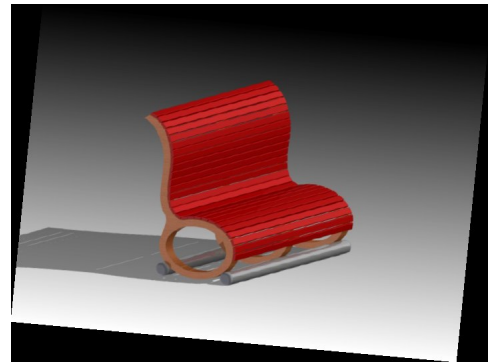


# Technical Department



Higher

Design & Manufacture

Materials & Processes  
Booklet

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# **Materials Exemplars**

## HDPE (High Density Polythene)



*Blow moulded HDPE milk bottle*

**Properties:** thermoplastic - flexible (more rigid than LDPE), translucent, waxy, weatherproof, good low temperature toughness (impact resistant), easy to process by most methods, low cost, chemical resistance.

**Typical Uses:** chemical drums, car body panels, toys, picnic ware, household buckets and bowls, cable insulation, carrier and mesh bags.

## LDPE (Low Density Polythene)

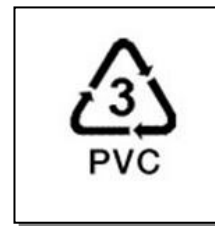


*'Unbreakable' LDPE bucket formed by injection moulding*

**Properties:** thermoplastic - flexible, opaque, impact resistant (tough), weatherproof, chemical resistance, low density, easily processed by most methods, low cost.

**Typical Uses:** squeeze bottles, toys, carrier bags, heavy duty sacks, general packaging, pipes.

## PVC (Polyvinyl chloride)



*Extruded PVC window channel, mitred and heat welded to form the window frame*

**Properties:** thermoplastic - rigid, hard (wear resistant), resistant to weathering, rigid, lightweight, can be coloured, formed by most methods.

**Typical Uses:** window frames, pipes, gutters, roofing, cable and wire insulation, car interiors and seat coverings, fashion and footwear, packaging, cling film, credit cards, synthetic leather and other coated fabrics.

## PC\* (Polycarbonate)



*Injection moulded polycarbonate lens on Oakley's ski goggles*

**Properties:** an engineering thermoplastic, so expensive, but with superior mechanical and thermal properties - high impact resistance and good optical properties. Usually extruded or injection moulded.

**Typical Uses:** light diffusers, skylights, riot shields, machine guards, safety spectacles, signs and displays, aircraft interiors and electrical housings.

## Acrylic\* (PMMA)



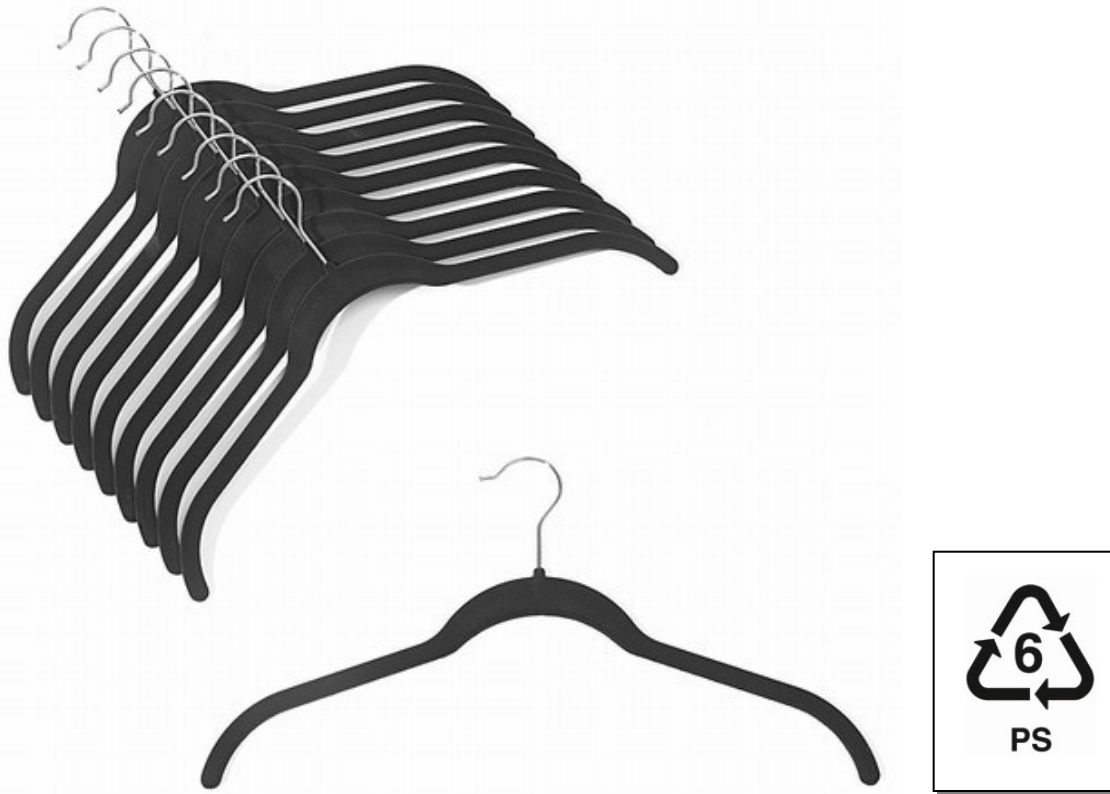
*Ducati's motorbike screens and light lens - compression moulded from acrylic*

**Properties:** thermoplastic - formed using most common processes. Good impact strength (higher than polystyrene or glass) but much lower than polycarbonate, stiff, resistant to wear (hard), easily machined.

