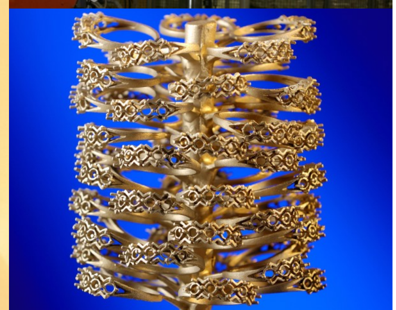
Ransom & Randolph

MAY-JUN
2019

Casting Connection



How Process Variables Impact Ceramic Shell Properties & Performance

The impact of shell material selection on shell properties has been explored extensively. Investigating how process variables, like dipping/draining techniques, impact ceramic shell properties and performance is unexplored territory.

Utilizing a Design of Experiment (DOE) process, the effects that certain controllable shell building process variables have on shell properties were explored. These input variables include; backup slurry viscosity, dwell time on the part in the slurry and the draining technique used.

Viscosity is a measure of the thinness or thickness of a fluid as measured by a flow cup. Thinner materials have a lower viscosity and thicker materials have a higher viscosity, by definition. The actual viscosity a foundry uses is likely determined by the parts being made, specifically the size, geometry and shape. Typically, primary slurries are thicker than backup slurries; although, with the influx in fiber-based slurries in the industry, backup slurry viscosities are approaching those of primary slurries.

Dwell time is the time that a ceramic shell assembly is submerged in the slurry. Slurry dwell time is often overlooked, but it is an important variable. A dried shell that is dipped into a slurry is, to some degree, a ceramic sponge, as it absorbs liquid. While the addition of polymers to a backup slurry can minimize the amount of liquid absorbed, all shells absorb liquid.

If a shell is dipped into a slurry for a short dwell time and is removed prior to

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Inside this issue

Meet Us at the Symposium

Calling all jewelry casters! Look for Michael Stover at The Santa Fe Symposium in Albuquerque, New Mexico May 19-22. Mike will be presenting on Sunday, May 19.

In daily practice, casters typically focus on eliminating variables at the front end of the investing process. What about the end result and the investment removal process?

Mike's paper, *How Process Variables Impact Investment Removal Properties*, explores variables that impact how investment removes from castings. He considers influences not typically thought to impact removal properties and studies process variables during removal. Do mixing ratios impact removal? Are there time and temperature influences that play a role in how the investment will remove? These questions are answered.

If you are unable to attend the Santa Fe Symposium, but are interested in the findings, please email us at: RR-Marketing@dentsply.com for a copy, available May 28th.

For show information, visit: http://www.santafesymposium.org/

Bastian Schulte
Application Engineer

Welcome Bastian!

R&R is pleased to announce Bastian Schulte's appointment as Application Engineer.

In this role, Schulte will be responsible for technical support to R&R ceramic shell customers, providing comprehensive product solutions and troubleshooting process issues. He will serve customers throughout the European Union, excluding Eastern Europe, United Kingdom, Benelux and Scandinavia.

Schulte joins the R&R team with 21 years of technical know-how and hands-on foundry experience; having held prior positions as Castings Material Engineer, Development Engineer and Production Engineer. He holds a Bachelor of Engineering – Applied Material Technology, specializing in Casting Technology from the University Duisburg-Essen in Duisburg, Germany. Schulte has his Trainer Certificate for foundry education and was awarded as Best Apprentice in Federal State in 2002.

"I am proud to announce the appointment of Bastian Schulte as our newest Application Engineer," said Michael J. Hendricks, R&R Applications Engineering Director. "We are confident that Bastian's abilities will benefit our customers in the European market and keep R&R at the forefront of technical service to the investment casting industry."

Schulte succeeded Mark Bijvoet, R&R European Technical Manager, upon his retirement.

How Process Variables Impact...

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the ceramic sponge absorbing its full capacity, the shell continues to absorb liquid from the slurry coat applied after it is removed from the slurry. The rheology of the slurry layer can change as it continues to absorb liquid, raising the viscosity of the slurry in that layer.

A longer slurry dwell time should result in the ceramic sponge absorbing its full capacity from the slurry and not from the shell coat; therefore, the rheology of the draining slurry coat from the part will be consistent and noticeably thinner. Essentially, a longer dwell time in a slurry acts similarly to a prewet in many cases.

In the shell building process, draining removes excess slurry from the freshly dipped cluster, ensures all sections of the cluster are covered in wet slurry and provides a uniform coat that can accept adequate stucco on all edges and surfaces. The actual draining technique is a combination of manipulation and time. Wet clusters are manipulated at vertical angles and rotated to keep the slurry uniform, as excess slurry drips off and back into the slurry tank. The time that it takes to achieve the uniform coat is varied as required.

