Injection Mold Design Guidelines

SEVENTH IN A SERIES

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for the Mold Marketing Task Group of the Copper Development Association

Maximizing Performance Using Copper Alloys

Leader Pins and Bushings (Aluminum Bronze Copper Alloys)
Leader pins and bushings provide the initial alignment of the cavity and core halves on mold closing. It is mandatory that the leader pins and bushings engage prior to any mold component entering or making contact with the opposite mold side. Four pins and bushings are used per mold, located at the four corners of the mold base. Sufficient mold base material must remain after machining the bore to provide support for the bushing.

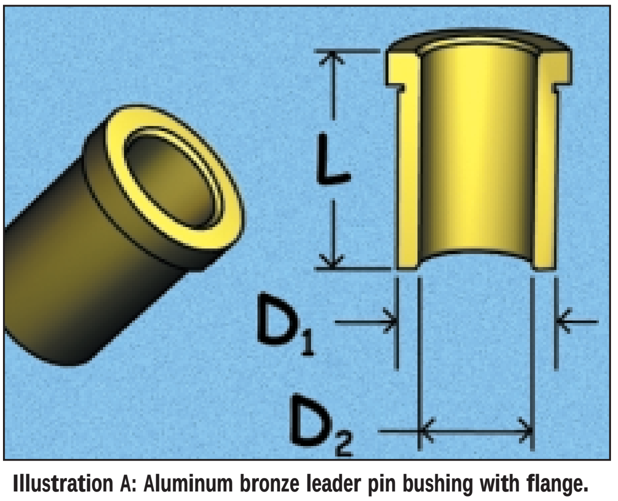

Illustration A: Aluminum bronze leader pin bushing with flange.

Three of the leader pins and bushings are located the same dimension from the edges of the mold base. The fourth bushing is offset at the zero-zero corner, the corner of the mold, which will be the top right hand stationary side of the mold when viewed from the parting line. The offset, insuring that the mold can not be assembled incorrectly, is at least one-sixteenth of an inch. Offset's on larger mold bases, or when space allows, is frequently one-eighth of an inch.

The most effective and longest lasting combination, compared to steel bushings, mates a case hardened groveless leader pin with C 62400 or C 95400 aluminum bronze leader pin bushings. Overall leader pin length should be at least the sum of the thickness of the "A" and "B" plate. The bearing length of the bushing should be two to two and one-half times the nominal diameter of the leader pin.(See Illustration A) Insufficient or excessive bearing lengths will result in premature failure. Maintain pin contact with the bushing at the parting line entrance; install the clearance at the back end of the bushing if necessary.

The normal standard "A" series mold construction, has the leader pins installed in the "A" plate and the bushings installed in the "B" plate. Reversed pin and bushing placement is permissible when warranted due to intentional plate movement. Installing bushings in floating plates and using the four leader pin bushings to guide the plates is standard practice in injection mold design.

Leader bushing length should be the plate thickness in which it will be inserted minus .005 to .010 inches. The counter bore for the flange should be installed .015 inches larger than the bushing to insure that it is not making contact. The plate hole diameter should be machined nominal to .0005 inches oversize to provide for a line-to-line or .0005 interference fit. While a leader pin bushing can be installed in a hole with a greater interference, too tight of a fit will cause the internal diameter of the leader pin to collapse, reducing the desired clearance between the pin and bushing.

The diameter of the leader pin must be sufficiently large to sup-

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MODERN PLASTICS,
BLACK CYAN MAGENTA YELLOW
PMS ID
5% 25% 50% 75% 95%
RHP

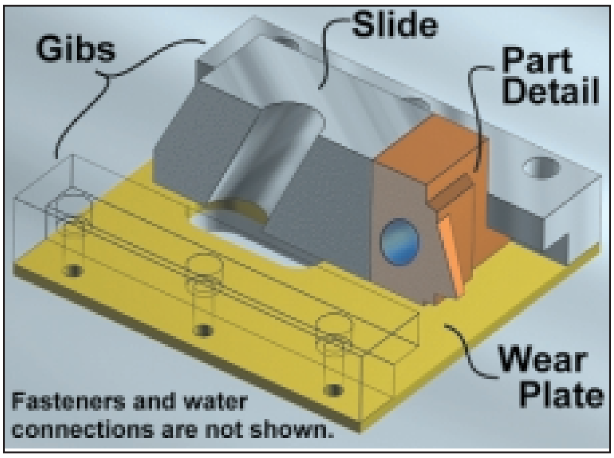

Illustration B: Wear plate installed under slide or moving mold member.

