Part Six

Preparing The Plastics

Preping the plastic basically consists of cutting your choice of plastic stock down to the proper size and fitting it into your tray.

As long as the minimum tolerances for the case size are met, it technically doesn't matter how much space you leave left over for the extra that gets lost in the tray.

However, you must make sure that the tray has a very good grip on the edges because in the event of not enough material being held in place, the plastic can pull out from the tray and break the ever important vacuum seal.

My particular set up has a 13-1/4" wide by 18" long suction area. I have sheets cut 16" x 19" leaving me with an 1-1/2" grip on either side and ½" grip either end.

Generally you're going to have more tension width-wise because of the shorter distance between the sides and less material to work with. The stretching force is much greater with less material, so more space on the width is required to compensate for that.

Part Six

Vacuum Forming Process

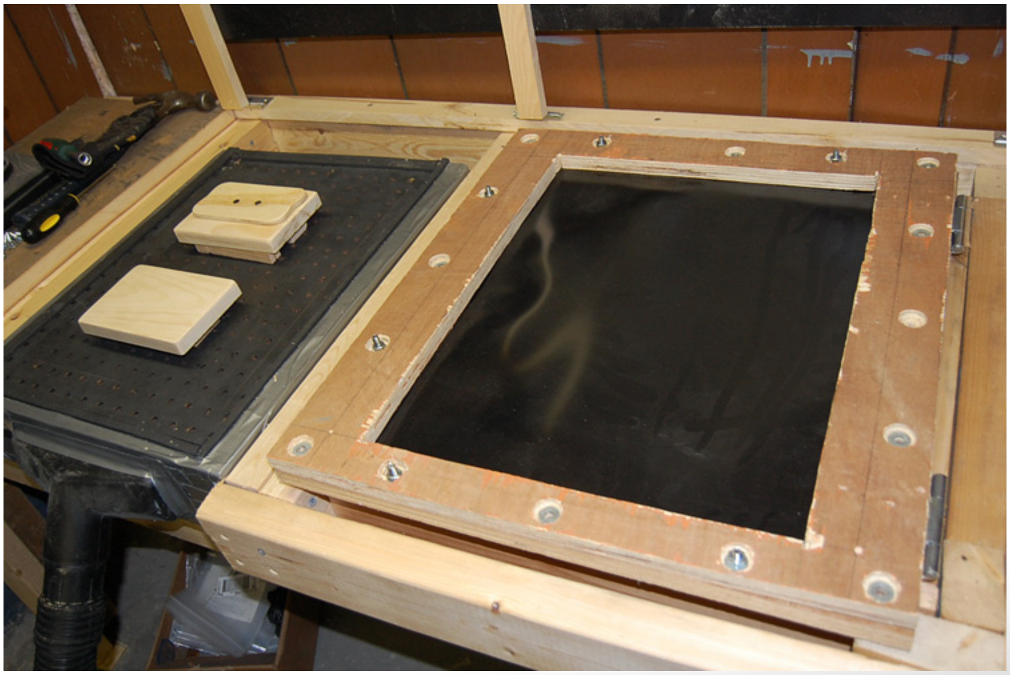
This is the fun part where you are now ready to heat your plastic and get the physical product! After securing the plastic into the tray, you are now ready to begin.

Now depending on your method which you've chosen to heat your plastic, there are some basic preparations you need to make which can be done while the plastic is heating up either way.

If using a conventional oven, you'll want to preheat up to 300 degrees F beforehand. A quick mental check list should be done to make sure of a few things before the plastic is ready.

1. Did you get your mold prepared on the vacuum table? You have only seconds to move the plastic from the heat source to the vacuum table. Having your mold half (or both if the table size permits) ready and in place is extremely important.

2. Do you have your heat gun and vacuum plugged in and ready to go? Scrambling to plug in these essentials wastes valuable time when you're racing the clock. Make sure they are plugged in and within reach!



