Shop Notes: Jewelry

Burn Out

Richard Austin (1936-1990) was a metalsmith and author, with several hundred articles to his credit.

After his death I was given custody of an extensive collection of manuscript material-mostly on the technical issues of metalworking.

This text represents the first effort to organize the material-an attempt merely to group the files by topic. None of this is finished, and the text makes reference to illustrations that were never done-illustrations which were stored separately in any case, making it extremely difficult to bring the parts together.

It is unlikely that I will ever be able to spend the time to sort this all out. But it seemed a shame to let these articles languish unread by those who might benefit from them in some small way. So I have decided to release them in their roughly sorted form in the hopes that someone may find them useful.

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DEWAXING

There are two fundamentally different approaches to the dewaxing process, steam dewaxing and dry dewaxing. Both are widely used and seem to offer advantages and disadvantages. Remember, the basic objective is to remove the wax from the mold cavity with minimum penetration into the investment material.

Steam Dewaxing - Steam dewaxing is widely used; however, it does require an additional piece of shop equipment. In practice, little or no temperature control is available. The system is going to operate very near 212^{O}F no matter what the application. A key feature of the process is the fact that it maintains the moisture level in the flask. This has the obvious advantage of blocking wax penetration into the investment.

Dry Dewaxing - Dry dewaxing can be accomplished in a conventional burnout oven if the controls are sufficiently accurate. The drying action tends to allow more wax to penetrate the pores of the investment.

There seems to be mixed opinion as to which method is superior. However, both offer the following advantages:

- Air Polution Is Minimized
- Casting Quality (Surface) Is Improved

Although the dewaxing step shortens the high temperature portion of the burnout cycle, total wax elimination time remains about the same.

It is important to allow enough time for dewaxing. At the low oven temperatures, it takes a long time to warm the inside of the flask. Depending on flask size, dewaxing times of 1-2 hours may be needed to achieve optimum results. The use of the dewaxing cycle is highly recommended.

BURNOUT

The whole question of burnout is a significant part of technological part of the casting process. Although it will not be treated in detail in this work certain fundamentals do bear on the selection and application of modeling materials.

The physical nature of the investment and the need to remove all traces of the model are the factors which determine the limits of the burnout process. Investment temperatures in excess of 1350 F are generally considered deterimental to the calcium sulfate based investments typically used in jewelry casting. There are two ways in which this high temperature can occur. As a practical matter most burnouts can and should be accomplished at a temperature of 1000 F. or less. There is no real reason to even approach 1350 F since most metal casting should be done into molds. With temperatures in the range of 700 F - 1000 F. The use of the lower burnout temperature eliminates waiting for the mold temperature to drop and the uncertainty of not being sure of what the mold temperature actually is.

The other variable factor is time. Other than the material which melts and runs from the mold the model is destroyed by pyralisis. In essence this means flameless burning where the carbon residue combines directly with oxygen in the air. The resulting carbon dioxide gas is flushed from the mold.

BURNOUT METHOD

Electric or gas furnace - Muffler / Non Muffler

Hot Plate - Electric Stove - Clay Pot

Gas Stove - Gas Ring

Bunsen Burner

Charcoal - Hang or Pack

THE MELT

Bernzomatic -

Prestolite - Acetylene

MAAP -

Natural Gas & Air -

PREHEAT

COLORATION

All of the books and articles on casting tell you that when your burnout is complete the investment will return to its original pristine white color. I've done thousands of castings and my investment always ends up with stains or tattle-tale gray. No matter what temperature I use or how long I wait there is come discoloration. The real point is to look at the investment from time to time. When all signs of carbon (black) are gone the color will quit changing and stabilize at a nice uneven, light grey. At this point the burnout it done.

BURNOUT

The physical nature of the investment and the need to remove all traces of the wax are the factors which determine the limits of the burnout process.

.1 Maximum Temperature - Investment temperatures in exeess of of 1350 F are generally considered deterimental to the calcium sulfate based investments ~~ktyp~~ typically used in jewelry casting. There are two ways in which this high temperature can occur. Obviously if the air temperature around the flask exceeds the temperature the flask will also finally overheat. However, radiant energy can also cause overheating of the flask even in ambient air temperatures which lower than 1350 F. For example, an electric heating element may be well over this temperature and the radient thermal energy can be absorbed by a flask causing the temperature to rise dramatically even in cooler surrounding air. As a practical matter most burnouts can be accomplished at a temperature of 1000 F. or less. There is no real reason to even approach 1350F since most metal casting should be done into molds with temperature in the range of 700 F - 1000 F the use of the lower burnout temperature eliminated waiting for the mold temperature to drop and the uncertainty of not being sure of what the mold temperature actually is.

