Innovative Dewax Method Unlocks Potential for Investment Casters

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Abstract

Totally new methods are infrequent in a mature industry like investment casting. However, just such an advance has occurred for the dewax process. This patent pending technique involves an inverted directional solidification approach. Wax is removed with little or no stress on the shell. By using this technique, it is possible to remove several constraints placed on the investment caster that are in place to prevent or reduce shell cracking.

Introduction

For the past half century the main methods of removing wax from investment casting shells in the USA has been the steam autoclave. The distant second most popular method is flash fire dewax. These two methods have been used to remove wax from an estimated 90-95% of all investment casting shells made during this time. The remaining few percent were accomplished by hot wax dewax, microwave dewax, and vapor dewax. The later three have significant environmental or technological issues that limit their suitability.

All of these methods, while substantially different, have one thing in common. Energy to melt the wax is applied in a relatively uniform manner at one time to the entire shell. This uniformity of applied energy has long been recognized as a problem leading to shell cracking. One method used to overcome the cracking is the common use of two different waxes for patterns and gating. The gating wax typically is required to have a melt point 10 degrees Fahrenheit below that of the pattern wax to help reduce cracking of the shell from internal wax pressure. Several other methods have been developed to also help prevent cracking.

A recent patent applied for invention, which Buntrock Industries has acquired rights to market the technology, removes the wax much differently than the current and past methods of removing wax. Instead of applying energy uniformly to the entire shell at once, energy is applied to a small horizontal band around the shell. The band is then progressively moved up the shell. This process has its origin in the metallurgy of directional solidification. This directional wax removal applies less stress to the ceramic shell because the entire wax is not being heated. Only a small portion of the wax is heated at one time and liquid wax merely runs out without building pressure. Figure 1 shows a schematic diagram of how directional wax melting is different from traditional dewax methods.

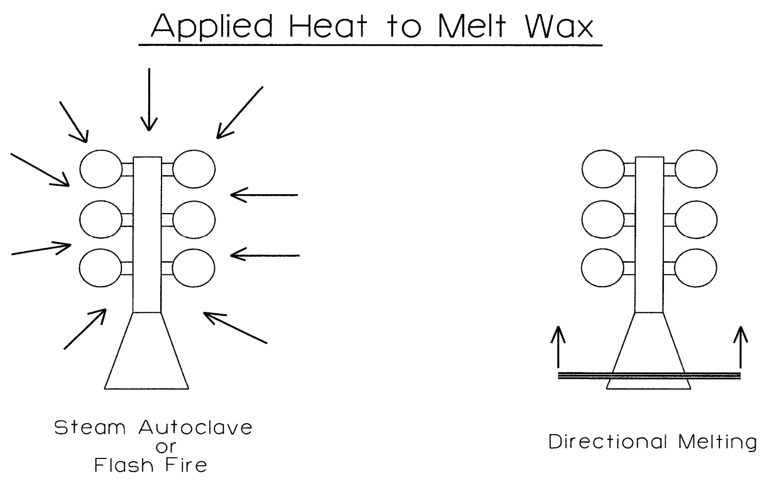

Figure 1. Comparison of traditional dewax and directional wax removal.

In theory, if the internal wax stress is significantly lowered, shell cracking should diminish and furthermore, the constraints used to make the autoclave or flash fire dewax process work acceptably, could be removed. That is to say, an engineer is no longer bound by the past ways of constructing a shell or by using normal methods for dewax crack prevention. Some of the things that may be able to be reduced or eliminated are:

1. Number of dips or shell thickness.
2. Different melting point waxes.
3. Shell reinforcement using wax, wire, ceramic string, ceramic rods
4. Dewax vents.
5. Patching of cracks in the shell.
6. Inclusions in the casting due to shell cracks and patching.

Furthermore, it may be possible to use completely different waxes than are currently used. For example, waxes that have high thermal conductivity are desirable for quick set up time after wax injection, but they are not used because they do poorly in the present dewax processes. Now, maybe they can be used.