You can see the plastic start to twist and wave. This is why it is important that your plastic be secured in place .

My first efforts on the tray were a bit over-kill, so as you see I did not need to use as many screws to make this work.

The plastic goes all the way to the screws to insure a nice bite!

*Important safety note: Make sure that you will not be overloading any of the circuits you're plugged into. With the heat gun, oven/heat-box and vacuum running all at once, if you're only connected to one 15 Apm circuit your most likely going to pop the breaker. If possible, the ideal situation is to have the heat source, vacuum and heat gun run off of different circuits. If that's not possible, you'll more likely than not have to scramble to unplug your heat source and replace it with the heat gun. If using an oven you shouldn't have to turn it down or off as it's most likely run off of a 220V dedicated line. (In the US anyway, the UK and Europe use 220V mains anyway, but still should be a dedicated line.)

3. Are your hands protected? Gloves! You need them! It doesn't matter what method you're using as a heat source, you're dealing with temperatures that will burn you and it's almost impossible not to keep your hands free of the heat. Oven mitts work, but if you have a decent part of high dexterity work gloves, you're going to have a much easier time with this.

Once you're good to go and the plastic is cooking nicely, there are a few things you need to watch out for. In terms of a time frame, you will have to pay close attention and look for a few specific tell tale signs that your plastic is ready.

As you watch, you'll notice that the plastic starts to bend and twist quite a bit. This is normal and happens as the plastic heats up at different speeds. The key component here is to make sure the plastic is heating evenly!

Outside of an oven, it is quite difficult to heat the entire surface area evenly from corner to corner, but this is not as critical as having the target area of the plastic (where the mold is going to contact the plastic) heated evenly.

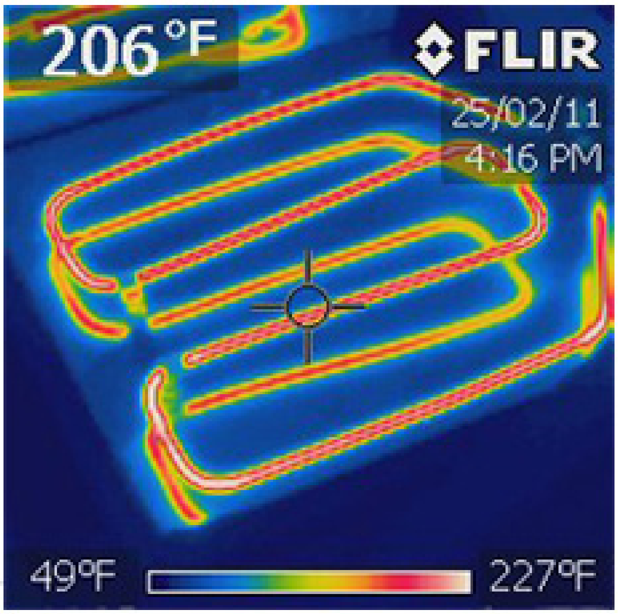
Seemingly 300 degrees F is the sweet spot for HIPS to become pliable enough to form the way it's supposed to. This might be a bit warmer for thicker sizes of HIPS or other materials.

ABS has a similar melting point while acrylic takes less than 221 degrees F. Timing is everything with this though and making sure you don't melt a hole in the material is priority number one.

