Eduqas GCSE D&T Technical Principles Core Knowledge and Understanding 2.1.11

Materials: Thermoforming and Thermosetting Polymers

Thermoforming Polymers

- These are materials that can be heated and shaped repeatedly, and are able to be recycled.

Acrylic is hard with good plasticity when heated, so it can be bent and folded easily. Acrylic resists weather well, but it is easy to scratch and can be brittle. It is popular for car headlights, protective visors and baths. It is a polymer frequently used for D&T school projects.

Polypropylene (PP) is a lightweight polymer that is strong and tough, with good heat and chemical resistance. It is used to make computer game cases, patio chairs, children's toys and food wrapping film.

Polyvinyl chloride (PVC) is a low-cost polymer. It can be flexible or rigid, glossy or matt, and has good strength, chemical and weather resistance. It is used to make window and door frames, guttering and building cladding.

High density polythene (HDPE) is a stiff and lightweight polymer that provides excellent chemical resistance. It has good plasticity when heated, perfect for buckets, bottles, pipes and washing up bowls.

Polystyrene (PS) is an inexpensive sheet or foamed polymer. It is available in a range of opaque colours as well as transparent. It is used in schools for vacuum forming.

Thermosetting Polymers

- These are materials that are formed once and cannot be recycled.

Melamine formaldehyde has excellent resistance to heat, moisture, scratching and staining, making it perfect for kitchen worktops and tableware.

Epoxy resin is supplied in two parts, the resin and the hardener. Once mixed, they create a very strong adhesive, with good chemical and heat resistance and excellent thermal insulation.

Urea formaldehyde is a hard, stiff polymer with excellent electrical insulation properties, making it suitable for switches, plugs and electrical fittings.

Polyester resin forms with a reaction of acids and alcohol. It is commonly used in sheet moulding compound, and in toner of laser printers.

Sources of polymers

Polymers can be made from natural and synthetic resources.

- Synthetic polymers are made from crude oil by scientists and engineers.
- Natural polymers are made using a variety of materials like silk, wool, cellulose and proteins.

Properties of polymers

There are many different polymers and the selection of specific polymers for particular purposes can relate to cost, resistance to corrosion, strength, strength/weight ratio, conductivity, elasticity, stiffness or malleability.

Differences between thermoforming and thermosetting polymers

The main difference is that a thermosetting polymer will strengthen when heated, and cannot be remoulded or heated after the initial forming. A thermoplastic can be reheated, remoulded and cooled as needed without causing a chemical change.

Availability of polymers

Polymers are available in a variety of forms including sheet, film, bar, rod and tube.

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Materials: Ferrous and Non-Ferrous Metals

Ferrous metals

- Metals that contain iron and are magnetic are ferrous metals.
- They are prone to rust and require a protective finish to prevent corrosion.

Cast iron is brittle if thin, can be cast in a mould, has strong compressive strength, good electrical and thermal conductivity, but poor resistance to corrosion. It is used for gates, manhole covers, drains and vices.

High carbon steel, also known as tool steel, is hard and brittle, less malleable than mild steel and is a good electrical and thermal conductor. Uses include tools, screwdrivers, and chisels.

Low carbon steel or mild steel is ductile and tough, easy to shape, braze and weld, a good conductor of heat and electricity, but again corrodes easily. Popular for nuts and bolts, screws, bicycle frames and car parts.

Alloys

An alloy is a mixture of metals with an element to improve its working properties or aesthetics.

- Brass is an alloy of copper and zinc.
- Bronze is an alloy of copper, aluminium and/or nickel.
- Stainless steel is an alloy of iron and chromium, nickel and magnesium.

Non-ferrous metals

- Metals that do not contain iron and are not magnetic are non-ferrous metals.
- They are metals that do not rust.

Aluminium is lightweight, malleable and strong. A good conductor of heat and electricity. Used in drinks cans, cycle frames and saucepans.

Copper is very malleable and an excellent conductor of electricity and heat – perfect for plumbing and central heating applications. It is orange/brown when polished, but will oxidise green.

Silver is a precious metal used in jewellery, it is soft and malleable when hot, highly corrosion-resistant and a good conductor.

