

CATEGORY: 5.0**MATERIALS**

Materials selection decisions are a crucial part of the product design process. Materials are selected on a basis of their performance against several factors, these can vary depending on the application.

Mechanical

Strength, Density, Hardness
Permeability, Friction, Elasticity

Electrical

Conductivity, Insulation, Flux Density

Others

Optical, Magnetic, Environmental, Thermal

Other aspects that effect the selection of all materials are Price, Availability, and Manufacturing Technique.

Effective materials management is essential for the smooth running of a manufacturing business. There is a balance to be achieved between holding enough materials to avoid a shortage, which may stop production and holding too much stock, which can have a negative effect on the business. An excess of stock can affect cash flow, costs money to store and has the risk of obsolescence. Effective management of the materials supply chain is essential to increase efficiency, flexibility and responsiveness.

The Institute of Materials (IoM)

The Institute of Materials serves the international materials community through its wide range of activities and by acting as the professional body for materials scientists and engineers. The Institute represents a wide range of expertise across the disciplines of ceramics, metals, polymers, and composites.

USEFUL CONTACTS

<http://www.iom3.org/>

Web site for the Institute of Materials.

<http://www.mcc.ac.uk/cem>

Web site for the Centre for Electronic Materials (CEM).

<http://www.emas.co.uk/>

Web site for the Engineering Materials Advisory Services Ltd.

METALS

Metals can be broken down into two main groups Ferrous and Non-ferrous. Ferrous metals are Iron, Steel and Steel Alloys. The most commonly used non-ferrous metals are Aluminium, Copper, Magnesium, Lead, Zinc, Nickel, Magnesium, Titanium and Tungsten, the majority of the non-ferrous metals are used in their alloy forms.

The [London Metal Exchange](#) (LME) is a non-ferrous metals trading market. The website provides information regarding current metal prices and monthly price and volume trends.

FERROUS

Iron

Two main forms of iron are available, these are Cast Iron and Wrought Iron. Cast iron is normally supplied in billet form and is used for producing complex shaped components. Cast iron is strong in compression, but weak in tension. Grey Cast Iron contains graphite and is used for applications such as machine tool bearing surfaces due to its self lubricating *and vibration damping* properties. Wrought Iron is a low cost material that can be easily formed into shape by working, cold or hot. A general background to wrought iron and its uses can be found at the [Wrought Iron Advisory Centre](#).

The [International Iron and Steel Institute](#) acts to support the interests of its members by conducting and publishing research activities, and acting as an iron and steel information source.

Steel

Steel is an alloy of iron with carbon. There are three main types of steels these are Non-Alloy Steel, Alloy Steel and Stainless Steel. Stainless steel contains a minimum of 10.5% of chromium.

The [UK Steel Association](#) represents the steel industry and promotes the industry and the importance of steel to the public and provides information and services to its members. Over 95 per cent of UK steel producing companies, and many steel processing companies, are members of the UK Steel Association.

The [British Stainless Steel Association](#) (BSSA) provides support to its members by promoting the use of stainless steel in the UK. The website provides a useful source of technical information on many different types of stainless steels and their application.

NON FERROUS

Aluminium

Aluminium is a very low density metal that can be alloyed with a number of different elements to provide a wide range of different physical properties. Aluminium is resistant to corrosion due to its oxide layer. Aluminium can be easily extruded, cast and machined. Aluminium is rarely used as a non-alloy due to its low strength properties. Alloys of aluminium can increase the strength significantly, especially after heat-treatment processes.

The [Aluminium Federation](#) acts as an information resource for manufacturers of aluminium products. ALFED provides this information in the form of books, publications, reports and standards. Furthermore ALFED has launched the Aluminium Information Service (AIS) to enable non-members to access the ALFED information resources.