Experimental Method

In order to fully demonstrate the feasibility of this new dewax technique, Buntrock Industries enlisted the help of Westpoint Solutions, Inc. to design and build a prototype machine for directional wax removal. Early work was done by lowering the shell into a hot oil bath. So, this method was used for the prototype equipment. Figure 2 shows the prototype machine. The temperature of the oil and the speed of lowering the shell into the oil are variable. A method of keeping the wax separate from the oil was incorporated into the design. At the bottom left of Figure 2, you can see the liquid wax outlet.

Figure 2 – Prototype directional dewax, hot oil dewax equipment

To prove the equipment and the process, a dewax test piece was needed to shell and run in the prototype equipment and in standard dewax processes. A suitable test piece would need to crack in the standard process and not in the directional dewax process. Figure 3 shows the wax assembly that was used. With this configuration of wax and also by varying the shell thickness and shell type, it was thought that shells would crack in either autoclave or flash fire dewax, but not in the directional melting process. Note that both the cone and gating have sharp edges to promote cracking. The wax in the cone must travel through a restriction to flow out of the shell.

Waxes were injected and assembled at IMDS Cencast in Molalla, Oregon. Some waxes were shelled at Cencast and some at Calcagno Foundry in Boring, Oregon. Those shells to be autoclaved were processed at Ti-Squared Technologies in Sweet Home, Oregon. The directional hot oil dewax was done using the prototype equipment at Buntrock Technology Lab in Portland, Oregon.