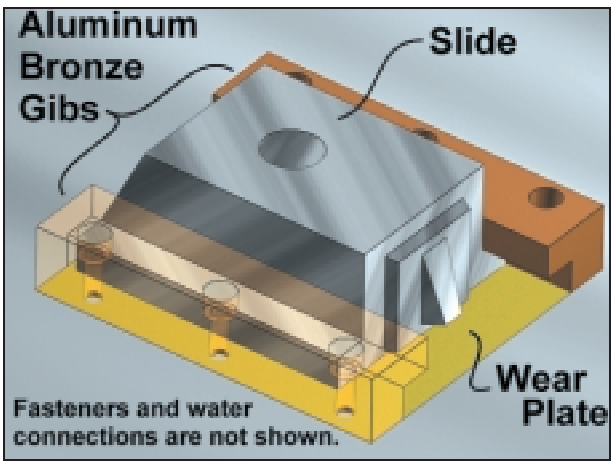

Illustration C: Gibs made from aluminum bronze guide slides and moving mold members.

port the total weight of the mold while, unfortunately, helping to line up the molding machine platens. Table A can be used as a guide in selecting leader pin nominal sizes.

Sizes above those normally considered standard use diameters appropriate for the weight of the mold.

Aluminum Bronze Slide Wear Plates

Mold movements, those not in the normal line of draw, use moving mechanisms referred to as slides, lifters, wedges, cams or side actions. These movements operate better when riding on an inserted bearing surface material. Typical mold base materials make horrible wear surfaces. In the early days of mold building a very hard steel plate was inserted in the mold base to act as a wear surface interface. While effective in providing the hardness differential between the mold base and moving mold component, the mechanism frequently costing $1,000 to $10,000 receives all the damage. The wear plate, with a typical cost of around $100, should be used both as the bearing area and the sacrificial mold component.

Aluminum bronze wear plates, Illustration B, should be used to act as the bearing surface between mold bases, cavities and cores and the moving components. When using aluminum bronze underneath slides the wear plates should extend beyond the bearing area and be retained outside the bearing area. The wear plate should be designed symmetrical if possible (bolt or dowel holes, cam pin clearance slots, etc.), allowing the plate to be inverted should chips or other debris ever mar the surface.

Aluminum Bronze Slide Gibs

Guides, either "L" or "T" shaped are used to locate and retain moving mold members. The most common application is with slides. Illustration C shows aluminum bronze gibs guiding of a convention slide movement. The mold should be designed for the slide gibs to guide the moving slide member for the full travel. Depending upon the weight of the slide carrier and the size of the mold the slide gibs should be long enough to provide accurate alignment of the slide to the mold cavity or core. The gib must act as a guide over the entire length of travel. They should be doweled using two solid dowels, with a clearance hole through the wear plate, to the mold base or mold component. It then should be held in place with two or more cap screws with the heads recessed into the gib.

The gib will serve two functions. The first is to precisely guide the slide in its movement and mating with the mold cavity and core. To accomplish this "Running or Sliding Fits" (RC class) is typically used in the mold design. Depending on the accuracy of alignment the standard tolerance range using American National Standard Institute tables falls between a

Recommended nominal leader pin and bushing diameter by mold base size

Width	Mold base lengths (up to)										
	8	9	10	12	14	16	18	24	26	30	36
7 7/8	.75	.75	.75	.75							
9 7/8	.75	.75	.75	1.00	1.00	1.00	1.00				
10 7/8				1.00	1.00	1.00	1.00	1.00			
11 7/8				1.00	1.00	1.00	1.00	1.00			
13 3/8					1.00	1.00	1.00	1.00	1.00	1.00	
14 7/8						1.25	1.25	1.25	1.25	1.25	1.25
15 7/8						1.25	1.25	1.25	1.25	1.25	1.25
16 1/2						1.25	1.25	1.25	1.25	1.25	1.25
17 7/8							1.25	1.25	1.25	1.25	1.25
19 1/2							1.25	1.25	1.25	1.25	1.25
23 3/4								1.50	1.50	1.50	1.50
25 7/8									1.50	1.50	1.50
To 36											2.00

Table A: Nominal diameter of bushings by mold size.

