Two Big Conferences Under One Roof!

PROGRAM & REGISTRATION INFORMATION

June 23–26, 2019
Sheraton Grand • Phoenix, Arizona

International Conference on Powder Metallurgy & Particulate Materials
Additive Manufacturing with Powder Metallurgy

For program details visit: POWDERMET2019.org or AMPM2019.org
☑ Need enhanced material performance?
☑ Looking for unique alloys with novel properties?
☑ Interested in lightweight solutions?

info@kymerainternational.com

☑ Under new ownership, Kymera International is seeking acquisition opportunities both big and small to complement its global leading material science portfolio.

ABOUT KYMERA INTERNATIONAL:
With 9 manufacturing sites in 7 countries, Kymera International is a global leading producer and distributor of powders, pastes and granules of aluminum, aluminum alloys, copper, copper oxide, bronze, brass, tin, zinc, silver coated, antimony, bismuth, magnesium, manganese sulfide, MIM ferrous materials and several specialty alloys.
TECHNICAL PROGRAM
Full conference registration provides access to both POWDERMET2019 and AMPM2019 technical sessions. Over 200 presentations from worldwide industry experts on the latest in powder metallurgy, particulate materials, and metal additive manufacturing. Visit POWDERMET2019.org or AMPM2019.org to find the latest conference program with complete abstracts, a schedule of events, and an exhibitor listing.

EXHIBIT
Over 100 booths showcasing leading suppliers of powder metallurgy and particulate materials processing equipment, powders, and metal additive manufacturing products.

SPECIAL CONFERENCE EVENTS
Including special guest speakers, luncheons, the Opening Night Reception, the PM Evening Alehouse, and the Closing Event—Rhinestone Rodeo!

Sponsored by:

Metal Powder Industries Federation
APMI International

Membership in either organization is not required for conference participation. MPIF is an international federation of independent and related trade associations representing companies engaged in various aspects of the powder metallurgy and particulate materials industries. MPIF includes the following trade associations:
- Powder Metallurgy Parts Association
- Metal Powder Producers Association
- Powder Metallurgy Equipment Association
- Refractory Metals Association
- Metal Injection Molding Association
- Association for Metal Additive Manufacturing

APMI International is a worldwide technical society for professionals interested in developments in powder metallurgy and particulate materials technology.

REGISTER ONLINE AT POWDERMET2019.org or AMPM2019.org

CONTENTS
Daily Schedule .................................................................................................................. 2
Distinguished Service to Powder Metallurgy Award ...................................................... 5
Metal AM Tutorial ........................................................................................................... 5
Exhibit ............................................................................................................................... 6
Program Committee ......................................................................................................... 9
POWDERMET2019 & AMPM2019 Technical Sessions and Special Interest Programs ......................................................... 10
Center for Powder Metallurgy Technology ................................................................. 14
PM Technology Scan—2019......................................................................................... 14
Schedule-at-a-Glance...................................................................................................... 18
Poster Program ............................................................................................................... 30
General Information ...................................................................................................... 32
Golf Tournament ............................................................................................................. 33
Registration Fees ............................................................................................................ 36
SUNDAY, JUNE 23

8:00 a.m.–2:00 p.m.
**APMI GOLF TOURNAMENT**
Troon North Golf Course
(Open to all attendees. Separate registration fee applies. Transportation departs from the Sheraton Grand lobby at 6:30 a.m.)

8:00 a.m.–5:00 p.m.
**EXHIBITOR SETUP**

2:00–6:00 p.m.
**POSTER DISPLAY**
(Authors set-up)

Noon–6:00 p.m.
**REGISTRATION OPEN**

1:30–4:30 p.m.
**METAL AM TUTORIAL**
See Tutorial description on page 5. (Open to all attendees. Separate registration fee applies.)

6:00–7:30 p.m.
**OPENING NIGHT RECEPTION**
Welcome to POWDERMET2019 & AMPM2019!
Join us as we kick-off the conferences as well as the 75th Anniversary celebration of MPIF! This casual opening reception will give you an opportunity to renew your acquaintances and network with your fellow PM/AM industry colleagues. Light food and beverages will be served as we welcome you to the Valley of the Sun, Phoenix!

MONDAY, JUNE 24

7:00–7:30 a.m.
**SPEAKER PREP FOR MONDAY SPEAKERS**

7:00 a.m.–5:30 p.m.
**REGISTRATION**

7:00 a.m.–5:30 p.m.
**PUBLICATIONS BOOTH**

8:00–9:15 a.m.
**OPENING GENERAL SESSION**
This conference opening session will feature welcome comments from MPIF Executive Director/CEO James P. Adams and MPIF President John F. Sweet, PMT. An overview of the annual MPIF State of the Industry report highlighting industry business conditions, technology trends, and the market for powder metallurgy and particulate materials will also be presented.

**Keynote Presentation:**
Connecting Dots in the Metal Powder World

Bill Stainton
Emmy Award-winning TV producer, writer, performer, and author

In the competitive metal powder industry, challenging problems require innovative solutions. And coming up with innovative solutions requires creative ideas. But where do these creative ideas come from? And how can we, as metal powder industry leaders, come up with them—effectively and on-demand? In this entertaining and enlightening program, multiple Emmy Award winner Bill Stainton will show us that creative ideas are not a function of the “lightning bolt” from above; they’re a function of connecting dots.

9:30–10:45 a.m.
**POWDERMET TECHNICAL SESSIONS**
01: Ferrous Materials & Properties I
02: Atomization I
03: Sintering Furnace Design and Atmospheres

9:30–11:45 a.m.
**EXHIBIT OPENS**
**POSTER DISPLAY**

10:15–11:45 a.m.
**POWDER METALLURGY PARTS ASSOCIATION**
Membership Meeting

11:00–11:45 a.m.
**GRANT TNT: Talk ‘N Technology—Part 1**

Noon–1:45 p.m.
**PM DESIGN EXCELLENCE AWARDS LUNCHEON**
This annual luncheon will highlight winners in the 2019 PM Design Excellence Awards Competition. (Stop in the exhibit hall after lunch to view the winning parts.)

1:45–2:45 p.m.
**PM CAFÉ: Desserts Served**

1:45–7:00 p.m.
**EXHIBIT OPEN POSTER DISPLAY**

2:00–3:00 p.m.
**GRANT TNT: Talk ‘N Technology—Part 2**
TUESDAY, JUNE 25

3:00–4:15 p.m.
POWDERMET TECHNICAL SESSIONS
04: Ferrous Materials and Properties II
05: Atomization II

AMPM TECHNICAL SESSIONS
A04: Nickel Alloys I
A05: Solid-State Processing
A06: Modeling of Metal AM I

3:00–4:15 p.m.
MANAGEMENT SESSION—PM Industry Trends: Management Economic Indicators

4:30–5:45 p.m.
MANAGEMENT SESSION—Implementing a Cultural Change: The Development of High-Performance Organization

4:30–5:20 p.m.
CPMT PRESENTATIONS—Evaluation of Acoustical Mixing and Rust Prevention of PM Ferrous Parts

4:30–5:45 p.m.
AMPM TECHNICAL SESSIONS
A07: Nickel Alloys II
A08: Exploratory Metal Powder Production
A09: Modeling of Metal AM II

5:20–5:45 p.m.
PM TECHNOLOGY SCAN 2019—Improvement in Precision/Accuracy/Variation Control

5:30–7:00 p.m.
PM EVENING ALEHOUSE
Sponsored by the Powder Metallurgy Equipment Association (PMEA)

PMIF and PMEA invite all registered delegates to the exhibit hall for 90 minutes of uninterrupted networking while you enjoy a glass of wine or a cold beer. Walk through the hall and visit with exhibitors to find out more about their products and services. It is also a great opportunity to get your Exhibitor Game Card filled out for a chance to win one of our grand prizes! Poster Authors will also be available for discussion.

7:00–7:30 a.m.
SPEAKER PREP FOR TUESDAY SPEAKERS

7:00 a.m.–5:00 p.m.
REGISTRATION

7:00 a.m.–5:00 p.m.
PUBLICATIONS BOOTH

7:30–8:30 a.m.
POWDER METALLURGY EQUIPMENT ASSOCIATION Membership Meeting

8:00–9:15 a.m.
POWDERMET TECHNICAL SESSIONS
06: Ferrous Materials and Properties III
07: MIM I
08: Non-Traditional Alloy Sintering

SPECIAL INTEREST PROGRAM
SIP 2-1: Powder Production for AM, PM, MIM: Differences, Similarities and Synergies

AMPM TECHNICAL SESSIONS
A10: Aluminum Alloys
A11: NDT Methods Applied to AM Powders and Components
A12: Metal AM: Processes and Applications

9:00–10:30 a.m.
AM CAFÉ: Coffee Served

9:00–11:45 a.m.
EXHIBIT OPENS
POSTER DISPLAY

9:30–10:30 a.m.
GRANT TNT: Talk ‘N Technology—Part 3

10:30–11:45 a.m.
POWDERMET TECHNICAL SESSIONS
09: Ferrous Materials and Properties IV
10: MIM II
11: Modeling I

SPECIAL INTEREST PROGRAM
SIP 2-2: Powder Production for AM, PM, MIM: Moving Away from Two-Fluid Atomization

11:00 a.m.–1:45 p.m.
INDUSTRY LUNCHEON
Recognizing PM Industry Achievements
The luncheon will recognize key industry individuals identified to receive major industry awards, among them the MPIF Distinguished Service to Powder Metallurgy Award and APMI’s new Class of Fellows, Joseph T. Strauss and John L. Johnson.

1:45–3:15 p.m.
PM CAFÉ: Desserts Served

1:45–4:30 p.m.
EXHIBIT OPENS
POSTER DISPLAY

2:00–3:15 p.m.
GRANT TNT: Talk ‘N Technology—Part 4

3:15–4:30 p.m.
POWDERMET TECHNICAL SESSIONS
12: Advanced Particulate Materials
13: Novel Sintering
14: Modeling II

SPECIAL INTEREST PROGRAM
SIP 2-3: Powder Production for AM, PM, MIM: Process Characterization, Parameters and Design

AMPM TECHNICAL SESSIONS
A13: Biomedical Applications
A14: Recycling of AM Powders I
A15: Process Enhancement and Monitoring

4:30–5:45 p.m.
AMPM TECHNICAL SESSIONS
A16: Organic Binder Based AM
A17: Recycling of AM Powders II
A18: Effect of AM Process on Mechanical Properties

5:20–5:45 p.m.
PM TECHNOLOGY SCAN 2019—Improvement in Precision/Accuracy/Variation Control

5:30–7:00 p.m.
PM EVENING ALEHOUSE
Sponsored by the Powder Metallurgy Equipment Association (PMEA)
Tuesday continued

6:00–10:00 p.m.
CLOSING EVENT—Rhinestone Rodeo!
Join us for an adventure of a lifetime, as we head to Corona Ranch for the Closing Event—Rhinestone Rodeo! The group will enjoy an interactive cocktail reception where networking will be the top priority. The group will then be invited to watch the exhilarating Charreada (Mexican Rodeo) and Western Rodeo show. For dinner, join us for a fiesta that will be sure to WOW your senses! Surprises will be awaiting you at every turn—and you won’t want to miss this unforgettable Closing Event.
Dress attire is casual. Shorts are permitted as this event will be held partially outdoors.