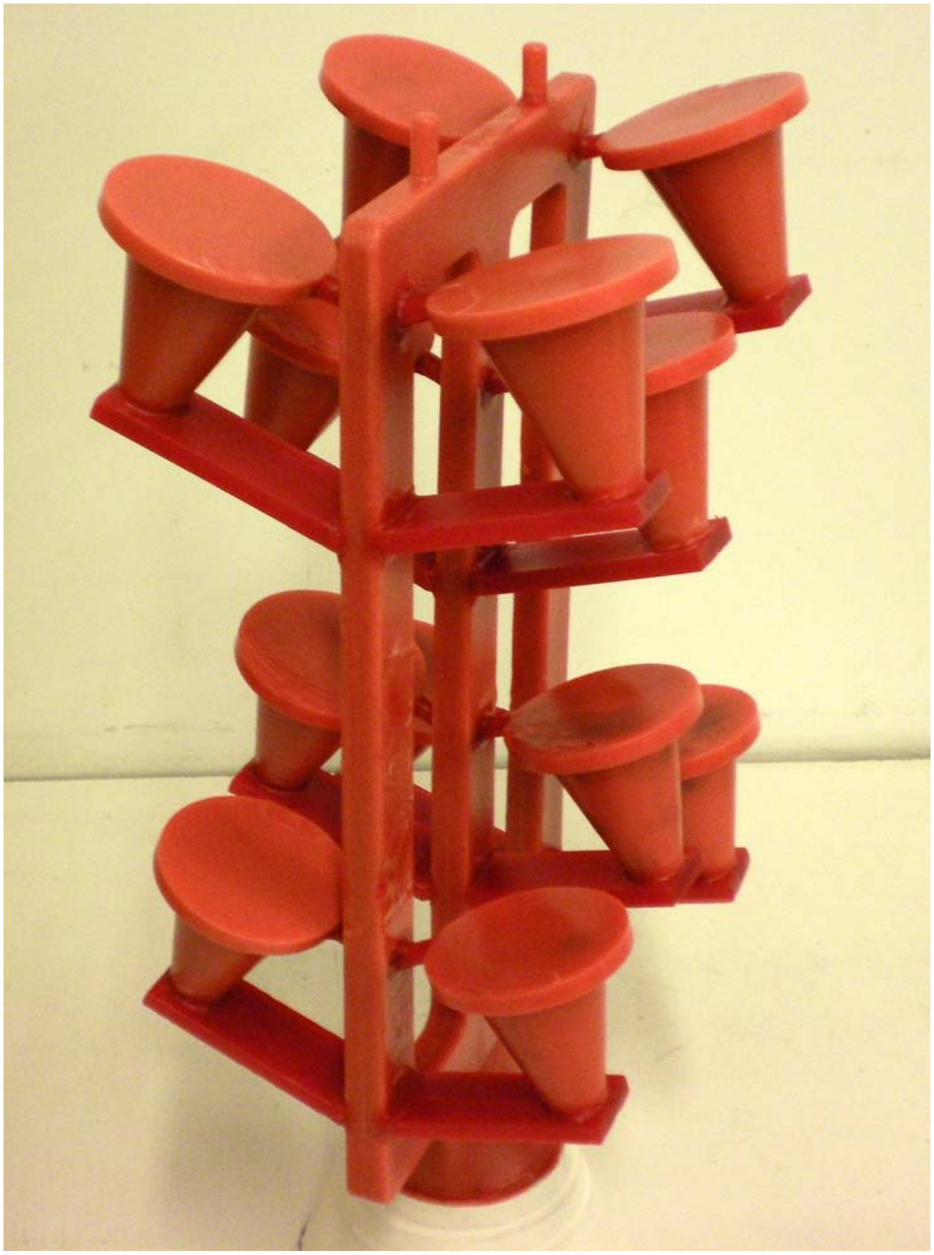

Figure 3 – Crack prone wax assembly 18" tall.

All wax assemblies had double prime dips at Cencast. Those receiving Fibercoat 1109 backup were dipped also at Cencast. Dip sequences were 2 primes + 2 or 3 Backups + seal. Thinner shells were made with one less backup. Standard fused silica backup shell was applied in a similar fashion at Calcagno Foundry. All backup stucco was 30x50 fused silica.

After the waxes were dipped and de-waxed, they were burned out to remove residual wax, oil, and carbon. They were then inspected visually with a magnifying glass for through wall cracks and also each cone was removed and sectioned. Interior cracks of the cone were counted. Observations were also made regarding cracking on the gating. Included below are some photos showing various stages of shells during the experiment. Not all conditions are shown.

