IMPROVEMENTS IN THE WAX ROOM: SOLUBLE WAXES

Soluble waxes are one of the products that allow the investment caster to do what makes investment casting truly unique. Unfortunately soluble waxes have not received the attention they deserve in proportion to the important role they play in the process. Soluble waxes are often relegated to the oldest and least functional machines and are regarded as messy, temperamental to inject and difficult to clean. The resultant soluble wax patterns are often filled with defects, cracks and crazing that have to be repaired or re-shot at great expense.

Many soluble wax formulas in use today were formulated over 25 years ago and still contain fibers and/or fillers which directly contribute to the problems previously described. A wish list of desirable soluble wax properties includes no fibers, and rapid leach among others. That product is available today and when used with sound wax room practices the investment caster can realize increased productivity at the beginning of the casting process.

Basic Description of Soluble Waxes

Soluble pattern wax or water soluble core waxes are used to form incredibly complex internal cavities inside a casting. Undercuts and blind holes that normal tooling is not able to achieve can be formed in wax patterns prior to shell application through the use of these water soluble cores. This is accomplished by injecting the water soluble pattern wax in to the shape of the required cavity. The soluble wax core is then put into a wax pattern die and the pattern wax is injected around the soluble wax core or “wrapped”. The water soluble wax is then leached or dissolved out of the pattern wax in a mild acid solution leaving a regular wax pattern with a cavity. This is what makes investment casting truly unique in the world of manufacturing. (It should be noted here that an investment caster could use a ceramic core to accomplish the same task but often at much higher tooling, equipment and vendor cost).

Soluble pattern wax materials consist of polyethylene glycols, effervescing agents and various fillers. Fibers are used as a material to give the soluble core wax strength during the cooling process to prevent open cracks. In the past, fillers such as silica, and mica were used to adjust shrinkage, flow and cavitation characteristics.

Problems of Soluble Waxes

Traditional problems of soluble waxes include long dwell times, fragility or lack of “toughness”, and being difficult to prep for “wrapping”. Incredibly slow leach times also hinders productivity and poor surface finish on soluble wax patterns are often accepted as a necessary evil of the overall process. Finally, fibers can clog drains systems and often have to be strained out of the effluent before being sent down the drain. In short, soluble wax is misunderstood and ultimately misused.

Because of the aforementioned problems, most soluble waxes are relegated to the oldest and least productive equipment in the wax room. The heating and conditioning equipment are often at or near the end of their useful life. Faulty or out of date controllers can easily overheat the soluble pattern material even before it makes it to the injection machine. The injection machines are also often in the same condition, with old controllers and less than tight seals. This sets the stage for failure of one of the most important steps in the investment casting process.

How to make better soluble patterns

Let’s start with the basics on how to improve the soluble wax pattern making process. This can be done in a week with little expense; it just takes a concentrated effort to follow until completion.

1. Get a thermometer (accurate and calibrated) to test at all points of the soluble pattern making process, if you do not know what is happening at the injection point, you can’t determine a feasible course of action. Most importantly check the

temperature of the soluble wax at the injection nozzle. Use a large cup and allow the thermometer to stabilize. (Photograph 1)

2. Upgrade your melt and injection equipment so they have accurate controllers.
3. Test the melting and conditioning tank. The temperature of the soluble wax during melting and conditioning should never exceed 200°F. Such a high temperature will start to decompose the effervescing agent giving off carbon dioxide gas.
4. Make sure there is sufficient agitation during melting through injection; due to the high solids content and filler density settling can take place quickly. Proper agitation also ensures that the temperature is homogenous throughout the tank. Take care that the speed and the angle of the agitator does not entrap air.
5. Do not inject into a cold die. Make sure your platens are not too cold or turn them off. If necessary, warm the die before injecting the soluble wax, and keep your platen temperature warm to make a good cosmetically looking soluble core. (It is opposite of pattern wax injection). This process will help the flow of the wax at injection, knitting of the wax at the furthest point opposite the feed, volumetric shrinkage and most of all, surface finish.
6. Observe the viscosity of your current soluble wax in your injection machine and determine the lowest possible temperature that it can be injected. It is important to inject at the lowest possible temperature (depending on soluble core configuration), because it will decrease dwell time and help keep the solids in suspension. Higher temperatures which allow components to settle can cause variations in surface finish, dimensions and strength.
7. Check to see if your dwell time is too long (unexplained cracking). Too much time in a cold mold can cause the soluble wax to cool at varying rates within the pattern which begin to cause stress cracks at the surface of the soluble pattern.
8. A good rule of thumb for injection pressure on soluble wax is 300-400 PSI. This depends on part size and configuration, and is easily adjusted.