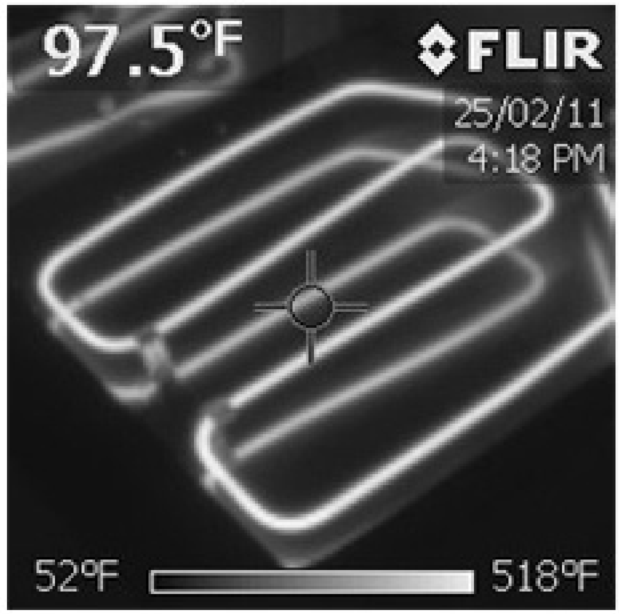
On average it takes about 10 to 12 minutes for an enclosed or covered plastic to get up to the melting point, less with an oven. When it reaches this point, the middle will begin to sag anywhere from 3 to 4 inches from the center of the tray.

This sag is one of the tell-tale signs that the plastic is ready to form. If you have the means of a digital IR thermometer or even better, a Thermal Imaging Unit, you can see where the plastic is ready and where it might need a bit of help getting up to temp.

I was actually able to acquire a thermal imaging unit for a short period of time. The below pictures are from that unit using my set up and .080 HIPS as my sheet stock.
The cross-hairs in the photos pinpoint the spot where the temperature reading in the top left is reading from.

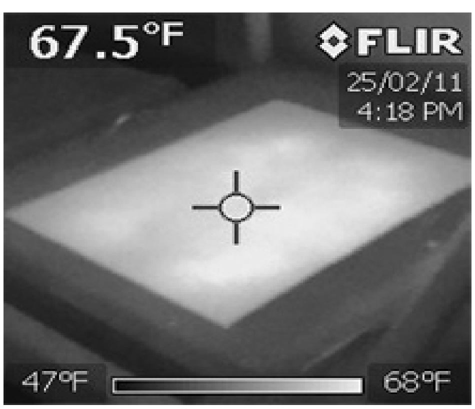


Heat Element warming up.

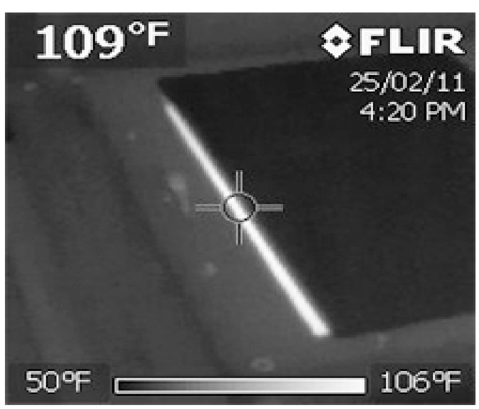


The reflection of the heat element is pretty hot as well and shows the reflective properties of the aluminium.

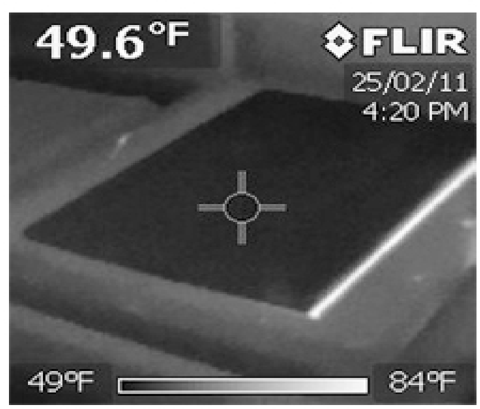
(Figure 6-1)



Plastic at room tempurature on top of heat box. Hottest spot is about 68 degrees F.