WEDNESDAY, JUNE 26

7:00–7:30 a.m.
SPEAKER PREP FOR WEDNESDAY SPEAKERS

7:00 a.m.–12:15 p.m.
REGISTRATION

7:00 a.m.–12:15 p.m.
PUBLICATIONS BOOTH

8:00–9:15 a.m.
POWDERMET TECHNICAL SESSIONS
15: Furnace & HIP Technology
16: Refractory Materials
17: Densification

SPECIAL INTEREST PROGRAM
SIP 3-1: Machinery Sensors & Information Technology: Industry Sensors I—’I’m Looking for Data

AMPM TECHNICAL SESSIONS
A19: Tribology and Corrosion
A20: Powder Characterization for AM
A21: Binder Jetting of Metal Powder

9:30–10:45 a.m.
POWDERMET TECHNICAL SESSIONS
18: Material Processing
19: Compacting Development and Optimization
20: PM Applications

SPECIAL INTEREST PROGRAM
SIP 3-2: Machinery Sensors & Information Technology: Industry Sensors II—Let’s Organize the Data

AMPM TECHNICAL SESSIONS
A22: AM Powder Flow Characterization
A23: Design of Metal AM Structures
A24: Copper-Based AM

11:00 a.m.–12:15 p.m.
POWDERMET TECHNICAL SESSIONS
21: Powder Test & Evaluation
22: Secondary Operations
23: Safety and Management

SPECIAL INTEREST PROGRAM
SIP 3-3: Machinery Sensors & Information Technology: Industry Sensors III—Impacting Business Operations with My Data

AMPM TECHNICAL SESSIONS
A25: Sintering of AM Materials
A26: Metal AM Post Processing

12:30–1:30 p.m.
CONFERENCE COMMITTEE MEETING
(By invitation)

2:00–5:00 p.m.
ASSOCIATION FOR METAL ADDITIVE MANUFACTURING
Membership Meeting

POWDERMET2019/AMPM2019 CONCLUDES
(Program, times and events subject to change)

RESTRICTIONS ON RECORDING
No photography, or audio or video recording of presentations is permitted.
Metal AM Tutorial

Optional Metal Additive Manufacturing Tutorial

Sunday, June 23 (1:30–4:30 p.m.)

Conducted by: Todd A. Palmer, The Pennsylvania State University
Joseph T. Strauss, FAPMI, HJE Company, Inc.

(Separate registration fee applies.)

This tutorial will provide a basis for determining process options, uses, properties, applications, and opportunities for cost-effective metal additive manufacturing (AM). Individuals who will benefit from the tutorial include engineers, business managers, procurement managers, component designers, and technicians. This course is a must for consumers of metal AM components and organizations that are exploring the opportunities associated with developing their own metal AM manufacturing facilities.

Registrants will receive a certificate of completion.

Included in the Tutorial:

• Overview of Metal AM Processes (Fusion and Solid State)
• Powder Feedstock Characteristics
• Fusion-Based Metal AM Processes: Beam-Material Interactions and Rapid Solidification Mechanisms
• Non-Fusion Metal AM Processes: Sintering and Solid-State Transformations
• Post-Processing, Properties and Performance

NEW THIS YEAR!

Distinguished Service to Powder Metallurgy Award

Recognizing individuals who have devoted a major part of their working careers (minimum 25 years) to one or more segments of the field of powder metallurgy and whose long-term contributions and achievements are such that, in the minds of their peers, they deserve this special recognition for outstanding and distinguished service. (Presentations at Industry Luncheon on Tuesday.)

2019 RECIPIENTS

(Company name in parenthesis indicates employer at time of retirement)

Denis Christopherson, PMT
Federal-Mogul Powertrain

Zhigang (Zak) Fang, FAPMI
University of Utah

Robert M. Gasior
Arconic Technical Center

Ryuchiyo Goto
(Engineered Sintered Components)

William A. Heath, PMT
(MPP)

Stephen J. Lanzel
Catalus Corporation

Deepak Madan
Luxfer Magtech

David Milligan
North American Höganäs Co.

Thomas Pfingstler
Atlas Pressed Metals

Daniel P. Reardon
Abbott Furnace Company

Christopher T. Schade
Hoeganaes Corporation

Michael Stucky
Norwood Injection Technologies, LLC

C. James Trombino, CAE
(Metal Powder Industries Federation)
Attend the PM industry’s largest tradeshow devoted exclusively to powder metallurgy, particulate materials, and metal additive manufacturing. With over 100 booths, this international marketplace will present leading companies featuring the latest PM & metal AM equipment, powders, products, and services.

Meet industry suppliers all together in one place.

**Here is what’s happening in the 2019 Exhibit Hall...**

**Extended Exhibit Hall Hours**
Open for over 12 hours, this year’s hall includes nearly 7 hours of non-compete time.

**PM Evening Alehouse**
Enjoy a 90-minute networking reception while you tour the exhibit hall—with a glass of wine or cold beer in hand! Sponsored by the Powder Metallurgy Equipment Association.

**Exhibitor Game Card—Your Chance to Win Up to $500**
Returns
Complete your game card by filling in all 25 squares with stickers from different exhibitors. Turn in a completed game card for a Starbucks gift card and a chance to win one of three grand prizes!

**AM/PM Café—Keep the Networking Going...**
Meet up for a morning cup of coffee or grab dessert after lunch. Then, tour the exhibit hall.

**Poster Display—Bringing Learning into the Hall**
Poster authors will be on hand to discuss their posters during the PM Evening Alehouse. To hear even more from the student grant recipients, attend the Grant TNT: Talk ‘N Technology sessions. (See Daily Schedule for details and times.)

**Showcase of PM Excellence—**
2019 PM Design Excellence Award Entries on Display
All entries will be on display in the exhibit hall, with winning parts to be identified following Monday’s Awards Luncheon. This “Showcase of PM Excellence” provides an opportunity to review the latest PM engineering innovations and applications.

The marketing of goods and services at the conference is reserved solely for MPIF exhibitors and sponsors. People engaging in these practices who are NOT connected to an exhibit booth or sponsorship will be asked to leave the premises and will forfeit all registration fees.
Exhibitors

ABBOTT FURNACE COMPANY
St. Marys, PA

ABTEX CORPORATION
Dresden, NY

AIR PRODUCTS AND CHEMICALS, INC.
Allentown, PA

ALD VACUUM TECHNOLOGIES, INC.
East Windsor, CT

AMERICAN CHEMET CORPORATION
East Helena, MT

AMETEK SPECIALTY METAL PRODUCTS
Eighty Four, PA

ANTON PAAR
Ashland, VA

ASBURY CARBONS
Asbury, NJ

ATI POWDER METALS
Oakdale, PA

BFG MANUFACTURING
Punxsutawney, PA

BLASCH PRECISION CERAMICS
Albany, NY

BRONSON & BRATTON, INC.
Burr Ridge, IL

BRUKER AXS
Madison, WI

CARPENTER TECHNOLOGY CORPORATION
Bridgeville, PA

CENTORR VACUUM INDUSTRIES, LLC
Nashua, NH

CHUNG YI MOLD (SUIZHOU) CO., LTD.
Jiangsu Province, China

CINCINNATI INCORPORATED
Cincinnati, OH

CM FURNACES, INC.
Bloomfield, NJ

CNPC POWDER NORTH AMERICAN INC.
Vancouver, British Columbia, Canada

COOKSONGOLD
Birmingham, United Kingdom

DORST AMERICA, INC.
Bethlehem, PA

ELCAN INDUSTRIES
Tuckahoe, NY

ELNIK SYSTEMS, LLC
Cedar Grove, NJ

ENGINEERED LUBRICANTS CO.
Maryland Heights, MO

EROWA TECHNOLOGY, INC.
Arlington Heights, IL

EXONE
North Huntingdon, PA

FREEMAN TECHNOLOGY
Tewkesbury, United Kingdom

GASBARRE PRODUCTS, INC.
DuBois, PA

GENICORE
Warszawa, Poland

GERARD DANIEL WORLDWIDE
Hanover, PA

GFMS/SYSTEM 3R
Lincolnshire, IL

GLOBAL TUNGSTEN & POWDERS CORP.
Towanda, PA

GRANUTOOLS
Awans, Belgium

GUANG DONG CINCY MOULD & MACHINERY CO. LTD.
Dong Guan City, China

H.C. STARCK INC.
Euclid, OH

HARPER INTERNATIONAL
Buffalo, NY

HERDING FILTRATION LLC
Waterford, MI

HOEGANAES CORPORATION
Cinnaminson, NJ

HÖGANÄS
Hollspople, PA

HORIBA INSTRUMENTS, INC.
Irvine, CA

IPS CERAMICS
Stoke-on-Trent, United Kingdom

KITTYHAWK PRODUCTS
Garden Grove, CA

KYMERA INTERNATIONAL
Research Triangle Park, NC

LECO CORPORATION
St. Joseph, MI

LINDE, LLC
Cincinnatis, NJ

LINE CRAFT, INC.
Lombard, IL

LUXFER MAGTECH
Manchester, NJ

MAKIN METAL POWDERS (UK) LTD
Lancashire, UK

MALVERN PANANALYTICAL
Westborough, MA

MICROCARE CORPORATION
New Britain, CT

NOVAMET SPECIALTY PRODUCTS CORPORATION
Lebanon, TN

ORS—OBJECT RESEARCH SYSTEMS
Montreal, Québec, Canada

ORTON CERAMIC FOUNDATION
Westerville, OH

OSTERWALDER INC.
Northampton, PA

PFEIFFER VACUUM
Nashua, NH

PLANSEE USA LLC
Franklin, MA

PRAXAIR SURFACE TECHNOLOGIES
Indianapolis, IN

PRAXAIR, INC.
Burr Ridge, IL

PRECISION EFORMING
Cortland, NY

QUANTUS TECHNOLOGIES
Lewis Center, OH

RENISHAW, INC.
West Dundee, IL

RIO TINTO METAL POWDERS
Sorel-Tracy, Québec, Canada

ROYAL METAL POWDERS INC.
Maryville, TN

RYER, INC.
Temecula, CA

SACMI USA LTD
Urbandale, IA

SANDVIK OSPREY
Clarks Summit, PA

SGL GROUP—THE CARBON COMPANY
St. Marys, PA

SINTERITE, A GASBARRE FURNACE GROUP
St. Marys, PA

SINTERZ-CIP, LTD.
Dzerzhinsk, Russia

SUMCA
Ambriesers Mayenne, France

SYMPATEC, INC.
Pennington, NJ

THE ALLOY ENGINEERING COMPANY
Berea, OH

THE MODAL SHOP, INC.
Cincinnati, OH

TRIBOTECC GmbH
Waxhaw, NC

ULTRA INFILTRANT
Zionsville, IN

UNITED STATES METAL POWDERS, INC.
Palmerton, PA

VAC-U-MAX
Belleville, NJ

VERDER SCIENTIFIC INC.
Newtown, PA

VORTE-SIV/MM INDUSTRIES, INC.
Salem, OH

WUXI CITY SINCERE REFRATORY CERAMICS CO., LTD.
Yixing City, China

(Listing as of January 25, 2019)
POWDERMET TECHNICAL SESSIONS

CONFEREE CHAIRMEN:

Daniel Reardon  
Abbott Furnace Company

Virendra Warke  
Entegris Inc.

TECHNICAL FORMAT

Two to three technical sessions will take place concurrently.

Each session will consist of:
• Three technical papers presented by the author
• Individual presentation times will run 25 minutes, including questions

Manuscripts from the technical sessions will be included in the conference proceedings.

GRANT TNT: TALK 'N TECHNOLOGY

Students who receive the National Science Foundation (NSF) Grant or the CPMT/Axel Madsen Conference Grant will present a 10-minute synopsis of their poster. Grant recipients and their poster titles will be available on the conference website.

