An Outline of Basic Metal Casting Methods

Simple gravity casting process

The casting, or moulding of materials has been around for thousands of years. The benefits of casting is to allow rapid duplication of an object in materials difficult to otherwise form, and/or to allow multiple copies. It also allows economy of material compared to shaping from a solid block, and the reproduction of intricate details can be made. Other objects, such as threaded rods, clips, etc. can also be embedded in the cast, if required.

Many materials can be cast, from expensive metals, to plastics, resins and plaster. Obviously the technique of casting can be used in our model making, and the techniques required are relatively simple, and the equipment can be quite basic.

One of the earliest methods of casting, (5000 years ago earliest enough for you?) and still used until 1965 by a famous manufacturer of jewellery, utilised moulds made from cuttlefish for casting gold rings and similar. That is, the cuttlefish bone bought from pet shops for your budgerigar. In simple terms, the item to be copied is pressed into the cuttlefish, carefully removed, the necessary sprues and risers formed, then molten metal poured in. The bone leaves a textured surface, which may not be needed, but depending on the object a little hand finishing can smooth the surface. For metals which require a high melting point, then you can not reuse the mould, but for white metal (pewter) you can most likely get a run of half a dozen or so. Obviously, the pattern used must have no undercuts, and be of a harder material than the cuttlefish bone.

It is most likely that we do not require an unwanted grainy finish on our items, so we need a finer material than cuttlefish. A similar technique (i.e. direct moulding from an impression of a pattern) uses sand as the mould material. For a large object, the pattern can be made from expanded polystyrene, and left in the sand. Pouring in the hot metal burns off the plastic, and metal fills the void left by the foam. (Polystyrene fumes are 'not nice' so be aware of exactly what you are playing with). For the size of objects we are probably concerned with, then a less grainy material than sand is desirable, and most likely a pattern more detailed than a carved slab of polystyrene foam.

Plaster of Paris is readily obtainable for a mould material, although a specialist silica based investment material is preferable. Using our hard pattern (plastic, metal, clay or even plasticine will do), it is held in the mixture until it is set, then carefully removed. It is most likely that you will need a two part mould. If the pattern is something like a coin, or disc, then lay it flat, half submerged in the investment. When the plaster is set, simply grease the surface of the mould and pattern, then pour in another mix of investment until the object is covered. When that is set, separate the two halves, remove the pattern, cut the filler/riser and passages for air to escape, bind the two pieces back together using soft wire, and pour in the metal – but first you need to know the following.

1air bubbles will form, generally where you don't want them in the plaster. These can be avoided by first painting a thin coat of plaster on the pattern before setting it in the mould box. You can vibrate the mould box while the investment is setting, or the best method is to place the mould box in a vacuum chamber. Although I have a high vacuum pump, a decent vacuum cleaner will suffice. Wickes, for example, sell a useful wet/dry unit for under £60.00. The vacuum chamber can be a simple wooden box, wrapped in polythene, or a substantial plastic bucket with a fitted, sealed lid. Common domestic sink waste water plastic fittings can be found which matches the vacuum cleaner tubing, or you can get away with simply ramming the tube into a hole, and taping over the outside joint with plastic insulation tape, or similar. It would be useful to inset a perspex sheet, so you can see what is happening. You will find the investment initially froths up as the air is extracted, and

then it slumps down, back into the mould box. You can then place the pattern into the mix, wriggling it slightly, so as to not trap air.
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3Small mould boxes can be made from Lego, or similar child's building blocks, or you can utilise suitable sized containers, milk cartons, lemonade plastic bottles and the like.
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5you need to insert locating pegs if making a two part mould, so that after the pattern is removed, you can accurately align the two parts.

1Pouring metal is dangerous. Make sure the mould is really, really dry. If plaster, leave it for a day or two to dry naturally, and when you are melting the metal, place the mould on top of the furnace. Before pouring the metal, put the mould into a sand box. This is a simple wooden box, (which for our purposes can be a foot or so square and nine inches deep) with about 6 inches of sand in it. The sand is heaped up around the mould to support it. Any spilled metal should fall on the sand, and can be left to cool. The metal can be recovered later.

Melting of metals
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I would suspect the most difficult metal we would be wanting to cast would be brass. If you are not fussy about the composition of the metal, then collect all the bits of scrap brass you can find – the edges of brass etched kits frets, broken brass padlocks, door handles, wood screws and the like. Because of the high price of copper much of what appears to be brass is merely brass plated steel, aluminium or other metal. The scrap can be 'purified' by melting it.

Ideally you will need a crucible and a suitable sized furnace, generally propane fired. However, You can melt brass in a tin (steel) can, over a coke forge. Use the vacuum cleaner mentioned previously (on blow, not suck) to blast air through a bed of coke. This is a nice thing to do on an autumn day! Better than a tin can, is to weld a plate on the bottom of a short length of steel pipe, a flat base can be useful, compared to the usual base of a crucible. (if you are tempted to melt aluminium in a steel pot, be aware that rust and aluminium and heat makes thermite – you may start a fire you can't put out!)