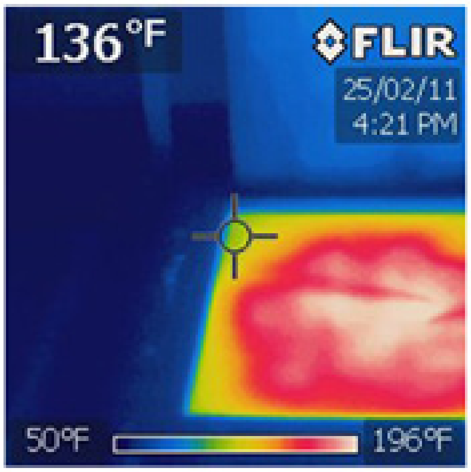
Plastic is covered by small sheet of plywood. Notice when covered within 2 minutes the plastic on the edge is up over 100 degrees F.



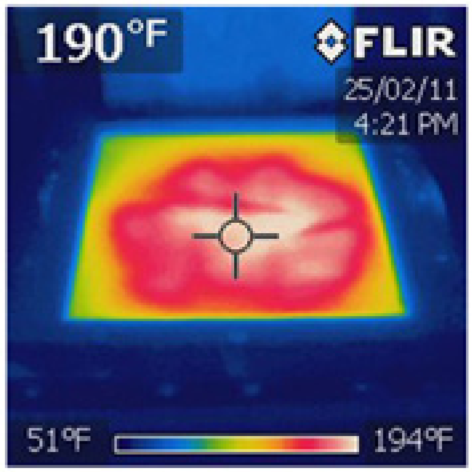
The Plywood on the top remains cool to the touch but is a vital insulator for for the plastic underneath. It can take almost twice as long uncovered due to heat loss.

(Figure 6-2)

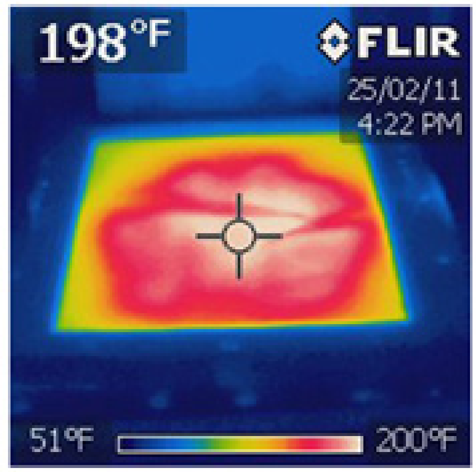
These were probably my best time-lapse photos of them all and the captions go on to explain the minute to minute details. But this also showed me how my technique could be improved in the future as the definate heat concentration is the middle, not as even around the edges as I would have liked. But learning is always part of the goal!



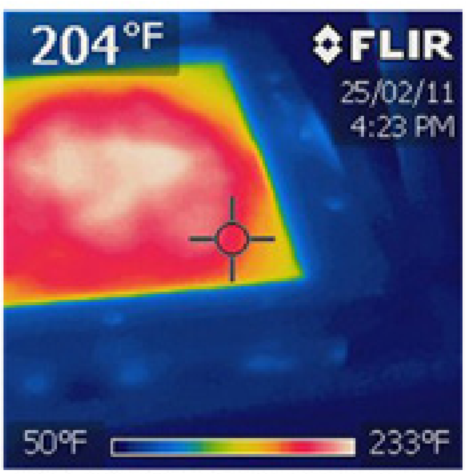
After 3 minutes of being covered, the coolest point on the plastic has jumped to 136 degrees F. The plastic has begun to twist and warp quite a bit.



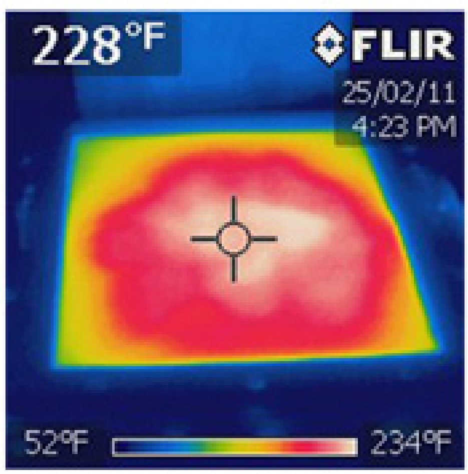
As you can tell, three minutes into the process, the hottest point is fast approaching the 200 degree mark. It is apparent in this set-up that the hottest point is in the center.