**Typical Uses:** glass substitute - car lens, shop signs, baths, machine guards, furniture, roof lights, glazing.



## PS (Polystyrene)



*Injection moulded polycarbonate lens on Oakley's ski goggles*

**Properties:** thermoplastic - low cost, brittle, rigid, transparent, low shrinkage, odour and taste free, easy to process. High Impact PS - hard (resistant to wear), rigid, translucent, impact strength (tough) up to x 7 general purpose PS.

**Typical Uses:** GPPS - Toys, rigid packaging, boxes, light diffusers, CD cases. HIPS - yoghurt pots, fridge linings, vending cups, toilet seats.

## Nylon (PA)



*Milwaukee drill case injection moulded from red nylon with elastomer grip bonded later*

**Properties:** an engineering thermoplastic, so expensive, but with superior mechanical and thermal properties - very tough (impact resistant), good thermal and chemical resistance, machines well, self-lubricating.

**Typical Uses:** fibres - textiles & upholstery, solid - curtain rails, bearings, gears and power tool casings.

## Cellulose Acetate (CA)



*Laminated cellulose acetate 1950s spectacles frame*

**Properties:** thermoplastic made from wood pulp, hard (resistant to wear), tough (impact resistant), can be made flexible, light and transparent.

**Typical Uses:** spectacle frames, cutlery handles, toothbrushes, tool handles, transparent wrapping, metallised parts (reflectors etc), pen barrels.

## PP (Polypropylene)



*Tic Tac's lid injection moulded with an integral hinged lid from polypropylene*

**Properties:** thermoplastic, flexible, rigid, opaque, good dimensional stability at high temperature and humidity conditions, difficult to process (blended to ease injection moulding), tough - impact resistant.

**Typical Uses:** hinged containers, food containers, coffee pot and washing m/c parts (where high temperature and moisture are critical), crates, chairs, rope.

## *ABS (Acrylonitrile butadiene styrene)*



*Philippe Starck Bubu II stool injection moulded ABS and then chromed finished*

**Properties:** an engineering thermoplastic, so expensive, but with superior mechanical and thermal properties - rigid, opaque, glossy, tough (impact resistant), good low temperature properties, good dimensional stability and easily electroplated.

**Typical Uses:** telephones, rigid luggage, crash helmets, domestic appliance housings (food mixers), electroplated parts, handles, computer cases.

## Epoxy Resin (ER)



*Steel barbeque - powder coated and then baked with epoxy to provide scratch & heat resistant finish*

**Properties:** thermoset, rigid, clear, very tough (impact resistant), chemical resistant, good adhesion properties, low curing, low shrinkage.

**Typical Uses:** adhesives, paints, wind turbine blades, encapsulation, electrical components, cardiac pacemakers, aerospace applications

## Melamine Formaldehyde (MF)



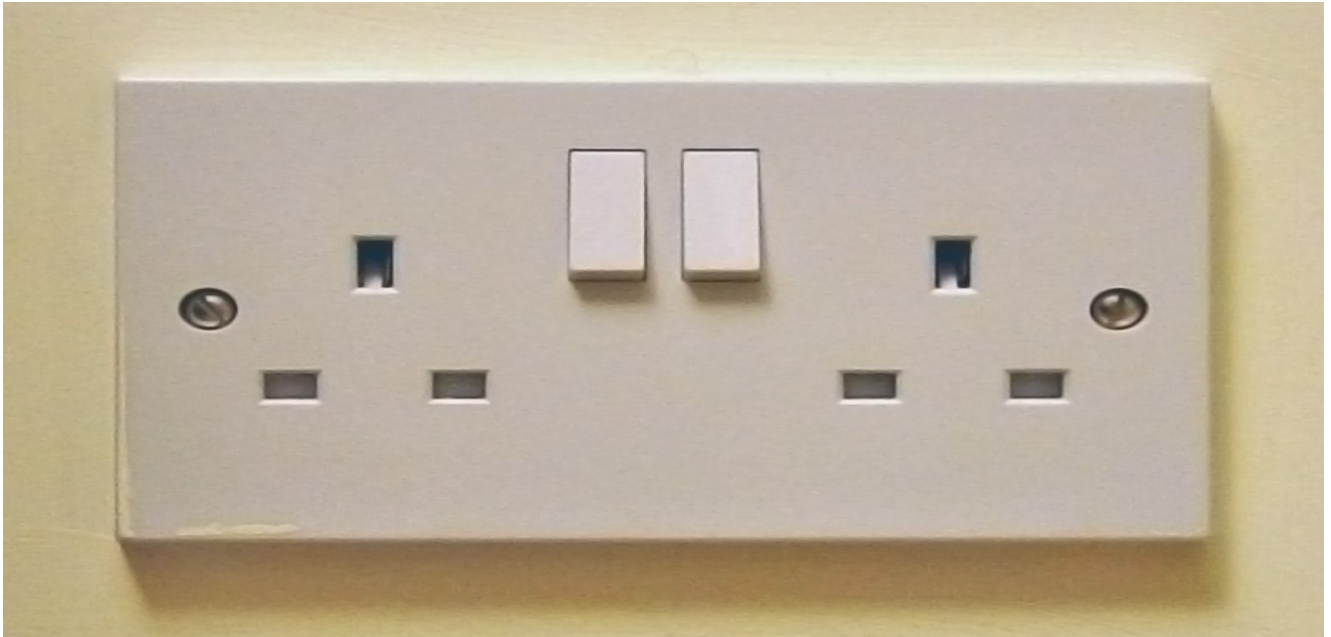
*Melamine Formaldehyde 1960s tableware compression moulded in two stages*

**Properties:** thermoset, hard (wear resistant), opaque - wide colour range, tough (impact resistant), self extinguishing, free from taint and odour, chemical resistant. Usually compression moulded and /or laminated.