AMPMM TECHNICAL SESSIONS

CONFEREE CHAIRMEN:

Mathieu Brochu  
McGill University

Juha Kotila  
EOS Finland

TECHNICAL FORMAT

Two to three technical sessions will take place concurrently.

Each session will consist of:
• Three technical papers presented by the author
• Individual presentation times will run 25 minutes, including questions

Manuscripts from the technical sessions will be included in the conference proceedings.

SPECIAL INTEREST PROGRAM

Special Interest Program (SIP) presentations are cutting-edge R&D and typically oral in nature, but all submitted publishable manuscripts will be included in the conference proceedings.

RESTRICTIONS ON RECORDING

No photography, or audio or video recording of presentations is permitted.
## POWDERMET TECHNICAL SESSIONS

### Monday Morning  9:30–10:45 a.m.

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Presenter</th>
<th>Location</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SESSION 01</strong></td>
<td><strong>Ferrous Materials and Properties I</strong>&lt;br&gt;Session Chairman: Craig Stringer, Atlas Pressed Metals</td>
<td>Development of High-Strength PM Alloy That Competes with Wrought 8620 Alloy in Structural Applications&lt;br&gt;Brad Morningstar, MPP</td>
<td>USA</td>
<td>9:30 a.m.</td>
</tr>
<tr>
<td></td>
<td>Fatigue Performance of a Sinter-Hardened Powdered Metal Steel&lt;br&gt;Ian Donaldson, FAPMI, GKN Sinter Metals</td>
<td>USA</td>
<td>9:55 a.m.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effect of Reducing Nickel in Current PM Materials&lt;br&gt;Neal Kraus, Hoeganaes Corporation</td>
<td>USA</td>
<td>10:20 a.m.</td>
<td></td>
</tr>
<tr>
<td><strong>SESSION 02</strong></td>
<td><strong>Atomization I</strong>&lt;br&gt;Session Chairman: John Meyer, Carpenter Technology Corporation</td>
<td>Production and Characteristics of Atomized Submicrometer Alloy Powders&lt;br&gt;Randall M. German, FAPMI, German Materials Technology</td>
<td>USA</td>
<td>9:30 a.m.</td>
</tr>
<tr>
<td></td>
<td>Comparison of Simulated and Experimental Observations of Pure Ni Gas Atomization: Surrogate for Development of Parameters to Produce Ni-Base Superalloy Feedstock Powders for AM&lt;br&gt;Trevor M. Riedemann, Ames Laboratory (USDOE)</td>
<td>USA</td>
<td>9:55 a.m.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Results of Satellite Reduction Strategy on Gas-Atomized Powder Quality for Additive Manufacturing&lt;br&gt;Iver E. Anderson, FAPMI, Ames Laboratory (USDOE)</td>
<td>USA</td>
<td>10:20 a.m.</td>
<td></td>
</tr>
<tr>
<td><strong>SESSION 03</strong></td>
<td><strong>Sintering Furnace Design and Atmospheres</strong>&lt;br&gt;Session Chairman: Kester Clarke, Colorado School of Mines</td>
<td>Controlled Atmosphere Technologies for Sintering High-Quality Components by Proper Lubrication and Lean Sintering Atmospheres&lt;br&gt;Akin Malas, Linde LLC</td>
<td>USA</td>
<td>9:30 a.m.</td>
</tr>
<tr>
<td></td>
<td>Precision Bronze Sintering Furnace Design&lt;br&gt;Ravi P. Malhotra, Sr., Malhotra Engineers</td>
<td>India</td>
<td>10:20 a.m.</td>
<td></td>
</tr>
</tbody>
</table>
**SPECIAL INTEREST PROGRAM**

**SIP 1**

Additive Machines, Capabilities and Processes

Program Organizers:
Joseph Capone, Ametek, Inc.
Stuart Jackson, Renishaw Inc.
Aaron LaLonde, SLM Solutions NA, Inc.

**Session Chairman:** Aaron LaLonde, SLM Solutions NA, Inc.

- **074 USA** 9:30 a.m.
  Development of 4600 Low-Alloy Steel for LPBF Applications
  Kerri Horvay,
  Hoeganaes Corporation

- **113 USA** 9:55 a.m.
  Additive Manufacturing for Growth Acceleration in the Powder Metallurgy Industry
  Sundar V. Atre,
  University of Louisville

- **204 USA** 10:20 a.m.
  Metallographic Characterization of Porous Low-Alloy Steel Samples Manufactured Using Both Powder Metallurgy and Additive Manufacturing Techniques
  Thomas F. Murphy, FAPMI,
  Hoeganaes Corporation

**AMPM TECHNICAL SESSIONS**

**SESSION A01**

Alloy Development

**Session Chairman:** Animesh Bose, FAPMI,
Desktop Metal, Inc.

- **074 USA** 9:30 a.m.
  Development of 4600 Low-Alloy Steel for LPBF Applications
  Kerri Horvay,
  Hoeganaes Corporation

- **113 USA** 9:55 a.m.
  Microstructure, Mechanical Properties and Corrosion Resistance of Laser-Powder-Bed-Fusion Processed Duplex Stainless Steel
  Sundar V. Atre,
  University of Louisville

- **204 USA** 10:20 a.m.
  Effects of Nitrogen Content in Properties and Microstructure of 420 Stainless Steel Fabricated by Laser-Powder Bed Fusion
  Sundar V. Atre,
  University of Louisville

**SESSION A02**

Process and Properties

**Session Chairman:** Anit Giri,
U.S. Army Research Laboratory

- **092 United Kingdom** 9:30 a.m.
  Building High-Integrity Parts with Multiple Lasers
  Marc Saunders,
  Renishaw Inc.

- **174 USA** 9:55 a.m.
  Texture Evolution in Electron Beam Powder Bed Produced Ti-6Al-4V with Varying Build Strategies
  Alec I. Saville,
  Colorado School of Mines

- **116 USA** 10:20 a.m.
  Effects of Nitrogen Content in Properties and Microstructure of 420 Stainless Steel Fabricated by Laser-Powder Bed Fusion
  Sundar V. Atre,
  University of Louisville

**SESSION A03**

Characterization Methods for AM Powders and Components

**Session Chairman:** Magnus Ahlfors,
Quintus Technologies

- **058 Canada** 9:30 a.m.
  Characterization of Triboelectrically Charged AM Metal Powder Using the Rotating Drum Technique
  Eileen Ross L. Esquiritu,
  McGill University

- **163 Belgium** 9:55 a.m.
  Metallic Powders Thermal Degradation: Influence on Spreadability, Packing Dynamics and Electrostatics
  Filip Francqui,
  GranuTools

- **086 USA** 10:20 a.m.
  Metallographic Characterization of Porous Low-Alloy Steel Samples Manufactured Using Both Powder Metallurgy and Additive Manufacturing Techniques
  Thomas F. Murphy, FAPMI,
  Hoeganaes Corporation
Monday, June 24

POWDERMET TECHNICAL SESSIONS

Monday Afternoon 3:00–4:15 p.m.

SESSION 04

Ferrous Materials and Properties II
Session Chairman: 
Mark Dougan, AMES S.A.

184  Germany  3:00 p.m.
The Support Effect and Its Impact on the Design of Complex-Shaped Sintered PM Parts
Markus Schneider, GKN Sinter Metals

014  USA  3:25 p.m.
The Effect of Laser Engraving on the Mechanical Behavior of Powder Metallurgy Components
Katrina S. Johnston, Drexel University

096  USA  3:50 p.m.
Production Experience with Enhanced Ferro-Phosphorus Material Showing Reduced Tool Wear
Alex Wartenberg, Hoeganaes Corporation

SESSION 05

Atomization II
Session Chairman: 
Arun Chattopadhyay, Uniformity Labs

035  Canada  3:00 p.m.
Demystifying the Mechanisms of Liquid Metal Disintegration: A 3D CFD Analysis of Water Droplet Impingement on Melt Stream
Cheng-Tse Wu, University of Toronto

166  USA  3:25 p.m.
In Situ Gas-Phased Passivation of Low-Pressure Gas-Atomized Calcium Powder
Charles Czahor, Iowa State University/Ames Laboratory

170  USA  3:50 p.m.
The Effect of Pour Tube Tip Extension on Close-Coupled Gas Atomization Die Flow
David J. Byrd, Ames Laboratory (USDOE)

MANAGEMENT SESSION

Management Economic Indicators
Session Chairman: 
John von Arx, Phoenix Sintered Metals LLC

USA  3:00 p.m.
PM Industry Trends: Management Economic Indicators
All MPIF members receive the "Monthly Economic Indicators & Industry Trends," but how can they maximize this benefit? This presentation will focus on select indicators that have a major impact on the PM industry.
Paul Sedor, Metal Powder Industries Federation
(No printed manuscript)
### AMPM TECHNICAL SESSIONS

**Monday Afternoon**  3:00–4:15 p.m.

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Speaker(s)</th>
<th>Country</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SESSION A04</strong></td>
<td>Nickel Alloys I</td>
<td>Arshad Harooni</td>
<td>USA</td>
<td>3:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Application of Directed Metal Deposition (DMD) for Manufacturing and Remanufacturing of Nickel Alloy Components</td>
<td>DM3D Technology</td>
<td>USA</td>
<td>3:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Properties and Microstructure of Inconel 625 Processed by Laser Powder Bed Fusion</td>
<td>Sundar V. Atre</td>
<td>USA</td>
<td>3:25 p.m.</td>
</tr>
<tr>
<td></td>
<td>Effects of Powder Characteristics on Building Quality of Selective Laser Melting of Hastelloy X</td>
<td>Yang Tian</td>
<td>Australia</td>
<td>3:50 p.m.</td>
</tr>
<tr>
<td><strong>SESSION A05</strong></td>
<td>Solid-State Processing</td>
<td>Andrew Klein</td>
<td>USA</td>
<td>3:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Fatigue Study of 316L Produced Using Binder Jet 3D Printing with Hot Isostatic Pressing</td>
<td>ExOne</td>
<td>USA</td>
<td>3:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Additive Manufacturing of Soft and Hard Magnetic Materials Used in Electrical Machines</td>
<td>Fabrice Bernier, National Research Council Canada</td>
<td>Canada</td>
<td>3:25 p.m.</td>
</tr>
<tr>
<td></td>
<td>High-Performance 3D Printed Stainless Steel: A Metallurgical Perspective on 3DEO's Intelligent Layering</td>
<td>Mahmood Shirooyeh</td>
<td>USA</td>
<td>3:50 p.m.</td>
</tr>
<tr>
<td><strong>SESSION A06</strong></td>
<td>Modeling of Metal AM I</td>
<td>Tatu Pinomaa</td>
<td>Finland</td>
<td>3:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Process-Structure-Properties Modeling of Selective Laser Melted Maraging Steel Using Phase-Field Method and Crystal Plasticity</td>
<td>VTT</td>
<td>Finland</td>
<td>3:00 p.m.</td>
</tr>
<tr>
<td></td>
<td>Marangoni Convection in Selective Laser Melting of 316L Stainless Steel</td>
<td>Prakash Gautam, Montana Technological University</td>
<td>USA</td>
<td>3:25 p.m.</td>
</tr>
</tbody>
</table>
MANAGEMENT SESSION—
Implementing a Cultural Change: The Development of a High-Performance Organization

Session Chairman: Jeffrey Danaher, Sr., Abbott Furnace Company
4:30–5:45 p.m.