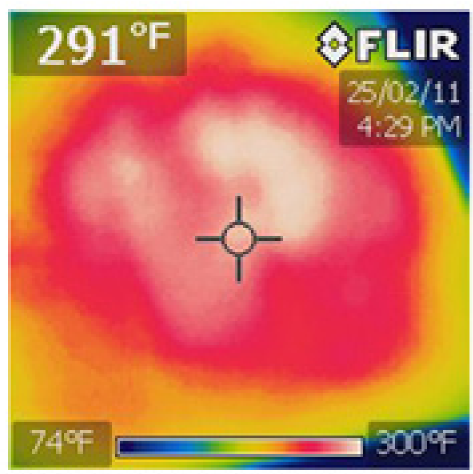
A minute later, the plastic hot spot has hit 200 degrees F. You can see the plastic warping getting wider at this point as it begins to pliable and sag.



At 4:23, the plastic near the edges is creeping up to the upper 100's to lower 200's. Though it's still about 100 degrees lower than idea forming temp, it's much weaker than it was two minutes ago which is good!



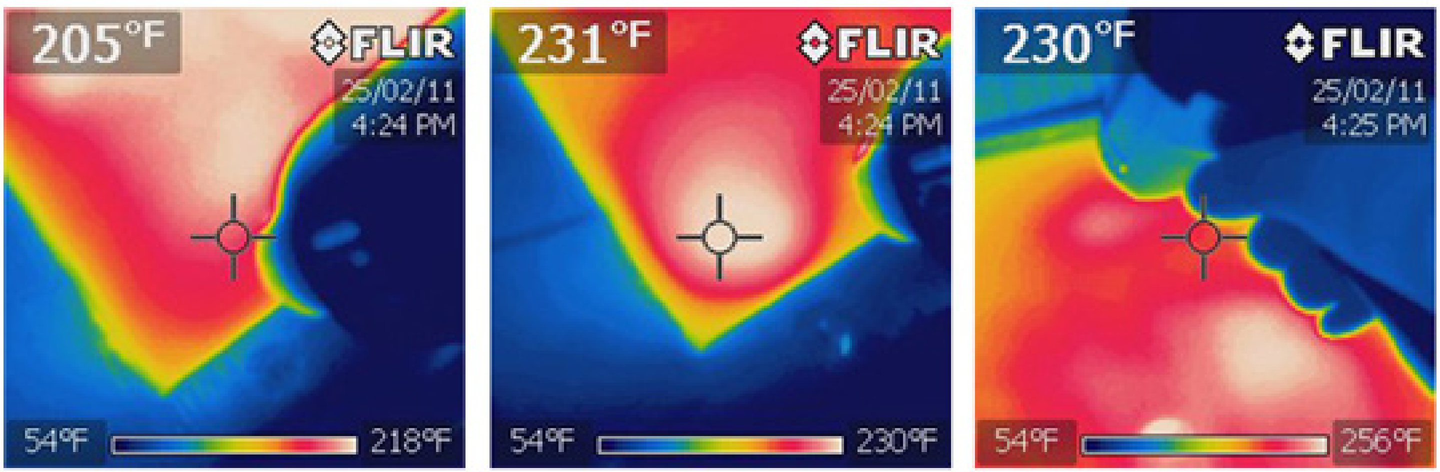
The diameter of the hotspot is important. As you can see, the heat ranges from 200 degrees F around the edges and 234 degrees at its hottest point. This is good because it means the area that needs to be most pliable is heating up evenly.



