APPLICATION DATA SHEET

COPPER • BRASS • BRONZE

Copper Alloy Molds— The Plastic Industry's Best Kept Secret

WHAT DO THESE DEVICES HAVE IN COMMON?

The main function of an injection mold, beside defining a part's shape, is to remove heat from the plastic as quickly as possible. The mold should be thought of as a heat transfer device much like the automobile radiator shown above. The faster the mold can transfer heat out of the molten plastic and solidify it, the faster the mold can be run. Reduced cycle time equates to reduced manufacturing cost.

This is where copper alloys outperform other metals used for molds. Copper alloys provide the best combination of high thermal conductivity and hardness for molds used in the plastic industry today. As seen in the table on page 2, hardness and conductivity vary over a range for each alloy system—steel, aluminum or copper. Copper alloys have thermal conductivities 3 to 9 times greater than the commonly used Type 420 stainless steel.

Uniform Heating

Another benefit of a high thermal conductivity metal is that it provides uniform heating. Look at a copper frying pan versus a stainless steel pan; the copper frying pan will heat up faster and will have a more uniform temperature profile than the stainless steel.

Hardness

Copper is known for its outstanding conductivity, both electrical and thermal. The high-strength, high-conductivity copper alloys discussed here offer the best combinations of thermal conductivity and mechanical properties of any industrial mold material. The table on the next page also shows how the thermal conductivity of the commonly used mold alloys varies with hardness and tensile strength.

The copper alloys offer the best conductivity over a wide range of hardness. Of course, the hardest mold materials are the tool steels. But mold wear is a surface phenomenon. Surface hardness as it relates to injection molding and other molding processes can, when necessary, be effectively enhanced by the application of surface treatments such as hard chrome, electroless nickel plating or titanium nitride coating.

Coefficient of Friction

Mold coatings used to increase hardness also have a secondary effect of decreasing the coefficient of friction. In addition to the coatings used for increasing hardness, other coatings such as Teflon are used to decrease surface friction.

Bearing and Wear Applications

Copper alloys have excellent wear characteristics against steel surfaces. The broad family of aluminum bronze and nickel-aluminum bronze alloys in both wrought and cast

COPPER DEVELOPMENT ASSOCIATION INC.
260 Madison Avenue, New York, NY 10016

form offer the best combinations of resistance to wear, abrasion, fatigue, deformation and corrosion. Recommended applications include slides, gibs, wear plates, mold locking devices, sleeve bearings, guide pin bushings, lifter blades, ejector sleeves and pins, and rotating mold components.

Chemical Resistance

Copper is resistant to the acids associated with the molding of vinyl plastics and the chemical attack associated with acetals. Corrosion rates in the hot acid environments associated with plastic molding are low and uniform. Pitting in corrosion tests of these mold materials in aqueous solutions of hydrochloric and hydrochlorous acids has not been observed. However, oxidation can occur if the temperature is above 392 F (200 C)—a temperature above the range used in molding thermoplastics. This tarnishing oxidation can occur as either cuprous oxide or black cupric oxide, both of which can be removed in hydrochloric acid.

Metal Cost

Copper alloys are often the most cost-effective mold materials when a total product cost analysis is made. Copper alloys can be more costly than other mold metals, but copper alloy molds often achieve the lowest total manufacturing cost. This is because the metal cost generally accounts for less than 15% of the finished mold cost, and also because the copper alloy mold is uniquely effective in decreasing molding cycle times.

The graph on the next page makes this point schematically. Cumulative Total Part Cost (tooling cost plus molding costs) is plotted on the vertical axis versus Thousands of Parts produced. Note the higher initial cost of the copper tool is paid for early in the production life, and from then on, the reduced production costs associated with the copper tooling result in an ever increasing margin, compared to the lower conductivity and lower productivity of a hardened steel mold.

In Use Today

Polyesters and copolyesters are currently used in a variety of molding applications. These polymers require good mold cooling, as they will "stick" to warm steel molds at temperatures above about 90 F (32 C). This sticking problem can be overcome if the molds are properly designed. Proper design usually means excellent cooling in the mold itself.

Copper alloy molds and components have proved of particular value in this regard when molding the heat-sensitive polyester resins. For many years, engineers and mold designers have specified copper alloys in difficult to cool areas, such as core pins, blades, slides, inserts and sprue bushings.

