

Brass

in focus

Brasses are versatile and cost-effective materials, ideal for designing complex and long lasting components. Ken Kempson explains.

Brass is an alloy of copper and zinc, the amount of zinc varying from five to 45 per cent to create a range of brasses, each with unique properties. There are two distinct types of brass. Those with less than 35 per cent zinc are known as alpha brasses because only one solid solution (alpha) is present. These alloys are ductile at room temperature and ideal for cold working. Brasses with more than 35 per cent are called alpha-beta or duplex alloys and are ideal for hot working (see Figure 1).

The properties of brass

Small amounts of other elements can be added to brass to improve its primary properties. See the table right.

■ **Machinability**

Brass has excellent machinability, however, this can be improved by adding three per cent lead to give free-cutting high-speed machining brasses.

■ **Strength**

Brasses are medium strength engineering materials. In the softened or annealed condition they are ductile and strong but, when hardened by cold working, their strength increases. The addition of small quantities of manganese, aluminium, tin, silicon, iron and nickel in brass produces a family of high tensile brasses that can have tensile strengths in excess of 500MN/m². 750MN/m² can be obtained in some alloys by extreme cold working. Brasses have good impact resistance and do not shatter or crack when subject to a high impact load.

■ **Corrosion resistance**

For general purposes the corrosion resistance of standard free machining alloys is excellent. The addition of tin in naval and admiralty brasses (originally developed for seawater service) further improves corrosion resistance. The addition of a small amount of arsenic to alpha brass alloys produces a dezincification resistant brass, frequently used for water fittings.

■ **Conductivity**

Brasses have good electrical and thermal conductivity. Combined with good corrosion resistance, this makes them ideal for the manufacture of electrical equipment. Condenser and heat exchanger tubing also makes use of the good thermal conductivity of copper alloys. Brasses do not spark when struck by other materials and are approved for use in hazardous environments. They are also suitable for use at cryogenic temperatures since their properties are retained or slightly improved (mechanical values are available at -197°C). Strength is maintained up to 200°C.

The presence of lead in brass has a lubricating effect providing good low friction and wear properties that are utilised in pinions, instrumentation and clock gears. The addition of silicon in

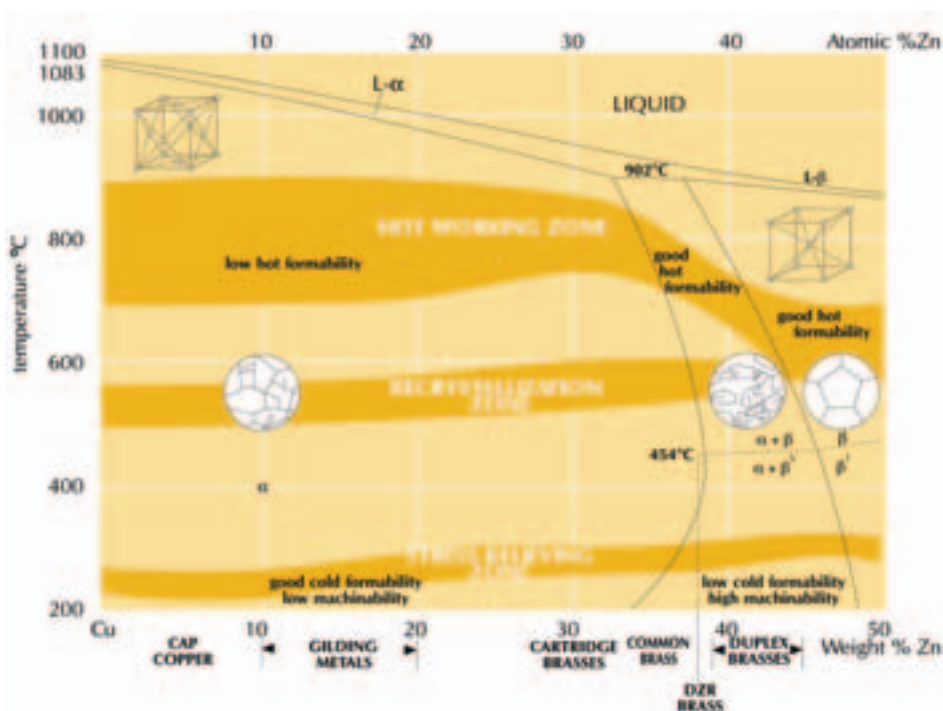


Figure 1: Copper-zinc phase diagram.

