Weld Repair of MoldMAX HH®, MoldMAX LH® & PROtherm® Mold Materials

MoldMAX HH, MoldMAX LH and PROtherm copper beryllium alloys can be effectively and safely welded using conventional welding equipment and processes. The main advantage of using copper beryllium in molds is cycle time reduction from the alloys' high thermal conductivity. However, copper beryllium's ability to very effectively dissipate heat requires careful selection of the welding method, shielding gas, and type of current to maximize heat input. Unlike other copper alloys, copper beryllium can be heat treated after welding to increase the hardness of the welded section. This paper presents guidelines and recommended welding and heat treating practices.

SURFACE PREPARATION

Before welding, a clean surface is necessary. Remove tenacious oxides or other surface contaminants, such as any plastic residue, by wire brushing the mold. Use a suitable, nonflammable solvent to remove organic contaminants. Grind out cracks or unsound metal completely, making sure that the machined grooves have rounded bottoms and sloping side walls. Perform welding immediately after surface cleaning.

PREHEATING

If the section size of the piece to be welded is larger than 0.25 inches, a preheating of the workpiece is necessary.
Preheat the mold to a uniform temperature of 400 °F (200°C) maximum.

WELDING

Gas tungsten arc welding (GTAW), also known as TIG welding, is best suited for sections up to 0.25 inches thick.
Gas metal arc welding (GMAW), also known as MIG welding, is suggested for heavier sections.

TIG Welding

TIG welding is widely used for rebuilding worn mold surfaces and for minor cosmetic repairs. In this process, an electric arc is struck between a non-consumable tungsten electrode and the workpiece. A filler metal is used which is consumed during welding. The electrode should be a sharply pointed tungsten rod containing 2% thoria. Use low oxygen grade argon or helium gas as a shielding gas.
Argon provides good control of arc, while helium permits deeper penetration. Pure argon is normally used for sections up to 0.0625 inches thick. Helium or a helium and argon mixture is typically used when hotter arcs are needed for larger section sizes. Maintain gas flow rate between 15 and 40 ft^3/hr.
Weldpak® copper beryllium should be used as a filler rod.
Available diameters from Materion Brush Performance Alloys include 1/16", 3/32", and 1/8". The power source should be high frequency AC for manual welding, and DC, electrode negative for automatic welding. See Table 1 for typical weld parameters.
Table 1 is intended as a guideline only, and specific welding parameters will depend on the section size and type of mold material.

MIG Welding

In MIG welding, the electrode from which the arc is struck is consumed during welding. MIG welding is typically used for heavier sections and larger repair jobs. The power source is reverse polarity DC, electrode positive. An argon and helium gas mixture is preferred for welding thicker sections.
Suggested welding parameters are 24 - 32 volts, 250 – 450 amps, and a 0.5 - 1.0 in^3/min wire feed rate. See Table 1 for typical weld parameters.

POST WELD HEAT TREATMENT

Heat treat at 600 °F (315 °C) for 3 hours after welding to increase hardness. The post weld heat treatment does not, however, restore hardness to the full hardness of the base metal. Maximum weld hardness is obtained by solution annealing and heat treating after welding.

VENTILATION

Provide adequate ventilation during welding copper beryllium since fumes are generated which may contain hazardous compounds.

SAFE HANDLING OF COPPER BERYLLIUM

Please refer to the Materion Corporation publications "Safety Facts 1 - Safety Practices for Welding Copper Beryllium", "Safety Facts 6 - Safety Practices for Heat Treating Copper Beryllium Parts", "Safety Facts 9 - Ventilation of Beryllium Dust-Generating Operations" and "Safety Facts 105 - Processing Copper Beryllium Alloys."

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, berylliumcontaining materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures.

Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

TABLE 1.
TYPICAL PARAMETERS FOR ARC WELDING MOLDMAX AND PROTHERM COPPER BERYLLIUM MOLD MATERIALS

Process	TIG				MIG
	Manual		Automatic		Manual
Mold Alloy	MoldMAX	PROtherm	MoldMAX	PROtherm	MoldMAX
Section Thickness	0.125 in (3.175 mm)	0.250 in (6.35 mm)	0.020 in (0.508 mm)	0.090 in (2.286 mm)	1.0 in (25.4 mm)
Preheat Temperature	none	300°F (150°C)	none	none	300°F (150°C)
Filler Metal Diameter	0.125 in (3.175 mm)	0.125 in (3.175 mm)	0.062 in (1.575 mm)	0.062 in (1.575 mm)	0.062 in (1.575 mm)
Shielding Gas	Ar	Ar	Ar	65% Ar, 35% He	Ar
Welding Power	AC	AC	DC	DC	DC
Polarity	-	-	Negative	Negative	Negative
Welding Current	180 Amps	225 -245 Amps	43 Amps	150 Amps	325 - 350 Amps
Arc Volatege	-	22-24 V	12 V	11 V	29 - 30 V
Travel Speed	-	-	27	20	-

REFERENCES
Welding Handbook, Vol. 4, Seventh Edition, Published by the American Welding Society, Miami, FL.
Welding, Brazing, Soldering, Brazing and Surfacing of Copper and Copper Alloys, Copper Development Association Inc., 1972.
Welding Copper Beryllium, Materion Brush Performance Alloys Inc.
Welding Data Book, Penton/IPC Publishers, 1978/1979.

TABLE 2. TROUBLESHOOTING GUIDE

Problem	Possible Causes	Solution
Arc Instability	1. Dirty surface condition 2. Narrow weld joint 3. Contaminated electrode 4. Electrode diameter too large 5. Arc too long	1. Clean thoroughly. Use wire brush or abrasives for cleaning. 2. Make joint wider. Bring electrode closer to workpiece. 3. Cut off end of electrode tip. Dress tip. 4. Use smaller diameter electrode that will handle required current. 5. Move electrode closer to workpiece.
Porosity	1. Dirty electrode 2. Dirty base material 3. Impurities present in shielding gas 4. Dirty filler metal 5. Weld speed too fast	1. Dress electrode. 2. Clean surface. 3. Use welding grade gas. Purge lines before striking arc. 4. Wire brush filer metal rod. 5. Optimize weld speed.
Excessive Spatter	1. Current too high	1. Reduce current.
Viscous Weld Pool	1. Lack of preheat 2. Low power input	1. Use preheating. 2. Balance gas mixture of argon and helium.
Incomplete Weld Penetration	1. Welding current too low 2. Welding speed too fast 3. Poor joint design 4. Electrode size too large	1. Increase current. 2. Slow down welding speed. 3. Check root opening. 4. Use smaller electrode.
Weld Deposit Too Soft	1. Wrong filler metal 2. Heat affected weld zone	1. Use WeldPak copper beryllium filler metal. 2. Heat treat after welding.