Additive Manufacturing Conference 2023

Dearborn, Michigan, USA
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2023 AFS Additive Manufacturing Conference

November 7-8, 2023
The Henry
Dearborn, MI

Designer, operator, casting buyer or supplier, the 2023 Additive Manufacturing (AM) for Metalcasting conference is a must-attend event. Industry experts in AM including academia and foundry professionals will lead sessions covering a comprehensive range of AM disciplines from designing for AM, to 3D printed sand molds & cores, printed hard tooling & fixtures, hybrid applications, and the latest in AM applied research. Several recent foundry case studies where AM was used to solve design, tooling, and/or production problems will be presented along with cases where AM created opportunities not available through conventional methods. Is direct metal printing going to replace casting? This along with many other questions will be answered when you join the network of industry practitioners and experts at the AFS Additive Manufacturing Conference in Dearborn, MI this November.

Tuesday, November 7th

7a **Registration/Breakfast**

SESSION 1**: Past, Present & Future**
Session Chair**:** ***Kirk Rogers****, M&P Gravity Works LLC, Poland, OH*

8a **Welcome/Introductions**
Dave Rittmeyer*, Additive Manufacturing Division Chair, Matthews Additive Technologies, Pittsburgh, PA*

8:15a **KEYNOTE: The Evolution of Binder Jet Sand 3D Printing: Exploring the Past, Present & Future...1**
Harold Sears*, Imagine Additive Consulting, Charlotte, NC*

Additive Manufacturing has begun to revolutionize the manufacturing industry, offering unprecedented possibilities for design, prototyping, and production. Among the various techniques, binder jet sand 3D printing has emerged as a versatile and promising method for creating complex sand molds and cores used in foundry applications. This presentation aims to delve into the past, present, and future of binder jet sand 3D printing technology, highlighting its evolution and the future potential.

The journey begins with an exploration of the origins of binder jet sand 3D printing, tracing its roots back to the early days. We will examine how it started and challenges faced during its development, leading up to the present state of the technology.

Building upon this foundation, we will then shift our focus to the present-day capabilities and applications of binder jet sand 3D printing. We will explore its diverse range of applications across industries such as automotive, aerospace, and architecture, where this technique has unlocked new design possibilities and enhanced manufacturing efficiency.
Lastly, we will embark on a journey into the future, uncovering the exciting potential and emerging trends in binder jet sand 3D printing. We will discuss recent one-on-one interviews with the CEOs of the two leading binder jet sand equipment companies and their thoughts on the future of this technology.

By the end of this presentation, attendees will gain a comprehensive understanding of the past achievements, current applications, and future prospects of binder jet sand 3D printing. Whether you are an industry professional, researcher, or enthusiast, this exploration will provide valuable insights into the transformative capabilities of this innovative manufacturing technique. Join us as we delve into the world of binder jet sand 3D printing and unlock the potential it holds for the future of the foundry industry.

9:15a **Re-imagining Cybersecurity: A Case Study for a Modern Casting/Foundry Company…13**

Mark Lamoncha, *Humtown Products, Columbiana, OH*
Brian Luffy, *Cybersecurity Manufacturing Innovation Institute, San Antonio, TX*

Mark L. with Humtown and Brian L. with the Cybersecurity Manufacturing Institute will share insights gleaned from their joint effort to re-imagine cybersecurity in a modern casting/foundry company. For the last 3+ months through a CyManII Industry Use Case, Humtown opened its doors, and networks to a partnership that included security modeling, resilience testing, and baselining energy consumption.

9:45a **3D Printed Smart Molds for Sand Casting: Monitoring Binder Curing...18**
Jerry Thiel, *University of Northern Iowa, Cedar Falls, IA*

Additive Manufacturing is enabling the casting of complex geometries including density-varying lattices directly from digital design data. Moreover, end-of-life products can be 3D-scanned and reversed-engineered for low volume replacement parts. By ink jetting binder into a bed of sand layer-by-layer, dimensionally accurate sand molds and cores can be printed to serve as soft tooling for sand casting. However, the related increase in geometry complexity can lead to challenges in ensuring casting quality and yield. One recently explored remedy is to introduce disposable and wireless sensors (the Internet of Things) to enable the collection of a diversity of data at difficult-to-access locations in molds. The presentation will describe work in wirelessly measuring of temperature, humidity, magnetic field, metal velocity, and barometric pressure. New ventilation designs and strategies - enabled with complex, 3D printed fluidic channels - can now be explored. Additionally, other advancements in 3D printed sand will be discussed including augmented reality for mold harvesting and complexity analysis for evaluating the suitability of 3D printed sand versus traditional casting.