Why are some organizations more successful than others? One of the most recognizable reasons, but also most difficult to define, is the culture of the organization. Measurements of success in a manufacturing facility include:

- Satisfied customers
- Profitability
- Excellent material utilization
- On-time deliveries
- Low absenteeism and turnover rate
- Happy employees

But how do organizations score highly on all of these metrics? For most successful organizations, the answer was a change in culture. This presentation will define a dramatic change in culture, clear vision, and plan based on a case study of a powder metallurgy parts manufacturing facility. It will outline organizational culture, the change process, and difficulties that can be expected. It will provide benchmarks for a high-performance organization, barriers to implementation, comprehensive strategic planning, and sustainable successes.

Speaker: Gary L. Ramsey, Consultant
(No printed manuscript)

CPMT PRESENTATIONS—
Evaluation of Acoustical Mixing and Rust Prevention of PM Ferrous Parts

Session Chairman: Thomas Pfingstler, Atlas Pressed Metals
4:30–5:20 p.m.

The Center for Powder Metallurgy Technology (CPMT) merges the academic and corporate PM worlds together with a joint goal to promote PM industry progress. Through collaboration, the transfer of knowledge and technology advancement is utilized to advance the growth of the PM industry. This oral presentation-only session will share recent R&D activities completed by CPMT.

Evaluation of Acoustical Mixing
4:30–4:55 p.m.
John Engquist, FAPMI, JENS Solutions Inc.
CPMT conducted a project to evaluate the acoustical mixing of an FC-0208 to determine the effects on powder characteristics and sintered properties. The acoustical mixing process was compared to a baseline mix prepared using a standard, commercial double cone blender. This presentation will review the results of the investigation.

Rust Prevention of PM Ferrous Parts
4:55–5:20 p.m.
Kenneth Schatz, Metco Industries, Inc.
CPMT has an ongoing project to evaluate the effectiveness of known rust preventative fluids applied to various PM ferrous-based materials. The rust preventative fluids are used to extend the shelf-life of the PM components. This presentation will provide the test results and introduce discussion of a new guideline for humidity testing.

Speaker: John Engquist, FAPMI, JENS Solutions Inc.

PM TECHNOLOGY SCAN 2019—
Improvement in Precision/Accuracy/Variation Control

Session Chairman: Blaine Stebick, Phoenix Sintered Metals LLC
5:20–5:45 p.m.

This presentation will focus upon recent technology developments, opportunities, perceived threats, challenges, and barriers to growth uncovered during the most recent Technology Assessment investigation performed by MPIF Technical Board members. (Open only to qualified MPIF member registrants)

Benefits of Precision/Accuracy/Variation Control
Powder metallurgy is an advanced metalworking technology, but as an industry, are we underestimating or limiting the growth of the industry by accepting the current state of the technology? Will improved process control dramatically affect the quality and cost of existing components or open new opportunities because of reduced secondary operations? This presentation is intended to stimulate discussion regarding the potential benefits of improving precision, accuracy, and variation control of PM components.

Speaker: John Engquist, FAPMI, JENS Solutions Inc.

Investigators:
John Engquist, FAPMI, JENS Solutions Inc.
Roger Lawcock, FAPMI, Stackpole International
Bruce Lindsley, Hoeganaes Corporation
Roland Warzel, North American Höganäs Co.
(No printed manuscript)
<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Speaker</th>
<th>Country</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SESSION A07</td>
<td>Nickel Alloys II</td>
<td>Ronald Aman</td>
<td>USA</td>
<td>4:30 p.m.</td>
</tr>
<tr>
<td></td>
<td>Influence of Alloy 718 Powder Size on Density, Microstructure, Mechanical Properties, and Production Costs in Metal AM</td>
<td>Carpenter Technology Corporation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SESSION A08</td>
<td>Exploratory Metal Powder Production</td>
<td>Marc S. Pepi</td>
<td>USA</td>
<td>4:30 p.m.</td>
</tr>
<tr>
<td></td>
<td>Progress Towards Expeditionary Production of AM-Grade Metallic Powder</td>
<td>U.S. Army Research Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SESSION A09</td>
<td>Modeling of Metal AM II</td>
<td>Lingbin Meng</td>
<td>USA</td>
<td>4:30 p.m.</td>
</tr>
<tr>
<td></td>
<td>Machine Learning-Enabled Molecular Dynamics Simulation of Laser Powder Bed Fusion Additive Manufacturing of Inconel718</td>
<td>Indiana University—Purdue University Indianapolis (IUPUI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Micromechanical Modeling-Based Damage Laws for Fatigue Design of Additively Manufactured IN718 Alloy</td>
<td>Anssi Laukkanen, VTT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SESSION A08</td>
<td>Development of Deployable Systems for Point-of-Need Recycling and Additive Manufacturing</td>
<td>Andrew LaTour, MolyWorks Materials Corporation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Melt-Free Continuous Titanium Alloy Powder: Production Facility and Development Center</td>
<td>Art Kracke, AAK Consulting LLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SESSION A09</td>
<td>Microstructure Prediction of Laser Powder Bed Fusion Processed Metal Using Combined Computational Fluid Dynamics and Cellular Automata Methods</td>
<td>Jing Zhang, Indiana University—Purdue University Indianapolis (IUPUI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session</td>
<td>Time</td>
<td>USA/Canada</td>
<td>Title</td>
<td>Speaker(s)</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>----------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>06</td>
<td>8:00 a.m.</td>
<td>Manufacturing Methods for High-Density Powdered Metal (PM) Applications and Their Effect on Mechanical Properties</td>
<td>Amber Tims, PMT, North American Höganäs Co.</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>8:00 a.m.</td>
<td>5 Reasons to Celebrate Mold Cleaning in Power Injection Molding</td>
<td>Steve Wilson, Cold Jet LLC</td>
<td></td>
</tr>
<tr>
<td>08</td>
<td>8:00 a.m.</td>
<td>Commercial Sintering of Chromium Powder Metallurgy (PM) Steels</td>
<td>Roland T. Warzel III, North American Höganäs Co.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>8:25 a.m.</td>
<td>Optimization of Liquid-Phase Sintering of Boron PM Steels Using Master Alloys</td>
<td>Simon Gélinas, Université Laval</td>
<td></td>
</tr>
<tr>
<td>135</td>
<td>8:25 a.m.</td>
<td>Effects of Sintering Conditions on the Diffusion Bonding of AgC-Cu Electrical Contacts</td>
<td>Daudi R. Waryoba, The Pennsylvania State University</td>
<td></td>
</tr>
<tr>
<td>187</td>
<td>8:50 a.m.</td>
<td>High-Strength Aluminum-Zinc Composite PM Grade with Trace Amount of Copper for Powder Metallurgy Applications</td>
<td>Jessu Joys, United States Metal Powders, Inc.</td>
<td></td>
</tr>
</tbody>
</table>

---

**Session Chairmen:**
- **Ferrous Materials and Properties III:** Julie Campbell-Tremblay, PMT, Rio Tinto Metal Powders
- **MIM I:** Michael Wiseman, ARC Group Worldwide
- **Non-Traditional Alloy Sintering:** Raymond Serafini, PMT, Linde, LLC
## SPECIAL INTEREST PROGRAM

### SESSION A10
**Aluminum Alloys**
*Session Chairman:* S.K. Tam, ORMCO  
**Program Organizers:** Carl Blais, Laval University  
Gilles L’Esperance, FAPMI, Ecole Polytechnique de Montreal

| 153  | Finland    | 8:00 a.m.  | High-Performance Aluminum Alloys by Additive Manufacturing  
Juha Kotila, EOS Finland |
| 069  | USA        | 8:25 a.m.  | Investigation of the Selective Laser Melting Process for AlSi10Mg and AA6061 Fabricated at High Laser Power  
Michael V. Pires, Lehigh University |
| 192  | USA        | 8:25 a.m.  | Improved Production Methods for Powders Used in Additive Manufacturing  
Christopher Schade, Hoeganaes Corporation |
| 193  | USA        | 8:50 a.m.  | Water-Atomized Metal Powders for PM, AM and MIM: Improvements and Potential Markets  
Chantal Labrecque, Rio Tinto Metal Powders |

### SESSION A11
**NDT Methods Applied to AM Powders and Components**
*Session Chairman:* Michael Stucky, Norwood Injection Technologies

| 085  | Canada     | 8:00 a.m.  | Quantification of Contaminants in 3D Printing Metal Powders Using Microfocus X-Ray Tomography  
Roger Pelletier, National Research Council Canada |
| 120  | USA        | 8:25 a.m.  | Assessing Post-Processing States of AM Builds with Analysis of Ultrasonic Dispersion Properties  
Ajay V. Krishnan, Incodema3D, LLC |
| 131  | USA        | 8:50 a.m.  | NDT of Metal Additively Manufactured Parts via Acoustic Resonance Testing  
Bryan Butsch, The Modal Shop, Inc. |

### SESSION A12
**Metal AM: Processes and Applications**
*Session Chairman:* Hyrum Lefler, Carpenter Technology Corporation

| 137  | USA        | 8:00 a.m.  | Manufacturing, Remanufacturing and Reconfiguration of Aerospace Components with Direct Metal Deposition (DMD)  
Arshad Harooni, DM3D Technology |
| 067  | USA        | 8:25 a.m.  | Fused-Filament Fabrication of Metal with a Markforged Metal X System  
Michelle Chao, Markforged |
| 161  | Germany    | 8:50 a.m.  | 3D Screen Printing of Metal Powder  
Guido Stiebritz, H.C. Starck Hermsdorf GmbH |
Schedule-at-a-Glance

**SUNDAY**
- APMI Golf Tournament
- Welcome Reception

**MONDAY**
- **OPENING GENERAL SESSION — KEYNOTE PRESENTATION**
  - SIP 1-1
    - A01: Alloy Development
    - A02: Process & Properties
    - A03: Char Meth-AM Pow Comp
- **PM DESIGN EXCELLENCE AWARDS LUNCHEON**
  - Grant TNT
- **AM Café**
  - EXHIBIT
  - PMPA Membership Meeting
- **EXHIBIT**
  - **CPMT Present**
  - **Tech Scan**
- **PMEA Membership Meeting**
  - AM Café PM Café PM Evening Alehouse

**Schedule-at-a-Glance**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 am</td>
<td>01: Ferrous Mat &amp; Prop I</td>
</tr>
<tr>
<td>9 am</td>
<td>02: Atomization I</td>
</tr>
<tr>
<td>10 am</td>
<td>03: Sint Furn Des &amp; Atmos</td>
</tr>
<tr>
<td>11 am</td>
<td>A01: Alloy Development</td>
</tr>
<tr>
<td>12 noon</td>
<td>A02: Process &amp; Properties</td>
</tr>
<tr>
<td>1 pm</td>
<td>A03: Char Meth-AM Pow Comp</td>
</tr>
<tr>
<td>2 pm</td>
<td>04: Ferrous Mat &amp; Prop II</td>
</tr>
<tr>
<td>3 pm</td>
<td>05: Atomization II</td>
</tr>
<tr>
<td>4 pm</td>
<td>Management Session</td>
</tr>
<tr>
<td>5 pm</td>
<td>CPMT Present</td>
</tr>
<tr>
<td>6 pm</td>
<td>Management Session</td>
</tr>
<tr>
<td>7 pm</td>
<td>Metal AM Tutorial</td>
</tr>
<tr>
<td>8 pm</td>
<td>Welcome Reception</td>
</tr>
</tbody>
</table>

