Lost Wax Casting: Investment/Centrifugal Casting

Instructor Notes

Reliability

This is a complex procedure, and might have to be repeated more than once. Results are often a boost in students' pride and provide a sense of success and accomplishment.

Teacher Tips

1. The creative design of the wax model takes time. Assorted wax forms can be purchased commercially, if desired for test runs.
2. The instructor should allow the student 1-2 weeks of class time to complete the casting. Model design or student creativity will lengthen the time required to accomplish this lab (see Figure 5.10 for topics and activities related to lost wax casting.)
3. The project can be completed by pairs of students.
4. Refer to Bovin and Murry, *Centrifugal or Lost Wax Jewelry Casting,* for additional background.
5. Show films on the following: wax casting, wax set-up, centrifugal casting, and vacuum casting.

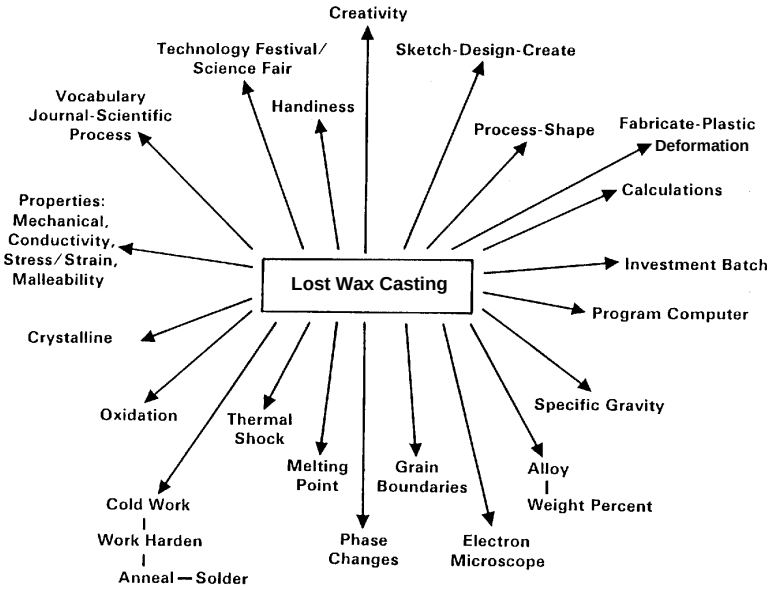

Figure 5.10. Lost Wax Casting

Safety

1. Students should wear gloves, aprons, and safety glasses.
2. Torch can be hazardous. Follow proper procedures with this equipment.
3. When adding flux, make sure students work in a vented area.
4. Use a shield when doing centrifugal casting (this usually is a part of the centrifugal equipment).
5. Burnout program must have cycled.
6. Flask should be 900°F ± 8° (422 – 477°C)
7. Check for cracking of investment. Exit of sterling at high speed in liquid form is not desired. Review vacuum procedure for cracked flask recovery technique.

Activity: Lost Wax Casting: Investment/Centrifugal Casting

Student Learning Objectives

At the end of the activity students will be able to:

- design and fabricate a project using the process of investment casting by either the centrifugal or vacuum method using a silver/copper (Ag/Cu) alloy.

Materials

- Investment plaster
- Wax, modeling and sprue
- Sterling silver
- Debubblizer (no bubble solution)
- Sodium borate ($Na_2B_4O_7$) or boric acid (H_3BO_3)
- Pickling solution

Equipment

- Gloves and safety glasses
- Burn-out oven
- Wax-forming tools
- Oxyacetylene torch or propane/oxy or natural gas
- Beaker (for pickling solution) (crock pot is safer)
- Centrifugal or vacuum casting apparatus
- Tongs, flask, and copper tweezers
- Rubber mixing bowl (1.5 qt)
- Plastic spatula (wood absorbs water)
- 5-gal bucket
- Jeweler saw

Procedure

1. Sketch in your journal preferably three variations of a design of a wax model you want to make.
2. Fabricate a wax model using techniques demonstrated by instructor with material that leaves no debris. Paraffin is not recommended.
3. Attach sprue to the wax model with inlay, sticky, or welding wax.

4. Weigh the wax model and sprue.
5. Multiply mass of the model and sprue (step 4) by 30%. Add this amount to the mass of the model and sprue to compensate for the soon to be attached sprue button.
6. Multiply mass from step 5 by 10.3 (density of sterling silver) which gives amount of sterling silver necessary to cast your model, sprue and button.
7. If investment requires, paint or dip model with debubblizer to reduce surface tension of wax. Allow 20 minutes to dry.

***Note**: If investment has built-in surface tension reducer, this step can be skipped*.

8. Secure flask on sprue base making sure model is 3/4 in. away from wall, and approximately 1 in. below top of flask.
9. Use the Table of Flask Dimensions to determine amounts of water and investment plaster for the particular type you are using.
10. Measure out the investment and water carefully, add the investment to the water (72°F or room temperature), and mix thoroughly following time schedule. Mix in a clean rubber mixing bowl. Any dried investment will cause a change in cure time.
11. Use the vacuum chamber to degas the investment in the mixing bowl for about 90 sec with glasses on during which time it will rise, fall, and froth.
12. Place the sprue base on the casting flask and pour investment carefully down the inside of the flask until wax model is covered by at least 1-2 cm (1/2 in.) of investment.
13. Place this casting flask in the vacuum chamber and degas for another 90 seconds.
14. Add remaining investment mixture to the top of the flask. For centrifugal, leave space if using vacuum technique.
15. Set the flask aside to set for prescribed time.
16. Scribe your initials lightly onto the top of the investment, when set, to identify your project.
17. Program furnace for a burnout cycle for particular investment (if not already done). See attached sheet “Science of Burnout” for further details.
18. Place flask into furnace and allow time for burnout.