Soluble wax removal from the pattern wax is also an important part of the process and must be maintained fastidiously. Leachability of the soluble wax cores depend greatly upon the formulation of the soluble wax. The concentration of the acid in the tank will have an effect on the rate of leaching as well but to a lesser degree. Citric acid and hydrochloric acid have been the most commonly used acids for soluble core removal over the years. Citric acid recently has become more popular or common due to environmental compatibility, handling issues and cost. Temperature of the leach bath of a constant (72°F) and proper circulation are a necessity ensure the fastest possible soluble removal. Finally, make sure your pattern is completely submersed throughout the leaching process this ensures that the acid solution is reaching into the cavities. The addition of liquid detergent in small quantities is helpful to keep residue off your wax patterns and keep your leach bath clean.

Once the soluble core material has been leached out the pattern should be rinsed and thoroughly inspected for any residual soluble core material or breakthrough. The wax patterns should not be allowed to dry before rinsing with water because the residue becomes difficult to remove and can cause quality issues in the casting down the line.
As the quantity of patterns going through the leach tank increases, the acid solution will become weaker as the acid is neutralized. Instead of adding fresh material to the existing acid solution, it is better to start with a completely fresh quantity, so the efficacy of the leach solution will be maintained and productivity can remain at its highest level.

These simple steps will often lead to the immediate realization of increased productivity and therefore increased profitability. Science though has provided us with more opportunity to improve the process through a new generation of soluble waxes that push the envelope ever further.

New Generation of Soluble Waxes

Westech Products, Incorporated has developed a new generation of soluble waxes that are designed to address some of the issues that have plagued previous generations of soluble core material. Westech focused on the following areas of improvement:

-Better surface
-Shorter dwell times
-Excellent strength
-Fast leach

Today's new generation of soluble waxes have more "pattern wax" like properties, which include much better flow at lower temperatures, rapid setup on injection, strength and of course much faster leach times This all improves productivity and profitability.

The formulations of the new generation soluble waxes have a lower viscosity at melting and injection. As a result they can be shot as low as 125°F in some cases, with amazing surface and no flow lines. Lower viscosity of the wax upon injection during the injection process gives you better flow characteristics, knitting and fill.

Simply having the ability of injecting the soluble wax at lower temperatures, thus reducing dwell times, even on large parts, becomes part of the productivity equation. It is possible with the new generation of soluble waxes to see a 20-40% reduction in dwell times.

The durability of the new generation soluble wax is designed without the use of fibers. This allows the injection of very large parts, cylindrical shapes and intricate small cores with less crazing, cracking and flow lines upon cooling without the hassle of fibers. Only when extreme situations call for unusual strength, fibers can still be added without severely affecting viscosity.

Amazingly the most important feature of the new generation of soluble waxes is the ability of the material to dissolve at up to 50% faster than most existing soluble wax formulas. Producing fewer bottlenecks in the leach tank area and smaller (or less) leach tanks are required to accomplish the same amount of production.

Advances in leach time reduction

We have strived to obtain faster leaching of the soluble wax out of wax patterns in a citric acid solution. The new generation soluble wax does that for you. As previously mentioned, the new generation soluble waxes have been developed to eliminate the use of fiber, but fiber can be added if needed. If fibers are added, the leachability of the soluble wax does not change.

To illustrate the improvement in leach time, a test was conducted using test tubes filled with the same volume (11ml) of different soluble waxes. Putting the soluble waxes in test tubes allowed for consistent volumes, while having the ability to observe the leaching progress over the test period. The test tube provides a "real life" situation where soluble core material has been injected into a deep recess and provides a "worst case" for leach out.

The test tubes were filled and allowed to cool for 24 hours, then inserted into a holder (Photograph 2). All samples were then submerged in a mild citric acid bath of 10% solution at the same time and observed at various times over a 3+ hour period (Photographs 3-6). As seen below in Graph 1, the new generation soluble wax reduced leach time by more than half the amount of time of the nearest soluble wax. This result represents a significant improvement in time savings providing new options for the investment caster.

