applied to the former, and heat/pressure applied. Pressure might be applied through vacuum bagging. A similar process can be used to form sheets of carbon fibre composite.

Carbon fibres may even be cut or granulated and combined with resin and filler materials to form a mouldable liquid. This can be used in an injection moulding process, or in extrusion moulding.

Applications:	
Sporting goods	Golf clubs, tennis rackets, racing bicycles, rowing boats, racing cars, crash helmets
Military and aeronautical applications	Planes, protective wear, spacecraft
Medical applications	X-ray equipment (to support limbs) as X-ray transparent, artificial limbs
Automobile applications	Car bodywork, components and component housings, seat frames
Environmental applications	Use as a chemical purifier, water purification devices
Domestic applications	Furniture, bathtubs, shower trays, hobby projects

Learners may find further applications, and could explain the reasons why carbon fibre has been used in each case.