I would suggest you melt down your scrap in a steel pot, then pour it into suitable ingot moulds. A few lengths of angle iron, laid as a 'V' in your sand box will do. You need the ingots to be a suitable size for the crucible you will be using when you actually do the melt for your final moulded items.

You will need a few basic tools to handle the scrap, and the crucible, and also a means of scraping off the dross from the surface of the melted metal. They can be simply made from steel bar (re-bar - the embossed steel rods used in concrete reinforcement, about half inch diameter - is good enough, it has a non slip surface and is tough). Ordinary mild steel may be too soft. The tools need handles about 18 inches long, so that your gloved hands are far enough away from the furnace or heat source. You will need a pair of tongs, with long handles, specifically formed to manipulate the crucible when full of hot, molten metal. A pair of welders gauntlets, possibly the leather apron would be fine, too. Make sure the work area is planned out, so you do not have to move far with the molten metal, and if you have to walk, carrying the crucible, ensure the pathway is clear, and that there are no flammable materials nearby. This is a nice outdoor task for autumn, providing the area is screened from draughts.

Crucibles are generally made of a porcelain type of material, so on the initial melt, you do not pack in the brass ingots, since they will expand as they get hot and if tightly packed will crack the crucible. Start by melting a small pool of metal, then place extra ingots in one by one. Since the first

melt to cast the ingots has removed all the corrosion, steel parts and paint from the scrap, you will find you ingots melt quicker, with less dross.

Although not essential, you can prevent oxidisation of the brass by pouring in a layer of Borax (sodium borate) crystals. These will melt and lie on the surface, insulating the metal from the atmosphere. (You may find Borax difficult to find these days, like most useful things it has been deemed dangerous. I'm uncertain if the substitute works as well for our purposes).

The foregoing applies to the melting of brass and aluminium. For melting white metal, much less heat is required. Simply using a small aluminium saucepan instead of a crucible and heat it on the kitchen stove.

Mould making

So far, the moulds I have described have their limitations. Generally they need a hard pattern with no undercuts or inclusions. Also, it has been one pattern/mould for one item, and there will be little surface detail present. To overcome the problem with undercuts and inclusions, we either need a flexible mould material, so that the hard pattern can be easily removed without damage, or a flexible pattern that can be pulled from a hard mould. Both systems are used.

In the past, I have vulcanised rubber sheet around a solid hard pattern. These moulds are capable of reproducing fine detail, including fingerprints! You need to handle the pattern with cotton gloves. The vulcanising process simply consists of putting the object in the mould frame packed with rubber, in an oven at 350deg F for an hour or so. The pressures generated will easily bend half inch thick steel plate with bolts fixed at 4inch centres. You will need to be careful when packing the mould so as not to exert too much pressure when vulcanising. Obviously plastic patterns are no use, and if fabricated from brass, then high temperature soldering is required. The mould rubber is cut apart from the pattern with a sharp scalpel. Depending on the grade of rubber, white metal can be poured straight into it, necessary fill holes being carved, of coarse. The two rubber sides are lightly clamped between two flat plates (If you had too much rubber distorting the original mould frame, you'd need to have curved clamping plates, else the void would be thinner than the pattern). The joint surface allows the air to escape as the mould is filled.

The more usual way of making rubber moulds today is using cold pour two part silicone rubber mixes. The 'best' for gravity white metal casting was 'Silastic 'G'. I used to purchase it from Strand Glass, but this rubber is no longer available. A better quality craft supplier will be able to provide a few alternatives, just make sure you purchase a type suitable for the temperature you require for your particular white metal.

If you have a hard metal pattern, then simply mix the two components, pour into the Lego mould box, submerge the pattern, and place in the vacuum chamber to remove the air bubbles, and leave to set. Carefully cut into the mould to remove the pattern. If the pattern is plastic, or other soft material, and you do not want to damage it by cutting into it, then make the mould in two parts, with locating indents as described previously for the plaster moulds. In both cases, you will need to carve out the filling holes, and allow plenty of mass for the header. The header metal should stay molten longer than the pattern area, and as the casting cools and shrinks, it is replenished by the molten metal in the header. The metal in the header also generates the pressure to force the liquid metal into all the detail nooks and crannies. In general, for rubber moulds, in particular if fine detail is present, you will need to run the mould half a dozen times or so to warm up the mould, so that the metal does not chill on entry.

I know of no flexible mould material that will withstand the temperature of molten brass.