CONCLUSION

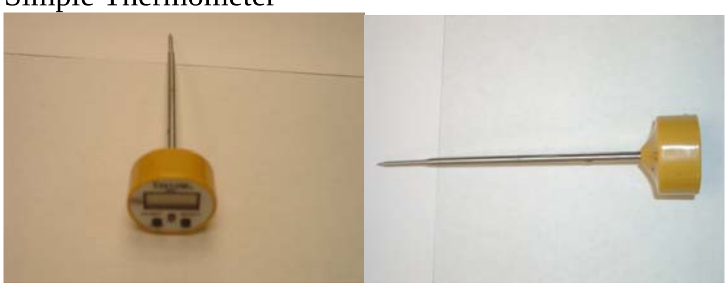
Soluble waxes and their use in creating complex internal cavities in the casting themselves are vitally important to the investment casting industry. When treated with care and respect, soluble waxes become a welcome tool to increase profitability. To get the optimum performance out of the soluble waxes, they need to be used with care and maintenance. Attention to simple details can improve your process and productivity immensely. Coupled with new advances in soluble wax formulation technology the soluble wax department does not have to be treated as an unwelcome relative any longer.

References:

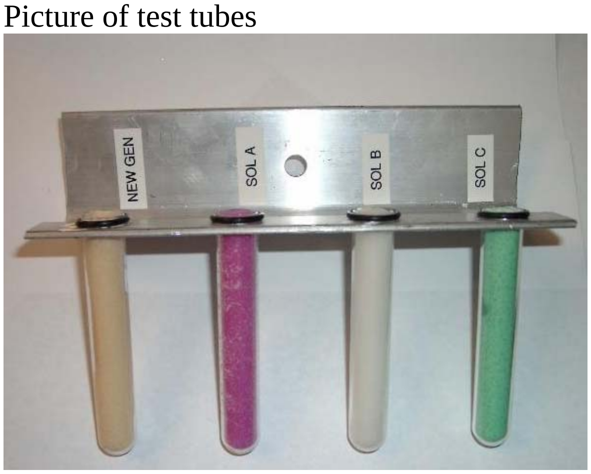
L. Carpenter, "The Use of Specialty Waxes in the Investment Casting Process", Investment Casting Waxes, AFS, Inc. 1988.

J. Argueso, "Frequently Encountered Problems in a Wax Room", reprinted from Modern Casting, 1993.

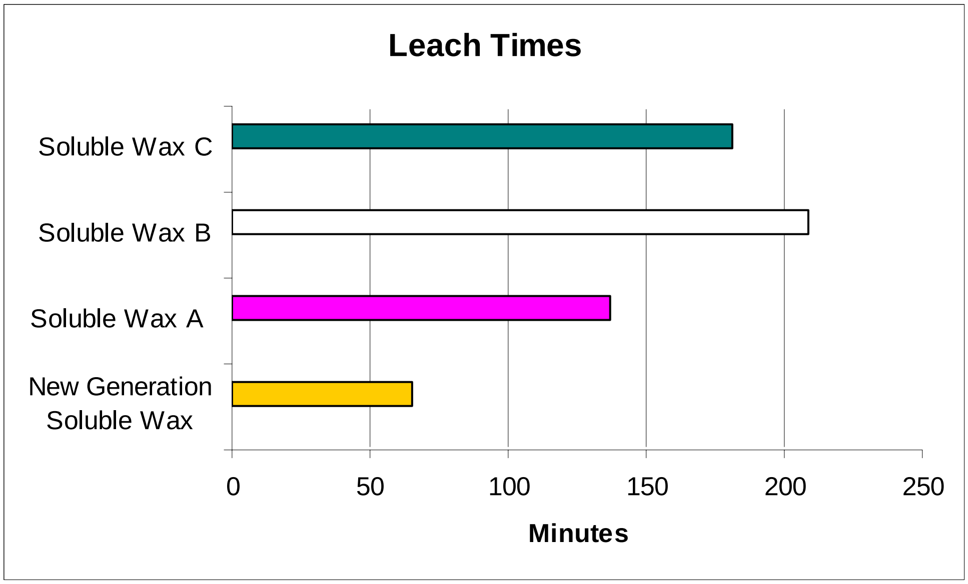
Photograph 1
Simple Thermometer



Photograph 2
Picture of test tubes



Graph 1



Photograph 3
Picture of test tubes in bath at 30 minutes

Photograph 4
Picture of test tube in bath at 45 minutes

Photograph 5

Picture of test tube in bath at 90 minutes

Photograph 6

Picture of test tube in bath at 150 minutes