**Typical Uses:** decorative laminates, lighting fixtures, dinnerware, heavy duty electrical equipment, laminating resins, surface coatings, bottle caps, toilet seats.



## *Urea Formaldehyde (UF)*



*Urea Formaldehyde 13A compression moulded socket*

**Properties:** thermoset, opaque, good adhesive qualities, stiff, hard (wear resistant), brittle, electrical insulator. Usually compression moulded and /or laminated.

**Typical Uses:** wood glue, electrical fittings, textile coating.



## Polyester Resin (PR)



*Epoxy resin and plaster powder cast light fitting*

**Properties:** thermoset, stiff, hard (wear resistant), brittle. Usually compression moulded and /or laminated.

**Typical Uses:** binds fibre glass and carbon fibre and is used in all GRP and some CRP products, casting, embedding.

## GRP (Glass fibre Reinforced Plastic)



*Eames Rocker 1948 - first mass produced GRP seat with steel legs and beech feet*

**Properties:** a composite material, commonly called fibreglass, made by binding glass fibres with the thermoset polyester resin. High strength to weight ratio, little waste, complex one piece shapes possible, weather resistant, opaque, brittle, laminated without pressure or heat in a simple mould.

**Typical Uses:** boat hulls, car bodies, storage tanks, playground items, roofing.

## *CRP (Carbon fibre Reinforced Plastic)*



*Detail of an ultra light carbon fibre car door mirror - woven fibre detail is usually visible on a product*

**Properties:** a composite material, commonly called carbon fibre, made by bonding woven carbon fibres with the thermoset epoxy or polyester resin. Very strong, lightweight, very expensive, little waste, complex one piece shapes possible; laminated under vacuum pressure in a polished mould or compression moulded and cured in an oven.

**Typical Uses:** top end products - sports equipment, bike frames, skis, golf clubs etc, race cars, aviation aerospace applications.

# Elastomers



*Sports shoe soles use a range of synthetic elastomers to provide comfort, cushioning and support.*

**Properties:** generic term for a group of natural (rubber) and synthetic plastics (EVA) with the ability to be stretched and then return to their original form (elasticity). Soft touch, non-slip grip, flexible, shock absorbing.

**Typical Uses:** sports shoes, handle grips, flexible tubing, vacuum cleaner hosing, wheel, tyres.

## **Mild Steel**



*Solid mild steel rod shopping trolley welded construction and galvanised (zinc) finish*

**Properties:** ferrous metal - silver grey in colour, will rust and a magnet will stick to surface, malleable (hammered to shape without fracture), ductile (stretched without fracture) and can be formed by all metal processes.

**Typical Uses:** nuts, bolts, screws, tube, girders, car bodies, panels for white goods such as washing machines.



## High Carbon Steel



*Estwing High Carbon Steel claw hammer - drop forged with an injection moulded elastomer grip*

**Properties:** ferrous metal - silver grey in colour, will rust and a magnet will stick to surface, malleable (hammered to shape without fracture), ductile (stretched without fracture) after forming it is hardened (wear resistant) and tempered to reduce brittleness (easily snapped). Also known as tool steel.

**Typical Uses:** cutting tools, knives, screwdrivers, punches.

## *Stainless Steel*



*Press formed stainless steel sink*

**Properties:** ferrous metal - silver in colour, non-rusting and corrosion resistant due to high chromium content, high quality alloy versions not attracted to a magnet, hard (wear resistant), difficult to cut and form.

**Typical Uses:** kitchen pots, cutlery, sinks, kettles, toasters, piping, furniture.

## High Speed Steel (HSS)



*HSS twist drill formed by grinding the flutes*

**Properties:** ferrous metal - silver in colour, corrosion resistant due to chromium and other elements content, it is able to cut when red hot without losing hardness.

**Typical Uses:** cutting tools, drills, taps, dies, milling and router cutters.



## *Cast Iron*



*Cast iron cooking pot*

**Properties:** ferrous metal - hard (wear resistant) skin and a soft core, very strong under compression, brittle, good fluidity and hence casts well, machines well.

**Typical Uses:** car engine blocks, exhaust manifolds, drain manhole covers, fire grates.

## **Brass**



*Cast brass door handle, polished and lacquer to prevent the metal tarnishing*

**Properties:** non-ferrous alloy of copper and zinc, usually cast but can be forged, drawn, rolled or machined. Decorative gold coloured, corrosion resistant metal, medium hardness (wear resistance).

**Typical Uses:** castings, decorative ironmongery, boat fittings, musical instruments, plumbing & electrical fittings.

## **Bronze**



*Cast Bronze sculpture of a chair*

**Properties:** non-ferrous alloy of copper and tin, cast to shape. Decorative gold coloured which tarnished to dark brown, corrosion resistant, medium hardness (wear resistance).

**Typical Uses:** bearings, coins, castings, sculptures, statutes, plumbing fittings.

## Duralumin



*Duralumin die cast camera body*

**Properties:** non-ferrous alloy of aluminium and copper, lightweight, silver coloured metal, good machinability, casts well, corrosion resistant, with a hard (wear resistant) outer surface.

**Typical Uses:** aero industry - fuselage, skin, fixings, engine parts - pistons.

## Aluminium



*Tubular Aluminium chair assembled with pop rivets and bolts*

**Properties:** non-ferrous element, silver coloured metal, lightweight, machines and casts well, corrosion resistant, but rarely used in pure metal form and more commonly found as an alloy with copper.

