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1-1/2" Vacu-Form Hemi Molds

Figure 1: Drilling out large holes with an adjustable hole cutter.

Figure 2: Removing hole centers on male side of mold.

Introduction:
While small 1-1/2" diameter plastic hemis are fairly easy to find on the market, the same can not be said for paper hemis. Those wishing to reproduce small paper shells similar to the consumer "Festival Ball" type products are faced with the challenge of finding or fabricating the small set of hemispheres required to make them. This typically involves pasting paper over a golf ball and then cutting it apart after it dries, or alternately trying to press daisy shaped disks of paper into a hemi mold. Both these methods are time consuming to say the least.

This article shows how to produce a vacu-form mold for producing six hemispheres at once. For those not familiar with the vacu-form method of molding paper mulch, you can read more about the whole process here.

The sticking point for most people who wish to try the vacu-form technique is producing the perforated molds in the various sizes required. The method shown here, engineered by Mike Fales of the Michigan Pyrotechnic Arts Guild, is the easiest way to create these molds. In fact, once you have the tooling done, you can quickly produce multiple copies of the molds and give them to your needy pyro friends!

Constructing the Mold
What we are really doing here is building one mold that produces the final mold of interest, which in turn produces the paper shapes that we want. The basic concept is to heat a sheet of plastic in an oven until it is very pliable, then press spherical shapes into the plastic and allow it to harden. The mold consists of a male plate with hemispheres protruding from it, while the female plate only requires holes that are about 3/8" larger in diameter than the hemispheres used to press the shapes. Lucky for us, these holes do not need to be spherical depressions, they can just be straight holes that run all the way through the plate!

The mold described here is used to press six 1-1/2"

Figure 3: Gluing wooden knobs into the holes to form the male mold.

Figure 4: Gluing standoff feet to bottom of female mold.

Figure 5: Alignment pins used to keep mold halves in place.

Figure 6: Clamping mold halves firmly together after coming out of the oven.

hemispheres into an 8" square sheet of plastic. The dimensions are designed so that the resulting square sheet can be cut round and mounted into the plastic hemisphere of an 8" shell when finished (see Figure 10).

Because this mold will be required to withstand 400 degree heat for at least 15 minutes, it must be constructed from wood, metal, plaster or something else that doesn't melt. I have chosen wood for ease of construction. Plywood is used for its strength and resistance to warping, although the glue holding it together will melt if left in the oven too long.

Start by cutting two 8" square pieces of defect-free 3/4" plywood. Align both pieces on top of each other and use screws to temporarily hold them together during the drilling operation. Use a black permanent marker to draw a line across the edge of both pieces so you will be able to align the pieces in this same position later.

Mark the center point of the top piece, then use a protractor to measure out five lines around the center with 72 degrees between each line. On each of these lines, mark a spot 2-1/8" out from the center, which is where you will be drilling.

The size of the holes you will be drilling here exceeds the range of spade bits you will likely be able to find. You will need to use a hole cutting type bit such as a hole saw, fostner bit or a ?? bit. I prefer the latter for it's ability to drill a very wide range of holes with only one bit. The adjustable nature of this kind of bit allows you to get any size hole you want. Figure 1 shows this bit being used to drill out the five holes. Make sure the center bit extends beyond the cutting bit by at least 1/4" so that it will mark the center point of the second board. You will stop drilling once you get all the way through the top board.

Once the top holes have all been drilled, separate the two boards and drill the second board to a depth of 1/2". You will need to use a chisel to remove the center plug as seen in Figure 2, since this hole does not go all the way through. The fostner bit has the advantage of removing all the material while still creating a flat bottom, which would be a better choice for this hole.

The wooden spheres used for this mold were purchased from an art supply store. They are 1-1/2" in diameter and are cut flat on one end. They are probably intended to be used as drawer knobs and may be found in hardware stores as well. The flat spot works out nicely for mounting them to the mold

Figure 7: Closeup shows how plastic forms around the wooden balls.

plate. Simply squirt wood glue in the counter-sunk holes and wedge the wood knobs in place as shown in Figure 3.

NOTE: if you want to try the quick-cut method shown at the end of this article, you will need to extend these spheres about 1/8" beyond the center point. In this case you would counter sink the holes to a depth of 3/8" instead of 1/2".

Because the spheres will extend out the bottom of the female plate, you will need to add some standoff legs to the bottom of the female plate, as seen in Figure 4. Gluing strips of scrap plywood here will do the job.

Lastly you will need to add four alignment pins as seen in Figure 5. Clamp the mold plates together and drill a 1/4" hole at each corner. It is recommended that you don't glue these pins in place, as the mold can wedge sometimes and removing the pins makes it easier to get the two halves apart. The pins should be at least 3" long so that they extend above the plate by 2-1/4".

More...

1-1/2" Vacu-Form Hemi Mold...

Figure 8: An acrylic mold removed after mold has completely cooled.

Figure 9: A PVC mold plate after drilling and trimming to fit an 8" shell casing.

Creating the Mold:
This may seem like a lot of work for something that you really only need to use one time to press a single plastic mold, but the time spent constructing this press is actually less than if you attempted to construct the mold out of fiber glass or gluing together pieces of plastic. The resulting one-piece mold is very sturdy and will hold up to the strong suction forces exerted on it during use. If the mold ever does break or if someone you know also wants one, it is an easy matter to crank out another one using the press.