Copper

Copper is used extensively as a electrical or heat conducting medium. Coppers main uses are for electrical wiring, electrical contacts and heat exchangers. When alloyed with zinc, brass is formed, which is used for large number of varied applications, such as architectural components ad bearings When copper is alloyed with silicon and phosphor then a phosphor bronze alloy is produced. This alloy is commonly used for plain bearings and springs. The [Copper Development Association](#) promotes the use of copper and its alloys. There is also a [Brass Section](#) that can be accessed.

The [British Non-Ferrous Metals Federation](#) (BNFMF-copper) represents the copper and brass industry. The BNFMF is also a member of the [Non-Ferrous Alliance](#) (NFA) an alliance of trade associations representing aluminium, lead, zinc, nickel and copper. Between them they represent almost the entire industry and cover the whole spectrum from major international players to small and medium sized companies.

Titanium

Titanium is a high strength low density metal with a much higher melting point than aluminium. Titanium is important for aerospace and military applications and is being further developed for uses in the off-shore oil industry. Production process is expensive preventing its more general use.

The [Titanium Information Group](#) (TIG) is an association that was set up with the purpose of increasing the awareness of the benefits of titanium.

Magnesium

Magnesium is used widely as an alloying element in aluminium alloys but in its own right in cast components. Lighter than aluminium its use may become more widespread in future.

Lead

Lead is used in a variety of applications though the dominant is by far lead acid batteries. Unlike other countries, in the UK it is also used in rolled and extruded building products for it's corrosion resistant and sound insulation properties, for roofs, flashings, weatherings and cladding.

The [Lead Development Association International](#) represents the lead industry and also plays a role in environmental issues. The [Lead Sheet Association](#) concentrate on training and technical advice/support.

Zinc

Zinc is principally for galvanizing steel. Building and construction is the main market for zinc coated sheet and profiled steel, roofing, guttering and ductwork. Hot dip galvanized sheets are also used for roofing and flooring. Galvanized steel is used in the automotive industry, where it provides protection against rust. Zinc coated steel is also used in the white goods sector, because producers require a surface that is corrosion resistant and has a smooth surface for painting.

Nickel

Nickel is used mainly as an alloying element for stainless and heat-resisting steels. These are used widely in industry and construction. The food industry depends on stainless steel for it's production units. Nickel forms the base metal for a wide range of high temperature alloys (with cobalt) for high temperature applications in turbines and aero engines. It has a relatively low thermal and electrical conductivity, high resistance to corrosion and oxidation, excellent strength and toughness at elevated temperatures.

The [Nickel Development Institute](#) represents the Nickel industry and focuses on promoting the use of Nickel.

Tin

Pure tin is a silvery white metal, which is soft, ductile and malleable. It is one of the oldest metals known to man, but it does not occur naturally as a metal. By far the most important tin mineral is cassiterite, a naturally occurring oxide of tin, which in its purest form contains 78.6% tin. Tin is a relatively scarce metal compared to some other base metals like copper, lead and zinc, with an average abundance of about 2ppm in the Earth's crust.

As a metal, the most important properties of tin are its low melting point, its non-toxicity, its resistance to corrosion, its attractive appearance and the ability to readily form alloys with most metals to create useful materials. Tin is rarely used in its pure form because of its softness, it is almost always used in combination with other metals, either as an alloying element or as a coating.

The [Tin Technology Ltd](#) is the world's foremost authority on tin with access to 70 years experience and knowledge.

Tungsten

Tungsten is one of the highest melting point materials and exhibits excellent high temperature properties, especially hardness. It is a heavy metal, it has a very low coefficient of expansion and it is oxidation and corrosion Resistant.

The [International Tungsten Industry Association](#) is based in the UK and promotes the use of tungsten around the world. It organises seminars and disseminates information regarding all stages of tungsten use.

Platinum

This material has a high density material similar to that of gold. It is a relatively soft material and provides very good resistance to corrosion and environmental attack. It is commonly used as an alloy in electrical circuits.

Chromium

This material exhibits excellent corrosion resistance properties and it acts as a barrier when electroplated onto the surface of steel.