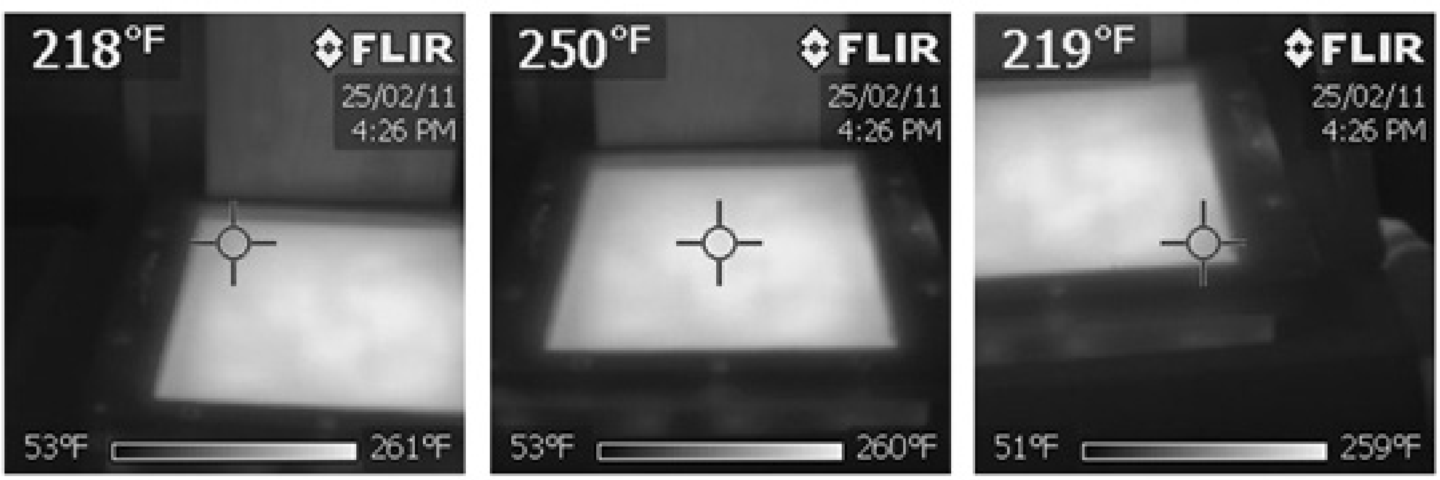
11 minutes after placing the tray on the heat box, the hottest point has reached optimal tempurature. Notice the scale change where yellow/orange is in the mid 200's. The time to form is now!

(Figure 6-3)

To make up for this lack of heat on the corners, taking the heat gun to the edges is a “Spot Heating” maneuver which quickly heats up one part of the plastic to help catch up with even hotter spots near the center. It’s a process that has to be repeated until the time comes to actually move the plastic to the vacuum table. I did find that keeping some form of cover over the plastic top so the heat cannot escape not only quickened the pace, but also led to a more even dispersion of the heat trapped under the cover .



These three pictures were taken to show the method of "Spot Heating" with a heat gun. With the open-top heat box designs, running into the need of this is common, especially around corners.

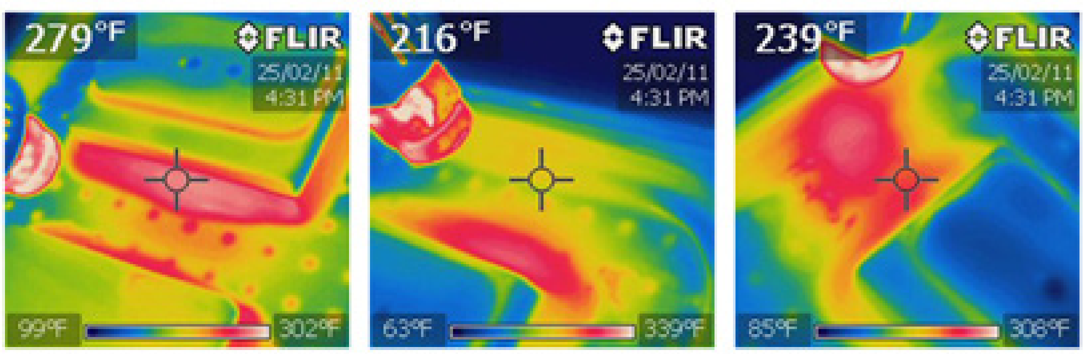


This three part display shows how the Spot Heat method can really even out the plastic surface temperature. The corners are within a degree of each other while the middle still remains the hottest part of the plastic.