**Typical Uses:** car bodies, cookware, engine parts, aircraft & boat construction.

## Copper



*Lacquered copper lamp shades - spun formed*

**Properties:** non-ferrous element, malleable (hammered without fracture), ductile (stretched without fracture), expensive, low melting point, excellent conductor of heat and electricity, turns green (verdigris) when exposed to air and water.

**Typical Uses:** water pipes, wiring cables, jewellery, printed circuit board connections, kitchen pots, roofing .

## Tin



*Sheet steel can protected from corrosion by tin outer finish*

**Properties:** non-ferrous element, very soft (slightly harder than lead), malleable (hammered into shape without fracture) it can be rolled, pressed, or hammered into extremely thin sheets (tin foil), low melting point.

**Typical Uses:** bearings, soft solder, finish for steel (tinplate), used in alloys (pewter).



## Lead



*Lead sheet used for weatherproofing a roof*

**Properties:** non-ferrous element, very soft, dense, malleable (hammered into shape without fracture), low melting point, poisonous, poor conductor of electricity and heat.

**Typical Uses:** roof flashings, solder, batteries, used in alloys (pewter).



## Zinc



*Die cast zinc alloy pencil sharpeners*

**Properties:** non-ferrous element, weak, difficult to work, brittle, in alloy form is used in die casting where intricate shapes can be produced.

**Typical Uses:** die cast products, protective hardwearing finish for steel (galvanising) - crash barriers, railings, dustbins, buckets.

## *Beech*



*Beech wooden spoon*

**Properties:** European hardwood, even surface, straight grained, strong timber.

**Typical Uses:** kitchenware - wooden spoons, spatulas, rolling pins, breadboards; furniture, steam-bending, turnery, flooring.

## Oak

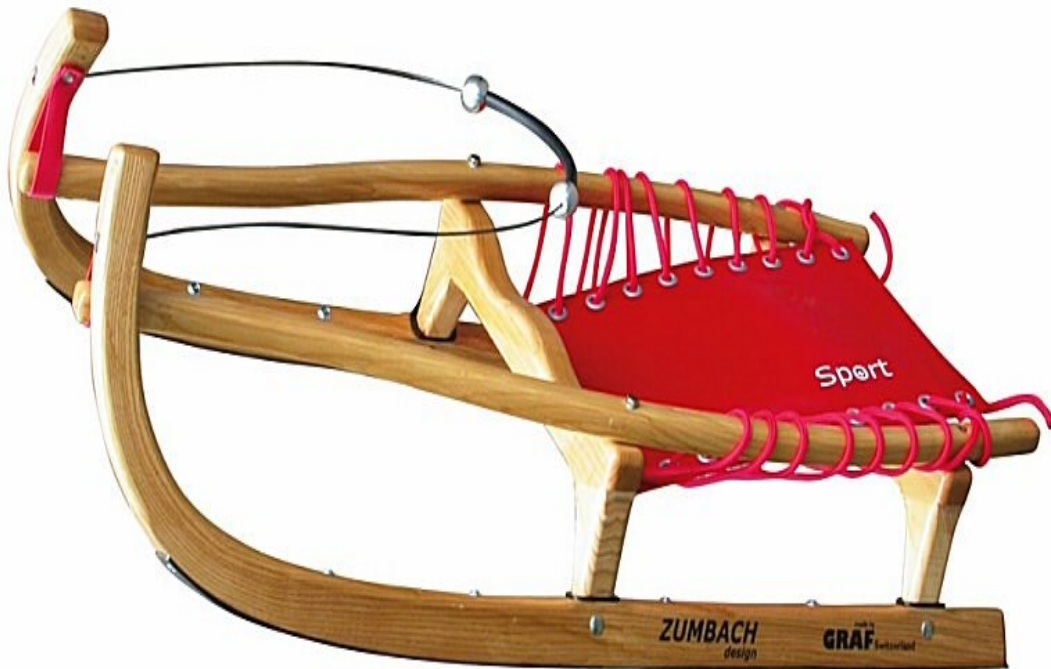


*Steam bent oak barrels*

**Properties:** European hardwood, strong, durable, hard, tough, open grained, corrodes steel due to tannic acid.

**Typical Uses:** cabinet making - furniture, flooring, boat building, veneers, barrels, turning.

## Ash



*Steam bent Ash sledge*

**Properties:** European hardwood, straight grained, course texture, good elasticity (bendable), works and finishes well.

**Typical Uses:** sports equipment, tool handles, cabinet making, laminating, plywood, drum and guitar bodies.

# Mahogany



*Traditional style snooker table - mahogany frame with turned legs*

**Properties:** tropical hardwood - so expensive, fairly strong, medium weight, easy to work, durable, some interlocking grain, prone to warping.

**Typical Uses:** high quality cabinet making - furniture, shop fittings, panelling, turnery, veneers, plywood.

## Teak



*Teak sun lounger - natural oils make the timber weather resistant but requires annual maintenance*

**Properties:** tropical hardwood - so expensive, hard, strong, durable, natural oils make it resistant to water - suitable for outdoor uses, works well but quickly blunts tools.

**Typical Uses:** high quality cabinet making, garden furniture, boat building, flooring, lab benches, veneers.

## Walnut



*Turned walnut salt and pepper set*

**Properties:** European hardwood - attractive grain, cross grain can make finishing difficult.

**Typical Uses:** high quality cabinet making, boat building, carving, veneers, flooring, gunstocks



## Balsa



*Model plane - lightweight balsa wood fuselage glued together before finishing with fabric*

**Properties:** tropical hardwood - so expensive, very fast growing, very light, easily to work, high strength to weight ratio but too weak for most applications.