10:15a **BREAK**

10:30a **Towards a Digital Twin of the 3D Sand Printing Process...36**
Nathaniel Bryant, *University of Northern Iowa, Cedar Falls, IA*

This presentation introduces a framework towards developing a digital twin for the 3D sand printing process, aiming to bridge the gap between virtual simulation and physical manufacturing. Integration of real-time monitoring and control systems can offer a comprehensive representation of the additive manufacturing workflow. This enables real-time analysis, predictive maintenance, and optimization of the process, leading to a deeper understanding of process dynamics and improved component quality. Moreover, leveraging machine learning algorithms and historical data, the digital twin enhances process control, potentially enabling adaptive adjustments and reducing defective prints. This presentation showcases the key components necessary to move towards a digital twin for 3D sand printing, highlighting its potential in improving mold and core production.

11a **Integration of Direct Additive for Aftermarket Parts in the Oil and Gas Industry...44**
Mark Volz, *Flowserve, Kalamazoo, MI*

Capabilities of LPBF have greatly advanced from when it first entered the market in the 90's but yet adoption in the Oil and Gas Industry remains limited when comparing to Aerospace and medical industries. This presentation walks through Flowserve's experience qualifying LPBF utilizing API 20S. It will discuss both technical and commercial requirements of the process and provide examples of utilizing the process to deliver parts to customers. The presentation concludes with their perspective on obstacles preventing greater adoption of the technology.

11:45a **Designing for 3DPS, a Precision Sand Casting Process...52**
Jiten Shah, *Product Development & Analysis LLC, Naperville, IL*

3D printed binder jet sand mold and core making is a digital manufacturing toolingless process and our preliminary research indicates tighter dimensional casting tolerances capabilities of this new precision sand casting process, compared to the conventional sand casting processes. The outcome of the research results will be presented along with the case studies and additionally a few design examples demonstrating the casting and rigging design flexibility and light-weighting opportunities including cost advantages with this new 3D printed precision sand process in various alloys will be shared.

12:15p **LUNCH**

SESSION 2: Specified Technology & Case Studies

Session Chair: **Brandon Lamoncha**, *Humtown Products, Columbiana, OH*

1:15p **Additive Manufacturing Influence and Benefits on Marine Castings...73**
Clayton Rasmussen, *Mercury Marine, Fond du Lac, WI*

Additive manufacturing (AM) has opened countless opportunities for the advancement of the casting industry. Mercury Marine is pushing the boundaries of traditional manufacturing of casting tooling and creation of prototypes through significant investment in applications of AM. Mercury Marine creates castings using a variety of methods including High Pressure Die Cast, Lost Foam, Gravity Pour, and Investment, each with specific benefits enabled by AM. Engineers can exercise their in-house additive capabilities and outside partnerships to increase their influence on casting quality, schedule attainment, and maintenance mitigation. Powder Bed, Wire Arc, Sand, and FDM will be showcased to exemplify AMs disruption of the casting environment, and its benefits to the entire casting industry.

2p **3D Sand Printing Adoption in a Production Environment...85**
Kyle Peterson, *Grede- Iron Mountain, Kingsford,* MI

Grede Foundry will share some of their experiences in evaluating, both technically and from business ROI perspective, 3D sand printing technology in their production foundry over the past 8 years. Since then, Grede has expanded with additional sand printers and have integrated for the applications in automotive, high volume high performance iron casting production.

2:30p **Investment Shell Cracking as the Result of Thermal Expansion of a Printed Pattern...93**
Thomas Mueller, *Mueller AMS, New Berlin, WI*

The leading cause of failure when casting printed investment casting patterns is cracking of the ceramic shell as the result of thermal expansion of the pattern during autoclave de-wax. Shell cracking can largely be avoided through careful selection of the build style of the printed pattern, use of a pattern material that has both a low coefficient of thermal expansion and a low heat deflection temperature and venting of the shell prior to autoclaving. However, the process changes required to avoid shell cracking add both cost and time to the casting process as well as making it virtually impossible to automate to the level that has been achieved for molded wax patterns. As a result, printed patterns are used, with few exceptions, only for prototypes and very low volume production.

