Magnesium Elektron

SERVICE & INNOVATION IN MAGNESIUM

Joining Magnesium Alloys

Datasheet : 250

Magnesium Elektron UK,
P.O. Box 23, Rake Lane, Swinton, Manchester, M27 8DD, England.
Tel: 0161 911 1000   Fax: 0161 911 1010
Web: www.magnesium-elektron.com   VAT No: GB 668 2142 26

A Division of MAGNESIUM ELEKTRON LIMITED. Registered in England No. 3141950.
Registered Office: The Victoria, 150-182 Harbour City, Salford Quays, Salford, M50 3SP
A Luxfer Group Company

Joining Magnesium Alloys

Magnesium alloys may be joined using methods similar to those used for other metallic materials i.e. bolting, screwing, riveting, welding and adhesive bonding. Soldering and brazing are also possible.

ADHESIVE BONDING

Magnesium alloys may be joined by the use of adhesives. Synthetic resins of various types have been successfully used for this purpose and information on suitable materials may be obtained from the manufacturers. The advantages include:

1. Fatigue characteristics are superior to other types of joints, and the absence of drilled holes avoids stress concentrations.
2. Thinner materials can be joined by adhesive bonding than by riveting.
3. Joints are automatically rendered watertight with great advantage to the prevention of corrosion.

Adhesive bonding has been used extensively in attaching stiffeners to sheet, in producing panels, doors and control surfaces, and for attaching the skins of honeycomb structures to the cores. Joint strength is adequate for such purposes. Peel strength can be greatly improved by the addition of a few well-placed rivets.

There are certain requirements to be met in the production of well-bonded joints but these are quite simple. Magnesium surfaces for bonding should be prepared by degreasing, glass bead blasting and chromating to ensure maximum bond strength. Components should be treated in accordance with DTD 911C.

BOLTING

The size and spacing of bolts will be governed by design. However, close spacing and the use of small diameter bolts will improve the load distribution.

Thick washers should be used under nuts and bolt heads to avoid damaging the flange or spot face.

Bolts should not be placed within two bolt diameters of an edge.

All joint faces should have clean surfaces and any method aimed at lessening electrolytic attack should be used where necessary.

PERMANENT SCREWED STUDS

Screw threads should be course with flat or rounded tops. Fine and sharp threads should be avoided to minimise the notch effect and improve the resistance to fatigue.

In general the ratio of thread length to diameter for studs should be about 3 : 1, but this ratio may have to be increased for greater loads.

Where stresses are moderate, studs may be screwed directly into the alloy. Where greater stresses are involved, heli-coil inserts should be used.

Studs must be tight fitting, and therefore the holes to take them should be tapped undersize to obtain a slight interference fit.

NON-PERMANENT SCREWED STUDS

Steel bushes should be used for non-permanent screwed studs, particularly where impact or alternating loads may be encountered. These bushes may be cast in or screwed directly into the alloy.

Studs and washers should be made of anodised aluminium, zinc-plated steel or cadmium-plated steel. In cases where galvanic corrosion might occur they should all be insulated. Painting over the joint area, or preferably the whole assembly, after bolting is usually satisfactory.

'Wet assembly' techniques are recommended for all studs, heli-inserts and mating faces. This uses a chromated, non-hardening, jointing compound which acts as a seal and prevents the ingress of moisture.

RIVETING OF MAGNESIUM ALLOYS

Aluminium alloy rivets to B.S. 1473 NR5 or NR6 can be used for magnesium alloys. Where the shear load is small pure aluminium rivets are suitable. The small closing pressures required by these softer rivets lessens the risk of damage.

The distance between any two rivets should never be less than three times the rivet diameter and the distance between the edges of both the rivet hole and the sheet should not be less than twice the rivet diameter.

Rivet holes may be drilled or punched. However, punched holes may have rough edges which could accentuate the notch effect leading to failure under dynamic load. They should therefore be punched undersize and drilled to the correct diameter.
Care must be taken not to crack or deform the material around the rivet holes by using incorrect length rivets, applying to great a closing pressure or using incorrect dollies. This again may lead to fatigue failures.
Light alloy rivets used in magnesium assemblies should be closed cold. Squeeze riveting is preferred to hammering, since it ensures greater control.

Joining Magnesium Alloys

SOLDERING, BRAZING & RESISTANT SPOT WELDING

Whilst these methods are possible they are not in genera commercial use.

WELDING

Magnesium alloys are normally welded using the inert gas tungsten arc (TIG or argon arc) process.

The process equipment is readily available and as with aluminium alloy welding an AC unit with a DC suppressor is required. The techniques for magnesium are similar to other light alloys.

Variations in individual welder practice are permitted provided that specifications or code of practice requirements are met.