Element	Quantity	Property enhanced
Lead	1 to 3 per cent	Machinability
Manganese Aluminium Silicon Nickel Iron	0.75 to 2.5 per cent	Yield strength Up to 500MN/m ²
Aluminium Arsenic Tin	0.4 to 1.5 per cent	Corrosion resistance especially in sea water

Elements can be added to brass to improve its primary properties.

special brasses makes them ideal for use in heavy duty bearings.

■ Hygiene

Copper is bacteriostatic and its content in brasses has the effect of restricting the growth of micro-organisms on brass surfaces. Tests on door knobs and finger plates have shown that those made of clean brass are far less likely than other materials to encourage the growth of the organisms causing nosocomial infections.



Tests on door knobs and finger plates have shown that those made of clean brass are more hygienic.

■ Aesthetics

Brasses are extensively used for durable decorative applications and for the manufacture of functional items where aesthetic appeal is required, as well as a long service life. Aluminium brasses have a distinctive silvery sheen and the addition of manganese to certain brasses gives them an attractive bronze colour when extruded. High tensile brasses, some of which are known as manganese brasses, are particularly suitable for architectural applications because they can be patinated to a range of durable brown and bronze finishes.

■ Recyclability

Recycling brass scrap is essential to the economics of the industry. The use of

brass scrap, bought at a much lower price than the metal mixture price, means that fabricated brass is cheaper than it might otherwise be. Scrap is obtained from offcuts from within the mill, swarf from machine shops, clippings from hot stampings and presswork and from brass components being recycled. It is easily remelted back to its original state without loss of properties and the high value of any swarf or scrap produced during manufacture should be taken into account when costing. Likewise, when calculating the lifetime cost of a product, the ease with which a brass component is recycled at the end of its life needs to be taken into account. Brass scrap typically has a value of 40 per cent of the new material.

Manufacturing processes

Brass can be turned into components by most common manufacturing processes.

Hot working

■ Casting

The fluidity of brass when molten permits it to be cast to shape by all casting processes. It is an ideal metal for investment casting and its ability to be gravity or pressure cast enables near net complex parts to be made in any volume depending on the process chosen. Brass can be centrifugally cast, ideal for the manufacture of tubular shaped components. It can also be continuously cast.

■ Extrusion

Billets, cut from continuously cast logs, preheated to between 600°C and 800°C, are forced through a die that is shaped in the form of the finished product. This gives round rod, square, hexagonal or special profiles as required. The use of a mandrel allows hollow extrusions to be produced.

Duplex materials that have good ductility at hot working temperatures are usually used for extrusion. The resulting structure of the material is uniform with a fine grain structure.

■ Hot stamping



Hot stamping.

Hot stampings are made by forming hot slugs of brass between shaped dies that are designed and made to give components that require minimum finishing.

Hot stampings have high strength, are free from porosity, are near-net-shape, give close consistent component tolerances, have a superior surface finish and give optimum metal usage. They are easy to jig for accurate finish machining of faces, holes and threads.

■ Hot rolling

Continuously cast metal slabs are reduced to the required thickness by hot rolling.

Cold working

Cold working leads to improved surface finish and dimensional accuracy. By applying progressive amounts of cold working the tensile strength, proof strength and hardness of the alloy increases, with a consequent reduction in ductility, as measured by elongation.

■ Drawing

The cold work in the case of extruded products such as rods, bars, sections, tubes and wire, is applied by drawing through reducing dies. Drawing extruded rod through a series of reducing dies produces wire, which is used for the manufacture of circlips, zip fasteners, rivets screws etc. Because of the amount of cold work imparted it may be necessary to anneal between draws.