The plastic you use to make your mold can be whatever you have on hand. The 1/16" acrylic sold in hardware stores makes a strong mold, although it is harder to press and drill out than other types of plastic. PVC is a very nice plastic to work with, as it molds easily and drills rapidly without molten plastic clogging the holes. It is available in 1/8" thick sheets and can be obtained from companies that make signs.

Whatever type of plastic you use, you will need to cut it into an 8" square sheet and then drill holes in the corners so that it fits over the alignment pins in your mold. The top mold plate is then placed on the guide pins and the whole apparatus is placed in a kitchen oven to heat up for a good 15 minutes. If you are using acrylic you will need to set the temperature to 425 degrees, while PVC only needs 400 degrees. The plastic will tend to heat more on the corners and some bubbling may occur there before the center is hot enough to press. This part will be cut from the final mold, so it is not a concern.

Once the mold has been cooking for about 15 minutes, it is time to pull it out and compress it. You will want to have at least six C clamps or bar clamps ready to go when you remove the mold from the oven. The plastic sheet will stretch and deform as the spheres are pushed into it, so it is important that the two mold halves be clamped firmly together in order to flatten out any wrinkles.

It takes a good deal of force to fully compress the mold. I prefer to place it on the floor and stand on it until it is nearly fully compressed, then use the C clamps to close it all the way. The mold will be hot, so be sure not to do this on a linoleum floor or you will have a permanent record of this endeavor (speaking from experience here). The plastic will cool quickly, so you have to move fast to close the mold. If it won't go down all the way, return it to the oven for more heating and then try again after a few minutes.

Once you get the mold clamped down solid, the whole thing must be left to completely cool to room temperature before opening it up. If

Figure 10: The finished 6 piece 1-1/2" vacu-form mold.

Figure 11: Output of the mold operation placed on drying screens.

Figure 12: Paper molds dried and ready for seperation.

the plastic is still warm and fluid then it will want to return to its previous flat state.

After a few hours, you should be able to pry open the mold and retrieve the prize, which should look like Figure 8. The plastic tends to grab onto the grain on the plywood, so some prying will be required to get the mold apart.

Next you need to take an 8" plastic shell hemisphere, the side with the indentation on the inside of the rim, and trace the outside of it onto the plastic mold such that the six spheres are centered. A band saw is then used to cut away the excess plastic, then sandpaper or a stationary sander is used to fine tune the edge of the mold so that it fits snugly into the 8" shell piece.

Now for the monotonous part- drilling out the mold. The entire surface of the mold must be perforated with small holes between 1/16" and 3/32" in size. I prefer 5/64" size, but anything in this range will work. If you make the holes too big, then you will get dimples on the outsides of your paper hemis. If you make them too small, you will spend half your life drilling holes because they need to be as close together as you can get them (see Figure 9). A small hand drill is ideal for this laborious task, as you will need to be able to easily hold it in one hand while drilling at various angles. Most holes can be drilled from the back side of the mold, but you will have to drill some of the holes right around the hemi edges from the top side.

Figure 10 shows the finished mold in place. Note that you do not need to glue the mold plate into the housing as long as it is a snug fit and doesn't fall out if turned upside down. The suction force will hold it firmly in place during use. This way you can use a single housing to hold a variety of different interchangeable mold plates. For example, an 8" housing could hold plates for six 1-1/2" molds (2" shell), three 2-1/2" molds (3" shell) and one 5-1/2" mold (6" shell). The molds for 4" and 5" shells are best done with a smaller housing in order to reduce waste from excess flange cutoff.

Using the Mold:

The procedure for producing vacu-form hemis is described here in full. These small hemis are pretty easy to produce, as their small size makes them sturdy and less susceptible to damage when ejecting them from the mold. Their small size makes them a little more difficult to flatten down on the inside after being drawn from the mulch vat. A small ball that just fits inside can be used for this purpose. They only need to be submerged in the mulch vat for a few seconds though, as it is easy to suck up a layer of mulch that is too thick for these tiny shells. When this happens you have to eject the bogus attempt back into the vat and let it dissolve back into mulch, then try it again.

Figure 11 shows some hemi sets ejected onto a drying screen prior to being dried in a DRY BOX. The dried versions can be seen in Figure 12. Cutting the small hemis out from these disks using scissors can be time consuming and annoying if you have to make very many of these, thus it is recommended that the procedure shown in Figure 13 be used if you plan on making a lot. This method requires that you make the extended mold as mentioned on page 1, then make a blade guide out of 1/8" thick plywood to rest the saw or

Figure 13: Using a saw or knife to easily trim hemis from mold.

Figure 14: A batch of hemis cut and ready to use.

Figure 15: Two hemis taped together to show roundness of the final product.

knife blade on when "beheading" the hemis.

A collection of finished hemis can be seen in Figure 14. If the tolerance on your mold was off a bit then the edges of the hemi mold tend to be rounded over, resulting in a cup-set that can have a walnut like flange around the seam. For a shell this small a defect like this doesn't really matter much. Figure 15 shows a cup set taped together, revealing a respectably round shape!

With small plastic shells costing only 38 cents apiece, one may wonder if making your own paper hemis is worth the trouble. Well, for those not able to purchase plastic, or prohibited from using it or otherwise just opposed to leaving sharp shards of non-degradable plastic all over their shoot sites, this is a viable alternative. The method of forming plastic shown here could also be used to make molds for other types of pyro uses as well, such as rocket nose cones and maybe even cylindrical cup sets similar to the type shown in this months autopsy.