At this point go to the lab “Alloying Sterling Silver.”

19. Prepare for casting by reading the directions for centrifugal casting or vacuum casting that follow, and mentally prepare yourself to follow the process.

If you are going to do centrifugal casting, follow steps 20a - 20l, then skip to step 22. If you are going to do vacuum casting, skip to steps 21a - 21i.

20. If casting with a Centrifugal Casting Machine, follow this procedure
    a. Put your flask in the machine and balance with counter weights. Return flask to oven.
    b. Wind casting arm and lock on stop rod.
    c. Preheat and flux crucible; add metal.
    d. Remove flask from furnace and place in cradle with open cone-shaped sprue end toward crucible.
    e. Push crucible carrier tight against flask with tongs. If the machine is a broken arm horizontal centrifugal caster, move arm back away from direction of travel.
    f. Melt metal as directed, fluxing lightly when necessary. Stir with carbon rod.
    g. When metal “rolls,” have another person hold counterweight arm firmly from above while releasing stop rod. Continue heating the metal.
    h. Simultaneously raise the torch heat from the metal, and release the casting arm.
    i. Allow machine to spin to complete stop. Do not stop it.
    j. Remove flask with tongs. Hold until button loses glow (~5 min), or set down for 5 min.
    k. Remove flask with tongs and quench in a bucket of water, wearing glasses. Observe thermal shock.
    l. Clean off investment residue with brush and water.
21. If casting with a Vacuum Assist Machine, follow this procedure
    a. Connect vacuum pump and casting unit. Turn on vacuum pump. Check vacuum setting with finger.
    b. Preheat and flux long-handled crucible or electrically heated graphite crucible. Add metal melt, flux, and stir with carbon rod.
    c. Remove flask from furnace and place on casting table, sprue hole up.
    d. Turn on vacuum pump: verify full reading on gauge.
    e. Pour molten metal into sprue hole.
    f. Direct flame on sprue button for several seconds, when using gas torch.
    g. Release vacuum and turn off machine.

h. Remove flask, and set on fire brick until button loses glow, or 5 min.

i. Clean off investment residue with brush and water.

22. Let cool in air for 5 min after making casting, then submerge into a bucket of water.
23. While water is bubbling, reach in with your hand and hold onto the flask. Keep flask under water. You will be able to feel the thermal shock of the investment material.
24. Break up investment and remove casted part. *Discard investment material into appropriate waste container and clean up your mess!!*
25. Place casting in pickling solution with copper tweezers to remove oxidation. **Caution**: Be sure to follow directions for pickling safety.
26. Remove sprue and button from casting using a jewelers saw or diagonal cutters.
27. Return sprue and button to instructor.
28. Rough casting procedure complete.

Note: Casting process can take place in 1 hour; however, burnout must go according to the schedule of the specific investment.

Science of Burnout

Several scientific facts about burnout are described in the following paragraphs. This is general information. Burnout will vary based on investment furnace temperature.

The flasks are heated slowly to 400° F. Why? The investment is mixed with water and water turns to steam at 212°F. The water as moisture can escape through the pores of the investment if heated slowly; if heated very quickly, the formed steam expands before it can escape and some of the investment around the cavities formed by wax eliminating may be loosened, resulting in damaged castings.

Water that is chemically combined with some of the chemicals in the investment as water hydration will be driven out at approximately 375°F.

Flasks should never be allowed to sit in a cold burnout furnace for an extended period of time or else they will dry out. If the investment is heated dry, it can act as a sponge and draw the wax into its pores. It is recommended that the burnout furnace be preheated to 300°F before placing the flasks inside the chamber. At 200°F to 300°F, most of the wax immediately melts and flows out through the sprue openings. The steam from the water in the heated moist investment helps to push the wax off the walls of the pattern cavities in the investment. Most commercial burnout furnaces do not have to be preheated since they are still warm from the previous day.

It takes approximately 1 hour for the wax to burn out and become “lost.” The wax will crackle and sizzle as it melts. Smoke and steam escape through the furnace’s vent.

Wax that does not flow out turns to carbon (a black powder) at 1000°F. The carbon is completely eliminated above 1400°F by combining with oxygen in the air to form the gas carbon dioxide (CO_2). The carbon dioxide is eliminated through the sprue opening and also through the pores of the investment.

Some of the carbon probably is not completely oxidized and turns into carbon monoxide (CO). This odorless, poisonous gas ignites and burns with a blue flame.

Note: The furnace temperature will rise faster (be hotter) than the temperature of the wet investment in the center of the flask. The difference in temperature can be more than 100°F. To permit the furnace temperature and flask temperature to equalize, the furnace temperature, when it is dropped to casting temperature, should be held for at least 1/2 hour.

If the flask is heated over 1500°F., the gypsum binder (calcium sulphate, $2CaSO_4 \cdot H_2O$) begins to break down into sulfur dioxide (SO_2) and sulfur trioxide (SO_3) and, if a casting is made over 1500°F., these gases will discolor (form sulfides with) the cast metals. (Source: Bovin, M. *Centrifugal or Lost Wax Jewelry Casting*. Bovin Publishing New York.)