POLYMERS/PLASTICS/RUBBER AND ADHESIVES

Polymers exist in two main forms, thermoplastics and thermosets. Thermoplastics are polymers that soften when heated and can be formed into a new shape and thermosets can not be changed in shape after heating without a significant change in material properties.

The [British Plastics Federation](#) is a trade association that represents the interests of all industries relating to plastics manufacture. The website provides basic information on plastics along with performance data.

[RAPRA technology Ltd](#). Polymer and Rubber Selection Software and Consultancy. The [Polymer Search on the Internet](#) that is part of the RAPRA page

[British Plastics and Rubber Online](#) is a on-line directory listing to UK companies that manufacture polymer related products.

RUBBER

There are two different types of rubber, Natural and Synthetic. The synthetic rubbers have been developed to provide resistance to chemical and environmental attack, whilst natural rubbers are chosen for applications where extreme elasticity, resilience and fatigue properties are required. Some commercial types of synthetic rubbers available are Neoprene, Hypalon and Nitrile.

Adhesive and Sealant

The [British Adhesives and Sealants Association](#) (BASA) represents the interests of suppliers of adhesives and sealants and provide a consultancy service on matters such as current and future legislations.

The [Centre For Adhesives and Sealant Science](#) is based at Virginia Polytechnic Institute and State University, USA, and provides education and conducts research on adhesive and sealant applications on a wide range of disciplines.

COMPOSITE

Composite materials are constructed from two or more elements to provide a material that has different properties to the individual elements. The constituent parts of a composite are the Matrix and the Reinforcement (Fibres). The matrix acts as the bulk material and transfers load between reinforcement, and the reinforcement provide strength and stiffness. The matrix also has another role, this is to protect the reinforcement from the environment, abrasion and impact. Another important material that can be included as part of a composite material component is the Core, this is usually a low density material that is used to fill the gap between two Reinforcement/Matrix 'skins' or laminates.

Composites production techniques include hand lay-up, pressure moulding and pultrusion. The form and arrangement of the fibres as they are introduced to the mould can vary significantly. They can be either short strands randomly orientated, a bundle of fibres, as a unidirectional fabric, as a woven fabric, as a braid (tubular) fabric or as a multi-axial fabric. The selection of the type of fibre arrangement depends on the loading condition requirements of the component.

There are three main classes of composite materials, polymer, metal and ceramic matrix composites.

Polymer Matrix Composites

These are the most common type of composites, the types of fibres that are widely used for this type of composite are glass, carbon and boron. Polymers are not recognised for being the strongest of materials, but in the thermosetting resin form they provide excellent abilities to be moulded into complex shapes and to adhere strongly to the fibres. Common types of resin used are Polyester, Vinylester and Epoxy. Accelerator and catalyst elements can be added to the resins in varying amounts to allow the polymerisation reaction to be controlled to provide varying material properties. Use of the catalyst element needs to be carefully controlled to ensure the reaction is not too rapid and to avoid insufficient curing.

Polyester resins are the most widely used, this is maybe due to the fact that they can be used to construct composites without the need to introduce pressure.

Vinyl ester resins are similar to polyesters but provide better resistance to chemical and water attack and also display improved toughness.

Epoxy resins exhibit higher levels of mechanical strength and they can also be more resilient to environmental attack.

Carbon Fibre

Many different types of carbon fibre are available. The base materials used for producing the fibre are polyacrylonitrile, pitch or cellulose. Modifying the production processes produces different classes of fibre, these being, high strength (standard modulus), intermediate modulus, high modulus, and ultra high modulus. A 'size' is applied to the surface of fibre to enable it to be handled in winding and fabric forming processes without incurring any damage.

Glass Fibre

Glass fibres are produced in three main forms:

E-glass (electrical grade)

Most commonly used, low cost, low impact strength

Widely used in marine industry

S-Glass (higher strength grade [also known as R-glass, and T-glass])

Higher tensile strength and modulus, relatively costly (E-glass X 10)

High cost restricts its use to aerospace and defence industries

C-glass (chemical resistant grade).