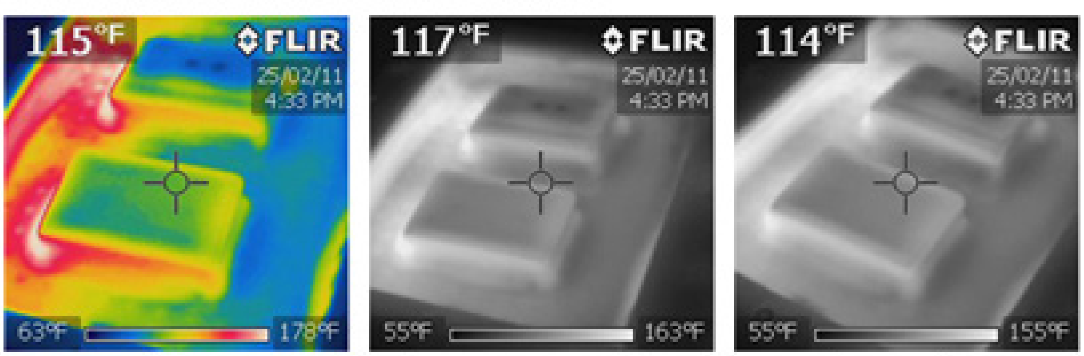
(Figure 6-4)

Once the areas are heated and ready, now comes the time to start forming. Normally the method I employ is to switch the vacuum on first. This is a quick step and lets me know that the vac-box is indeed working the way it's supposed to. Second I make sure my heat gun is close at hand and is powered. The third step is to lift the tray off the heat box and move it above the vac-table. The 4th is then to make sure everything is lined up and then laying the plastic "STRAIGHT" down over the mold(s). Making sure you're putting the plastic down as straight as possible is a critical step because if the plastic goes on the moulds at an angle it will not stretch evenly and will cause all kinds of alignment issues with the other half.

The next set of images shows how quickly the plastic begins to cool once away from the heat source. Because of this, spot heating is a necessity to make sure all areas of the mold are being covered evenly. It is important to remember that when spot heating you do not aim directly at the mold, but more toward the outer edges where the plastic is already sucked down to the table. The plastic on the mold will heat up and get sucked down in tight to it, but if you put too much direct heat on the mold, the wood underneath heats up and doesn't cool as quick, thus making the plastic stretch more and possibly rip!



The above images show when the plastic is laid over the moulds. Spot Heating is essential with this part because of how fast the plastic is cooling. Within 15 seconds of being off the heat box, the plastic can cool as much as 100 degrees, so the race against time most of the time needs help. It is important to remember that when spot heating get the whole area and flat parts in front near the mould, other wise the plastic will stretch and become uneven.



These are more of the same, only they are showing the gradual slow down in the cooling process after Spot Heating. As the plastic becomes cooler and harder, it does retain the heat a bit better, but because the heat isn't as hot, it doesn't really affect the stability of the plastic that much and it can now be handled.

(Figure 6-5)

Part Six

Breaking Free

Perhaps the most frustrating part of the whole ordeal is getting the mold out of the plastic once it's been formed.

There are however a couple of ways to make this a bit easier, however most depend on the prep work that you did before hand.

Wood can be particularly difficult because it has next to no give like unhardened clay. Presumably if you only wanted to use a mold once, a non-hardened clay mold could be ideal because you can break it up then take it out a piece at a time.

Wood on the other hand is a different story, as it is quite difficult to take out a piece at a time and usually bonds tighter to the plastic.