As the cluster exits the slurry tank, more than half of the wet slurry on the cluster is estimated to drain off and back into the tank as excess. Recognizing this, it is important to understand what can be done to speed up the time it takes for this excess slurry to drain. If a cluster is constantly being manipulated and rotated, the drain time is extended. However, if the cluster is held motionless for a short time immediately after it exits the slurry, more of the excess slurry drains off. The remaining slurry can then be spread evenly through manipulation and rotation. We refer to this concept of motionless draining of excess slurry before manipulation as a gush.

The input variables were tested at three levels (Table 1) to determine their impact on standard shell properties like strength, thickness and permeability.

Factor	Level 1	Level 2	Level 3
Viscosity (seconds Zahn 5)	10	14	N/A
Dwell Time (seconds in slurry)	3	10	20
Draining Technique (gush seconds/manipulation seconds)	Drain 1 - 0/10	Drain 2 - 0/20	Gush + Drain 1 - 10/10

Table 1 – Input Variable Definition

The DOE software utilized determines which factors are significant based on the calculated p-value. The p-value measures the probability that the results were obtained by chance. Any p-value less than 0.05 indicates that there is at least a 95% chance that the design factor is significant. In Table 2, factors that have a significant effect on the design outputs are marked with an X.

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EICF Helsinki Seminar & Exhibition

Heading to Helsinki for EICF?

What: Lectures, suppliers exhibition & industry visit
When: May 20-22, 2019
Where: Helsinki, Finland
Venue: Marina Congress Center

Stop by to see Carel Wegman, Bastian Schulte and Stefan Frank at table top 10.

For show information, visit: https://www.eicf.org/events/helsinki-2019/welcome/

Carel Wegman

Bastian Schulte

Stefan Frank

european investment casters' federation

Jewelry FAQ

Q. Is your investment hazardous?

A. Due to the presence of respirable particles (<10 microns) of crystalline silica in investments, these products do carry a respirable warning. It is extremely important to determine the level of exposure to which your operators are regularly subjected. The Safety Data Sheets (SDS) outline the personal protection guidelines for operators, based on the amount of exposure. Refer to the SDS for the product you are using and contact a health and safety expert with any questions you may have.

Have a Jewelry Question?

Ask our jewelry expert!
Mike.Stover@dentsply.com

For more jewelry FAQs, visit: www.ransom-randolph.com/jewelry-faqs

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Factor	MOR (green)	AFL (green)	Thickness (flat)	Thickness (round)	Permeability (hot)	Edge build (top)	Edge build (bottom)
Viscosity							
Dwell Time		X	X	X		X	
Draining Technique				X			X

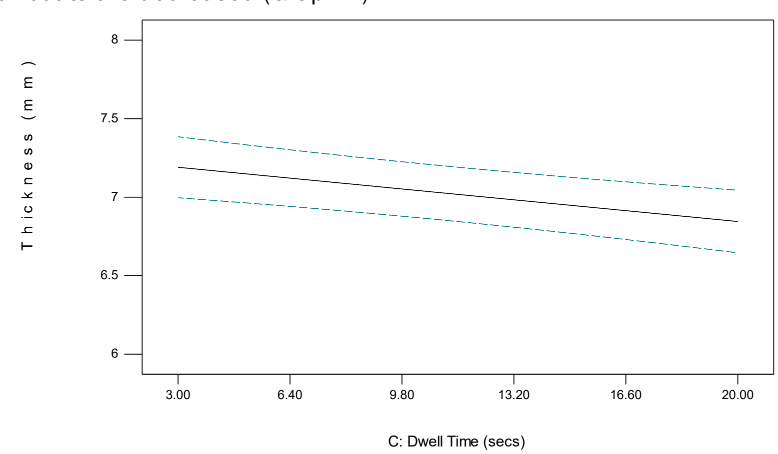
Table 2 – Significant Factors Affecting Design Output

This information allows us to make some interesting observations:

- A four second change of viscosity did not impact any of the design responses. This result is somewhat surprising as viscosity control in a foundry is thought to be a key factor in process control. Further testing would need to be conducted to identify how large a change is required to affect the responses.
- No factor interactions were produced, meaning that each factor produced a response that is independent of the results from the other input factors.
- Draining technique and dwell times impact the shell properties tested. One of the primary objectives was to look specifically at this possibility and determine if or how this could be incorporated in the shell building process.

A closer look at the data shows the effect of each significant factor and allows a better understanding of the impact of draining and dwell times on shell properties.

As dwell time of the part in the slurry is increased, the thickness of the shell coats are decreased (Graph 1).