2. Thermal Shock - Although the investment is remarkably sturdy material, sudden changes in temperature can cause cracking. It is generally agreed that the moist flash should be introduced to an atmosphere which starts at 300 F or less and that the temperature should be slowly brought up to 1000 F over a period of about an hour.

(48) BURNOUT TECHNIQUES - GARRISON

1. Process is really not too sensitive to complete burnout.
2. Flask must be properly cured - green investment shows up as fuzzy or fin castings. 12-24 hour hold on invested models - claims asbestos liners help.
3. 30 day hold on flask is O.K. - Sit on flat plate and wax closed end.
4. Melt out at low temperature versus burn out for CIP. Metal still bite the stone.
5. When you can see pink inside the sprue opening you are ready to cast.
6. Place ~~plasti~~ flasks on side or with sprue opening up.
7. Cycle 2 hours in preheated 400° F, 2 hours at 800° F, hold at 1400 till opening is pink.
8. Attributes massive pitting and excess shrinkage to too high flask temperature at time of cast.
9. Incomplete cast results from cold mold, incomplete melt or cold melt or poor spruing. Also "short pour" problem.
10. Burnout vegatable matter at 1200° F for 2 hours plus.
11. Fast cycle burnout. Invest, wait 45 minutes, preheat on top of stone in metal container until just too warm to hold ~~min~~ maintain for ~~11~~ 1 1/2 hours, go directly to 1200 - 1300° F furnace.

CASTING FOR EVERYONE - Garrison

1. Vacuum, pull piston, boil water to evacuate space, mechanical pump.
2. Vacuum needs best possible seal, silicone lab grease can help.
3. Pressure can provide greater then vacuum force. CO_2, N_2, or pumped air will work fine.

4. Pressure systems are more ~~forging/than~~ forgiving than vacuum.

5. Centrifugal systems can be horizontal or verticle and straight or broken arm.

6. Force of gravity and accelleration may not be uniform and model could be positioned to take this into account. Recommends a long sprue to get around this?

7. To avoid balance weight both arms of centrifuge.

8. Centrifuge is old reliable can be wound as needed, its fast, and it works.

9. Combination units are O.K. but more than really exceded.

10. Melt problem

    I. Electric

        A. Carbon Arc

        B. Induction

    II. Gas Fired Systems

        A. Single Gass

            1. Gasoline

            2. Propane

            3. Butane

            4. Acetylene

        B. Two Gas Systems

            1. Oxygen - Natural Gas

            2. Oxygen - Propane

            3. Oxygen - Acetylene

            4. Oxygen - Hydrogen

11. Atmosphere can be

            1. Reducing

            2. Oxidizing

            3. Neutral

12. Metals can oxidize or absorb oxygen to mess up the system.
13. Gasoline is messy but makes lots of BTU at low temperature. O.K. for gold or silver but N.G. for brass, bronze. Propane (Household) works up to 1/2 oz. of gold or silver but not much else. Acetylens not too bad.
14. Pressure - Vacuum systems, does sprue become the crucible.
15. Sprue to avoid errosion by too many sharp turns for the metal.

BURNOUT

PREHEATING

The use of preheating in commercial casting is quite common. This heating serves several purposes. First it may decrease the overall system energy requirement for the burnout cycle. Second it allows much of the wax to flow out of the cavity. This minimizes the amount of wax which must actually be burned out. This decreases smoking which lowers the load on the ventilating system and decreases total air polution.

ALTERNATE BURNOUT METHODS

In my personal opinion, professional metalsmiths should purchase the best quality tools and equipment which they can afford. However, circumstances may dictate that you improvise. Since burnout equipment is relatively expensive and difficult to move, it is useful to consider some alternates. These may suffice for an occasional casting or for casting material which is too large to put in your present furnace.

Any alternate burnout procedure must meet the basic requirements of the materials. It must reach a temperature in excess of one thousand degrees Fahrenheit but not go beyond thirteen hundred degrees Fahrenheit. There needs to be some air flow present in the burnout chamber, and it is obviously useful to have access to the chamber for inspection. The process of inspection is even more important in the absence of other precise controls.