Comparison of Mold Alloy Properties

ALLOY UNS NO.	DESCRIPTION	NOMINAL PROPERTIES: THERMAL CONDUCTIVITY (Btu/ft²/ft/hr/°F) at 68 F (W/m•°K) at 293 K	ROCKWELL HARDNESS*	TENSILE STRENGTH* (ksi) (MPa)
STEEL				
S42000	Type 420 Stainless Steel	14.4 24.9	C 27-52	125-250 863-1725
T20813	H-13 Tool Steel	14.4 24.9	C 38-54	206 1421
T51620	P-20 Tool Steel	22.0 38.1	C 28-50	146 1007
ALUMINUM				
A96061	Type 6061 T6	96.5 166.9	B 60	40 276
A97075	Type 7075 T6	75.0 129.8	B 88	67 462
COPPER				
C62400	Aluminum Bronze	36.0 62.3	B 92	105 725
C17200	BeCu - High Hardness	60.6 104.8	C 41	190 1311
C17200	BeCu - Moderate Hardness	75.7 131.0	C 30	170 1173
C17510	BeCu - High Conductivity	135.0 233.6	B 96	110 759
C18200/18400	Cr - Hardened Copper	187.0 325.5	B 60-80	51-70 352-483
C64700	NiSi - Hardened Copper	94.0 162.6	B 94	105 725
C18000	NiSiCr - Hardened Copper	125.0 216.3	B 94	100 690

* For 1-inch rod; properties vary with product form and size.
Note: The copper alloys are also available in cast versions with similar properties.

APPLICATIONS OF COPPER ALLOY TOOL COMPONENTS

Sprue Bushing

Copper alloy sprue bushings are used to achieve better temperature control of the contained melt inside. For those applications where the melt is prematurely freezing-off inside the sprue bushing, a copper alloy sprue bushing *increases the rate at which heat can be transferred to the melt* and keeps it molten.

For those applications where the sprue and runner is thicker than the part and is limiting the cycle time, a copper alloy sprue bushing *increases the rate at which heat can be transferred from the melt* and solidifies the sprue faster. This produces a faster molding cycle which equates to reduced manufacturing cost.

Hot Runner Manifold Heater

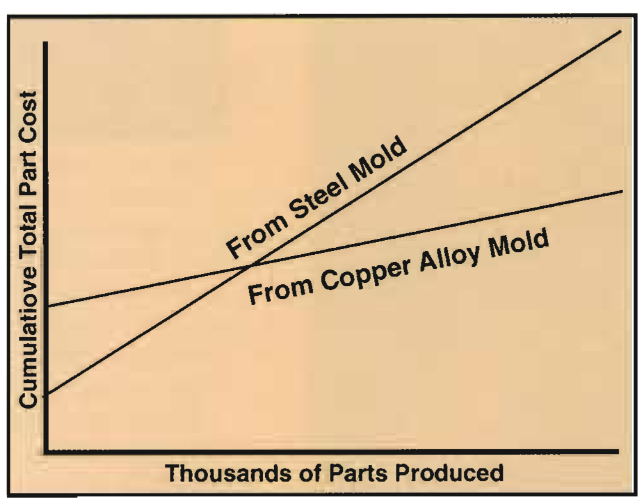
For more demanding applications, where a hot runner manifold is needed, a copper alloy heater module provides faster start-up times because of faster heat transfer to the melt. It will also provide better melt temperature control because of faster heat transfer response.

Engraving

Engraving can be done with copper alloys. The same care has to be taken to provide draft angles and relief as with other mold materials.

Molds for Injection- and Blow-Molding

Copper alloy molds provide faster cycle times for both injection- and blow-molded parts because of their superior heat transfer characteristics. Faster cycle times reflect better equipment utilization, forestalling the need to purchase additional equipment.



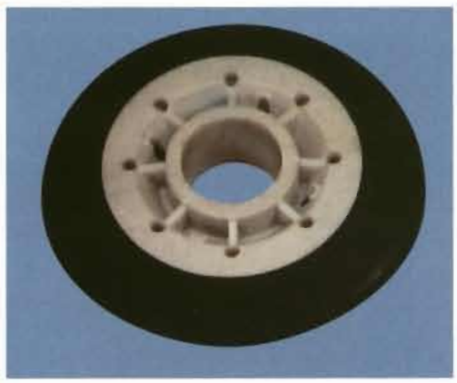
Graph showing how total manufacturing costs can be reduced by switching to copper alloy molds.

Cores

In most thermoplastic processing, the plastic shrinks onto the core and may separate from the cavity wall. When that happens, the majority of the cooling of the plastic is from the core. Molders have found that cycle times can be dramatically cut by inserting copper alloy cores in their molds. Copper alloy cores can be of any geometry—from simple cores to the most complex.

Products

A wide range of resins and plastic products are molded using copper alloy tooling. These products range from high mechanical-property and tight dimensional tolerance requirements to those with lower requirements.



THE FUTURE

The future applications for copper alloys in the plastic industry are bounded only by your imagination and creativity in applying sound engineering to this proven group of materials. For more information contact:

Copper Development Association Inc.
260 Madison Avenue
New York, NY 10016
Phone: 212-251-7200
FAX: 212-251-7234
Internet: http://www.copper.org

A7006-00/96

COPPER DEVELOPMENT ASSOCIATION INC.
260 Madison Avenue, New York, NY 10016