H5 and a H8 for the dimension between the gibs and a g 4 to an f 7 for the slide carrier. As always, when providing clearances in injection molds the overriding factor is to insure against flash while holding the required product dimension. When those two considerations have been accounted for, only then can the application of normal clearances be incorporated to the mold to achieve the desired condition.

The second function is for the gib to retain the slide and keep it from derailing. Clearance up and down can be greater than side to side if the opposite mold side will hold the slide in position in molding. If no contact will be made when the mold is closed, than the slide gibs must provide that assistance.

Gibs have two surfaces that could be used to assist in guiding the slide carrier. Only one surface should be used as the bearing guide, typically the top surface. The other surface should be cleared an additional .001 of an inch or more to reduce friction.

Aluminum bronze Guided Ejector System Bushings
High-speed molds using small diameter ejector pins require support for the ejector and ejector retainer plate to insure smooth operation. Another effective use of aluminum bronze is in the bushings used in conjunction with groveless leader pins installed on the ejector side of the mold. Leader pins, with nominal diameters of .750, 1.00, 1.25, 1.50 and 2.00 inches, are placed at the four corners in the ejector housing. The greater the mold length and the heavier the mold plates, the larger the nominal diameter of the leader pin should be. (Illustration D).

Common practice is to insert the leader pin head into the support plate. This provides a safe, handy and convenient method for the mold maker to assemble the ejector system as the ejector plates are supported in the proper position. The only disadvantage to this construction method is if the support plate will have a higher rate of thermal expansion that the ejector plates. When high mold temperate differentials are anticipated, mounting the leader pin heads in the ejector housing plate reduces interference created by uneven thermal expansion between the two components.

When manufacturing guided ejector bushings, the shoulder is placed closer to the middle of the bushing. A counter bore is machined in the ejector plate to trap the bushing between it and the ejector retainer plate. The bushing should be designed to extend the full thickness of both the ejector and ejector retainer plates. The side wall of the bushing should be one-fourth of an inch to provide strength. As the guided ejector system is difficult to access in the assembled mold, a method to lubricate from the outside of the mold is recommend. Grease fittings into connecting spiral grooves machined into the bushing is the preferred method of providing lubrication to the bearing surfaces.

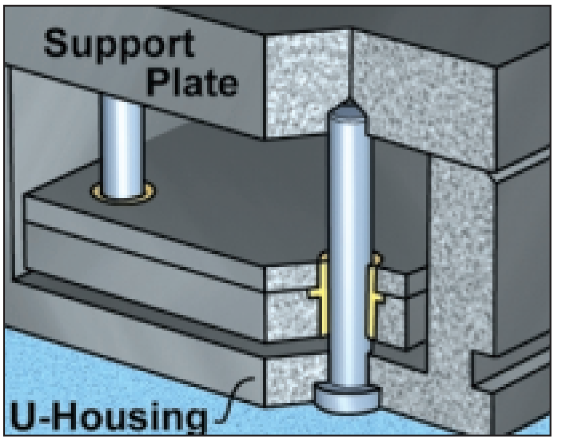

Illustration D: Four aluminum bronze bushings with mid-busing flange used to guide ejector system.

Angle Interlock Face Plates
Injection mold leader pins and bushings act as a rough alignment system. Interlocks are used to provide the final and precision mating of the cavity and core. Two styles of interlocks are used. The first is straight interlock and its function is to line up the two mold halves prior to the mold closing. These interlocks are either mounted on the side of the mold base and are called straight side locks or mounted on the face of the mold at the parting line and called top mount interlocks. Straight interlocks normally align the entire mold rather than individual cavities and cores and the interlocking concept and is used when alignment is necessary on mold closing. This system is mandatory when using vertical shut offs or telescoping cores.

The second style of interlocking is a tapered concept installed in the mold base or on the cavity and core. This interlocking method is used when the objective is to hold the two mold halves in register during the mold filling and cooling stage, obviously after the mold has closed. This type of interlocking insures that the mold halfs, when closed will not shift in relationship to each other. The nominal angle for this interlocking system is typically not less than 10 or more than 15 degrees. The female interlock is almost always on the cavity side of the mold. Placing the female interlock on the side of the mold that runs the warmest reduces the incidence of the mold not closing due to differential of thermal expansion created by the normal practice of running the cavity side of the mold warmer. Larger molds use a double tapered interlock system where the interlocks are machined directly into the mold base, or in mono-block construction, the cavity and core blocks.