■ Riveting, cold heading, thread rolling

The single-phase alloys can be readily riveted-over and are used to manufacture cold-formed parts. Rivets, pins, screws and similar items are



mass-produced from wire by cold heading.

■ **Seamless tube**

Tube is made from hollow extruded tubeshells, which are cold drawn to size by a succession of passes drawing dies, with interstage anneals as required and supplied either in straight lengths or coil. A selection of brasses is available with properties to suit applications from telescopic aerials to marine condensers.

Brass tubes can be made to bespoke shapes and sizes. The inside shapes can be different from the outside and can have specified wall thickness, uniform or uneven. Another frequent need is for an oblong tube with the corners either square or typically radiused to half the wall thickness. Often, one side must be significantly thicker than the other. For tubular heat exchangers, such as oil coolers, there are concentric tubes, the flow of coolant can be made turbulent by helical grooves or raised ridges.

■ **Cold rolling**

Slabs of continuously cast metal that have been reduced in thickness by hot rolling are passed through a series of rolls. Each pass reduces the thickness of the material increasing its strength, but reducing its ductility. Hard rolled brasses have better ductility longitudinally in line with the rolling direction, rather than in the transverse direction. This is ideal for springs or other flexible parts.

■ **Cold stamping and pressing**

Alpha brasses in sheet and strip have good cold deformation properties and are therefore readily formed and shaped by cold stamping or pressing. Cold stamping and pressing is typically used to produce connectors, precision mechanics, key blanks, contact elements, decorative ware, jewellery and clock making items.

■ **Deep drawing**

Cold rolled brass strip is ideal for deep drawing. The starting sheet of flat brass is larger than the area of the punch and the outer parts of the sheet are drawn in towards the die as the operation proceeds. Cartridge cases made from 70/30 (cartridge) brass are a typical example of a deep drawn product.

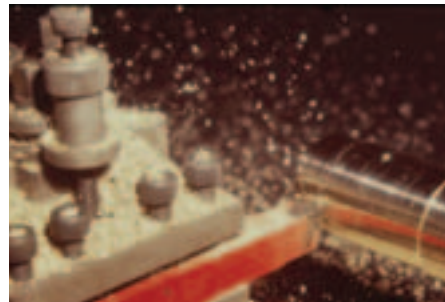
■ **Spinning**

This can be a useful production

technique for making dished ends of hollow vessels, flanges for water vessels, ball floats, electrical switchgear products and similar items. Diameters up to 4000mm and thicknesses up to 25mm can now be spun to close tolerances, maintained through short or long production runs. Tooling costs are much lower than press tools and differing material thickness can be tried on the same tool during product development.

■ **Machining**

During machining the cutting tool forms chips or shavings by producing a continual series of fractures of the metal being cut. Whilst all brasses are intrinsically easy to machine, this can be improved with the addition of small amounts of lead. Higher machining speeds and lower rates of tool wear mean that overall production costs are minimised, tolerances are held during long production runs and surface finish is excellent.



Machining.

■ **Joining**

Brasses lend themselves to being joined by most common processes. The close tolerances to which brass components can be manufactured makes it ideal for joining by silver brazing which produces leak tight joints without melting and distorting the brasses to be joined. Modern MIG and TIG welding processes can successfully weld most brasses with the correct choice of filler alloy.

The CuproBraz process is a new joining method applied in the manufacture of high strength and performance radiators and other automotive heat exchangers that are 10 per cent cheaper than aluminium equivalents and 35 per cent lighter than traditional copper brass radiators. This environmentally friendly process produces strong and reliable brazed copper/brass joints using a specially developed fluxless brazing process.

The brasses are a versatile family of copper alloys which can be manufactured by the full range of metal forming processes from cost-effective, durable, recyclable components.

For more information visit Copper Development Association's website www.brass.org.