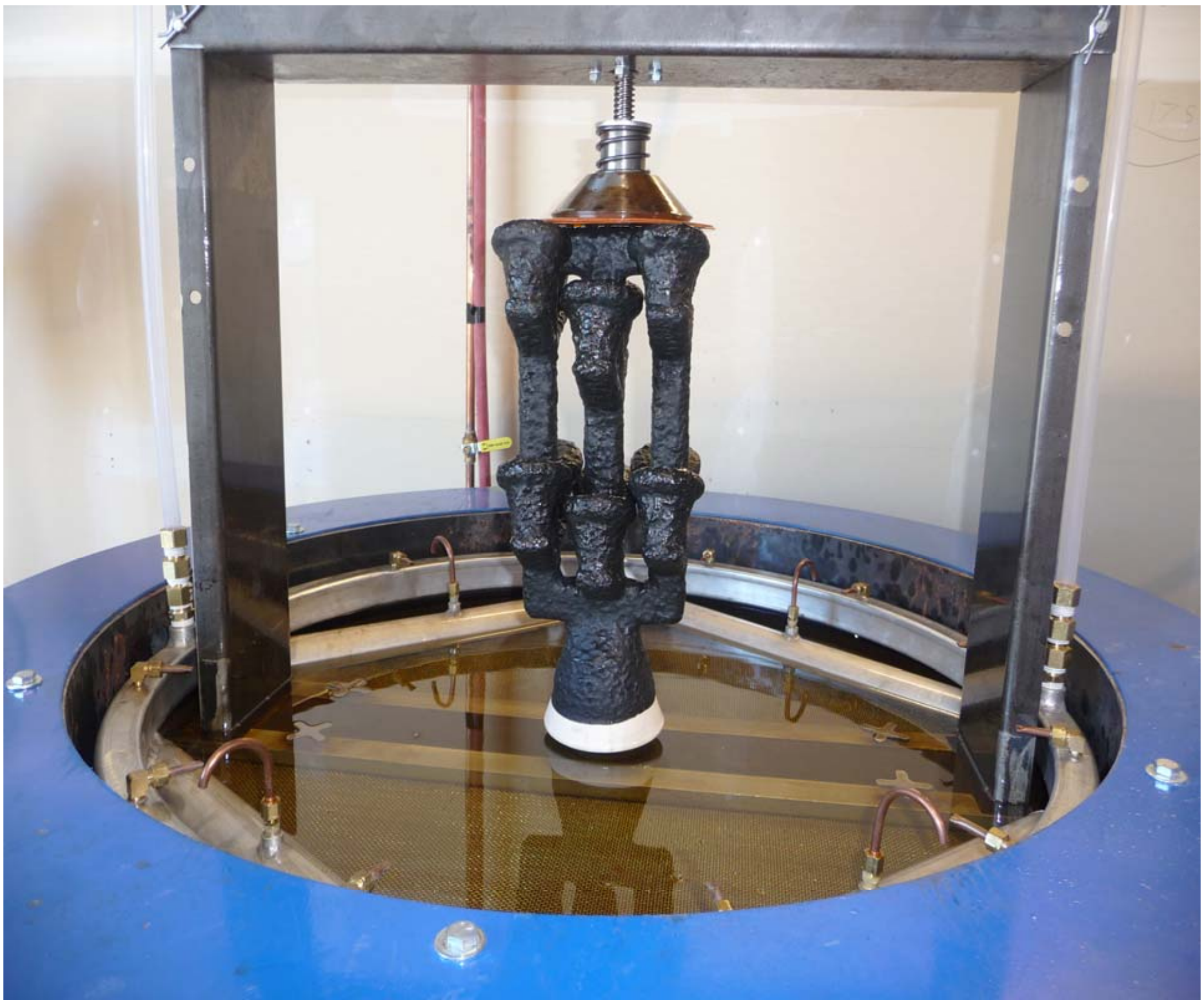

Figure 4 – Fibercoat 1109 shell after directional hot oil wax removal.

Figure 5 – Fused Silica shell after flash fire dewax.

Figure 6 – Fibercoat 1109 shell after autoclave dewax.

Figure 7 – Through wall crack on Fibercoat 1109 shell after flash fire dewax.

