Beyond Wax
With the advent of low-cost 3-D printers, more jewelry makers and designers are now working with resin-based models. Are you ready?
By Shawna Kulpa

You’ve been doing this for years. A wise and grizzled expert, you’ve been casting wax jewelry models since the Eisenhower days. But lately you’ve been getting more and more calls from jewelers investing in these so-called 3-D printers, creating models from this plastic-like resin material. The price of these machines is so low that now every mom-and-pop jeweler and hobbyist can afford one and has started growing their own models. Heck, some of them are even printing models right on their kitchen tables! But now they have to have their homegrown models cast—so they contact you, trusting in your years of experience. Send it in, you tell ’em. After all, how different could casting this resin stuff be from wax?

Turns out, quite a bit.

“I always tell people there’s a reason they call it lost-wax casting and not lost-resin casting,” says Linus Dros of Au Enterprises, a contract caster in Berkley, Michigan. For jewelry makers, he says, “our systems, our temperatures, all of our processes, they all revolve around casting wax.”

That means that whether you cast others’ designs, like our grizzled veteran above, or have invested in a 3-D machine of your own and now need to make it work, you need to take a different approach. If you do, and think about casting in a new way, you’ll be able to have just as much success with resins as with wax. If you don’t, then get ready, because resins
are not forgiving.

“They’re like a bunch of gang members waiting out in a dark alley for you,” warns J. Tyler Teague of JETT Research in Johnson City, Tennessee. “They will kick your butt in a minute.”

Getting Started

Perhaps the best way to begin a discussion about these resins is to define what we really mean by “resin.” Drogs notes that it’s unfortunately become something of a catch-all term: “Many jewelers think that if it’s not wax, it’s resin, and that all resins are alike.” The problem, he adds, is that they’re not all alike, and to treat them as such can lead to bad castings.

So to be specific, when we say “resin” we typically mean a liquid material that’s solidified by light—what chemists call a photopolymer. This material is particularly prevalent among the new lower-cost systems that, over the past few years, have been spreading CAD/CAM technology to jewelry makers at all levels. (See “The Build Up,” Nov. 2012, MJSA Journal.) It should also be noted that not all 3-D printers use a photopolymer. Some—most notably those produced by SolidScape, as well as the latest versions of the Projet CPX printers by 3D Systems—instead work with either real wax or a proprietary compound specially designed to mimic wax’s properties. As several experts have noted, these latter systems don’t have the issues outlined here, and are more closely in tune with traditional lost-wax casting.

The photopolymer, on the other hand, is definitely not wax. Not only that, the photopolymers themselves aren’t even the same: There is no one formula common to all 3-D printers. Rather, each one has, as Drogs says, it’s own “secret goo”—the proprietary ingredients that have been added to help replicate the lost-wax experience.

“Off-the-shelf photopolymers can produce very crisp details, but these base formulas by themselves don’t cast well,” says Steve Adler of Portland, Oregon–based A3DM Technologies, a specialist in additive manufacturing technologies for precious metal products. “Most manufacturers of 3-D printers serving the jewelry industry have therefore added wax-like substances to the material to make it burn more readily.” It’s a delicate balance between adding enough wax to cast well, but not so much you lose crisp printing details, Adler says—and every manufacturer has its own way of achieving it.

As a result, each 3-D printer will have a photopolymer resin with its own particular needs—for instance, a burnout schedule for one may not work with another. “The first thing I ask a customer who is sending me a photopolymer model is what machine did it come from,” Drogs says. “Once I know that, I can adjust my process accordingly.”
And that’s the key: adjustment. While the specific differences may vary by degree—some formulas may lead to easier direct casting, for instance—all of the photopolymers do require some accommodations from the caster. It’s just a matter of knowing how each resin differs from casting wax, and then proceeding accordingly.