**Additional Events**
- A04: Nickel Alloys I
- A05: Solid State Proc
- A06: Model of Metal AM I
- A07: Nickel Alloys II
- A08: Expl Metal Pow Prod
- A09: Model of Metal AM II
- A10: Aluminum Alloys
- A11: NDT Meth App AM Pow & Comp
- A12: Metal AM: Proc & Applications
- A13: Biomedical Applic
- A14: Modeling II
- A15: Recycl of AM Powd I
- A16: Organic Binder Based AM
- A17: Recycl of AM Powd II
- A18: Eff of AM Proc Mech Prop
- A19: Tribol & Corrosion
- A20: Powd Char for AM
- A21: Bind Jet of Met Pow
- A22: AM Pow Flow Char
- A23: Des of Met AM Struct
- A24: Copper-Based AM
- A25: Sintering of AM
- A26: Met AM Post Proc
- A27: Furn & HIP Tech
- A28: Refractory Matls
- A29: Densification
- A30: PM Applications
- A31: PowdTest & Evalu
- A32: Secondary Operat
- A33: Safety & Mgmt
- A34: Posters

**PM Design Excellence Awards Luncheon**

**AM Café**

**PMPA Membership Meeting**

**EXHIBIT**

**PM Evening Alehouse**

**Poster Authors**
### Tuesday, June 25

#### TECHNICAL SESSIONS

<table>
<thead>
<tr>
<th>SESSION 09</th>
<th>Ferrous Materials and Properties IV</th>
</tr>
</thead>
</table>
| **097** USA | 10:30 a.m. | Advanced Material Options for High-Temperature Sintering  
Kylan McQuaig, Hoeganaes Corporation |
| **028** Canada | 10:55 a.m. | The Effect of Sintering Temperature on the As-Sintered and Heat Treated Properties of Pre-Alloyed Mo Low-Carbon Steel Alloyed with Ferromanganese  
Peng Shen, Stackpole International |
| **130** USA | 11:20 a.m. | Fatigue and Fracture Behavior of Solid-and Liquid-Phase Sintered Fe PM Samples with C, Ni and Cu Additions and Comparisons with Fatigue and Fracture Behavior of AM Coupons  
Vibhor Chaswal, The Pennsylvania State University, DuBois |

<table>
<thead>
<tr>
<th>SESSION 10</th>
<th>MIM II</th>
</tr>
</thead>
</table>
| **177** USA | 10:30 a.m. | Properties and Dimensional Performance of Pre-Alloy and Master Alloy Powders on Stainless Steel Metal Injection Molded Parts  
James A. Sago, MPP |
| **055** USA | 10:55 a.m. | The Effects of Sintering Temperature on the Microstructural Evolution of 718  
Rees Jones, ARC Group Worldwide |
| **138** USA | 11:20 a.m. | Optimizing Extrusion Process Using Water Atomized 17-4 Stainless Steel Powders  
Jian Zhang, Indiana University—Purdue University Indianapolis (IUPUI) |

<table>
<thead>
<tr>
<th>SESSION 11</th>
<th>Modeling I</th>
</tr>
</thead>
</table>
| **063** USA | 10:30 a.m. | Numerical Simulation of Close-Coupled Gas Atomization: Impact of Geometric and Fluid Parameters  
Franz Hernandez, Ames Laboratory (USDOE) |
| **165** USA | 10:55 a.m. | Powder Flow in Additive Manufacturing—Challenges and Opportunities  
Andres D. Orlando, Jenike & Johanson, Inc. |
| **031** USA | 11:20 a.m. | Importance of Particle-Size Distribution and Thermal Stress Factors—A Theoretical Approach to Predict Defects in AM Parts  
Arun K. Chattopadhyay, Uniformity Labs |
## SPECIAL INTEREST PROGRAM

**Tuesday Morning**  
10:30–11:45 a.m.

### Powder Production for AM, PM, MIM: Moving Away from Two-Fluid Atomization

**Program Organizers:**  
Carl Blais, Laval University  
Gilles L'Esperance, FAPMI, Ecole Polytechnique de Montreal

The emergence of metal additive manufacturing (AM) and its numerous technologies has created a demand for metal powders with specific characteristics such as particle size distribution, particle morphology, chemical composition, and cost. These requirements are not exactly new and other processes relying on metal powders, such as conventional powder metallurgy (PM) and metal injection molding (MIM), have similar requirements. Presentations will include insightful analyses of metal powders manufactured by different techniques utilized by the PM, MIM and AM industry.

**Session Chairman:** Gilles L'Esperance, FAPMI, Ecole Polytechnique de Montreal

<table>
<thead>
<tr>
<th>Session</th>
<th>Country</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>196</td>
<td>Canada</td>
<td>10:55 a.m.</td>
<td>Solving AM Challenges with Plasma Atomization</td>
<td>Frédéric Marion, AP&amp;C</td>
<td></td>
</tr>
<tr>
<td>197</td>
<td>Canada</td>
<td>11:20 a.m.</td>
<td>Description of Various Additive Manufacturing Applications Made with Powders Produced with a Proprietary Atomizing Technology</td>
<td>Amir Nobari, 5N Plus Micro Powders</td>
<td></td>
</tr>
</tbody>
</table>

### AMPM TECHNICAL SESSIONS

**Tuesday Morning**  
10:30–11:45 a.m.

#### SESSION A13

**Biomedical Applications**

**Session Chairman:** Katie Jo Sunday, Hoeganaes Corporation

<table>
<thead>
<tr>
<th>Session</th>
<th>Country</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>040</td>
<td>United Kingdom</td>
<td>10:30 a.m.</td>
<td>Alloys-by-Design: a Biomedical Titanium Alloy for Additive Manufacturing</td>
<td>Enrique Alabort, OxMet Technologies</td>
<td></td>
</tr>
</tbody>
</table>

#### SESSION A14

**Recycling of AM Powders I**

**Session Chairman:** Alan Taylor, GKN Sinter Metals

<table>
<thead>
<tr>
<th>Session</th>
<th>Country</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>112</td>
<td>USA</td>
<td>10:30 a.m.</td>
<td>Powder Reconditioning of AM Feedstock to Increase Processing Efficiency</td>
<td>Timothy E. Prost, Ames Laboratory</td>
<td></td>
</tr>
<tr>
<td>071</td>
<td>USA</td>
<td>10:55 a.m.</td>
<td>Recyclability of Ti-48Al-2Nb-2Cr Powder in Additive Manufacturing</td>
<td>Andrzej L. Wojcieszynski, ATI Specialty Materials</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>United Kingdom</td>
<td>11:20 a.m.</td>
<td>Development of Enhanced Tool Steels for Powder Bed Fusion Additive Manufacturing</td>
<td>Martin A. Kearns, Sandvik Osprey Limited</td>
<td></td>
</tr>
</tbody>
</table>

#### SESSION A15

**Process Enhancement and Monitoring**

**Session Chairman:** Bhaskar Dutta, DM3D Technology, LLC

<table>
<thead>
<tr>
<th>Session</th>
<th>Country</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>095</td>
<td>United Kingdom</td>
<td>10:30 a.m.</td>
<td>Real-Time Process Monitoring Accelerates Process Development and Streamlines Process Control</td>
<td>Marc Saunders, Renishaw Inc.</td>
<td></td>
</tr>
<tr>
<td>129</td>
<td>USA</td>
<td>10:55 a.m.</td>
<td>Improving Productivity in Laser Powder Bed Fusion Systems</td>
<td>James W. Sears, Carpenter Technology Corporation</td>
<td></td>
</tr>
<tr>
<td>172</td>
<td>USA</td>
<td>11:20 a.m.</td>
<td>In-Process Monitoring for Laser Metal Deposition</td>
<td>Melanie A. Lang, Formalloy</td>
<td></td>
</tr>
<tr>
<td>SESSION 12</td>
<td>Tuesday Afternoon</td>
<td>3:15–4:30 p.m.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>------------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>061 USA</strong></td>
<td>3:15 p.m.</td>
<td>Investigation of Powder Processing, Heat Treating, and Texturing to Improve Gas-Atomized Alnico Magnets for Use in Electric Drive Motors</td>
<td>Emily A. Rinko, Iowa State University</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>132 USA</strong></td>
<td>3:40 p.m.</td>
<td>Multistage Foaming of Powder Particles for Structural and Functional Applications</td>
<td>Samuel Brennan, Millersville University</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>044 USA</strong></td>
<td>4:05 p.m.</td>
<td>Results of Experiments with Cold Spray Deposition of Fe-Based ODS Alloys Using As-Atomized Spherical GARS Powder</td>
<td>Rebecca Whitesell, Iowa State University</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION 13</th>
<th>Tuesday Afternoon</th>
<th>3:15–4:30 p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>104 USA</strong></td>
<td>3:15 p.m.</td>
<td>Microgravity Liquid-Phase Sintering</td>
</tr>
<tr>
<td><strong>156 USA</strong></td>
<td>3:40 p.m.</td>
<td>Spark Plasma Sintering of Tungsten and Lanthanated Tungsten</td>
</tr>
<tr>
<td><strong>049 USA</strong></td>
<td>4:05 p.m.</td>
<td>Manipulating Bimodal Grain-Size Distribution to Enhance Material Properties in a Spark Plasma Sintered Nanostructured FeNiZr Alloy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION 14</th>
<th>Tuesday Afternoon</th>
<th>3:15–4:30 p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>148 Italy</strong></td>
<td>3:15 p.m.</td>
<td>The Analysis of the Densification Curve of Metallic Powders in Uniaxial Cold Compaction</td>
</tr>
<tr>
<td><strong>149 Italy</strong></td>
<td>3:40 p.m.</td>
<td>A Design Procedure to Define the Optimum Hardness of Parts Subject to Contact Stresses</td>
</tr>
<tr>
<td><strong>090 USA</strong></td>
<td>4:05 p.m.</td>
<td>Modeling of Plasma Spray Process for Thermal Barrier Coating</td>
</tr>
</tbody>
</table>
The emergence of metal additive manufacturing (AM) and its numerous technologies has created a demand for metal powders with specific characteristics such as particle size distribution, particle morphology, chemical composition, and cost. These requirements are not exactly new and other processes relying on metal powders, such as conventional powder metallurgy (PM) and metal injection molding (MIM), have similar requirements. Presentations will include insightful analyses of metal powders manufactured by different techniques utilized by the PM, MIM, and AM industry.