Provides higher chemical resistance, used for outer layers of composites

Aramid Fibre (Kevlar)

Man-made organic fibre

Tensile strength is high, low compressive strength, high thermal insulation and fire resistance. This fibre type has a high resistance to shock loading and has a low density, these two factors combined promote its use in bullet proof jackets.

Metal Matrix Composites

This type of composite construction is commonly used to increase the strength of low density metals such as aluminium, copper and magnesium alloys. The complex nature of these materials limits their use to high performance applications, in industries such as, automotive, aerospace, and power. Some of the commonly used fibres, whiskers and particle materials are Boron/Tungsten, Alumina, Graphite and Silicon Carbide.

Ceramic Matrix Composites

For applications where high strength is required and high temperatures, Silicon Carbide and Boron Nitride and other ceramic fibres are used to reinforce ceramics, such as aluminium oxide and Silicon Carbide.

The [Composites Processing Association](#) is a UK based organisation that actively promotes the increased use of composites in a wide ranging number of applications and market sectors.

The [NetComposites](#) is an online resource for 'Knowledge in Composites' and is a body that advances the use of composites. The 'Guide to Composites' section provides a useful introduction to composite materials, applications and construction.

CERAMICS AND GLASS

Ceramics are crystalline, inorganic, non-metals that provide the following generalised material properties low in density, high moduli, very hard, low toughness, very high melting points, Excellent electrical and thermal insulation.

There are four main applications for ceramics, which are Engineering Ceramics, Tiling, Pottery and Glass. Glass is a non-crystalline solid.

Commonly used ceramics are Alumina, Magnesia, Silica, Silicon Carbide, Silicon Nitride Porcelain, and Zirconia.

The [British Ceramic Confederation](#) provides support for its members by acting in the ceramics industry interests and promoting the use and development of ceramic materials.

The [British Glass](#) website is a resource that combines the activities of the British Glass Manufacturers Confederation (BGMC) and Glass Technology Services Limited (GTS). The BGMC represents the interests of the glass manufacturing industry and GTS carries out independent technical research.

The [Society of Glass Technology](#) aims to advance the technology and application of glass over a wide range of market sectors.
SEE ALSO GLASS FIBRE ABOVE

CONSTRUCTION

The construction industry uses a wide range of materials to build a variety of different structures. Materials have a number of functions in construction, mainly to provide a physical structure of the building and a barrier against the weather elements.

Several Associations provide advice and support on Construction Materials.

Bricks are ceramic materials.

[Brick Development Organisation](#)

[The Concrete Centre](#)

[Concrete Society](#)

And for Construction Steel the [Steel Construction Institute](#)

ELECTRICAL / ELECTRONIC MATERIALS

Copper – low electrical resistance and low cost promotes its use for conducting electricity.

Silicon – the most widely produced semiconductor material.

Germanium – Used in manufacture of transistors and integrated circuits as a semiconductor.

Gallium Arsenide – Used to convert electricity into coherent light, as in LED's.

Indium – silvery-white metal, used as an alloy as solder and flux.

Conjugated polymers – organic molecular semiconductors and opto-electronic devices.

[Centre for Electronic Materials](#) (CEM) is located in the Department of Electrical Engineering and Electronics at UMIST and conducts research into electronic materials.

[Electronic and Photonic Molecular Materials](#) based at Sheffield University carries out research into organic and polymeric materials and their electrical and optical characteristics.

WOOD

Commonly referred to as a composite due to their cellulose and fibrous structure. Woods are low density materials that provide structural support in bulk form. Strength of woods are difficult to predict due to their grain and knot structure. Woods are regularly selected on an aesthetic basis to show their grain and colours. There are two groups of wood types, softwood and hardwood. The forms of wood supplied can vary from rough sawn timber, planed timber, fabricated board and wood pulp.

The [Institute of Wood Science](#) (IWSc) acts to further an improved awareness wood-based materials and manufacturing processes.

The [Timber Trade Federation](#) promotes the use of timber and aims to provide a prosperous timber market place.