Aluminum bronze wear plates, Illustration E, mounted on the face of one of the interlock serve three extremely important functions. First, they prevent galling, common when two similar steel interfaces would normally contact each other, due to the differential in hardness and material composition while providing low friction characteristics. Next, the aluminum bronze faceplates provide an efficient method of fitting and adjusting during mold construction or at mold maintenance intervals. Last, they are less expensive to replace should any damage to the interlocking system occur over the life of the mold. Aluminum bronze faceplates should be at least one quarter of an inch thick and mounted with recessed flat head screws.

Friction Between Materials
Friction has been described as the resistance to motion when one component is moved upon another. It typically is defined as "that force which acts between two bodies at their surface of contact, so as to resist their sliding on each other." Every moving part in a mold must overcome friction to perform its function with the least amount of force. Therefore low coefficients of friction are a desirable attribute. The measurement used is based on the coefficient of static friction. These values will be higher than those describing sliding friction. Two categories of fric-

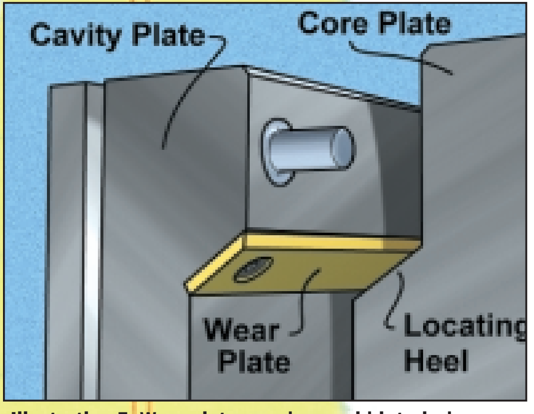

Illustration E: Wear plates used on mold interlocks.

tion should be viewed. The first when the components do not have lubrication and the second, when lubrication is used. Table B lists static coefficient of the two materials. In additionally using dissimilar materials will prevent galling and transfer of the material from one component to the other. The use of aluminum bronze will provide a superb bearing surface and will be inexpensive to install and maintain. All moving parts in an injection mold, with the exception of ejector pins and ejector sleeve and components making direct contact with the plastic material should use lubrication. Typically a high temperature lubrication that will not migrate is recommended.

High Wear Areas in Molds

Although the copper alloys C 17200, C17510 and C 18000 are generally recommended for cores in plastic forming areas of the mold, there can be applications where C 62400 or C 95400 is a viable option. One such application is when lifters are used to mold slight undercuts and the mechanism is mounted on the side face of the core. The thermal conductivity rate of the material is better than that of steel, but not as good as the plastics forming alloys. The aluminum bronze, with its great non lubricated wear properties and low coefficient of friction, has been shown to be the ideal material for these applications. Caution should be used not to install delicate detail close to side walls, as the material does not have the strength of the C 17200, C 17510 or C 18000 alloys.

Static coefficients of friction when steel is in contact with steel or aluminum bronze

Material	Not Lubricated	Lubricated
Steel against steel	0.8	0.16
Aluminum bronze against steel	0.35	Not measurable

Table B: Static coefficient of friction between mold materials.

The mounting, sliding and pivoting ends of lifters is another great application for the aluminum bronze materials. Wear plates and guides for wedges and raising mold members all benefit from the ideal bearing surfaces provided by the C 62400 or C95400 materials.

In addition to leader pin and guided ejector system bushings, aluminum bronze bearings are used to provide a wear surface for large diameter ejector return pins and to support knock out rods extending through the ejector housing. The material serves as an excellent guide method on racks used in unscrewing molds and moving cams in molds.

Experience has shown that the C 62400 or C 95400 aluminum bronze copper alloy is an effective method of providing an excellent round or flat bearing surface in injection molds and plastic tooling. The life of a mold is greatly extended with the application of this material and the cost of maintenance is reduced when the lowest cost component requires replacement. ■

Acknowledgements

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Disclaimer

These guidelines are a result of research at WMU and industry experience gained with the use of copper alloys in injection molding. While the information contained is deemed reliable, due to the wide variety of plastics materials, mold designs and possible molding applications available, no warranties are expressed or implied in the application of these guidelines.

Contact Information

Information on copper alloys is available from the Copper Development Association, at 800-232-3282. Technical clarification of the guidelines can be made by contacting Bob Dealey, Dealey's Mold Engineering at 262-245-5800

For more information about the use of copper alloys in tooling, please circle 675 on the reader service card.