**Typical Uses:** model making, buoyancy, surfboards, insulation - heat, sound and vibration.



## Scots Pine



*Scots pine storage cabinet*

**Properties:** European softwood - straight grained but knotty, fairly strong, easy to work, inexpensive, low durability.

**Typical Uses:** furniture, joinery, plywood, construction work, telegraph poles.

## Red Pine



*Red pine timber framing before being covered with plasterboard to form house walls and ceilings*

**Properties:** European softwood - straight grained but knotty, fairly strong, easy to work, inexpensive, low durability.

**Typical Uses:** floorboards, joinery, construction work, window frames, Christmas trees, crates, pallets, pulp wood (paper and cardboard).

## Cedar



*Cedar shed - natural oils make the timber ideal for exterior work*

**Properties:** European softwood - light, soft, weak, natural oils make it suitable for exterior use.

**Typical Uses:** building cladding, shingles (roof tiles), sheds, timber greenhouses, fences and posts.



## *Parana Pine*



*Parana pine stair*

**Properties:** Tropical softwood - hard, straight grain, knot-free, strong and durable, smooth finish, tends to warp, expensive.

**Typical Uses:** quality interior joinery, staircases, built-in furniture, flooring, plywood.

## *Spruce*



*Spruce violin body*

**Properties:** European softwood - fairly strong, small hard knots, resistant to splitting, resin pockets, not durable.

**Typical Uses:** construction, general indoor work, whitewood furniture, paper, musical instruments.

## MDF (Medium Density Fibreboard)



*MDF cover for a radiator - the material can be painted to suit or covered with a timber veneer*

**Properties:** manufactured board - composite material; compressed fine wood fibres with no grain and a smooth stable surface, excellent machining and painting, available in standard sizes.

**Typical Uses:** furniture, painted work, base for decorative veneers.

## *Plywood*



*Birch veneered plywood chair laminated and stem bent around a mould.*

**Properties:** manufactured board - composite material: thin veneers glued with grain at right angles, stable, strong board of standard sizes.

**Typical Uses:** furniture, joinery, boats (marine ply grade only 100% water resistant), construction, drawer bases, cabinet backs.



## **Blockboard**



*Lacquer blockboard shelving used in bar and shopfitting applications*

**Properties:** manufactured board - composite material: stiff, heavy, good load bearing capacities, available in standard sizes.

**Typical Uses:** furniture, worktops, base for decorative veneers.

## Chipboard



*Melamine coated chipboard used in the kitchen cabinets and work surfaces*

**Properties:** manufactured board - composite material: compressed wood chips bonded with resin, stiffness and strength vary with density, available in standard sizes.

**Typical Uses:** furniture carcase, worktops, base for decorative wood or plastic veneers

## Hardboard



*Moulded hardboard door skin over a pine frame finished to look like a solid timber panelled door*

**Properties:** manufactured board - composite material: highly compressed wood fibre bonded with oil, cardboard-like with one textured surface, weak and brittle, available in standard sizes.

**Typical Uses:** low cost furniture parts -cabinet backs - drawer bottoms, pressed formed for internal panelled doors.

## Veneer



*Walnut veneered plywood steam bent to form the chair seat*

**Properties:** thin layer of solid timber or plastic finished to look like an expensive timber.

**Typical Uses:** finish applied to manufactured boards - chipboard, MDF, or blockboard or used to form plywood layers where the grain is glued at right angles.

