Getting Started in Sand Casting

Sand casting overview.

Sand Casting is a process used to make many metal copies from a master part. Almost any metal can be cast, but zinc, aluminum, brass, bronze and iron are the most commonly used materials. Sand casting is an ancient art that is still widely used today. It is entirely practical to make cast parts in your own hobby foundry. All you need is a work space, preferably outside and clear of anything combustible.

The process starts by making a master part. The master part is called a "pattern". A pattern is typically made of wood, but can be made of almost any durable material. The pattern is placed in a 2 part box, called a "flask", and is covered on all sides by a special sand. The flask is split in two so it can be opened and the pattern removed from the sand. After the pattern is removed, a cavity is left in the sand that can be filled with molten metal, producing a copy of the original pattern.

After the molten metal cools the part is "shaken out" of the sand, cleaned of clinging sand, and finished as needed. With a small furnace and a few flasks you can pour a fair number of parts in a day. A lot depends on how big your parts are, the capacity of your furnace, and your ability to ram up the sand molds.

What you can make using the sand casting process.

Sand casting is a process that makes a wide range of metal items. Huge items like locomotive parts, and ship engines are made by sand casting. Medium to small size items such as machine parts, brass plaques belt buckles, model engines, furniture hardware and artwork all can be sand cast. Reasonably fine shapes and details can be reproduced.

Items with extremely fine detail or small size such as jewelry are typically made by another casting process called "lost wax", or "investment" casting. This process uses wax as the pattern. The wax is covered with a liquid ceramic shell called investment and dried. The wax is melted out and the hollow shell is filled with molten metal. Although investment casting shares much of the same equipment and material, the process is different from sand casting and not covered in this book.

Safety.

Understand one thing very clearly: You can be seriously burned, maimed, or killed by metal casting. Melting metal involves extremely high temperatures, potentially explosive gasses as fuels, hazardous chemicals and fumes, and potentially explosive mixtures of molten metal and water. If you want to cast metal, You and only You are responsible for fully understanding the process, hazards, and proper safety procedures and equipment necessary.

This document makes no effort to fully explain the safety hazards present. The only way to be safe is to fully understand the process. This requires study. You should read not just one, but several books on the topic to get the big picture and important details. Much important information is available from manufacturers and vendors concerning individual products. Most important is to have an experienced person at your side during your first few pours. Consult with this person before changing any part of the process, or trying new ones.

In General:

- Wear safety clothing: At a minimum leather shoes, leather apron and gloves.
- Wear safety equipment: At a minimum, Full metal mesh face mask, safety glasses under the mask. Respirators may be necessary in some cases depending on chemicals used and ventilation present in the work place.
- Molten metal will cause an explosion if allowed to come into contact with even the slightest trace of water. Never use damp equipment or pour in a wet environment. Never put water

on a fire caused by molten metal. Use only dry sand to cover burning materials that may contain molten metal.

- Concrete will explode if molten metal comes into contact with it. There is water bound up in the chemical structure of cement that will flash to steam. This can propel pieces at extreme velocities.
- Have a clean, orderly work place. Plan your every move. Have a back up plan in case you can't complete the pour as planned.
- Have a place to put down hot items in an emergency or after use. Have a bed of sand available to place hot items on, or to place a damaged crucible on.
- Have a plan on what to do with unused molten metal. Don't leave molten metal in a crucible to solidify.
- Keep on lookers at a safe distance and out of your way. Don't let yourself become distracted by them. Remove them from the area if you are distracted or feel that the process is not right or hazardous. Focus on what you are doing.

Where to start:

The best place to start is with a simple design, cast in aluminum. Get experience with aluminum before trying higher temperature metals. My first part was a simple cross style play sword for my kids. Then I made a hand wheel for my homemade milling machine, followed by a couple of base pedestals and a bed casting for it. These were all simple patterns to make and easy to pull from the sand. At most they required a typical 2 part mold (cope and drag), and some were done in just a one part "open face" sand bed.

What you need to get started.

Patterns:

The idea here is to make a pattern, typically of wood and to ram it into a pliable sand. The pattern should have a smooth finish that can be pulled out without disturbing the sand. Sharp corners should be avoided. Exterior corners should be rounded, and interior corners should be filleted. The pattern needs "draft". Draft is a taper on the pattern side that allows it to be removed from the sand without pulling the sand out with the pattern.

Sometimes another metal part that has broken can be used as a pattern to make a replacement part. Newer high production techniques use Styrofoam patterns that are vaporized in the mold during casting.