**Session Chairman:** Carl Blais, Laval University

**198 USA** 3:15 p.m.  
**Process Influence on Non-Ferrous Metal Powders**  
Thomas W. Pelletiers, Kymera International

**199 USA** 3:40 p.m.  
**Industrial Gas Atomization for Additive Manufacturing and Beyond**  
John Meyer, Carpenter Technology Corporation

**062 USA** 4:05 p.m.  
**Development of Effective Tools for Precise Selection of Atomization Parameters to Optimize Powder Production**  
Jordan A. Tiarks, Ames Laboratory (USDOE)
### POWDERMET TECHNICAL SESSIONS

#### Wednesday Morning 8:00–9:15 a.m.

<table>
<thead>
<tr>
<th>SESSION 15</th>
<th>Furnace and HIP Technology</th>
<th>Wednesday, June 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>144</td>
<td>USA</td>
<td>8:00 a.m.</td>
</tr>
<tr>
<td>Introduction to Furnace Technology as It Relates to Various Powdered Metal Applications</td>
<td>Michael Hager, Verder Scientific, Inc</td>
<td></td>
</tr>
<tr>
<td>065</td>
<td>Australia</td>
<td>8:25 a.m.</td>
</tr>
<tr>
<td>The Evolution of Hot Isostatic Pressing for the Treatment of Radioactive Wastes</td>
<td>Salvatore (Sam) Moricca, AMEPT LLC</td>
<td></td>
</tr>
<tr>
<td>079-R</td>
<td>USA</td>
<td>8:50 a.m.</td>
</tr>
<tr>
<td>The Influence of Hot Isostatic Pressing (HIP) and Heat Treatment on the Microstructure and Properties of PBF IN718</td>
<td>Magnus Ahlfors, Quintus Technologies</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION 16</th>
<th>Refractory Materials</th>
<th>Wednesday, June 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>082</td>
<td>USA</td>
<td>8:00 a.m.</td>
</tr>
<tr>
<td>Additive Manufacturing of Polymer Derived Ceramics</td>
<td>Xuehui Yang, Indiana University—Purdue University Indianapolis (IUPUI)</td>
<td></td>
</tr>
<tr>
<td>066</td>
<td>Germany</td>
<td>8:25 a.m.</td>
</tr>
<tr>
<td>On the Metallurgy and Manufacture of Cast Metallic Heat Resistant Alloys as Components for Powder Processing Applications</td>
<td>Shankar Venkataraman, Schmidt + Clemens Group</td>
<td></td>
</tr>
<tr>
<td>118</td>
<td>Germany</td>
<td>8:50 a.m.</td>
</tr>
<tr>
<td>NbC-TiC7N3 Cermets for Machining and for Wear Protection</td>
<td>Mathias Woydt, BAM Federal Institute for Materials and Testing</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION 17</th>
<th>Densification</th>
<th>Wednesday, June 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>013</td>
<td>Canada</td>
<td>8:00 a.m.</td>
</tr>
<tr>
<td>075</td>
<td>USA</td>
<td>8:25 a.m.</td>
</tr>
<tr>
<td>The Influence of Precursor Derived Secondary Structures on the Sintering Behavior of Binder Jet 3D Printed Titanium Dioxide</td>
<td>Lynora Grant, Rice University</td>
<td></td>
</tr>
<tr>
<td>145</td>
<td>USA</td>
<td>8:50 a.m.</td>
</tr>
<tr>
<td>Loose Powder Sintering: An Overview of Densification Behavior Pore Formation of Copper and 435 Steel Powders</td>
<td>Arun K. Chattopadhyay, Uniformity Labs</td>
<td></td>
</tr>
</tbody>
</table>
### Tribology and Corrosion
**Session Chairman:** Rajiv Tandon, Luxfer Magtech

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Authors</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A19</td>
<td>Corrosion Properties of Inconel 625 Processed by Laser Powder Bed Fusion</td>
<td>Sundar V. Atre, University of Louisville</td>
<td>USA</td>
</tr>
<tr>
<td>A19</td>
<td>Advanced Corrosion Studies of Alloys Fabricated by Laser Powder Bed Fusion</td>
<td>Sundar V. Atre, University of Louisville</td>
<td>USA</td>
</tr>
<tr>
<td>A20</td>
<td>Sensors Related to Sintering</td>
<td>Dustin Yetzer, Abbott Furnace Company</td>
<td>USA</td>
</tr>
<tr>
<td>A20</td>
<td>Quality Monitoring in the Overall Manufacturing Process Using Acoustic Resonance</td>
<td>Bryan Butsch, The Modal Shop, Inc.</td>
<td>USA</td>
</tr>
<tr>
<td>A21</td>
<td>3D Measurement and Inspection</td>
<td>Andrew R. Kitahara, Carnegie Mellon University</td>
<td>USA</td>
</tr>
</tbody>
</table>

### Powder Characterization for AM
**Session Chairman:** Andrzej Wojcieszynski, ATI Powder Metals

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Authors</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A20</td>
<td>Automated Particle Size and Shape Characterization of Metal Powders for Additive Manufacturing</td>
<td>Alan F. Rawle, Malvern Panalytical</td>
<td>USA</td>
</tr>
<tr>
<td>A20</td>
<td>Effects of Powder Characteristics, Recycling, and Process Parameters on the Microstructural and Mechanical Properties of Direct Energy Deposition Ti-6Al-4V</td>
<td>Courtney B. Morgan, Center for Advanced Vehicular Systems (CAVS)—Mississippi State University</td>
<td>USA</td>
</tr>
<tr>
<td>A21</td>
<td>SuperPowder: A Computer Vision Approach to Morphological Distribution Analysis for Metal Powders</td>
<td>Andrew R. Kitahara</td>
<td>USA</td>
</tr>
</tbody>
</table>

### Binder Jetting of Metal Powder
**Session Chairman:** Robert M. Gasior, Arconic Technology Center

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Authors</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A21</td>
<td>Dimensional Stability in Binder Jet 3D Direct Metal Printing</td>
<td>James W. Sears, Carpenter Technology Corporation</td>
<td>USA</td>
</tr>
<tr>
<td>A21</td>
<td>Fatigue Study of 316L Produced Using Binder Jet 3D Printing with Hot Isostatic Pressing</td>
<td>Andrew Klein, ExOne</td>
<td>USA</td>
</tr>
<tr>
<td>A21</td>
<td>A Review of Additive Manufacturing Methods for Tungsten Heavy Alloy</td>
<td>Michael T. Stawovy, H. C. Starck Inc.</td>
<td>USA</td>
</tr>
</tbody>
</table>

The ability to control processes is directly related to monitoring the variables driving the process. In PM, temperature, velocity, flow, position, pressure, and force are all examples of data critical to the quality of product produced. Developments in sensors monitoring and controlling various processes in the PM industry are explored defining current state-of-the-art, emerging new technology, and the architecture used to deliver this data to enterprise wide information systems. Combining the data can enable real time decisions improving quality, efficiency, accuracy, and delivery.

**Session Chairman:** Thomas W. Pelletiers, Kymera International

**Program Organizers:**
- Thomas W. Pelletiers, Kymera International
- Blaine Stebick, Phoenix Sintered Metals LLC
- William R. Gasbarre, FAPMI, Gasbarre Products, Inc.
- Daniel P. Reardon, Abbott Furnace Company

The ability to control processes is directly related to monitoring the variables driving the process. In PM, temperature, velocity, flow, position, pressure, and force are all examples of data critical to the quality of product produced. Developments in sensors monitoring and controlling various processes in the PM industry are explored defining current state-of-the-art, emerging new technology, and the architecture used to deliver this data to enterprise wide information systems. Combining the data can enable real time decisions improving quality, efficiency, accuracy, and delivery.

**Session Chairman:** Thomas W. Pelletiers, Kymera International
# POWDERMET TECHNICAL SESSIONS

## Material Processing
### Session Chairman:
Richard Walker, Pressure Technology, Inc.

<table>
<thead>
<tr>
<th>Session</th>
<th>Location</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>083-R</td>
<td>USA</td>
<td>9:30 a.m.</td>
<td>Manufacturing Methods for High-Density Powdered Metal (PM) Applications and Their Effect on Mechanical Properties</td>
<td>Amber Tims, North American Höganäs Co.</td>
</tr>
<tr>
<td>064</td>
<td>Malaysia</td>
<td>9:55 a.m.</td>
<td>A Preliminary Process for Incorporation of Graphene Reinforcement in Copper-Based Feedstock</td>
<td>Faiz Ahmad, Universiti Teknologi PETRONAS (UTP)</td>
</tr>
<tr>
<td>135-R</td>
<td>USA</td>
<td>10:20 a.m.</td>
<td>Effects of Sintering Conditions on the Diffusion Bonding of AgC-Cu Electrical Contacts</td>
<td>Daudi R. Waryoba, The Pennsylvania State University</td>
</tr>
</tbody>
</table>

## Compacting Development and Optimization
### Session Chairman:
Jerry Falleur, PMT, AAM—Powertrain

<table>
<thead>
<tr>
<th>Session</th>
<th>Location</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>126</td>
<td>Switzerland</td>
<td>9:30 a.m.</td>
<td>A Revolutionary Approach to Tooling Changeover on Multi-Level Presses</td>
<td>Guillermo Polo, Osterwalder Inc.</td>
</tr>
<tr>
<td>005</td>
<td>USA</td>
<td>9:55 a.m.</td>
<td>Room Temperature Compaction for Higher Density in Powder Metal Parts</td>
<td>Kalathur S. Narasimhan, FAPMI, P2P Technologies</td>
</tr>
<tr>
<td>171</td>
<td>Germany</td>
<td>10:20 a.m.</td>
<td>Modern Automation Systems for Powder Compaction Presses</td>
<td>Nicolas Hemmer, KOMAGE Gellner Maschinenfabrik KG</td>
</tr>
</tbody>
</table>

## PM Applications
### Session Chairman:
Robert Hayes, Phoenix Sintered Metals LLC

<table>
<thead>
<tr>
<th>Session</th>
<th>Location</th>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>124</td>
<td>Spain</td>
<td>9:30 a.m.</td>
<td>Methods for the Reduction of the Friction Coefficient of Sintered Bushings</td>
<td>Mark J. Dougan, AMES PM Tech Center</td>
</tr>
<tr>
<td>176</td>
<td>USA</td>
<td>9:55 a.m.</td>
<td>Wear Resistance and Mechanical Properties of PM Alloy Materials</td>
<td>Arthur E. Jones, Symmco Inc.</td>
</tr>
<tr>
<td>187-R</td>
<td>USA</td>
<td>10:20 a.m.</td>
<td>High-Strength Aluminum-Zinc Composite PM Grade with Trace Amount of Copper for Powder Metallurgy Applications</td>
<td>Jessu Joys, United States Metal Powders, Inc.</td>
</tr>
</tbody>
</table>
### SPECIAL INTEREST PROGRAM

**Wednesday Morning**

9:30–10:45 a.m.

**AMPM TECHNICAL SESSIONS**

**Wednesday Morning**

9:30–10:45 a.m.

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Country</th>
<th>Time</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SESSION A22</strong></td>
<td>AM Powder Flow Characterization</td>
<td>Canada</td>
<td>9:30 a.m.</td>
<td>Eileen Ross L. Espiritu, McGill University</td>
</tr>
<tr>
<td></td>
<td>Understanding the Factors Influencing Powder Spreadability for Laser Powder Bed Fusion</td>
<td>Canada</td>
<td>9:30 a.m.</td>
<td>Eileen Ross L. Espiritu, McGill University</td>
</tr>
<tr>
<td></td>
<td>Powder Flowability and Density: Effect of Humidity and Impact on the Reproducibility of the Measurements</td>
<td>Canada</td>
<td>9:55 a.m.</td>
<td>Louis-Philippe Lefebvre, National Research Council Canada</td>
</tr>
<tr>
<td><strong>SESSION A23</strong></td>
<td>Design of Metal AM Structures</td>
<td>United Kingdom</td>
<td>9:30 a.m.</td>
<td>Daniel Barba, University of Oxford</td>
</tr>
<tr>
<td></td>
<td>Multifunctional Lattices by Additive Manufacturing</td>
<td>United Kingdom</td>
<td>9:55 a.m.</td>
<td>Sam Catchpole-Smith, University of Nottingham</td>
</tr>
<tr>
<td></td>
<td>On the Size-Dependent Strength of Additive Manufactured Titanium</td>
<td>Spain</td>
<td>10:20 a.m.</td>
<td>Carles Alabort, Polytechnic University of Valencia</td>
</tr>
<tr>
<td><strong>SESSION A24</strong></td>
<td>Copper-Based AM</td>
<td>USA</td>
<td>9:30 a.m.</td>
<td>Paramjot Singh, University of Louisville</td>
</tr>
<tr>
<td></td>
<td>Effect of Solids Loading, and Volumetric Flow Rate on Properties of Metal-Fused Filament Fabricated (MF3) Bronze</td>
<td>USA</td>
<td>9:55 a.m.</td>
<td>Martin Bullemer, AMCM GmbH</td>
</tr>
<tr>
<td></td>
<td>No presentation scheduled at this time.</td>
<td>Germany</td>
<td>10:20 a.m.</td>
<td></td>
</tr>
</tbody>
</table>
## POWDERMET TECHNICAL SESSIONS

### Wednesday Morning 11:00 a.m.–12:15 p.m.

#### SESSION 21
**Powder Test and Evaluation**

**Session Chairman:** Jessu Joys, United States Metal Powders, Inc.

- **038** USA 11:00 a.m.  
  3D Digital Image Correlation: The Ultimate Tool for Displacements and Strains Testing  
  Charles-Olivier Amyot, Trilion Quality Systems

- **043** Canada 11:25 a.m.  
  Powder Properties Characterization of PM Lubricants Using FT4 Powder Rheometer  
  Jean V. Reid, H.L. Blachford Ltd.

