Ceramic Shell Casting
Start with a Raw Pattern

Usually this is a material that will melt or dissolve. Traditionally, wax is used as in this sculpture by Rosso. Plastics, wood, foam etc. can all be used in a pattern. With all materials you must be concerned with expansion. You can also 3D print a pattern. If you are using a FDM type printer, you must be concerned with the expansion of gas during burn-out. If you are using a powder based printer, using a powder that dissolves easily in water is helpful.
Wax can be modeled directly or cast into molds. In additions to being able to cast multiples quickly, molds can also be used to rapidly develop an idea – such as the use of various textures on the cast to the left.
Then a system of gates, vents and a cup is added. These will become the channels in which the bronze flows to the pattern. Note that the forms in the picture on the right are 3D printed.
Identical smaller patterns can be placed onto a “tree” gating system and be cast inside one single mold.
Rapid Prototyping can also be used to create patterns for ceramic shell. Often these used engineered materials designed specifically to burn-out easily in the kiln.
This process can allow for very large castings – often in one single shot with the appropriate gating and reinforcements in the mold.
Next the piece is dipped into the ceramic shell.

This liquid slurry is made up of colloidal silica and 200 mesh fused silica powder. Slurries can also contain an anti-foaming agent, a wetting agent and frequently a drying indicator. Some shells will use an ethyl silicate for increase drying time. Most types must be kept in motion to keep the solids from separating, however there is a company who adds a suspending agent which allows the product to remain in suspension without stirring. This is fine for smaller shells. This refractory material is actually closely related to space shuttle tiles.
Next a stucco of fused silica sand is applied.

The stucco is most commonly fused silica, however zircon and alumiasilicate (calcined mullite), alumina, zirconia are all used and each has advantages and disadvantages.

The first coat of stucco will be very fine (around 100 grit) and often zircon is used in this layer. It creates a slightly more detailed casting and is more resistant to higher temperatures. Most foundries will work through 2-3 grits of stucco. Often they will be more than one material
After the pattern dries the piece is brushed off.

This keeps the coarse stucco from contaminating the slurry. It takes between 6-12 hours to dry between coats. It is very important for the coats to be dry before dipping again.
The process of dipping is repeated between 8-12 times. This usually around one week.

Wearing a dust mask is also very important around silica.

- Make sure you wear a dust mask when dipping.
- Also be sure not to contaminate the slurry with anything! Water droplets can ruin the whole batch.
- The shells viscosity is measured daily with a zahn cup. Fused silica flour is added if the mix is too thin. If the mix is too thick, more colloidal is added unless the thickness is due to evaporation. In this case distilled, de-ionized water can be added in small amounts.
- IT IS VERY IMPORTANT NOT TO CONTAMINATE THE SLURRY!
Mixers

• Often professional foundries will keep more than one slurry tank running – one for the fine layers of stucco and an additional tank(s) for the coarse. This helps keep the coarse stucco from contaminating the fine layers.

• The mixer can be as simple as a paint mixer set up on a drill press on a slow speed and a five gallon bucket.

• There are two basic approaches: having a spinning propeller inside a large vat or having a spinning tank with a “L” shaped arm scraping the sides and bottom.

• The tear drop shape to the barrel on the lower right is very common among the propeller type mixers.
• I prefer the spinning tank as it gives a larger area for dipping and introduces less air into the mix.

• Overall this is the safer machine as well and comes in a wide variety of sizes. I have seen these tanks as small and 20” in diameter and as large as 6’ in diameter
Fluidized Sand Beds

- Larger foundries will use fluidized sand beds to stucco the shell instead of applying it by hand.
- This allows for a clean even coat to be quickly applied to the shell and can be somewhat automated (a hoist is used to lower the shell into the shell tank, drain, then lower it into the stucco bed).
- These may be as large as 10’ cubed – in this case it is very important not to fall into the bed when it is fluidized as it will be like being in quicksand. People have actually died after falling into large sand beds.
• Large foundries will use and automated process to dip, stucco and dry the shells.
Larger shells are often reinforced with stainless steel wire.

- Because the shell tends to thin at the edges, using clips is very common.
- Fibers are also often added to the outer layers of the shell – for example fiberglass is dipped into the slurry and then applied to the surface. After this dries, normal dipping resumes.
- Screws are often inserted into large waxes or small 3/8” holes are drilled into them to keep the two sides from pulling apart – after casting these holes are welded over and chased back.
- There are some newer “engineered” shell products that are designed maintain thickness on edge as well as a number of other properties such as easier removal after casting.
When 3/8” of shell is built up they are prepped for burn-out.

The bottoms of the cups are removed and the styrofoam is pulled out. Also notches are cut into the shell to relieve gas pressure. This is often done with a hand saw – I find that diamond blades work very well.

NOTE: it is important to wear a dust mask when grinding or cutting shell.
The shell molds are then placed into a hot kiln. The kiln must be pre-heated to 1450 degrees. This causes the wax to melt out very quickly without expanding. If the molds are placed into a cold kiln, the wax will expand and crack the molds. Note: some materials are dissolved with solvents (some plastics will dissolve in acetone) or are washed out with water – such as with the “lost powder” method of casting.
The kiln is then closed and the wax melts out the bottom of the kiln and collects in a water basin.
Autoclave Dewaxing

- Some foundries will use an autoclave to steam out the wax.
- The major advantage to this method is to the environment. Wax is a petroleum based product and burning it out releases carbon into the environment.
- This method also allows a greater recovery of the wax
- A small autoclave can be built with 5 gallon bucket
The final step of course is to pour the molds.
Pouring brass that has a high amount of zinc