**Resins Versus Wax**

So what are some of those differences, and their special requirements? Unlike wax, which is ready to cast fresh off the mill, photopolymer resin models are cured as they’re built layer by layer. However, the models are only partially cured by the printer, leaving parts of the resin still tacky. The models must therefore be cleaned with a recommended solvent, like isopropyl alcohol. Many are also then post-cured within a light box to make them suitable for investment. (Note: Check with your supplier to determine the best approach for your models.)

Unfortunately, depending on the geometry of the design, even a light box isn’t always enough to cure the photopolymer thoroughly. Tom Dougherty, owner of Studio 2015 in Woodstock, Illinois, uses a Digital Wax Systems (DWS) printer, and he learned this lesson through a lot of trial and error. Ultimately, Dougherty and his team found a way around this: “We bought a little tiny dehydrator for fruits and vegetables and use it to dehydrate the models.”

Other casters have found success by placing fresh resin models in ovens and using heat in order to finish curing them. (Adler does note that the heat and dehydration can sometimes lead to pattern shrinkage, and the piece should be measured afterward to make sure it’s still dimensionally stable and sized correctly. However, he adds, “we’re doing that same type of compensation in casting all the time, whether with wax or resin.”)

Resin’s special requirements continue into the investing stage of casting. “I first started out trying to cast it as it was advertised to me, that I could use my standard investment [with] regular procedures,” says Allan Beck, shop manager and custom jewelry designer at Simmons Fine Jewelry in Meridian, Idaho. “I have some beautiful photos of what happened. It looks like clinkers out of an old, coal-burning furnace, full of porosity and holes.”

While it is possible to use a regular gypsum-based investment, some casters have had the most success when they mix it at a lower water-to-powder ratio. Unlike wax, resins can expand quite a bit during burnout, so you need the investment to be strong enough to withstand this expansion.
“If the investment is not strong, the swelling of the resin can break and damage thin areas of investment, causing them to later fall into the mold cavity once the resin finally burns away,” says Teague.

According to Drogs, when casting resin models, ideally you want to use a low cristobalite investment system. “Something like Ransom & Randolph’s Plasticast [which was developed specifically for casting plastic models] is going to give you more strength so it is more resistant to expansion rate,” says Drogs.

Beck learned that firsthand after initially trying to cast resin using his regular Ransom & Randolph UltraVest investment. “Standard investment wasn’t hard enough to take the twisting and turning the models underwent during burnout,” he explains. This prompted him to make the switch to Plasticast. “I went to using Plasticast, and I mixed it with 36 parts water to 100 parts powder, which is stiffer than most people do.”

Alternately, some casters swear by using dental investments to cast resin models. That’s true of Taner Seyben of DMJ Casting in New York City, who uses it whenever he casts models with a lot of fine detail. “If I see something really difficult, I’d rather use dental investment,” he says. “It’s stronger, so I know it’s not going to break.” However, while dental investments can also sometimes yield a smoother casting, “they’re like concrete,” warns Teague, so “you better have a really powerful water blaster or a lot of time to pick off the investment, because it takes a while.”

Burnout is where the differences be-ween wax and resin really stand out. Unlike wax, which melts away during burnout, resin doesn’t melt, it combu-sts, and at a much higher temperature than a wax’s melting point. Because of this, it’s important that the burnout oven have a good air supply. This is typically not a problem with gas ovens, but electric ovens tend to suffer from a poor airflow. However, they can be modified. “We made modifications to our electric kilns,” says Dougherty. “We created openings in the top and bottom of the kilns that allow more oxygen into them.”

Another trick to increase air supply is to flip the flask over during burnout. Initially you’ll want to start burnout with your button down, so the wax from the tree and sprues can run out as it melts. Once you get up to 500°F/260°C to 600°F/316°C, where resins start to combust, flip the flask upside down.

“You can flip the flask over so the button is up and you’ll get maximum exposure to the available oxygen inside the oven to combust those resin materials,” says Teague.