- **023** Canada 11:50 a.m.  
  Using Powder Rheology Measurements to Optimize the Mixing Time of an Iron-Based Premix for Best Die-Filling Performance  
  Boris Nijikovsky, Université du Québec

#### SESSION 22
**Secondary Operations**

**Session Chairman:** John Lyons, III, Line Craft, Inc.

- **030** USA 11:00 a.m.  
  Effect of Hybrid Post-Sinter Treatment on Sinter Hardened (SH) Structural Parts from PM Steels  
  Leonid I. Frayman, Allegheny Coatings/Pamlico Coatings Group

- **070** USA 11:25 a.m.  
  Effect of Carbon Content on the Machinability of Powdered Metal Copper Steels  
  Cody Kalinoski, Engineered Sintered Components

- **012** USA 11:50 a.m.  
  Study on Corrosion Performance and Microstructure of Sinter Hardened Artifacts Subjected to Various Finishing  
  Leonid I. Frayman, Allegheny Coatings/Pamlico Coatings Group

#### SESSION 23
**Safety and Management**

**Session Chairman:** Arthur E. Jones, Symmco, Inc.

- **139** USA 11:00 a.m.  
  Contaminated Cartridge-Type Dust Collectors May Pose Serious Health and Environmental Risks  
  Michael W. Seitz, BlueSky Global

- **150** Canada 11:25 a.m.  
  Metal Powder Recycling—Closing the Loop on Sustainability  
  Josh Lifshitz, Globe Metal

- **175** USA 11:50 a.m.  
  Talent Acquisition, Utilization and Retention in the PM Industry... It’s Time to End the Recycle  
  Rocco Petrilli, PKPM Advisory Group
### SPECIAL INTEREST PROGRAM

**Wednesday Morning** 11:00 a.m.–12:15 p.m.

**SIP 3-3**

**Machining Sensors and Information Technology: Industry Sensors III—Impacting Business Operations with My Data**

*Program Organizers:*
- Thomas W. Pelletiers, Kymera International
- Blaine Stebick, Phoenix Sintered Metals LLC
- Willam R. Gasbarre, FAPMI, Gasbarre Products, Inc.
- Daniel P. Reardon, Abbott Furnace Company

The ability to control processes is directly related to monitoring the variables driving the process. In PM, temperature, velocity, flow, position, pressure, and force are all examples of data critical to the quality of product produced. Developments in sensors monitoring and controlling various processes in the PM industry are explored defining current state-of-the-art, emerging new technology, and the architecture used to deliver this data to enterprise wide information systems. Combining the data can enable real-time decisions improving quality, efficiency, accuracy, and delivery.

**Session Chairman:** Daniel P. Reardon, Abbott Furnace Company

<table>
<thead>
<tr>
<th>Session</th>
<th>USA</th>
<th>Time</th>
<th>Title</th>
<th>Speakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>188</td>
<td></td>
<td>11:00</td>
<td>A Platform for Data Science Applications to Industrial Processes—Part I</td>
<td>Dilsat Dalkiran, SAP America</td>
</tr>
<tr>
<td>202</td>
<td></td>
<td>11:25</td>
<td>A Platform for Data Science Applications to Industrial Processes—Part II</td>
<td>Dilsat Dalkiran, SAP America</td>
</tr>
<tr>
<td>205</td>
<td></td>
<td>11:50</td>
<td>Industry 4.0 and Big Data: The Signal and the Noise</td>
<td>Steven R. Schmid, University of Notre Dame</td>
</tr>
</tbody>
</table>

### AMPM TECHNICAL SESSIONS

**Wednesday Morning** 11:00 a.m.–12:15 p.m.

<table>
<thead>
<tr>
<th>SESSION A25</th>
<th>USA</th>
<th>Time</th>
<th>Title</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>034</td>
<td></td>
<td>11:00</td>
<td>Binder-Jet 3D Direct Metal Printing of Cobalt Chrome Moly Alloy</td>
<td>James W. Sears, Carpenter Technology Corporation</td>
</tr>
<tr>
<td>056</td>
<td></td>
<td>11:25</td>
<td>Simulations of the Stress Field Around a Sinter-Crack</td>
<td>Reid Carazzone, Rice University</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION A26</th>
<th>USA</th>
<th>Time</th>
<th>Title</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>107</td>
<td></td>
<td>11:00</td>
<td>Machining of Metal AM Parts in an Industry 4.0 Environment—Design, Process Control and Inspection Techniques</td>
<td>Dan Skulan, Renishaw Inc.</td>
</tr>
<tr>
<td>079</td>
<td></td>
<td>11:25</td>
<td>The Influence of Hot Isostatic Pressing (HIP) and Heat Treatment on the Microstructure and Properties of PBF IN718</td>
<td>Magnus Ahlfors, Quintus Technologies</td>
</tr>
<tr>
<td>109</td>
<td></td>
<td>11:50</td>
<td>Changing the Additive Manufacturing Industry with New, Efficient Furnace Technology</td>
<td>Janusz Kowalewski, Ipsen</td>
</tr>
</tbody>
</table>
INTERNATIONAL POSTERS dealing with various aspects of PM and particulate materials technologies will be displayed daily starting on Monday morning. Authors will be available at their posters for discussion Monday (5:30–7:00 p.m.) during the PM Evening Alehouse. “Outstanding Poster” and “Poster of Merit” awards will be given by the Poster Awards Committee for displays that meet the established criteria. Award ribbons will be posted prior to the designated discussion period on Monday. Grant TNT: Talk ‘N Technology also have dedicated times throughout the conference. See the Daily Schedule for details. Additionally, 44 National Science Foundation Grant recipients and CPMT student posters will be on display.

POSTER A: MATERIALS

009 India
Effect of Phosphorous Addition on Tribological Behavior of Copper Processed Through Powder Metallurgy
Leelav Rajendran, Vikram Sarabhai Space Centre

042 Taiwan
Thermoelectric Properties of Zn4Sb3 Prepared by Mechanical Alloying and Different Consolidation Routes
Pee-Yew Lee, National Taiwan Ocean University

101 USA
A Low-Cost, Industrial Scalable, Cleantech Method for Recycling Stainless Steel Machining Waste into 3D Printable Powders, Using High-Energy Milling Equipment
Steven R. Longpre, BSS Additive

159 USA
Improvement of Core Loss in Oriented Electrical Steels with Mn-Doped MgO Insulation Coating Layer
Bong Gu Kim, Indiana University—Purdue University Indianapolis (IUPUI)

POSTER B: PROCESSING

011 USA
Hybrid Post-Sinter Treatment of Sinter Hardened Artifacts from PM Steels
Andrew A. Serafini, The Pennsylvania State University—Dubois

025 Taiwan
Preparation of Highly Anisotropic NdFeB Powders and Enhancing Their Coercivity by the Dye-Free Grain Boundary Diffusion Process
Hung-Shang, Huang China Steel Corporation

039 USA
Influence of SLM Processing Parameters on Mechanical Properties of Tungsten-Heavy Alloys
Bartlomiej K. Bancewicz, Lehigh University

045 USA
Effect of Scanning Strategies on the Melt Pool Geometry During Powder Bed Fusion Additive Manufacturing
Antonio Magana-Ceballos, California State University—Los Angeles

050 Canada
A Novel Method for Determining the Packing Factor of Powder for Electron Beam Powder Bed Fusion Application
Basel Alchikh-Sulaiman, McGill University

POSTER C: PROPERTIES

128 USA
Electron Beam Physical Vapour Deposition Models for Thermal Barrier Coating Fabrications
Anvesh Dhulipalla, Indiana University—Purdue University Indianapolis (IUPUI)

155 USA
3D Printing of Biomimetic Inspired Zircon Ceramic Structures
Piyush P. Raikar, Indiana University—Purdue University Indianapolis (IUPUI)

152 USA
Creep Modeling of 3D Printed Inconel718
Harshal Dhamade, Indiana University—Purdue University Indianapolis (IUPUI)

154 USA
Thermal Fatigue Modeling of Thermal Barrier Coating
Abhilash Gulhane, Indiana University—Purdue University Indianapolis (IUPUI)

STUDENT GRANT POSTER PROGRAM

Continuing our quest to introduce the science of PM to students, 40 National Science Foundation (NSF) and 4 CPMT/Axel Madsen Conference Grant recipients will prepare project posters on PM & metal AM to be displayed during the conference. Additionally, each recipient will present a 10-minute synopsis of the poster during a scheduled Grant TNT: Talk ‘N Technology. Grant recipients and their poster titles will be available on the conference website. MPIF is grateful to the National Science Foundation for its support of students to attend the POWDERMET2019 & AMPM2019 annual conferences. This support provides student participants with opportunities to exchange ideas with leading researchers and engineers from worldwide industrial and governmental facilities, as well as with students and faculty from both domestic and international universities. Student participants will learn the latest research areas and results in powder metallurgy fields of interest. These opportunities will not only improve the students’ knowledge in the field, but also develop scientists and engineers who are ideally suited to create the next generation of designs in powder metallurgy and metal additive manufacturing that will push materials and manufacturing capabilities.

The Axel Madsen Conference Grant Program was established by the Madsen family to encourage students to learn more about PM technology and eventually pursue careers in the PM industry.
Make the Most of Your Conference Experience

From attendees to exhibitors or from speakers to students, networking is one of the most important functions of a conference. Form or strengthen relationships, get face-to-face time with customers or students, and ask follow-up questions to researchers in your field. Gain customers, suppliers, colleagues, or mentors.

Networking Opportunities

- **OPENING NIGHT RECEPTION**
  Don't miss the kick-off celebration to the entire conference as attendees are welcomed to Phoenix. Say hello to old and new friends and learn the latest industry buzz.

- **PM DESIGN EXCELLENCE AWARDS LUNCHEON**
  A luncheon highlighting the winners of the 2019 PM Design Excellence Awards that provides an opportunity to learn about new uses of PM and the top companies in the industry.

- **PM EVENING ALEHOUSE**
  Grab a beverage and shake hands with exhibitors, poster authors, and fellow attendees.

- **INDUSTRY LUNCHEON**
  A luncheon recognizing key industry individuals, this luncheon is an opportunity to connect big names with faces.

- **CLOSING EVENT—Rhinestone Rodeo!**
  Grab your rope and spurs and head over to the biggest social event of the conference! This is an ideal time to connect with other attendees and discuss all that you've learned throughout the conference. This is a fun and unique way to connect and network with your fellow PM/AM industry peers.

Conference Networking 101

- **PREPARE, PREPARE, PREPARE.**
  1. Download the Conference App.
  2. Review the program.
  3. Find out who's going.
  4. Schedule meetings at the AM/PM Café.