Find out more about brass

Copper Development Association (CDA) gives free brass lectures to universities offering design engineering degrees. The lecture clarifies what brass is, the different types of brass and the effect of alloying elements on the base alloy. Properties of brass and the manufacturing processes, as discussed in this feature, are explained in more detail and illustrated with numerous samples. The lecture concludes with a series of case studies illustrating the benefits of designing in brass.

A CPD approved presentation that covers similar material to the university lecture, but which is tailored more specifically to meet the needs of practising designers, is available to design teams and consultancies. More in depth

presentations on particular manufacturing techniques are available on request. A CDA representative visits the company premises eliminating the need to travel and saving time.

In addition, CDA are running full day CPD 'Brass in focus' seminars for designers and engineers. See www.brass.org/news/training/seminars.htm for more details.

For more information about the university lectures, in-house presentations, or to register for a seminar, contact Copper Development Association, 5 Grovelands Business Centre, Boundary Way, Hemel Hempstead, Herts, HP2 7TE. Telephone 01442 275700, Fax 01442 275716 or Email helpline@copperdev.co.uk

Case study

Brass goes nuclear

Raditec, A/V systems, environment monitoring specialists, supplies nuclear radiation tolerant image acquisition systems including television cameras, endoscopes, borescopes and accessories for use in nuclear facilities. Raditec also provides systems for hostile and high temperature environments, for example chemical plant monitoring.

The company approached Abakus Scientific to design and build a unique and versatile zoom lens that could withstand a nuclear exposure level of Cobalt 60 (1xMGray). Specifications for instruments exposed to gamma irradiation in nuclear environments incorporate a figure for the summation of the total dose that the device must survive whilst retaining an acceptable degree of functionality.

So why brass?

Brass, unlike plastic, is unaffected for all practical purposes by extended exposure to a nuclear environment. The plastic material Teflon, for example, is

one of the worst materials for nuclear applications and produces fluorine when irradiated. Brass, by contrast, produces no harmful or hazardous chemical by-products. In the case of this nuclear tolerant zoom lens, (tolerant is used here as the preferred term rather than nuclear resistant, since the construction and functional materials cannot avoid exposure, but must exhibit the optimum tolerance), the application could be typically a camera system for the inspection of fuel rods in nuclear reprocessing. In this environment any component failure is potentially hazardous and very expensive so it is essential that the materials used give the product compatibility with the environment and a long and trouble free life.

Brass is used extensively in these nuclear tolerant units. The specification for the lens mounting and carrier system for such a high accuracy product requires it to be made from a stable, corrosion resistant material that can be machined to extremely close tolerances with a high degree of repeatability, giving a very fine surface

finish using both traditional and modern CNC techniques. Brass also has good bearing properties, particularly when used in contact with other materials, also a requirement of the system. Readily available from stock in a variety of sizes, brass meets all of these criteria, yielding a life of many years.

Dr Kath Langley, Manufacturing Director, Abakus, comments: "We are aware of the full spectrum of materials available to us in lens body construction and we regularly subject alternative materials to life trials. In the case of the 'discrete' lens, the tiny brass gear wheels and the toothed ring are critical to the zoom function. We first tried using plastic for the ring and in tests it exhibited severe distortion in a short time, becoming almost a soft cornered, triangular shape. The second trial used steel and rapidly displayed tiny traces of corrosion impeding its function.

We returned to the free-machining CZ 121 brass that we use as standard in most other lenses and the product now functions perfectly and experiences no long-term deterioration. We would have liked the small weight-saving potentially available with plastics, also the marginal economy of steel, but at the end of the day they were not up to meeting the specification.

"One novel feature of this product is the lens iris. After a serious number-crunching exercise we developed a uniquely profiled, machined miniature brass plate which revolves and controls iris aperture in a 'diameter-linear', rather than f-stop linear, manner from full aperture through to the total blackout condition required for TV camera calibration. The smoothness of operation could not be obtained with any other material than brass, its inherent lubricity, surface to surface, eliminates the need for organic or fluorocarbon lubrication."