## *Processes Exemplars*

# Injection Moulding

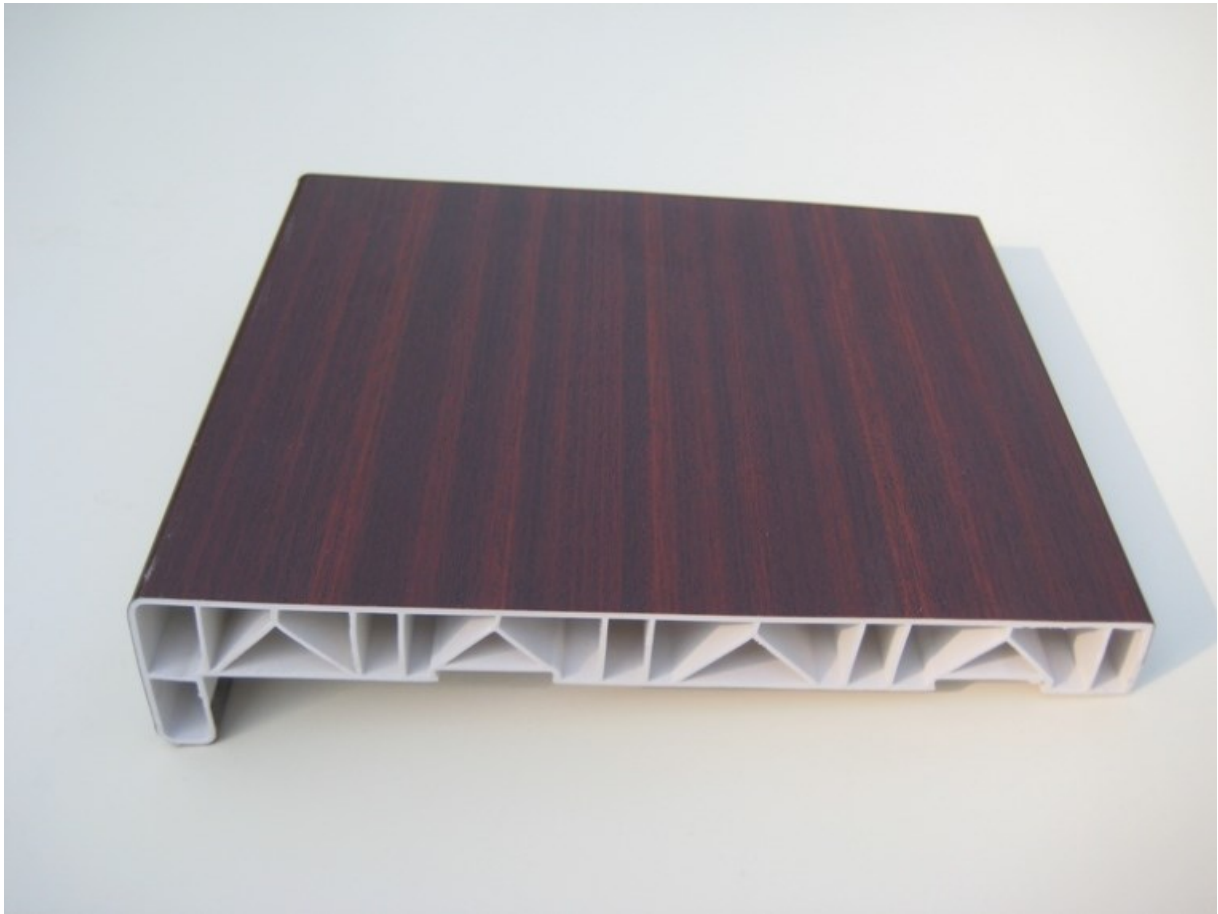


*Satellite remote control - injection moulded in HIPS with elastomer grip and buttons*

**Properties:** thermoplastic forming process where plastic is injected into a shaped mould and the formed shape is automatically ejected after cooling; complex 3D shapes with fine detail and texture possible, injection sprue and ejection pins marks visible on inner surface; bosses, stiffening webs, metal inserts and snap fixing moulded in; join lines visible.

**Typical Uses:** medium/high volume and high speed process for thermoplastic; casings for electrical goods - phones, TVs, laptops etc; food containers.

## Extrusion



*PVC extruded window ceil - finished with a plastic laminate mahogany film*

**Properties:** thermoplastic and metal forming process where the heated material is forced through a shaped die; uniform cross section shape with hollows possible, normally requires no further finishing other than cutting to length, no waste.

**Typical Uses:** medium/high volume continuous process for thermoplastic and metal (steel, aluminium, copper); pipes, cable, window frames, channels.



## Rotational Moulding



*Cozy Coupe - child's toy rotational moulded from LDPE*

**Properties:** thermoplastic forming process where pellets are place inside a hollow shaped mould and then heated an spun around; hollow one piece products, uniform wall thickness, suitable for very large items, low mould cost, some surface detail possible, little finishing required, mould join line and flash visible.

**Typical Uses:** low/medium volume process for thermoplastic; balls, road cones, storage tanks.

## *Vacuum Forming*



*Disposable sandwich triangle - vacuum formed in polystyrene*

**Properties:** thermoplastic forming process where a sheet is heated and then sucked around a shaped former; low cost process, suitable for smooth shapes with some detailing and tapered edges, some thinning of material on deeper moulds, trimming required after forming.

**Typical Uses:** low/medium volume process for thermoplastic; fridge liners, baths, disposable food packaging.

## *Blow Moulding*



*Blow moulded water bottle from PET*

**Properties:** thermoplastic forming process where a hollow tube is gripped between two halves of a mould and then air is used to force it to shape; rapid forming of hollow objects with one open narrow end, some shapes not possible due to extraction from mould, some thinning of material on larger moulds, little finishing required, mould join line and flash visible.

**Typical Uses:** medium/high volume process for thermoplastic; hollow bottles and containers.

## *Laminating Plastics*



*GRP - fibreglass laminated desk*

**Properties:** thermosetting resin used to bind fibre glass (no pressure or heat for low cost product) or carbon fibre (vacuum pressed then baked for high end products) and then laid over a shaped former until cured; strong, lightweight, weather resistant, opaque, brittle.

**Typical Uses:** low/medium volume process for thermoset; CRP - high end sports equipment, performance car parts, aerospace; GRP - car bodies, boats, playground rides.

## Joining Plastics



*Calculator - injection moulded hinge and sliding battery lid, case screwed and copper battery contacts staked to the HIPS*

**Properties:** plastics are permanently joined with adhesives or fixed using mechanical fastening such as nut & bolt.

Thermoplastics can be joined by 'staking' where an extended stud is heated and then compressed to fix the parts. Integral fixings can also build into component to allow parts to snap-together.

**Typical Uses:** low/medium/high volume process; integral fixings - battery covers in remotes, adhesives - steam iron's water tank glued onto case; self-taping screws - laptop case.

## Compression Moulding



*Compression moulded urea formaldehyde heat resistant light fitting*

**Properties:** thermoset and elastomer forming process (mainly) where liquid/heated material is compressed in a mould until cured and then automatically ejected; complex solid 3D shapes with fine detail and texture possible, moderate mould cost, little/no waste, bosses, stiffening webs, metal inserts moulded in; little finishing required, mould join line, ejector pin marks, and flash visible.

**Typical Uses:** medium/high volume and medium speed process for thermosets and elastomers; electrical fittings, tableware, pot handles.

## *Finishing Plastics*



*ABS shower head - injection moulded and then finished with electroplated chrome*

**Properties:** plastics can be self-coloured with pigments before forming and so further finishing is not always necessary.

Texture can be built-in to the mould design to enhance the surface detail.

Certain plastics, such as ABS can be electroplated to look like a metal product.

**Typical Uses:** car body panels are spray painted to ensure a colour match with the rest of the vehicle, dial and knobs chromed ABS, handle and grips moulded with texture.