Photopolymers, unlike wax, can contain acids if they haven’t been fully cured—and that can pose one more challenge during the burnout cycle. Those acids will interact with gypsum-based investments, leading to surface imperfections and failed castings. (For more about this, see “Direct Casting Photopolymer Resin Models” by Gary Dawson and Joe Strauss, a paper presented at the 2013 Santa Fe Symposium, santafesymposium.org.)
To prevent this, many casters will spray models with a light coating of a clear acrylic-based material, such as a Krylon fixative spray. This forms a barrier between the model and the investment, so that any interaction that might happen is prevented. In addition, it can also improve the resin’s finish.

“If you spray gently and lightly, you could actually fill in some of the grow lines that are present [on the model],” says Dougherty. “This is great for improving the external quality of your casting.”

One final note about burning out photopolymer resins: As noted earlier, not all resins are the same, and not only will the burnout schedule differ from that associated with lost-wax casting, it will also probably differ among the different resins. Always check with the supplier of the 3-D printer to obtain the recommended burnout times.

Back to the Beginning

In addition to all of the above, one of the best ways to avoid potential problems is to start at the beginning, and look at the design. Most casters agree that large items, such as a high school ring or a wide and flat pendant, are among the hardest things to cast, given resin’s tendency to expand. “They [resin models] press on the investment in one plane or direction,” says Beck, and that pressure can often result in the investment cracking. The larger the surface volume in a piece, the more likely it may cause headaches.

“Say you have a piece with a 10 mm cross section. Even if it only expands 2 percent, 2 percent of 10 mm is 0.2 mm, and that’s a lot when you consider that the investment doesn’t want to go anywhere,” explains Teague. “But if you only have something that’s 1 mm, 2 percent of that is 0.02 mm, so the investment won’t even notice.” Jewelers can improve their chances of a successful casting of large pieces by designing them so they can grow it hollow, with thin cross section bars supporting it inside.

That expansion also comes into play with lettering. If you have a model with long, skinny letters measuring up to 2 mm, it’s helpful to remember that just because you can grow it, doesn’t mean you can cast it.

“When you start the burnout and that resin starts to expand, you have all these little, skinny bits of investment between these 2 mm tall letters,” explains Teague. The expanding resin can crush those small bits of investment. Even if they do survive burnout, they still have to face molten metal rushing into the mold cavity.

“With tall, skinny lettering, the mold cavity is going to look like a series of skyscrapers.
Now picture the metal rushing in. Those little skyscrapers are just going to get plowed down, leaving you with lettering that looks like crap,” says Teague.

How can you avoid this? Create smaller lettering. “You don’t need more than a height of 0.6 or 0.5 mm on lettering to be able to see it,” says Teague. In addition to not creating tall letters, the designer should also add a draft angle to the letters, making the top of the letters as wide as needed but tapering the width toward the base. Instead of creating skyscrapers in the cavity, the model will now create little Incan pyramids, which are better suited to handle the resin’s expansion during burnout as well as the subsequent rush of molten metal.

If you’re contracting out your casting, discuss all such issues with your caster—and listen to them. Some casters, for instance, recommend having designers divide up their designs in CAD and grow them as separate components to make them easier to cast. “I would always break out pieces,” says Dougherty. “I would always separate my heads, my shanks. I wanted to have pieces divided out so that I didn’t have any issues when I’m casting.”

And if you’re not contracting out your casting, then follow the old scientific method of observing and watching. “One of the most important things for me is that as I make changes when I’m trying something new that I’m very deliberate in what I do,” says Beck. “Don’t change a whole pile of things at once, and keep good records so that you know what it is you changed and how it affected things.”

Also, don’t be afraid to experiment. When Andy Andrews of Best Cast in River Edge, New Jersey, had problems with weak investment while casting resin models, he and his team experimented by tweaking the investment’s recommended mixing instructions. They adjusted their mixing speed, increased the bench dry time, and changed the water-to-powder ratio—and saw a significant increase in the strength of the investment molds.

“Had we continued to blindly follow the investment instructions to a tee, we would never have discovered the potential to do this,” says Andrews.

While casting resin models will require you to modify your long-held casting practices, you’ll soon adapt to this new world—and before long, you may even become an expert.

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