If investment casting using printed patterns is to be a viable means of production for un-moldable geometries such as those created by generative design, these process limitations must be overcome. In this study, the factors contributing to the force exerted on the shell are identified and an expression is developed to predict the force on the shell as a function of temperature. The expression is used to determine the sensitivity of the exerted force to each of the primary factors.

3p **BREAK**

3:15p **3D Printed Lost Foam Molds CF Reinforced Polycarbonate...111**
Marshall Miller, *3D Systems, Rock Spring, GA*

Lost foam molding equipment is traditionally produced from aluminum billet at great expense that changes weekly and long delivery times. Pellet extrusion technology allows for the rapid and inexpensive production of

lost foam molding equipment from reinforced polymers that can withstand the temperatures and pressures of the Lost Foam Pattern production process at a fraction of the cost.

3:45p **Dimensional Process Control & Current Known Design Capabilities of AMEC Process...125**
Sarah Jordan, *Skuld LLC, London. OH*

Casting consists of essentially two items: metallurgy and dimensional control. Research is currently underway to determine the tolerance control of the Additive Manufacturing Evaporative Casting (AMEC) process including the print itself and the resultant casting. This talk will also cover what is currently known of the process's design capabilities, including what new design possibilities are enabled.

4:15p **PANEL: How to take advantage of Additive Manufacturing Standards?...N/A**
Kirk Rogers, Ph.D., *M&P Gravity Works LLC, Poland, OH*

SAE International (Formerly Society of Automotive Engineers) and American Society for Testing and Materials (ASTM) have been the most active Standards Development Organizations (SDO) in the Additive manufacturing industry for the last 15+ years. Since 1999, SAE has authored ~50 specifications and guidance documents sponsored primarily by aeronautical and space industries as part of Aerospace Materials Standards. Since 2009 ASTM Committee F42 has published over 50 standards. The collective standards cover a wide range of aspects of 3D printing. Everyone from those new to AM to those who have been 3D printing for years can use them to improve the consistency of their work efforts.

During this presentation the organization of the standards for the 2 SDO's will be highlighted to increase attendees understanding. Standards applicable the Foundry industry will be discussed. Opportunities to utilize and take advantage of AM standards to speed operations and start Additive manufacturing conversations with foundry customers will be discussed.

The link to both the SAE AMS and ASTM AM standards summaries will be provided.

4:45p **Ask an Expert: Question & Answer Session**
All speakers/presenters

5p **DAY 1 CONCLUDES**

5:30p **NETWORKING RECEPTION** *(drinks, appetizers & socializing)*

Wednesday, November 8th

7a **Registration/Breakfast**

SESSION 3: **Industry Support & Resources**
Session Chair: **Jiten Shah**, *Product Development & Analysis LLC, Naperville, IL*

8a **Welcome/Introductions**
Dave Rittmeyer, *Additive Manufacturing Division Chair, Matthews Additive Technologies, Pittsburgh, PA*

8:15a **DoD Perspectives on Additive Manufacturing to Support the Casting Industrial Base...139**
Benjamin R. Ewing, *Naval Surface Warfare Center, Crane Division, Fort Wayne, IN*

While the DoD purchases a fraction of the castings and forgings produced in the United States they are critical supplies that fuel military superiority for our armed forces. Additive manufacturing may seem to be a competitor to castings and forgings but there is a hybrid role between the different technologies which can accelerate delivery

of needed products to the DoD and shorten lead times. One of the main challenges is the fact that DoD programs tend to procure low-volumes of castings and forgings, especially in the sustainment phase of a weapon system. When the DoD is competing with high volume orders, such as those in automotive, it can be unattractive for manufacturers to take on these challenging orders. This presentation will highlight challenges within the DoD on procurement of castings and forgings and how additive manufacturing can be a catalyst within industry to meet the needs of our armed forces.

9a **Additive Manufacturing Technology Roadmap for Casting & Forging...147**
Litsa Rubino, *National Center for Defense Manufacturing and Machining (NCDMM), Warren, OH*

Additive manufacturing is gaining momentum as a tool to reduce manufacturing cost and lead times and to allow low volume, high mix products. America Makes, the national institute for additive manufacturing, is working with AFS and other industry experts to develop a technical roadmap for use of the technology in the castings & forgings industry. This presentation will share progress on that effort and what to expect moving forward.