The [Wood Bureau](#) aims to promote improved knowledge of wood and its uses through education.

PAPER AND BOARD

The [Department of Paper Science at UMIST](#) provides education and conducts research into all aspects of paper production. The department also houses the Paper Testing Laboratory to analyse paper performance.

The [PIRA net](#) Paper and Board Section provide testing and consultancy services on all aspects of paper manufacture.

The [Paper Industry Technical Association](#) provides its members with information on paper and its associated activities.

TEXTILES (INCLUDING NATURAL, SYNTHETIC, LEATHER)

The [Textile Institute](#) promotes the use of best practices within the textile industry and associated areas.

The [School of Textiles and Design](#) is based at Sheffield University. It is involved with education and research on all areas involved with textile manufacture and design.

[European Fine Fibre Network](#) is a dedicated group of researchers and manufacturers that are aiming to develop the processes of producing high quality animal fibres of European origin

<http://www.leathernet.com/> provides a web based service for the leather industry with information on news and markets and hosts a free trading board.

BIOMATERIAL

A number of organisations provide information on Biomaterials.

[Biomaterials Online](#)

[Medical Devices Faraday Partnership](#)

[Centre for Biomaterials and Tissue Engineering](#)

[Biotechnology And Biological Sciences Research Council](#)

RECYCLING

Recycling of materials is becoming a more and more important issue in any manufacturing environment. There are many different action groups aiming to increase the awareness of the manufacturers and consumers to the need for reducing the amount of virgin material used and increasing material reuse activities. One major driving factor for encouraging recycling of materials is the [Climate Change Levy](#).

The [Waste and Resources Action Plan](#) (WRAP) is aiming to reduce the amount of waste materials produced and to increase the amount of material being recycled.

The [Aluminium Packaging Recycling Association](#) (Alupro) is responsible for encouraging and developing recycling collection initiatives, for consumer education, and for representing the aluminium packaging industry to government.

The [British Metals Recycling Association](#) is a new association that is the result of the British Metals Federation and the British Secondary Metals Association. It is aimed at protecting the interests of the scrap metal merchants and promoting recycling of metals.

[PaperChain 2000 Paper Re-cycling Project](#)

The UK based PaperChain project was launched in 1995 to increase the amount of paper recycled and to ensure that paper manufacturers are provided with reliable sources of recovered paper. This is achieved by working with local authorities and businesses to try to constantly increase the amount of paper that is recycled. This website is a source of information about the PaperChain and other related developments, in the form of debates, publications and research.

“[Sustainable Development](#) is a simple idea of ensuring a better quality of life for everyone, now and for generations to come”. The aims of sustainable development are to continually develop society on social and economic, whilst protecting the natural environment and using natural resources efficiently.

Life Cycle Analysis (LCA) is a technique that evaluates the function of a product throughout its entire life, from raw material extraction, through production and utilisation, to disposal. The main advantage of the LCA process lies in being able to identify where significant reductions in environmental impact can be made.

HANDLING AND STORAGE

(see also the Section under Manufacturing Processes /Materials Handling)

Material transportation and storage technique needs careful considered when defining manufacturing processes in order that the correct balance of stock is available and the stock is easily accessed by using the appropriate equipment.

The [British Materials Handling Federation](#) (BMHF) is an organisation that represents the materials handling equipment manufacturers and promotes the correct selection and use of handling equipment.

The [Storage Equipment Manufacturers Association](#) (SEMA) promotes all aspects of materials storage, including the design, manufacture and installation of equipment.

[Cranfield Centre for Logistics and Supply Chain Management](#) (CCLT) is a resource for research, education and advanced techniques in logistics, supply chain management and transportation management.

OTHERS MATERIALS

Additional information will be appearing in this section on other types of Materials with links to sources of information.

Abrasives

[The British Abrasives Federation](#)

Diamond

Natural and industrial (CBN) diamonds

Magnetic

[Wolfson Centre for Magnetism Technology](#)