Graph 1 – Effect of Dwell Time on Shell Thickness

For parts where bridging is a concern, increasing dwell time could decrease the thickness in recessed locations. Increasing dwell time could also remove the need to prewet certain parts. A foundry could experiment to see if a longer dwell time could replace any prewetting on their parts. Conversely, to increase shell thickness, the dwell time in the slurry could be reduced.

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How Process Variables Impact...

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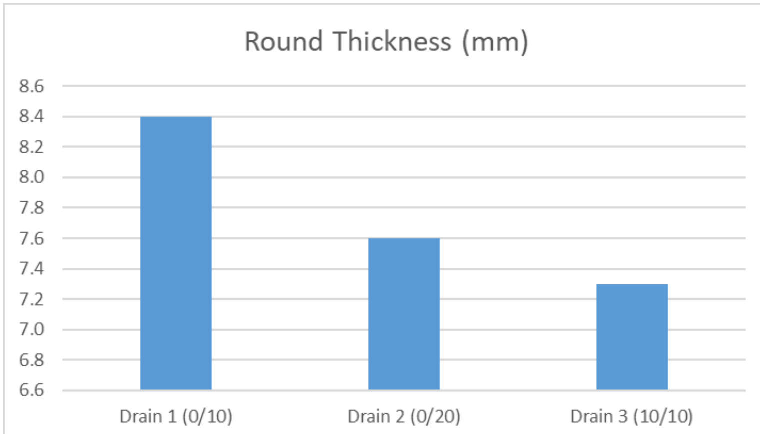
While the draining technique did not have an effect on flat surface thickness, it did affect the thickness on round permeability samples (Graph 2). A shorter drain time (drain 1) will result in a thicker shell. Adding a stagnate portion, or gush (drain 3) created a thinner shell sample than when constantly manipulated (drain 2), even though the overall drain time was the same for both.



Graph 2– Effect of Draining Technique on Thickness of Round Parts

In practice this indicates that adding a stagnate drain or gush to each dip cycle before manipulation could reduce the time required to fully drain the parts. This time savings would likely be greater when multiple trees

"Foundries should develop individualized draining techniques based on part structure in order to optimize shell build."

are dipped robotically and there is slurry dripping off one part and on to another. For seal coats, an extended gush could be implemented to allow excess slurry to drain off the parts faster.

In summary, foundries should develop individualized draining techniques based on part structure in order to optimize shell build. While flat parts can have a simplified drain time without concern for uneven shell building, complex parts may require a combination of different draining techniques. For parts where bridging is a concern, the addition of a stagnate drain or gush could benefit the process by creating a thinner coat in recessed locations. For foundries suffering from edge cracking, a reduction in the drain time may prove more beneficial than increasing viscosity in building uniform edges.

Minimizing dwell and drain times allows the foundry to improve casting throughput, taking less time per shell dip. Cycle times could be adjusted to improve throughput without a negative impact to shell strength; simply by reducing slurry dwell and drain times. In facilities where shells are handled manually, reducing dwell and drain times may positively impact physical ergonomics for shell room personnel. In robot rooms, speeding the rotation cycle may be possible.

An excerpt from: Berta, Wolfe, Hendricks (2018) *How Process Variables Impact Ceramic Shell Properties and Performance.* Maumee, OH: Ransom & Randolph. To request a complete copy of this paper, please email R&R at: RR-Marketing@dentsply.com.

R&R Technical Service & Support

R&R maintains the largest, most advanced product application and development laboratory, research foundry and technical staff for benefit of the industry. With unique testing equipment, we are the only industry supplier able to look at shell strength and flexibility properties in real-time and at temperature. These resources are used to develop new products, analyze material performance and service customer needs.

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Ransom & Randolph

At R&R, *Investing with Innovation™* is more than just a slogan, it's a way of life. Dedicated to advancing the investment casting industry, we take pride in providing foundries with extensive process knowledge, exceptional technical expertise and innovative product technology. By coupling our revolutionary product developments with our experienced staff, manufacturing and warehousing facilities, we successfully help you become a casting industry leader. R&R is a wholly owned subsidiary of Dentsply Sirona (NASDAQ: XRAY).

R&R's core businesses are comprised of ceramic shell, industrial mold, jewelry and dental investment casting.

R&R takes great pride in providing customers with a pleasant procurement experience. R&R's Maumee, Ohio based customer service team services North America and US export customers. Our UK-based agent, HTM Tradeco, Ltd., provides service for the European Union. From initial order placement through delivery, R&R's customer service team takes responsibility for accurate and efficient processing of your material needs. As a result, R&R's customer service team is unmatched in the industry.

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