Alloys: properties and uses

Brass is a non-ferrous alloy that is strong, ductile and a good conductor of heat. It works well when cast, is golden in colour but darkens with age. Used for taps, door fittings, hinges, locks and door handles. Due to its workability and durability, brass is commonly used for musical instruments.

Bronze is another non-ferrous alloy. It is hard and corrosion resistant, making it useful for bearings (due to its low friction) and outdoor mechanical components and monuments. Darker than copper, it is more reddish-brown. Bronze is also used in nautical applications due to its corrosion resistance.

Stainless steel is a ferrous alloy that is shiny silver when polished. It is hard and tough with good resistance to stains and corrosion. Used extensively in kitchen sinks, cutlery and hospital equipment. Stainless steel is also used in architecture, aerospace and general transport.

Properties of metals

- **Hardness –** a metal's ability to withstand friction and abrasion.
- **Toughness –** how well a metal can resist fracturing when force is applied.
- **Elasticity –** the rate at which a metal distorts in size and shape under stress.
- **Conductivity** – how well a metal allows electricity or heat to flow through it.
- **Ductility –** the ability of the metal to be drawn or deformed without fracture.
- **Tensile strength** – the amount of load a metal can withstand before failure.
- **Malleability** – the metal's ability to be bent or shaped easily.

Finishing metals

Metal finishing is the process of placing a coating onto a metal for cleaning, polishing or improving the surface in a functional or visual context. Finishing is the last step in the manufacturing process to provide environmental protection and improve aesthetic qualities. Popular finishing processes for metals include electroplating, anodising, powder coating, hot blackening, brushing, sand blasting and buff polishing.

Metals availability

Metals are sold in a variety of forms including sheet, bar, rod, tube and angle.

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Materials: Natural and Manufactured Timber

Hardwoods

- This wood comes from trees that lose their leaves during autumn and are known as deciduous trees.
- Hardwood trees are slow-growing and therefore less amounts are available, which makes it more expensive.

Oak is a moderate brown colour with close, straight grain. Oak is a tough and durable hardwood, it polishes well and is used for high quality furniture, doors, skirting and staircases.

Beech is a pink-tinted, closely grained hardwood. Beech is a very tough and durable material and is smooth to finish. It is popular with products that require a hard-wearing and robust material.

Mahogany is a dark red/brown hardwood with very close grain. It cuts and polishes easily, and gives a deep finish, popular for furniture and cabinet making.

Natural timber availability

Hardwoods and softwoods are available in a variety of forms including plank, board, strip, square and dowel. Natural timbers need to be cut at the sawmill and seasoned before use. Many are planed and cut to standard sizes ready for sale.

Softwoods

- This wood comes from trees that are evergreen, possibly bearing pinecones and needles, not leaves and are known as coniferous trees.
- Softwood trees grow quicker and in more locations. They are readily available and less expensive.

Pine is a pale-yellow coloured wood with darker brown grain. It is lightweight, easy to work, used for construction and furniture products.

Cedar is lightweight, pale with even texture. It is more expensive than pine but not as strong. Good for outdoor use, fencing, decking and shed construction.

Larch is a darker shade with brown grain, used for exterior cladding and boats, as it is water resistant and durable. It is more expensive than other softwoods.

Manufactured board

Man-made boards like MDF (medium density fibreboard), plywood and chipboard are all manufactured boards. They are made from wood fibres, normally collected from recycled wooden materials, bonded together with resins to form sheets.

MDF is made from small fibres which are mixed with a wax and resin, then heated and compressed into the desired thickness. MDF has no grain, and is easy to work. It is popular for interior DIY furniture.

Chipboard is made from small ‘chips’ of timber bonded together to produce a dense sheet. Kitchen worktops can be made using chipboard with an additional veneer applied for aesthetic and functional purposes.

Plywood is made from layers of wood, bonded together at an angle of 90 degrees to increase strength and rigidity. Sometimes, the facing layers can be high quality, e.g. birch, to provide a better aesthetic finish.

