Suggested Procedures For Making High-Temperature Aluminum-Filled Epoxy Matched Compression Molding Dies

There are a number of ways to make compression molding dies. Usually, for high production rates, they are machined out of aluminum or steel, which gives the highest quality, longest lasting tools. Lead times are long and costs are high for this type of tooling. Aluminum-filled epoxies offer short lead times and low costs for short-run prototype and medium-run production tooling.

Containment Box: Aluminum-filled epoxies have excellent compression strengths, but are brittle and quite easy to crack if the casting is loaded in shear. Therefore, it is important to make a metal containment box, which becomes part of the die and keeps the casting loaded in compression. This box can be made from aluminum bar stock and is either welded, or bolted and pined together. The box should fully contain the epoxy on all four sides. The back should be left open to facilitate casting.

Once the box is fabricated, sandblast the interior surfaces of the box to enhance the bond of the epoxy to the metal. Tabs and brackets can be attached to the exterior surfaces of the box to locate and mount the box to the press platens.

Both die-half boxes (upper and lower) should match exactly in the X and Y dimensions. The Z dimensions for the two halves can be different, depending upon the cross-section thickness of the part.

Rigging the Die Halves: The matched die set can be made from one or two masters. Assuming the master(s) will be made from machined modeling board, two masters can be generated by machining one master creating the outside surface of the part and the other master creating the inside surface. Both masters can be machined incorporating flats that would allow the aluminum box to be rigged. Both masters can be indexed to allow casting the guide-pin bushings in place.

A lower-cost option is to make one master, representing the finished surface of the part and incorporating flat areas for locating the box. Once that die has been cast, wax up the part thickness in the die cavity. The second box should be matched and indexed to the box containing the first casting. The first die becomes the master against which the second die is made.

Note: Make sure the master(s) have the exact finish and contour that you want for the finished die. Spend extra time perfecting the master to eliminate time modifying the cast-die surface. Seal the master surface with materials recommended by the modeling plank supplier.

Making Epoxy Dies for Short-Run Prototypes: Matched compression dies designed for prototype or short production runs of 100 parts or less can be made by applying a surface coat and casting behind it with aluminum-filled epoxy resin and aluminum needle bulk filler.

Apply 4-5 coats of PTM&W PA0801 Teflon-based mold release to the sealed surface of the master. Wipe off and buff with a clean rag immediately after each application.

Rig the aluminum box onto the machined flat areas of the master. Do not apply wax to the inside surfaces of the box. Anchor the box to the master in such a way that the box will not move or leak during the casting process.
Mix PTM&W PT1945 carbide-filled high-temperature epoxy surface coat with the B hardener at 100:10 parts by weight (pbw) mix ratio. Mix the resin and hardener thoroughly and then pour into another container and mix again.

Brush coat the entire surface contained within the aluminum box, including the inside surfaces of the box. Try to keep the thickness of this coating around 0.030-inches thick. At this point some people use a hot-air gun to blow on the back surface of the coating to pop any small bubbles which may be trapped due to the brushing process. Be careful not to apply too much heat to any one area, causing that area to cure faster than others.

Allow the surface coat to cure to the point where you can touch the back surface and leave a fingerprint without the material transferring to your finger. Do not let the surface coat gel to a hard glossy condition because the casting resin will not properly bond. If it cures hard, you must sand the back surface before casting against it.

Once the surface coat has gelled to the proper consistency, mix PTM&W PT4935 high-temperature aluminum-filled casting resin with the B1 hardener at 100:12 pbw. Note: If the cross-section thickness of the casting is more than 6-inches, use the B2 hardener at 100:12 pbw. Wet-out the back of the surface coat with the PT4935/hardener mix.

Add PTM&W aluminum needles to the bucket containing the mixed casting resin. Blend in twice as much aluminum needles, by weight, as the casting resin/hardener mixture. Make sure the needles are completely absorbed. This mixture should yield a concrete-slurry-like consistency. Pour this mixture into the lowest point of the cavity and allow the cast material to fill to about ½-inch below the top of the aluminum box.

At this point, it is best to vibrate the master on a vibratory table or by attaching an air-driven vibratory device to the master. Vibration will force the needles to settle to the face of the tool. As the needles settle, keep adding dry needles to the back surface of the casting. The needles will keep settling to the point where needles are resting upon needles, and no more can be added. The idea is to pack as many needles into the casting as possible. This will increase the heat transfer capacity of the casting, keep shrinkage to a minimum, and lower the cost of the casting.

The addition of extra needles should bring the back of the cast surface up to the top surface of the aluminum box. It is all right to over fill the back because after curing, the back can be machined flat. If you do not want to machine the back surface, fill with needles to just below the top of the box and then top off with the pure PT4935/hardener mix. The back surface must be completely flat and even with the top of the box so that when mounted against the press platen, the epoxy has no room to flex under pressure. Some people bond an aluminum plate to the back of the die, resting against the casting resin.

Making Epoxy Dies for Medium-Run Production: If the compression molding dies will be used for 100 or more parts, there is an added step to the procedure:

After applying the PT1945 surface coat and letting it tack-off, laminate four or more plies of fiberglass cloth (Style 7500, 10-oz. works well) with PTM&W PT2848 A/B high-temperature laminating resin at 100:16.5 pbw. Use proper laminating techniques to minimize trapped air. Allow the laminate to gel but not cure hard. At this point brush coat the back of the laminate with the PT4935/hardener mix and proceed to finish the tool as outlined above. There is always a possibility of the casting developing cracks during service. A laminated surface will keep the crack from showing through to the surface. The added step of making a thin laminate will increase the life of the tool immensely.

Curing the Die Halves: If the B1 hardener was used with PT4935 and the master cannot be moved into an oven, the die halves should cure sufficiently at room temperature (24-48 hrs.) to be taken off the master and post cured. For best results, the dies should be given an overnight cure at 100-120 F. before being removed from the master. If PT4935 B2 hardener was used, a heat set before removal from the master is mandatory.

For post curing, both dies should be mated together with guide pins and clamped. The cure cycle is a step cure beginning in a cold oven. Raise the temperature, at a rate not to exceed 3 F./minute, to 150 F. Allow to soak at that temperature and each succeeding step for 2-4 hours, depending upon the thickness of the dies. The thicker the dies, the longer the soak times. Raise the temperature in increments of 50 F. until the final cure, which should be 50 F. above the maximum temperature the dies will see in production. Allow to soak at that temperature for a minimum of 4-hours. At that point, turn off the oven, crack the door open and allow the dies to return to room temperature.

Additional Thoughts: For large dies, some people will incorporate steel rebar that is wired together, much like is done for reinforcing concrete. This will keep the die from separating if cracks do occur.

As an added precaution, some will insert pins through the sides of the aluminum box into the cast area before the casting is made. This helps to insure that the casting will not separate from the sides of the box

If provisions for heating and cooling the dies are needed, copper tubing can be coiled against the back surface of the laminate before the casting resin is poured. It is a good idea to wax the surface of the tubing so that the epoxy does not bond to it. This allows the tubing to expand and contract within the casting without cracking it.

A good sealer should be applied to the PT1945 surface coat before the dies are used in production. Chemlease MMP117 is an excellent product. Consult with your supplier for application instructions.

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