If you're not too concerned about casting quality, the burnout process is quite forgiving. Within reason, low temperatures simply extend the burnout time. If you will examine Table 69, you will see that visible color appears in the range of nine hundred to eleven hundred degrees Fahrenheit. By thirteen hundred degrees Fahrenheit, the color is obvious. With some experience, you should be able to estimate the color visually in a darkened room. Temperature measuring pellets or ceramic cones provide a reasonably precise method of temperature measurement. There is a very simple and effective way to estimate temperature. Most common aluminum alloys melt at about twelve hundred degrees Fahrenheit. If you embed an aluminum nail in a small block of investment (see Figure 70), it can be used as a gauge. As the nail starts to bend or sag, you're in the proper temperature range. Another more precise method is to use a conventional thermocouple measuring device. These can be salvaged from old electrical equipment, including burnout furnaces. Salvage outlets may also sell thermocouple units.

There are several general ways in which you can construct a simple burnout system:

- Charcoal Systems
- Hot Plate Systems
- Gas-Fired Systems

Charcoal Burnout - Note: this section will be an abbreviated version of the article published in the 1976 Gems and Minerals.

Hot Plates - The general procedure is the same whether you use an electric hot plate or a gas burned as a heat source. Both sources will provide temperatures well above thirteen hundred degrees Fahrenheit. Therefore, it is necessary to isolate the flask from direct contact with the heat source. The second requirement is to provide a chamber, and the third element is to provide for some flow of air. One common approach has been to use a heat deflector and ceramic flower pot. This kind of set-up is illustrated in Figure 69.

BURNOUT

GENERAL

When the time comes to do your burnout, do you place the flask in the oven with the sprue up or down or do you lay the flask on its side? Do you start one way and change somewhere through the burnout cycle? Every one of these procedures will be found somewhere in the casting literature. Actually it's reasonable, since they would probably all work. I think I've tried every conceivable way that you might position the flask in the oven. In the final analysis, I fall back on logic.

If you consider what happens when you begin a burnout, the first stage is simple melting. At this point, it would make the most sense to have the flask with the sprue downward to allow the melted wax to run out. This is the common practice in essentially all industrial investment casting production. This is very logical since there's no use to burn the wax which you can simply melt out. It also minimizes wax absorption into the investment. In many cases, a low temperature dewaxing cycle is used first. This may be a steam oven or low temperature electric oven. The wax can be caught in a pan and does not have to "burn". The dewaxing cycle significantly decreases air polution. It may also mean that you need less air flow in your hood system which can also provide economies in heating and cooling. Putting the sprue downward minimizes the total amount of wax melted into the pores of the investment this way. Once all of the wax is melted out, it makes relatively no difference how you position the flasks as long as there is free movement of air around the sprue opening. Since the balance of the burnout procedure is a pyrolitic reaction where the carbon in the residue combines with the oxygen in the air, a free flow of air to the flask is necessary. Obviously, if the flask were face downward on the smooth bottom of the furnace, relatively little air would be able to circulate around the sprue opening. My solution to this has been rather simple. A long time ago, I purchased a soft fire brick and cut it into small blocks with a hacksaw. I use these as trivets in the bottom of the oven. I put the flask sprue down over these and proceded with the burnout. The wax can run out freely, and later there is plenty of air circulation without trying to move them. As a practical matter, the less you have to work in the hot oven, the safer the whole process is.

There is one other factor which is worth considering. There are several different possible configurations for the electric heating elements in furnaces. In some cases, there are heating elements in the bottom of the furnace. There is some evidence to suggest that contact with the melted wax may shorten the life of the equipment. If your oven has coils in the bottom, it might be worthwhile to have a welding shop make a small 18 gauge stainless steel pan to catch the melted wax. Alternately, a thin layer of ceramic material (such as a sliced up fire brick) will absorb the wax and allow it to burn without coming into direct contact with the elements.

BURNOUT

INTERNAL FLASK TEMPERATURE

Unless the oven and flask are allowed to come to equilibrium for an extended period of time, the temperature inside a flask will not be the same as the indicated temperature on the oven's pyrometer. The mass and insulating effect of the investment causes the flask temperature to lag during heating and lead during cooling. A period of hours may be needed to achieve equilibrium between the flask and the oven chamber.

There is a second and less obvious factor which influences the actual flask temperature during burnout. The presence of residual water in the investment delays the temperature rise in the flask. When the flask temperature reaches 212^{o}F (water's boiling point), the investment remains at 212^{o}F until all the water evaporates, even if the oven temperature continues to rise. A typical relationship between oven temperature and flask temperature is illustrated in Figure 100.