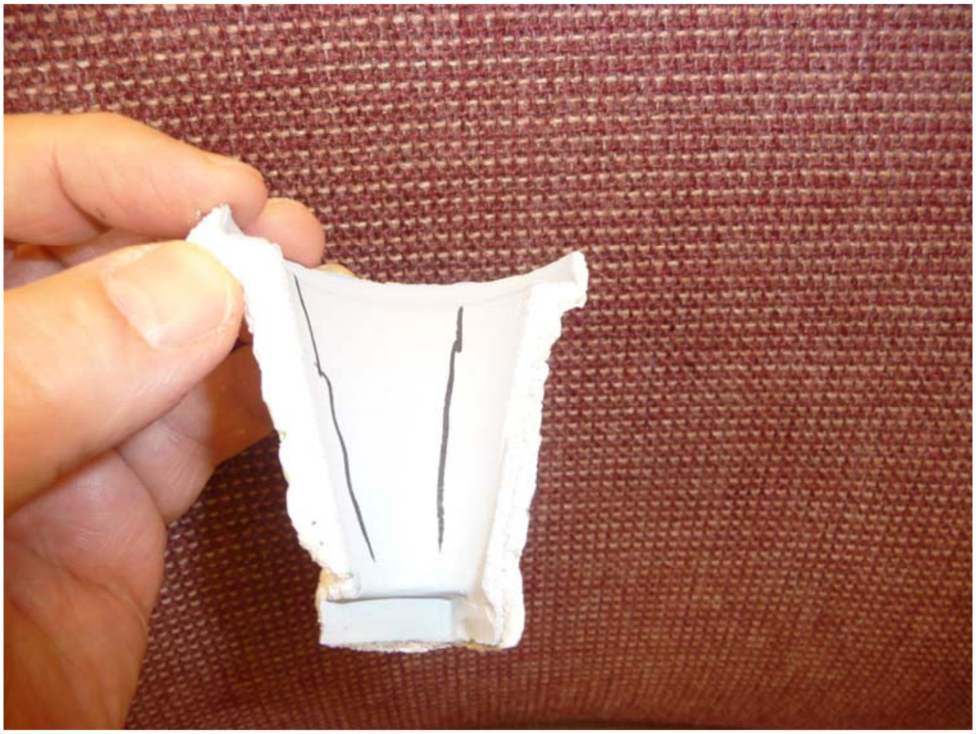

Figure 8 – Interior cracks on prime coat of Fibercoat 1109 after autoclave.

Results

Backup Shell	Number BU Dips	Avg. Shell Thickness	Type of Dewax	Outside Cracks	Inside Cracks	Gating Cracks
FC1109	2	0.25	Flash Fire	0	7	N/A
	2	0.25	Autoclave	0	0	N/A
	2	0.25	Directional	0	0	N/A
Fused Silica	3	0.25	Flash Fire	13	32	N/A
	3	0.25	Autoclave	0	0	2
	3	0.25	Directional	0	0	3

Both autoclave and directional melting proved to be better than flash fire dewax and Fibercoat 1109 was much better than the fused silica shell system when flash fired dewaxed. It is clear that the test wax assembly does not discriminate between autoclave and directional dewax.

Two more shells were made but only in the fused silica shell. One less dip was applied making the shell thinner. In addition the wax gate was restricted in size by about 50%. This restriction and thin shell are shown in Figure 9 below. One shell was dewaxed in the autoclave and one in the hot oil directional melting equipment.

Figure 9 – Fused silica backup shell with 2 backup dips and restriction in gating.

The results of these two trial molds are presented below.

Backup Shell	Number BU Dips	Avg. Shell Thickness	Type of Dewax	Outside Cracks	Inside Cracks	Gating Cracks
Fused Silica	2	0.17	Autoclave	2	2	12
	2	0.17	Directional	0	7	2

The autoclaved fused silica shell had one cone that was severely cracked across and around the top. Shown in figure 10. All of the restricted gates of the autoclaved shell were cracked while there were only 2 cracked in the directional melting dewax method. Cracks in the gating are shown in Figure 11, but difficult to see except for the red wax bleeding through the shell.

Figure 10 – Severely cracked fused silica thin shell, autoclave dewax, restricted gate.

Figure 11 – Fused silica thin shell, autoclaved, restricted gating. All 12 gates cracked.
Red wax bleeding through shell because of cracks.

Discussion

The concept of directional dewax has been shown to be reasonably accurate. It does appear that there is an advantage to this technique. There are some issues when using hot oil that need more investigation. For example, melting the wax from the ceramic cup was time consuming. This causes the shell to heat up while over the hot oil. There are methods of heat shielding that could reduce this effect.

Care was taken to transport shells to various locations for dipping and dewax so not to damage the shells.

Clearly, some amount of optimization needs to be done. For example in shortening the time. We used about 15 minutes, but could possibly gone faster with higher temperature oil. Our oil was 290 deg. F.

A separate mold was dewaxed by directional melting but water was used instead of oil. The shell construction was Fibercoat 1109 and about 0.35 inches thick, so not particularly challenging.

One advantage of this new method of dewax is that it is a low energy method and likely can be shown to be considerably more energy efficient, although I have not done that.

Conclusions

1. Hot oil directional wax removal was shown to be the least stressful on difficult parts to dewax.
2. Hot oil directional dewax would allow engineers more latitude in choosing wax and shell properties, shell thickness, and gating design.
3. More work needs to be done to learn how best to take advantage of this new technology.