Patterns can be copies of a part. An original item can be copied by making a silicon rubber molding of the part. This rubber mold can be used to make wax copies, plaster copies or even low melting temperature metal copies. These copies in turn are used as patterns for the final part production.

Typically the part needs to be symmetrical about the parting line, so that the pattern can be pulled from the sand without disturbing the sand impression. Undercuts and cores can be done, but it takes a bit of experience.

Sand:

Generally speaking, Petrobond Premix foundry sand is an excellent sand for hobby and art casting of most metals. This is an oil bonded sand and is easy for the inexperienced foundry operator to use. It is safer than water / clay (green) bonded sands because it doesn't have the moisture that can cause steam problems (explosions). The surface finish on your part can be very good. It's not uncommon to have a finger print left in the sand show up on the finished part. The finish in general will have a matte finish, with fine texturing from the sand.

You should get enough sand to completely encase your pattern with at least 2 inches of sand on all sides. The sand lasts a long time, and can be used many times. Just scrape off the burned sand clinging to the part and discard it.

Flasks:

Sand Casting requires a “flask” to contain the sand. You can make your own flask from wood. It’s just a 2 part box that comes apart in the middle. The top part is called the “cope”, and the bottom part is the “drag”. Both halves are identical in size. The top part has pins on the ends to align it with mating sockets on the drag. The flask should be big enough to hold 2 to 3 inches of sand beyond your pattern on all sides. You will also need room for a opening shaft (the “sprue”) thru which to pour the molten metal and have it run thru a channel (the “gate”) into the cavity left by your pattern. The sprue is usually about 1 ½ inch in diameter. I use a piece of wooden clothes hanger rod for the purpose.

The flask can be made from ½ to ¾ inch thick boards. The height will depend on what you want to cast, but mine are 4 inches tall. I have several flasks of varying lengths and widths. A bigger flask just uses more sand, so err on the large side if you are not sure.

Crucibles:

A crucible is needed to withstand the extreme temperatures encountered in melting metals. The crucible material must have a much higher melting point than that of the metal being melted and it must have good strength even when white hot. It is possible to use a homemade steel crucible to melt metals such as zinc and aluminum, because these metals melt at a temperature below that of steel. The problem with carbon steel as a crucible is scaling (flaking) of the steel crucible surface. This scale can contaminate the melt.

There are 2 common types of material that crucibles are made from. The first is called Clay Graphite, and the other is Silicon Carbide.

Clay graphite crucibles are a less expensive option. They are not as strong as Silicon carbide however, and are not recommended for inexperienced users. Clay graphite crucibles can be used in induction, gas fired and electric resistance furnaces.

Silicon carbide has the added advantage of being a much more durable material than clay or clay bonded graphite. It is less apt to fracture in use and spill a load of molten metal. Silicon carbide crucibles are eroded over time by iron, therefore clay or clay bonded graphite crucibles are recommended for cast iron and steel use. For zinc, aluminum, brass and bronze, silicon carbide crucibles are rugged and will provide a great many melts.

Crucibles are sold by a size number. The number represents the maximum capacity of the crucible in pounds of aluminum. Thus a number 4 will hold a maximum of 4 pounds of molten aluminum. The same crucible will hold 3 times that much brass, so a number 4 will hold 12 pounds of brass.

Get smaller (easier to handle) size to begin with, and get a silicon carbide one (stronger) if your budget permits.

Tongs and Shanks:

Tongs are used to lift the crucible from the furnace. A shank is used to hold and pour the crucible. Smaller sized crucibles can both be lifted and poured with tongs. You can make your own tongs or buy commercial ones. David Gingery’s books show how to make your own. In either case the tongs must fit properly to hold the crucible snugly without crushing it.

Furnaces:

Furnaces for hobby use can be charcoal, gas fired or electric.

If you are starting off and want a really low cost furnace, check out a charcoal fired furnace. David Gingery has written an excellent book “The Charcoal Foundry” that will show you how to make one (see reading material section). The charcoal furnace can melt all metals, even cast iron! The down side is that it is somewhat slow and messy to use.

Electric furnaces have the advantage of being easy to operate, just turn on the switch. Also they are completely quite, unlike some gas fired units. Additionally they don't emit byproducts of the fuel burning, although you still can get gasses from fluxes, degassers, and contamination in the metal stock that are dangerous. So you still need to use good ventilation.

