Finding Flaws

IDENTIFYING AND PREVENTING WAX DEFECTS

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In any kind of manufacturing, there are defects in materials, process, or products that need to be corrected. Ideally, problems should be prevented early in the process, rather than fixed at the end—especially since the final rework stage is one of the most costly labor steps in jewelry manufacturing.

Of course, to prevent them, you must know what causes them. And that's not quite as simple as it sounds—for casting, in particular. Manufacturers often waste thousands, perhaps millions, of dollars trying to diagnose defects in the casting process, when actually the flaws can be traced back to one of the most overlooked areas: the wax department.

What follows are some of the most common wax defects. Once identified correctly, these problems are usually simple to fix, saving you money immediately.

Air Bubbles in the Wax

Bubbles under the surface of the wax appear either when air is injected into the mold along with the wax or when air in the mold is trapped during the wax injection process. In either case, an air bubble can pop when the casting investment is vacuumed, and when it does the void fills with the investment slurry. Later, the metal fills around these formations and—*presto!*—investment inclusions, which most often appear as small, rounded holes in the castings.

You can inspect waxes for the presence of bubbles by holding them up to a small table lamp. The bubbles will appear as light spots, although how easy it is to see them will depend on the "readability" of your wax. You can then pop them with a heated pointed tool and fill the exposed holes with wax. Due to the flow dynamics of wax in a mold, these defects will tend to show up in approximately the same places on all your waxes or castings of the same style.

A better solution is to eliminate the source of the bubbles whenever possible. How that is accomplished depends on whether the air is being trapped during the wax injection process or is being introduced with the wax.

Trapped air. If air doesn't escape the mold at an equal or faster rate than that at which the wax is being injected, it will become trapped. These types of trapped air bubbles can be reduced or prevented by the proper application of powder in mold vents, which allows air to escape from the mold cavity during injection. Reducing the injection pressure and slowing the injection rate will also help.

Air can also be trapped in molds if, because of the way the model is gated, the wax must flow backward turbulently to fill the pattern. This type of gating configuration can cause problems in casting as well.

Introduced air. Several sources can introduce air into the mold. One source is dissolved gas in the wax. Another is air that becomes trapped when new wax chips or dots are loaded into the wax pot: If small spaces between the cold chips are covered by a molten surface before the air can escape, these bubbles can be injected into the mold.

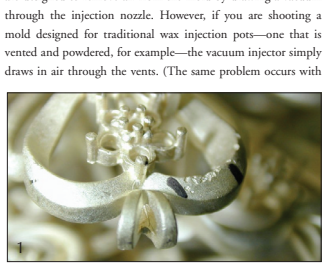
To overcome these challenges, pre-melt the wax in a reservoir unit and vacuum de-gas it before loading it into production wax pots. To do this, you will need a transparent lid with an airtight seal and a fitting for a vacuum line, as well as a separate vacuum release valve. If you don't have these resources, you could vacuum de-gas the production pots; just remember to isolate the pressure gauge on a wax pot during the process. (To do so, install a small ball valve between the gauge and the wax pot, and close the valve before starting the vacuum pump.) Also, never de-gas a full wax pot, or you will likely end up with wax in the vacuum hose.

Another source of introduced air is water vapor from condensation in compressed air lines. The pistons of an air compressor heat up during use, warming the air. This warm, humid air travels along the air pipes into the often air-conditioned wax injection room. The pipes are cooler in this room, so water vapor condenses and collects. This water eventually makes its way into the wax pot, where it will provide hours of air-bubble-repair enjoyment. To avoid this problem, you need to dry the air going to your wax pots. The use of line dryers, desiccant dryers, or a combination of the two is highly recommended.

Under certain conditions, automatic vacuum wax injectors can also cause bubbles in waxes. This is a source that most manufacturing companies don't consider and wax pot manufacturers don't want to discuss. Tool suppliers might tell you that a new automatic vacuum wax injector will cure your wax injection problems and increase your production. It would be more accurate to say that a well-engineered, properly aligned and maintained, autoclamp vacuum wax injector can help produce waxes of consistent high quality and weight if used with properly prepared molds.

Waxes produced by automatic vacuum wax injectors are generally more consistent than those shot by hand on conventional wax pots. That's because the parameters are easier to repeat: Once you establish the proper combinations of wax injection pressure, clamp pressure, and forward force against the nozzle for each mold or mold group, automatic wax injectors can increase your production through decreased rejection rates.

But much depends on the mold itself. Most of these machines are designed to remove air from the mold by drawing a vacuum through the injection nozzle. However, if you are shooting a mold designed for traditional wax injection pots—one that is vented and powdered, for example—the vacuum injector simply draws in air through the vents. (The same problem occurs with



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unvented molds that do not make a complete seal on the injection nozzle.) If air gets into a mold through either a vent or a leak, you gain nothing from the vacuum stage of the injector's process. Rather, some air will be drawn through the molten wax in the injection nozzle, creating small bubbles that will then be injected into the mold with no chance of escaping.

Improper Pressures

An inadequate escape route for air during wax injection can also cause the wax pattern not to fill completely. When this occurs, workers are often tempted to adjust the injection, clamp, or forward pressures, or all three. However, this may only contribute to the wax bubble problem.

For example: The pattern doesn't fill, so the worker turns up the injection pressure. The injection pressure is now so high that the worker must apply greater clamping pressure on the mold to keep the wax from leaking out the sides. This additional clamping can close off small vents, further trapping air in the mold.

The worker may also raise the forward pressure. But too much forward pressure will cause the mold to split at the injection nozzle, allowing air into the wax stream. Because of this tendency, additional clamp pressure must be applied to keep the wax from leaking—which, again, will lead to small vents being sealed and air being trapped.