Now, onto the flexible pattern technique. The most usual flexible pattern is made of wax. When it is hot, it is fluid and can be simply poured out of the mould, to be reused if necessary. Some wax will normally be trapped in inclusions in the mould, and this can be simply burnt out. The whole process is briefly described below.

Lost wax vacuum casting – brass and similar metals

The lost wax process is ideal when many identical, often small, detailed objects are required. It is also used when perhaps only one art/craft type item is required – e.g. dental plates are often originally sculpted in wax, a plaster mould taken, the wax melted and burnt out, then plastic or metal is injected into the mould) I guess we are more likely to want to replicate miniature axle boxes, buffer stocks and the like – the many, not the one.

Modelling wax is quite a good medium to work in, if you are creating an original piece. You can take a silicone rubber mould from it. Many plastics or metals are suitable for pattern making, as are resins such as 'milliput'. We just want an actual size pattern for casting our silicone rubber mould.

Once the mould is made (two part or more, to allow easy future removal of the wax pattern), then a sprue or runner will need to be cut into the join line area. The mould is held between two flat plates, and molten wax is injected into the void, replicating the pattern in wax. The injection pressure is about 7ibf/sq in and the temperature depends on the melting point of the wax from about 150deg f upwards. Different waxes exhibit different properties. Now, although special heated pressure vessels are used for wax injection, for experimental purposes and small items, you could use a simple hot melt glue gun. You could even use the glue instead of wax – provided it doesn't stick to your silicone rubber mould, of course.

You make a number of the wax copies, then attach them by the sprues, in a tree formation around a thicker central sprue. For this vacuum forming process, your mould box can be a short length of metal tube, say three inch diameter and three inch long, but other sizes are fine. Your tree, with branches needs to be about two inches in diameter and two inches high, with a maybe a three inch long trunk, so that the branches are able to sit well within the three inch tube, but with the end of the trunk exposed.

Place the tube on a smooth surface, within your vacuum box, and suspend your tree in the centre, trunk upwards, allowing about half an inch below the bottom item to the base surface. Pour in your investment so that all the branches are covered. Evacuate the box, to 'boil off' the entrapped air, and then leave it for the investment to set, for a day or so.

Gradually warm the mould and metal tube, so that the wax melts and runs out of the mould. Collect it for re-use if required. You will now realise that your tree branches should be more like a pine tree, with ascending branches, and not like a weeping willow, which would entrap the wax.

Keep the mould dry, until you are wanting to make the cast. When you are melting the metal for the cast, slowly bring the mould into the furnace area, above the crucible, so it is gradually heated, and the remaining wax in the mould is burnt off.

As mentioned, this is going to be vacuum casting, so you will need a steel plate with a connection to your vacuum system from the centre of the plate. You will be placing your mould over this, so that the vacuum draws air down through you steel tube mould case. The whole set-up would ideally be

in your sand box. Simply turn on the vacuum, and pour in your metal. Leave to cool, and break out the plaster from the tube, and break it away from your tree pattern. Cut off the sprues, and set aside for re-melting.

You will need to practice to get a smooth work flow, and initially perform a few dry runs. Turning on the vacuum too soon will chill the mould. Make sure the metal is hot enough, the dross removed, remember the borax (if any) and ensure all your required tools are to hand, etc.

The advantage of the vacuum casting method is 'scalability' You can choose the size of flask to suit the size of your tree, and the process stays similar.

Instead of a vacuum to suck down the metal, for small casts, pressure can be used to push down the metal from above. A jeweller friend of mine simply placed half a raw potato on the top of a small flask, and the steam generated enough pressure to force down the molten metal.

Traditionally in the jewellery trade centrifugal casting has been used. The mould is whirled around on the end of a string. Fun if the string breaks, or the mould collides with your work mate! There are also centrifugal machines, built into a dustbin sized container, but I believe the vacuum system is far superior, being easier to handle and safer, giving consistent results.

White metal

The temperatures required are not as high as for brass, and it is most usual for white metal to be cast direct into rubber moulds. Often these moulds take the form of flat rubber discs, spun to give a centrifugal force to the molten metal, which is poured into a centre cavity. If only a few items are required, then it will be cheaper to use the lost wax process as outlined for brass. Rubber is not porous like the plaster based investment, so if the benefit of a vacuum process is required the rubber mould will require plenty of cut or drilled vents. However, if that is skilfully done, then the wax pattern/investment stage can be eliminated, the pewter being poured directly into the rubber mould.

I've only given a brief outline of how to go about casting various metals, which may encourage you to 'have a go'. Do not be disappointed if it turns out wrong. At least you should be able to recover the metal to remelt and use again. Of course, it goes without saying that you take care of your own health and safety issues, I've no idea what your scrap brass is coated in, or if you decide to try melting lead at too high a temperature, whatever. One safety tip, however – clothing – wear cotton, wool or leather, and do not tuck your trousers inside your wellies!