9:45a **Best Practices for 3D printed Digital Light Processing (DLP) Investment Casting Pattern Burnout...169**
Justin Swartz, *Intrepid Automation, San Diego, CA*
Pat Morrison, *HRE Performance Wheels, Vista, CA*

Collaborative presentation by Intrepid Automation and O'Fallon Casting, winners of the ICI and AFS "Casting of the Year" competition. With the growing adoption of additive manufacturing in investment casting processes, the utilization of 3D printed patterns offers numerous advantages: design flexibility, customization, and reduced lead times. However, successful burnout of 3D printed patterns requires careful consideration of several factors to ensure optimal results and minimize defects. This presentation will provide an overview of the DLP process and its relevance to investment casting. It will highlight the unique characteristics of 3D printed patterns, such as intricate geometries, material properties, and surface finish, which influence the burnout process. The main focus of the presentation will be on best practices for achieving successful burnout of 3D printed investment casting patterns.

10:15a **BREAK**

10:30a **PANEL**: **3D Sand Printing Service Providers...183**
Dave Rittmeyer, *Matthews Additive Technologies, Pittsburgh, PA*
Brandon Lamoncha, *Humtown Products, Columbiana, OH*
Steve Slininger, *Liberty Pattern Company, New Liberty, IA*

Hear from the industry leaders on how they are supporting the foundry industry. You will be able to talk with the three companies who collectively own or operate nearly 1/3 of the printers in North America. Learn from their experiences with Furan, IOB, CHP and PDB binders.

11:30a **3D Printed Sand's Impact on Product Lifecycle Speed...206**
Ted Kahaian, *TEI, Farmington Hills, MI*

Most people think 3D printed sand is "slow" and therefore not ripe for production. I would like to display how 3D printed sand GREATLY reduces: design, development, prototyping and other key cycles therefore drastically reduces the lifecycle timeline for a part. I want to display that it is NOT slow when viewed from a bigger scope.

12:00p **An Introduction to Additive Manufacturing for Investment Casting...212**
Joshua O'Dell, *University of Northern Iowa, Cedar Falls, IA*

This presentation outlines the various applications and material options in which additive manufacturing can be used to produce expendable patterns for investment casting. The introduction of additive manufacturing into the investment casting process enables the creation of more complex geometries, and greater design freedom when compared to conventional pattern production techniques. This increased design flexibility opens new possibilities for creating innovative investment cast parts.

12:30p **LUNCH**

SESSION 4: Enabling Technologies

Session Chair: **Dave Rittmeyer**, *Matthews Additive Technologies, Pittsburgh, PA*

1:30p **Update on Advancing Developments for 3D Coatings...217**
Daniel Cygal, *HA International LLC, Westmont, IL*

As 3D additive technology advances, so do the performance expectations on the consumables used in the 3D Sand Printing Process. We'll review the latest technology in coatings for additive manufacturing.

2p **Updates on Advancing Developments for 3D Consumables - Resin Systems, Mold Coatings, Additives and Printhead Cleaners...223**
Kelley Kerns, *HA International LLC, Westmont, IL*

As 3D additive technology advances, so do the performance expectations on the consumables used in the 3D Sand Printing Process. We'll cover the latest in resin technology, including IOB, coatings (surface smoothing), and sand additives that are available.

2:30p **In-process Removal of Stair-steps in 3D-Printed Molds and Cores by Controlled Binder Migration...232**
Christoph Hartmann, *Fraunhofer Institute for Casting, Garching, Germany*

3D printing, or binder jetting, has become an established process for making cores and molds in the foundry industry. In this process, a print head selectively deposits binder onto a thin layer of sand particles. The build platform lowers, a new layer of sand is applied, and the routine is repeated. After the binder is deposited, fluid begins to migrate into the voids between the sand particles, causing part size variations, sand adhesion and rounded corners. Another characteristic feature is the appearance of gray sand around the printed area. In this presentation, the migration behavior of a furan binder is analyzed as a function of material parameters. Its properties and distribution are controlled by varying droplet sizes and patterns. With a model understanding of binder behavior, an additional layer of data processing can be added prior to printing. This allows the binder behavior to be taken into account by exploiting the previously negative effect of migration. Stair-step removal is chosen as a demonstration of the process. Stair-steps are a consequence of the layer-by-layer nature of the process and its discrete data preparation in slices, resulting in a surface with discrete edges that should be smooth in the 3D model. By controlling the binder migration to allow more or less migration depending on the position within the stair-step, the previously discrete surface can be smoothed with the stair-step removed to achieve a near-net-shape finish.