These kinds of defects are more commonly associated with hand wax injection because of its variable nature. This is where auto-clamp systems are a big plus; they allow you to discover, document, and repeat the ideal pressure combinations, eliminating the three pressures from the list of suspected defect sources relatively easily.

Powder & Spray Procedures

Part of the wax department training that is often incomplete is the proper use and application of powder and silicone spray for rubber molds. Silicone sprays act as lubricants or mold release agents to facilitate easy, distortion-free removal of the wax from the rubber mold cavity. Powder creates a microscopic path for the air in the mold to escape through the vents as wax is injected. Each of these products must be used correctly for best results.

Ideally, the powder used should be very fine and organic (burnable), such as cornstarch or rice flour. Talcum powder is commonly used in the wax injection areas of the jewelry business because it is not as susceptible to humidity as cornstarch. However, talc is a mineral and does not burn out if it gets on or in the wax. Because it is lighter than metal, it floats to the surface of the molten metal stream and causes a grainy, rough surface on the casting (Figure 1).

Worse yet, many factories allow talcum powder to be applied with a "powder hammer," a piece of cloth wrapped around the talcum powder and tightly bound with string or rubber bands. Not only does this "tool" indiscriminately apply powder throughout the mold cavity, it also applies whatever dirt or foreign matter that happened to be on the table where it was laid.

Another potential problem is the misuse of silicone mold release sprays. I have been to factories where the liberal application of powder is immediately followed by a good dose of silicone spray, or vice versa. The powder traps or absorbs the liquid of the silicone spray, making a positive formation in the mold cavity. When the mold is injected, the wax flows over and around these formations of wet powder. This results in a pitted surface that, in extreme cases, can have an appearance similar to that caused by investment erosion or spalling (Figure 2).

These wet powder formations usually remain in the mold when the wax is extracted, and they duplicate the same surface defect over and over if not removed. Even if the clump of wet powder stayed with the wax when it was pulled from the mold, the powder would likely be washed out during the investing process and show up as a negative space in the casting surface.

The overuse of silicone mold release spray alone can also produce surface defects. These defects, which appear as smooth, rounded, irregularly shaped negative spaces in the casting surface, are caused when wax is injected into the mold cavity before the mold release spray has had time to dry. The wax pushes the droplets around before ultimately forming around them. I have seen this defect incorrectly identified as gas porosity several times.


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To reduce the occurrence of such problems, make sure rubber molds are handled correctly. First, switch to cornstarch or rice flour, which will burn out cleanly if it accidentally gets on the

wax. [Editor's Note: See also "Getting to the Root of the Problem," page 23.] To overcome the humidity issue, keep the powder in a sealed container when not in use, and keep a small porous packet of desiccant in the container. Just don't forget to replace or regenerate the desiccant packet from time to time.

When applying powder, apply it only to areas where the wax and the powder will have minimal contact. While bending the mold so that the vents are open, apply a light dusting of powder into the vent areas using a small, soft brush, then use a compressed air gun with "dry" air to blow out the excess powder. Release the tension on the mold so that the vents close, then spray with a very fine, light mist of a silicone mold release agent. Avoid sprays that spit larger droplets onto your molds.

Cleanliness is also critical. Install regular inspection and cleaning procedures for rubber molds. Keep workstations and wax trays clean and free of contaminants that could get in or on the waxes. While this type of contamination may not cause problems with the metal itself, it can cause surface defects, increasing the work time needed to obtain a level, smooth surface on the casting. In addition, because eliminating surface defects requires the removal of metal, it increases the rate of metal loss, and increases the possibility of working down to subsurface porosity, resulting in more repair work.

Poor Seals on the Wax Tree

The wax tree can also contribute to defects. One of the most important issues here is the quality of the connection between the gate and the sprue. (The gate is the part connecting the jewelry wax pattern to the central trunk of the tree. The sprue is the central trunk.)

The gate/sprue connection (filet) should be sealed and smooth all the way around. Many people mistakenly use a wax pen to melt a hole into the sprue, then insert the gate into that molten spot. This method leaves sharp inward angles or points in the wax, which will turn into sharp brittle pieces of investment that can break off during casting. When they do, they are pushed to the outside of the mold cavity because of the difference in density between the metal and the investment.

To avoid this potential inclusion, the wax pen can be used to create a filet around the base of the gate/sprue junction. But to do this job faster and reduce the chances of a defect, dip the end of the wax gate into a small melting reservoir of sticky wax. (Thanks to Eddie Bell of The Bell Group in Albuquerque, New Mexico, who showed me this trick years ago.) You still need to seal around the base of the gate/sprue to create a smooth filet, but the sticky wax supplies some material to create the filet with. It also makes the tree building function much faster.

Be aware, though: The travel time between wax reservoir and sprue can allow the surface of the sticky wax to cool slightly. When this happens, unsealed gates sometimes snap off the sprue. To avoid this problem, pick up your wax pen once per row or column and seal the connections.

Fixing Your System

Knowing that you have defects is easy; the challenge is in knowing where the defects really come from and how to fix them—especially when there are several stacked causes. It isn't enough to fix some of the problems. You must fix them all.

For consistent results, you must go through your system continually to reduce or eliminate all the possibilities that can cause these types of defects. The good news it that none of the prevention measures described in this article are difficult to implement. I have often observed that causes of the problems I am called in to solve are relatively obvious, and may have been noticed before. But because the defects have grown slowly over time, or the workers were too busy, the problem reached a critical point. The practices that are causing the problem have become "normal" and go unrecognized or forgotten. By questioning everything and forcing yourself to become aware of all potential problems, you can stop them well before they reach the rework stage.