## Turning



*Stainless steel table leg turned automatically on a CNC lathe*

**Properties:** timber, metal and some plastics are gripped and spun as a shaped cutting tool moves over the surface to form cylindrical and conical products; CNC lathes control all the cutting action and quickly produce, very accurate components, again and again based on a CAD drawing, subtractive process and so waste material is produced and the material grain will not follow the contour and part might be weaker than those produced by moulding.

**Typical Uses:** low volume; components, bolts.

## Milling



*Cast stainless steel golf club head - face machined on a CNC lathe*

**Properties:** timber, metal and some plastics gripped while a shaped cutter moves along and down the surface to machine a 3D shape; CNC lathes control all the cutting action and quickly produce, very accurate components, again and again based on a CAD drawing, subtractive process and so waste material is produced and the material grain will not follow the contour and part might be weaker than those produced by moulding.

**Typical Uses:** low volume, components production, specialised parts.

## Die Casting



*Stanley safety knife - die cast in zinc alloy*

**Properties:** liquid aluminium, magnesium and zinc alloys forced into a shaped die and when cool automatically ejected; complex 3D shapes with fine detail and texture possible, high die cost, little/no waste, little finishing required; die split line, flash edge and ejector pin marks visible.

**Typical Uses:** medium/high volume and high speed metal forming process; toys, engine parts, camera bodies.

## **Pressing**



*Pressed steel panels spot welded to form a central heating radiator*

**Properties:** a press forming process for sheet metal where it is shaped between two metal dies (heated thermoplastic sheet can be formed in a similar way - thermoforming); ridged 3D forms produced, used with other metal press forming techniques - piercing, blanking, and drawing; stretch marks, wall thinning, sharp internal corners and deep draws avoided, limitless range of shaped possible, expensive tooling cost, no further processing required other than finishing.

**Typical Uses:** low/medium/high volume and high speed metal joining; pans, sinks, car body panels.

## Stamping (Blanking)



*Nickel alloy blank which will be embossed to form a 10p coin*

**Properties:** a press forming process for sheet metal where a flat blank shape is punched out using a hydraulic press; used with other press forming techniques - piercing, pressing, and drawing; shearing cuts visible on edges, rapid process, accurate, limitless range of shaped possible, expensive tooling cost, waste produced but recyclable.

**Typical Uses:** medium/high volume and high speed metal forming process; pans, sinks, car body panels.

## Punching (Piercing)



*Mild steel bicycle chain sprocket - internal shaping formed by piercing - outside by blanking*

**Properties:** a press forming process for sheet metal where shaped holes are punched out using a hydraulic press, used with other press forming techniques - blanking, pressing, and drawing; shearing cuts visible on holes edges, rapid process, accurate, multiple holes can be cut in one operation, limitless range of shaped holes possible, expensive tooling cost, waste produced but recyclable.

**Typical Uses:** medium/high volume and high speed metal forming process; pans, sinks, car body panels, washers.

## Spot Welding



*Sheet steel paper punch - hinge plates spot welded onto the base*

**Properties:** sheet metal joining process where two sheets are gripped between two electrodes which heat and melt the surfaces together; permanent and strong join, rapid process, circular weld visible, often automated with robots welder, limited to 3mm thick sheets, seam welding version uses rollers to welded a continuous join, dissimilar metals cannot be joined .

**Typical Uses:** sheet steels and aluminium low/ medium/high volume and high speed metal joining process; assembling car body panels, radiators, white good - washing machine panels, seam weld - food tin cans.



## Arc Welding



*School chair - plywood back and set with welded tubular steel frame*

**Properties:** metal joining process where a consumable electrode melts joining the two surfaces together; permanent and very strong join, rapid process, welded section visible, can automated with robots welder, unlimited metal thickness, dissimilar metals can be welded (steel to stainless steel etc).

**Typical Uses:** steels and aluminium, low/ medium volume and high speed metal joining process; buildings, bridges, railings, car body panels.

## Riveting



*Airstream's polished aluminium caravan with panels joined to frame with pop rivets*

**Properties:** permanent mechanical fastening where the rivet is hammered or pressed so that it expands and joins the pieces together; strong join, can be automated - rapid process, dissimilar materials can be joined (leather to steel etc), pop -riveting used where access is limited, less popular joining technique due to advances in adhesives.

**Typical Uses:** wide range of materials permanently joined; white good - washing machine components, aircraft skin to fuselage, jewellery.

## Adhesives



*BMW's chromed ABS decal glued onto the painted steel boot panel*

**Properties:** permanent process which can be used to join most materials (plastics are more problematic and thermoplastics are usually heat welded); strong, quick, little preparation required, material usually clamp while adhesive cures, can be waterproof and heat resistant, wait time for curing makes adhesives a slow process.

**Typical Uses:** wide range of materials permanently joined; PVA - wood furniture, contact adhesive - laminates to wood, hot melt glue - rapid bonding of card, tensol - gluing acrylic only.

## *Fitted Joints*



*Injection moulded camera tripod - HIPS ball and socket with elastomer feet*

**Properties:** semi-permanent process usually used with wood but certain methods are used for metals and plastics; strong, machining required, joint used along with adhesive, use can restrict a product's design, not suitable of flat packed furniture.

**Typical Uses:** high quality assembled timber and manufactured board furniture; ball and socket - metal and plastics where movement is required, spline used to join rotating metal shafts.

## **Bolts**



*Galvanized steel crash barrier - bolted together to enable damaged sections to be replaced*

**Properties:** semi-permanent process usually used with metal but large section timber can be fixed with coat bolts; can fix dissimilar materials, standard component bought in by manufacturers from specialised companies, inexpensive, strong, machining required, can restrict a product's design.