3:15p **BREAK**

3:30p **Developments in Inkjet that Contribute to the Advancement of Additive Manufacturing in Metal Casting...243**
Stephanie LeRette, *FUJIFILM Dimatix, Inc.*

Macro level dynamics are driving more efficient ways to manufacture products, while reducing waste, reducing time to market, and enabling more complex designs. Additive manufacturing technologies in its many forms is a key contributor with innovations that are estimated to reach over $37B worldwide by 2026 (Source: 2021 industrytoday.com) Furthermore, in a survey conducted by Sculpto in 2021, 35% of users indicated that they are already use Binder jetting technologies while 15% consider future use. A key enabler in the transition to Additive Manufacturing are piezoelectric printheads used in a new generation of production 3D Printers targeted at foundries and designed to meet their needs of productivity and innovation.
FUJIFILM Dimatix, with over 30 years of experience in industrial digital printing using piezoelectric inkjet technology, developed a range of printheads to address the specific requirements for the sand-casting industry resulting with several industry leading products by OEM customers currently in production worldwide.
In this session you'll hear about:

- Trends in additive manufacturing sand casting
- How FUJIFILM Dimati
- x inkjet printheads enable additive manufacturing for sand casting
- Trends and advancements in additive manufacturing and their impact on production
- Case study example discussion

4p **PANEL: New Equipment & Process Capabilities**

1. **3D Printing for Foundry Applications – We are Past the Adoption Inflection Point...253**
   Kirk Keithly, *ExOne, Lapeer, MI*

   Sand 3D printing is no longer viewed as a novel technology within the foundry world, with binder jetting systems installed and running at core shops, rapid prototype casters, and production foundries around the world. But as this technology's footprint expands, so does the capability of the equipment. Join ExOne Technical Application Director Kirk Keithly for this session exploring new developments in the additive manufacturing space. From entry-level to fully-automated production systems, we'll explore the latest in 3D printing hardware that is allowing foundries to produce more with less labor. We'll also discuss variations in the process, from resin systems to media available for processing and discuss how workflows are pushing toward more automation and data intelligence.

2. **The Maturation of 3D Printed Aggregates: Serial & Volume Production...262**
   Aaron Howard, *VoxelJet America, Inc., Canton, MI*
   Has binder-jetting finally reached the "Slope of Enlightenment" – or did it already pass?
   This technology has existed for over two decades, yet the adoption rate suggests that the marketplace is still sluggish to respond. Is the equipment too slow or is it the user rate of acceptance? Exploring current limitations may reveal that its both; however, this would also suggest that all "Additive Manufacturing" is still maturing, while "3D Printing" has long outlived its hype.

3. **3D Sand Printing with BlueNano™: A Green, Sustainable, Sand Binder for use with All Metals and Any Particulate Media...272**
   Daniel Shirkey, *Lightspeed Concepts, Albion, MI -*
   A U. S. Patent Applied For binder, BlueNano™ has been developed to advance additive manufacturing of foundry sand cores and molds. The binder's engineered starch molecule is sand agnostic and can be used with virtually all cast metals. It is a low temperature reclaimable binder that doesn't stink. The building blocks are plant based, locally sourced and not subject to special regulations or embargoes. It is a green, sustainable, sand binder with low life cycle energy that accommodates Metalcasting Industry 4.0. Additionally, it is a one-part binder that increases production rates and reduces desanding/depowdering time and labor.

5p CONFERENCE CONCLUDES

Thursday, November 9th

9a TOUR of Aristo-Cast *(Almont, MI)*

- 7:50a Shuttle picks up from hotel
- 11a Shuttle picks up from Aristo-Cast
- 12/12:30p Shuttle arrives back to hotel

11a 2nd TOUR of Aristo-Cast *(Almont, MI)*

- *Shuttle not provided/ self-drive only*