As no flux is used, there is no risk of subsequent corrosion of the welded joint through flux entrapment. A higher strength efficiency and less distortion is achieved than with gas welding. The tensile strength of an undressed butt weld made by the argon arc process usually exceeds 90% of that of the parent material in the unnealed state. The weld metal is usually very fine grained because of the rapid chill and in tensile tests fracture usually occurs in the heat-effected zone of the parent material.

The specific heat of magnesium is relatively high (1000 $Jkg^{-1}K^{-1}$) but on a volume basis it is lower than for other metals. The volume heat capacity of magnesium is only three quarters that of aluminium.

Since the melting points of magnesium and aluminium are close and the latent heat of fusion of magnesium is lower, the heat required to melt magnesium is only two thirds that for the same volume of aluminium.

Magnesium has a high coefficient of expansion ($26 \times 10^{-6}K^{-1}$) and high thermal conductivity (100 $Wm^{-1}K^{-1}$) and hence there is a tendency towards distortion especially when welding thinner components.

There is no fire hazard in welding magnesium although it will oxidise fairly rapidly in air above its melting point. Except when in a finely divided form, magnesium will not burn until it melts.

The welding rods are usually of the same composition as the parent material but a filler rod of lower melting point may be used to allow the filler metal to remain liquid until the thermally altered parent metal is completely solid and thereby minimise junction cracking. For example, ELEKTRON ZRE1 rod on ELEKTRON RZ5 castings and AZ91 rod on AZ81 castings. It is not recommended that magnesium-zirconium alloys be welded to magnesium-aluminium or magnesium-manganese alloys.

Preparation for Welding

Grease or chromate coatings should be removed prior to welding. Wire brushing of chromated surfaces is usually sufficient.

Care should be taken to ensure the edges of the work are smooth and free from contamination. Milled or sawn edges are satisfactory but might need filling to remove burrs. The filler rod should also be cleaned. Weld preparation should be in accordance with BS3019 Part II.

Cracks in castings up to 10 mm thick should be bevelled (by routing) to an included angle of 90° on one side. Castings above this thickness should be double bevelled.

It is important that before welding is carried out, the casting is in the correct temper condition. This may involve a pre-weld heat treatment. Castings are pre-heated to 250–350°C unless the job is very small when it may suffice to play a torch over the area concerned. The actual pre-heat temperature will depend on the treatments to be applied to the casting later i.e. it must not exceed the final solution treatment temperature, where applicable.

The weld is built up in layers until about 6 mm surplus is obtained which can then be ground off. If multi-pass runs are necessary then beads should be deposited on each side alternately to minimise distortion.

Postweld Heat Treatment of Castings

Heat treatment to relieve residual stresses should follow welding unless the casting has to be heat treated at a higher temperature to meet the relevant specification for the parent metal.

The table shows recommended heat treatment schedules for the welding of magnesium castings. The heat treating procedures shown are based on both the temper of the casting before the welding operation and the temper desired after welding.

Post-welding heat treatments are normally all that is required for adequate stress relief of castings and for optimum mechanical properties in weld areas.

The solution treatments here require the use of a protective atmosphere to prevent oxidation or burning.

Welded Mg-Al-Zn alloy castings that do not require solution treatment after welding should be stress relieved 1hr at 260°C, to eliminate the possibility of stress-corrosion cracking.

Joining Magnesium Alloys

POSTWELD HEAT TREATMENTS FOR MAGNESIUM ALLOY CASTINGS

ELEKTRON Alloy	Welding Rod	Temper Before Welding	Temper After Welding	Postweld Heat Treatment
AZ81	AZ81/AZ92	T4	T4	0.5 hr @ 415±5°C
AZ91	AZ91/AZ101	T4 T4 or T6	T4 T6	0.5 hr @ 415±5°C 0.5 hr @ 415±5°C plus 4hr @ 215°C
EQ21	EQ21	T4 or T6	T6	1hr @ 505±5°C, quench, plus 16hr @ 200°C
MSR-B	MSR-B	T4 or T6	T6	1hr @ 510±5°C, quench, plus 16hr @ 200°C
RZ5	RZ5/ZRE1	F or T5	T5	2 hr @ 330°C
WE43	WE43	T4 or T6	T6	1hr @ 510±5°C, quench, plus 16hr @ 250°C
WE54	WE54	T4 or T6	T6	1hr @ 510±5°C, quench or air cool plus 16hr @ 250°C
ZC63	ZC63	T4 or T6	T6	1hr @ 425±5°C, quench, plus 16hr @ 200°C
ZRE1	ZRE1	F or T5	T5	2 hr @ 345°C and / or 5hr @ 215°C or 24 hr @ 220°C

Certificate No. FM12677