**Typical Uses:** used where the product will be dismantled for maintenance etc, engines, machines.



## Screws



*Dualit toaster - aluminium and stainless steel fixed with self tapping screw*

**Properties:** semi-permanent process usually used with wood and metal; can fix dissimilar materials, standard component bought in by manufacturers from specialised companies, inexpensive, strong.

**Typical Uses:** used where the product will be dismantled for maintenance etc, not very attractive so avoided on quality applications, door hinges, electrical cases - laptops etc.

## Patent Devices



*Microwave oven is secured with anti-tamper screws to prevent the user from opening the case*

**Properties:** semi-permanent process usually used with wood and metal; can fix dissimilar materials, standard component bought in by manufacturers from specialised companies, inexpensive, strong.

**Typical Uses:** used where the product will be dismantled for maintenance etc, not very attractive so avoided on quality applications, knock down (KD) fitting used with flat packed furniture, wall mount for flat screen TVs.



## *Sand Casting*



*Sand cast aluminium car wheel rim after machine finishing*

**Properties:** metal forming process where molten metal is poured into a hollow mould made using a wooden pattern in sand; complex 3D shape can be produced, cores are used to form hollow sections, machining required to finish casting; internal corners rounded, bosses, stiffening webs, tapered edges visible.

**Typical Uses:** low/medium/high volume and low speed metal forming process usually in cast iron, brass, or aluminium; engine parts, vices, wheel rims.

## Forging



*Drop forged high carbon steel axe head fixed to a GRP (fibreglass) shaft*

**Properties:** metal forming process where the material is heated and then hammered into shape; hand forges - skilled, slow process, drop forging - high volume automated with shaped dies used to hammer metal into shape; improved strength over fabricated product due to grain structure following part's contour, further work may be required to finish forging.

**Typical Uses:** low/medium/high volume and low/medium speed metal forming process usually in steel; hand - gates, railings, horse shoes; drop forged - engine parts, spanners.

## *Finishing Metals*



*Torch - machined from aluminium and finished by anodising*

**Properties:** to protect and make the metal more attractive; wide range of finished available, hand applied, dipped, sprayed or electro-plated;

**Typical Uses:** low/medium/high volume; galvanising is used on steel in harsh, impact prone environments, lacquer is used on brass and copper to prevent tarnishing, epoxy powder is backed to provide an hardwearing attractive finish.

## Turning Wood

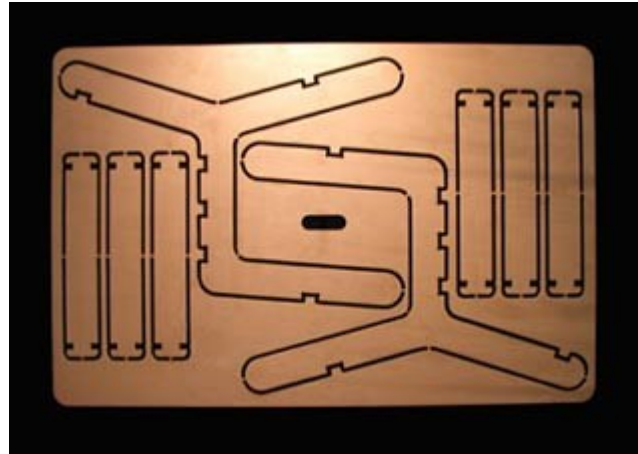


*Shaker style rocking chair with turned legs*

**Properties:** timber forming process where wood is held and spun as a cutting tool is moved along the surface to form cylindrical and conical shapes; CNC or copying lathes are used for batches of the component, manual lathe with a skilled operator used to machine one-offs, a subtractive process and so waste is produced.

**Typical Uses:** low/medium volume, stair spindles, newel posts, tool handles, bowls.

## Routing



*Flat-packed chair cut with a CNC router from a sheet of 18mm MDF*

**Properties:** wood machining process where a shaped cutter is fed along and into the material to machine 3D shapes; used to cut the material or form joints; CNC routers use CAD drawings to control the cutting and are suitable for batches production, manual hand router with a semi-skilled operator used to machine one-offs, a subtractive process and so waste is produced.

**Typical Uses:** low volume; CNC - sign writing, manufactured board furniture, hand router - shop fitting, cabinet making, one-off products.

## *Spindle Moulding*



*MDF skirting board - standard lengths machined on a spindle moulder*

**Properties:** wood machining process where a shaped cutter rotates and the wood is fed across to produce material with a uniform cross-section shape; a series of standard cutters are available, a subtractive process and so waste is produced.

**Typical Uses:** low/medium volume; skirting board, picture rails, decking boards.



## Laminating Wood



*Glue-lam steam bent roofing beam in red pine*

**Properties:** building up layers of timber to form lengths, sections and shapes that are not normally possible; when used with steam the sections can be bent and moulded into curves, the timber can be selected and then tested to ensure load bearing strength.

**Typical Uses:** low/medium volume process; glue-lam beams for architecture application, furniture.

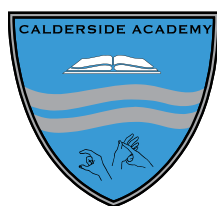
## Finishing Wood



*Teak sun lounger suitable for exterior use and regularly finished with teak oil to protect the timber*

**Properties:** to protect and make the wood more attractive; wide range of finishes available, hand applied, dipped, sprayed; manufactured boards such as MDF can be painted to appear like a solid timber grain and chipboard is often finished with a plastic laminate in wood effect or coloured.

**Typical Uses:** low/medium/high volume; plastic laminate - manufactured boards furniture, kitchen cabinets; varnish - solid timber; oil - teak and cedar for exterior uses; paint - pine and MDF.



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