With professional systems, they have a reverse function that after the plastic has cooled enough over the mold but is still pliable, it shoots a burst of air into the vacuum chamber which loosens the grip on the molds.

A clever idea, but one difficult to replicate with home equipment and a single vacuum.

Part Six

Breaking Free

The best way I've found to remove the mold is in a series of steps.

-Step one is to use a rotary tool to roughly cute the casing half out of the plastic sheet. This will make working with the piece much easier.

-Second is to use the rotary tool again to trim off as much excess as possible, getting as close to the edge of the mold as you can without actually cutting into it.

-Step three is to anchor the mold to a surface in a way that you can swing a hammer underneath either side and edge of it. If you have a vice, this is the perfect tool because you can use the same blocks you have screwed to the back of the mold half as an anchor point in the vice.

-Step four is using a piece of ¼" plywood or something similar to wedge into the edge or side of the casing and simply tap with a hammer to loosen the moulds grip. This is where you have to be extremely careful because the tension on the plastic is never greater than when trying to remove it off the mold, especially around the corners! You're most likely going to split your corners on the first few times until you get the feel for what's not enough and what's too much! Fortunately, these are the easiest of all case failures to fix.

Compressed air is another option where you can drill a small hole in the top of the plastic if that area is going to be cut out anyway and fire a short burst into it. This works better with clay and plaster than wood though, but is a helpful technique if you have a compressor.

Part Six

Trimming and Sanding

Once you have gotten the mold out of the plastic, you're going to have to cut down the edges to make an even edge. The best technique I've found is to make up a simple rig that holds your rotary tool straight up with a cut wheel facing down.

You can then set your height and actually run your case half under the blade which will give you a nice even cut all the way around. It is important to leave about a 1/16th or more extra than your plan calls for because the next step requires the finish sanding.

There are two ways to do this, both equally effective. If you have the tool or can get the use of one, a disk sander (normally 10") is an excellent a quick way sand down your case evenly. If that doesn't work, a simpler method of stapling down a sheet of 80 to 120 grit sand paper to a flat surface and sanding the case halves that way also works well for cheap.

This was a little tool I devised when I was working on The Nimbus 64. I needed a way to make my case halves even in the absence of a disc sander.

Originally I had the rotary tool mounted flat on a surface and sanding a drum attached. However the control and height adjustment just took too long and wasn't consistant enough.

So I built a 90 degree bracket, took some 8" pipe clamps, drilled a few hole and there it was. My adjustable case leveler.

You could technically use a drill press for this application as well, but I find that for the smaller diameter cut wheels, the drill press just does not turn the wheel at fast enough RPM's to cut instead of melt it. Might just be my drill press though.

Part Six

Two Halves = A Whole

The only part left to do with the case halves now is making a plan on how to hold them together. Again, a number of different methods are useable for this and it will mostly depend on your case design.

However, a few tried and true methods work wonders. The “Tooth Lock” method is probably the simplest and fastest means of connecting two pieces. This consists of taking little tabs of plastic and cutting them in about ¼” strips and whatever the depth of the internal part of your case for length (top to bottom). Then simply cementing or plastic-welding them into the bottom half of your case.

This will allow you to then drill a screw pilot hole through the top half of the case and into the tab, where you can then place a screw and hold the case together. It can take 6 to 12 of these tabs to get a decent hold, but it will be going nowhere once locked in place.

Another method is to epoxy or plastic-weld threaded spacers into the front or back face on the inside of the casing and use screws hold them together. This can hold just as well but is a bit trickier to implement as it requires more pieces to fit more precisely in certain places.

A bit difficult to see, but the left picture shows the screw posts which I made by taking little nylon spacers and tapping them out to a 6-32 thread size. The pic on the right shows the lip that was fit in place on the back side. In retrospect, since I already had that lip I could have ditched the screw post idea entirely and screwed right to the lip, but again, live and learn. The “Tooth Lock” method is similar to the lip, except it only uses little slivers of plastic thus saving room in the casing.