Finishes for hardwoods and softwoods

Surface finishes can be aesthetic and functional. High-traffic areas like floors might require a hard-wearing and sealing finish like polyurethane, which can be oil or water based, and matt, semigloss or high gloss finish.

Waxes and oils are popular to provide enhancement of the natural grain in the wood.

Stains and varnishes help to add colour to natural wood, and even change colours to match colour schemes. Preservatives are sometimes used to provide protection and ensure the wood is long-lasting.

Finishes for manufactured boards

Man-made boards like plywood are often finished depending on the visibility of the veneers. Plywood can have natural grain on the face veneers, so a spray-on lacquer or a paint-on varnish might be best.

MDF can be stained to match other natural woods, or it can be painted. However, as MDF is very porous, it is best to seal any exposed edges first to avoid paint being absorbed.

Chipboard can look unattractive and is normally finished with a veneer. On kitchen worktops, this is a melamine layer that provides heat, scratch and water resistance, and a variety of colours and patterns that can enhance the look of the user’s kitchen.

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Materials: Paper and Boards

Categories of papers and boards

Papers and boards are made from wood pulp which originates from trees. Wood pulp is rolled out into thin sheets at an industrial setting called a papermill.

- Paper density is measured by weight in grams per square metre (gsm).
- Paper comes in standard sizes, A0 is the largest, down to A10 (postal stamp size). In schools, A4 and A3 are very common paper sizes.

Types of paper

- Tracing paper (40 – 90 gsm) – translucent, smooth and strong, non-absorbent. Used for copying sketches and drawings, used as an overlay.
- Layout paper (50 gsm) – smooth, translucent and cheap to purchase. Great for designing, sketching and developing ideas.
- Copier paper (80gsm) – smooth, opaque, clean white finish. Uncoated and finishes well when printed on. Also used for photocopying.
- Cartridge paper (80 – 140 gsm) – thick, textured surface finish, a creamy off-white colour. Works well with paints, watercolours, pastels and inks.

Boards

Board is categorised by weight as well as thickness. The thickness of board is measured in microns, with one micron equal to 1/1000th of a mm.

Corrugated cardboard (3000 microns) – strong and lightweight, with two or more layers of wavy 'fluted' sheets to provide additional rigidity. Corrugated card is available in different thicknesses, making it perfect for packaging various items. It is fully recyclable, but not water-resistant.

Mounting board (1400 microns) – has a rigid and smooth surface, normally black and white in colour but available in other colours. It is popular for framing mounts, scale architectural modelling and concept designs.

Folding boxboard (300 – 1699 microns) – This is a stiff board normally made from recycled paper. It scores and folds well, bending without splitting, perfect for packaging supermarket foods.

Laminating papers, cards and boards

Some materials can be coated to add thickness, weight and strength for specific purposes. This additional layer is known as laminating. Many food containers and drinks cartons are laminated to ensure food and drinks are retained effectively and hygienically, and to keep produce fresh. Laminated cardboard is also good for book binding.

Adding surface finishes to papers, cards and boards

Surface finishes can be aesthetic and functional. Varnish can be added to card to give a glossy finish. Sometimes, part of a logo or brand name is varnished so that it stands out to the customer from the rest of the detail. Edge staining is another finishing process where dye is applied to the edge of a book to improve visual quality. UV (ultraviolet) varnishing produces a high-gloss finish on card, which is great for marketing materials like business cards. Embossing is a process that can create raised patterns or shapes in card and paper, usually by stamping. This is popular in greetings cards, perfume boxes and invitations.

Folding ability and absorbency

Some uses require materials to remain rigid, and to resist folding or creasing, such as corrugated cardboard coffee cups. These need to insulate heat, retain hot liquid, and must not leak. Other products, like sandwich containers, are die cut, flat packed items that erect easily to provide display, packaging and keep food stuffs fresh. These have crease lines, fold easily, and are again waxed inside to resist absorbency.

Greener solutions

A lot of paper-, card- and board-based packaging is designed to be easily fully recycled. This provides a 'cradle to cradle' approach and reduces waste and the need for new materials. Reusability is also high, where containers can be washed and used again for the same or similar purposes.