On the down side the upper temperature of a inexpensive electric furnace is limited to melting lead, zinc and aluminum, typically. There are high temperature electric elements available but the cost can be in the hundreds of dollars for a single element. Also you must be real careful not to contact exposed heating elements when lifting out the crucible due to the danger of electrocution. Be sure to disconnect the power to the unit by unplugging the furnace completely. Just turning off the temperature controller doesn't guarantee that the power is not present on the elements and wiring. Another draw back to electric units is the life time of the heating elements is limited. Different things can adversely impact the elements life, including quick heating / cooling, reactive gasses in the furnace, and mechanical damage. I have somewhere around 20 heats on my original elements, but your mileage may vary.....

Gas furnaces are more versatile in the range of temperatures available. Propane or natural gas can be used to melt most alloys up to and including iron (not steel from what I understand...). The fuel is probably a bit more expensive than the same amount of electrical energy needed, but the difference is probably minor. The gas units have the advantage of being fairly reliable and maintenance free.

On the down side for gas furnaces is safety and noise. Gas furnaces the danger of explosions if the blower quits (on a blown furnace) or the unit flames out and then re-ignites after flooding the chamber. Also lighting the units can be a hazard. Gas leaks and storage are also a consideration. Commercial furnaces have systems for safety, but home built units often omit these expensive options. Another problem is that gas fired units tend to range from moderately loud to Saturn-5 impersonations. The burning gas and combustion air expands in volume and creates jet engine sorts of sounds and impressive flame columns rising from the vent hole...

So I guess it comes down to what temperatures you need. I would go with an electric unit for aluminum or lower, but a gas unit is a must for anything with a higher melting point.

Chemicals:

Parting Dust: Parting dust is a fine powder used to prevent the sand from sticking to the patterns. It is also used to prevent the cope sand from sticking to the drag sand at the parting line of the flask. Get a small box and use an old gym sock and the dusting bag.

Fluxes: I would recommend that you use a flux when melting your metal at all times. A flux will help separate the dross and slag from the metal and also creates a floating layer that protects the melt from oxidation and absorbing hydrogen and other gasses. The heavier contaminants such as steel bits will sink, while the oxides will float to the top and can be skimmed off. I add about 1/2 the amount at the beginning of the melt. Then I skim the surface after the metal has completely melted, and add the second 1/2. Allow time for the material to super heat to pouring temperature, and skim again just prior to pouring. Get the small size if you are starting out casting aluminum, and intend to try another metal later.

Degassers: Using a degasser depends a lot on what you are going to do with the metal, and the initial condition of the metal source. Degasser helps to eliminate gas from the melt. If you have gas in the melt it may come out of solution at the sand / metal interface in the mold and leave surface bubbles and defects. Another problem with dissolved gas is internal voids and porosity. Items such as artwork that require a fine surface finish or structural machine parts will benefit from degassing. The condition of the feed stock also plays a big part. New metal of graded quality is not as much of a problem as recycled metals. The big difference is the surface area of the feed stock. Scrap tends to have a large surface area per unit volume and is more likely to pick up gas during melting. Get the small size degasser to start with.

Tools:

A lot of foundry men will make some of the basic tools such as slicks (used for smoothing and patching damaged sand areas) and sprue cutters (cuts a funnel shaped opening in the sand thru which molten metal is poured into the cavity) by bending up old teaspoons and flatware to suit. If you are using green (water bonded) sand you can find a camel hair artists brush at art supply stores that will work fine as a swab for slicking up the sand before / after pulling a pattern. I use sections of hardwood clothes hanger rods from the closet for sprue and riser patterns. Just cut a funnel shape on top after pulling the dowel material out of the sand.

Important Reading.

For sand casting I would recommend some information from two books. The first is the "Bible" by C.W. Ammen titled "The complete Handbook of Sand Casting". This book is very complete in all aspects of small foundry operation. The second is a more basic book by William A. Cannon titled "How to Cast Small Metal and Rubber Parts". This book is a good introduction to casting simple, single sided items such as plaques and belt buckles.

David Gingery has written an excellent series of books on building a machine shop from scrap, using sand casting as the basis for making the necessary parts. His books are available from Lindsay Publications.

On line resources.

I'd suggest that you also check out the HFA (HomeFoundryAssociation) at http://members.nbci.com/HWilkinson/index.htm There are a number of excellent links from there. Also there is a mailing list called hobbicast that you can sign up (free) that links you to a bunch of people who are very knowledgeable on a wide variety of subjects.

To learn more about the Gingery style of furnace, check out Lindsay books at http://www.lindsaybks.com/. There you can find a lot of information about building a charcoal furnace, and electric furnace or a gas fired model. Lindsay also has an extensive library of home foundry books. Tell him I sent you!

Check out this foundry page http://www.angelfire.com/fl4/quietgenius/tools.html by Lionel Oliver. It has a lot of good information and pictures to help you get started.