- **ONCE YOU’RE THERE**
  1. Connect with colleagues and/or customers.
  2. Utilize evening social events—the informal setting is a good way to get to know people.
  3. Don't hesitate to ask questions or seek out speakers or exhibitors at social events.
  4. Make time to attend the exhibit hall.
  5. Visit the poster sessions.

- **POST-CONFERENCE**
  1. Follow up with people you met by connecting on LinkedIn or sending them a quick email.
  2. Share what you have learned with co-workers.

TIP: Put Away the Smartphone—nothing beats face-to-face interaction.
GENERAL INFORMATION

CONFERENCE VENUE & HEADQUARTERS HOTEL
All conference events will take place at:

Sheraton Grand Phoenix
340 N. 3rd Street
Phoenix, AZ 85004
602-262-2500

REGISTRATION
• Register and reserve hotel rooms at POWDERMET2019.org or AMPM2019.org.
• Advance registration discounts are for a limited time and will guarantee participation in selected events.
• Payment must accompany registration by May 10 to qualify for lowest rates.
• Rates increase after May 10.
• Higher rates apply for registration on site.
• MPIF and APMI International members receive discounted rates.
• Children under the age of 17 will not be permitted.

FULL THREE-DAY CONFERENCE REGISTRATION
The POWDERMET2019/AMPM2019 conference registration fee includes:
• Opening General Session and technical events for both co-located conferences (POWDERMET2019 & AMPM2019)
• Exhibit hall admission
• Meal functions: Opening Night Reception, Industry and PM Design Excellence Awards Luncheons, PM Evening Alehouse, and the Closing Event—Rhinestone Rodeo!
• Registration bag with handout materials
• Post-conference digital proceedings for POWDERMET2019 and AMPM2019 technical manuscripts

DAILY REGISTRATION
Daily rates include:
• Opening General Session (where applicable) and technical events for both co-located conferences (POWDERMET2019 & AMPM2019)
• Exhibit hall admission
• Meal functions: Opening Night Reception, Industry and PM Design Excellence Awards Luncheons, PM Evening Alehouse
• Registration bag with handout materials
• Post-conference digital proceedings for POWDERMET2019 and AMPM2019 technical manuscripts

LET PHOENIX SURPRISE YOU!
Although Phoenix sits within the Sonoran Desert, there is more to see and do in this stunning desert backdrop. Downtown Phoenix has been brought to life, giving its visitors more restaurants and bars to explore, great music to discover and stunning street art to stumble upon. As Arizona’s urban center, Downtown Phoenix provides unique year-round experiences thanks to a rich history, diverse culture and fantastic art community. Come early or stay longer so that you can enjoy all that the city has to offer!

Have you ever...
- wanted to hike up the hump of a camel? Camelback Mountain is a prominent landmark in Phoenix. The mountain, which summits at 2,704 feet above sea level, resembles the hump and head of a kneeling camel.
- wanted to see a 50-foot tall cactus that can live up to 200 years? The Saguaro Cactus, found in Sonoran Desert, can’t be found in any other desert in the world.
- wanted to see a major professional sporting event before or after the conference? You are in luck—Phoenix is one of the few U.S. cities with franchises in all four major professional sports leagues: Phoenix Suns (NBA), Arizona Diamondbacks (MLB), Arizona Cardinals (NFL) and Arizona Coyotes (NHL).
- wanted to visit the MIM Museum? The Musical Instrument Museum (MIM) tunes you into thousands of instrument sounds with a headset that syncs seamlessly as you move throughout the gallery.

Daily rates do not include luncheons, Opening Reception, dinner events, or manuscript proceedings. Meal tickets and proceedings may be purchased separately.

SPouse REGISTRATION
Spouse registration is designed to allow significant others, not affiliated with the PM industry, to join you at the Opening Night Reception, the Closing Event—Rhinestone Rodeo, and the exhibit hall, including the PM Evening Alehouse.

All registrations will be acknowledged by e-mail. Important: If you do not receive an acknowledgment within 4–7 days, please contact Stephanie Schember at sschember@mpif.org.

STUDENT REGISTRATION
(Non-NSF/CPMT Grant Recipients)
The student rate includes:
• Opening General Session and technical events for both co-located conferences (POWDERMET2019 & AMPM2019)
• Exhibit hall admission
• Meal functions: Opening Night Reception, Industry Luncheon, the PM Design Excellence Award Luncheon, and the PM Evening Alehouse*
• Post-conference digital proceedings for POWDERMET2019 and AMPM2019 technical manuscripts
• Registration bag with handouts

To qualify for the student rate, you must:
• Be enrolled as a full-time engineering student who is not employed in the industry
• Provide proof of active student status with your conference registration
• Provide the university name as your organization when you register for the conference

*Meal tickets for the Opening Night Reception and the Closing Event—Rhinestone Rodeo are not included in the student package. These tickets must be purchased separately.
MEAL TICKET SALES
Additional tickets for the Opening Night Reception, the Industry and PM Design Excellence Awards Luncheons, and the Closing Event—Rhinestone Rodeo! will be available for purchase only to:
• Daily registrants
• POWDERMET/AMPM conference registrants
• Accompanying spouses/guests of full-conference registrants
• Exhibitor personnel
• Students

Individual meal ticket sales are intended as add-ons to existing conference registrations. Individuals who are not conference registrants, as listed above, will not be able to purchase meal tickets.

ADMISSION TO EXHIBIT HALL
• Admission to the exhibit hall is included as part of full-conference and daily registration rates.
• Exhibit-only admission is not available for purchase.
• Qualified PM parts manufacturers are eligible for complimentary exhibit passes. Please visit POWDERMET2019.org or AMPM2019.org for details.

CANCELLATIONS AND REFUNDS
• Registration cancellations and refunds are only accepted in writing.
• If you cancel by telephone, you must still confirm by email or fax at the time of cancellation in order to receive a refund.
• A $325 cancellation fee will be deducted from refunds on all cancellations received through June 7 (no refunds for the APMI Golf Tournament). No refunds will be given after this date.
• Individuals who fail to cancel in writing by June 7 and do not attend the conference will be subject to the full fee.

Important: If you do not receive a cancellation acknowledgment within 2–3 business days, please contact Stephanie Schember at sschember@mpif.org.

REQUEST FOR FOREIGN VISAS
Some travelers entering the U.S. must obtain a visa and should apply for a visa as early as possible due to U.S. government increased security and entry requirements. Request a special letter of invitation at POWDERMET2019.org or AMPM2019.org. For further questions, contact Stephanie Schember at sschember@mpif.org.

SUGGESTED DRESS
Business or business casual attire is appropriate for all conference events. Casual attire (shorts permitted) is appropriate for the Closing Event—Rhinestone Rodeo!

14th Annual APMI International Golf Tournament
Revered as the crown jewel or Scottsdale, the challenge, visual sensation and special ambiance of Troon North sets the standard by which all other courses are measured. Recent course renovations by original designer and British Open Champion Tom Weiskopf has created a new layout to bring back the classic desert golf experience. Stretching through natural ravines and foothills in the shadows of Pinnacle Peak, the giant granite boulders lie strewn across the rugged landscape of Arizona’s Sonoran Desert, providing a standard unmatched in the American Southwest. Whether you are playing for the first time or a regular, Troon North in sunny Arizona offer golf connoisseurs the best in desert golf!

Attendees may register as foursome or as individuals. To sponsor a foursome, please contact Diane Haggerty (dhaggerty@mpif.org).

TROON NORTH GOLF OUTING
Sunday, June 23
8:00 a.m.–2:00 p.m. (Bus departure 6:30 a.m.)

Attire: Course dress code is soft spikes, slacks, Bermuda shorts, and shirts with sleeves and collar.

Cancillation Policy: There are no refunds for cancellation of the golf tournament.

Tournament Fee: $140.00—includes transportation, breakfast, greens fees and cart.

Rental Clubs: $50.00 per set

Participation in the tournament may be limited. Sign up early to reserve your spot!

PEOPLE WITH DISABILITIES
Attendees with disabilities that require special needs should contact MPIF (dhaggerty@mpif.org) in advance so that arrangements can be made.

HOTEL RESERVATIONS
Register early to guarantee group rates at the hotel. Higher rates may apply once our room block is filled or after the advance registration deadline of May 10. Room reservations will be acknowledged by email. Hotel rooms before and after the conference may be available but at a higher rate.

SPECIAL CONFERENCE RATE
Single or Double: $144.00 plus taxes per night.

Hotel reservations, changes, and cancellations
• Credit card information is required in order to process your reservation. Your card will be charged the first night’s room and tax as a deposit by the hotel.
• This deposit is refundable for cancellations received at least 48 hours prior to the confirmed day of arrival and cancellation number is obtained.
• For changes to your reservations or to cancel, contact the Sheraton Grand Phoenix.

STAY AT THE HEADQUARTERS HOTEL
You are highly encouraged to stay at the Sheraton Grand Phoenix—the headquarters hotel. Not only will you be at the center of all the activities, but the convenience far outweighs any benefits from staying at other hotels. Please help your association meet its contracted obligations by staying at the headquarters hotel.

CODE OF CONDUCT POLICY
Presenters, Vendors and all other Attendees at MPIF/APMI/CPMT events are expected to comply with instructions from staff members, and are expected to conduct themselves at all times in a courteous, professional and respectful manner, refraining from language and conduct that might bring discredit upon themselves, their organizations, and MPIF/APMI/CPMT. Such conduct includes, but is not limited to disrupting the businesslike atmosphere, harassment, discrimination, inappropriate language, failing to comply with local, state, and federal laws, and conduct that puts themselves and others at risk. This code of conduct applies to both official activities of the event and its program as well as to any informal and social activities taking place in connection with the event. Presenters, and any other Attendees who do not comply with this code of conduct may be removed from the event and barred from attending future MPIF/APMI/CPMT sponsored or co-sponsored events.

STAY AT THE HEADQUARTERS HOTEL
You are highly encouraged to stay at the Sheraton Grand Phoenix—the headquarters hotel. Not only will you be at the center of all the activities, but the convenience far outweighs any benefits from staying at other hotels. Please help your association meet its contracted obligations by staying at the headquarters hotel.

CODE OF CONDUCT POLICY
Presenters, Vendors and all other Attendees at MPIF/APMI/CPMT events are expected to comply with instructions from staff members, and are expected to conduct themselves at all times in a courteous, professional and respectful manner, refraining from language and conduct that might bring discredit upon themselves, their organizations, and MPIF/APMI/CPMT. Such conduct includes, but is not limited to disrupting the businesslike atmosphere, harassment, discrimination, inappropriate language, failing to comply with local, state, and federal laws, and conduct that puts themselves and others at risk. This code of conduct applies to both official activities of the event and its program as well as to any informal and social activities taking place in connection with the event. Presenters, and any other Attendees who do not comply with this code of conduct may be removed from the event and barred from attending future MPIF/APMI/CPMT sponsored or co-sponsored events.

Important: If you do not receive a cancellation acknowledgment within 2–3 business days, please contact Stephanie Schember at sschember@mpif.org.

REQUEST FOR FOREIGN VISAS
Some travelers entering the U.S. must obtain a visa and should apply for a visa as early as possible due to U.S. government increased security and entry requirements. Request a special letter of invitation at POWDERMET2019.org or AMPM2019.org. For further questions, contact Stephanie Schember at sschember@mpif.org.

SUGGESTED DRESS
Business or business casual attire is appropriate for all conference events. Casual attire (shorts permitted) is appropriate for the Closing Event—Rhinestone Rodeo!
Be a Part of the Action...
## REGISTRATION FEES AND TICKET PRICES

### FULL CONFERENCE REGISTRATION
(Includes Opening Night Reception, PM Evening Alehouse, Opening General Session, POWDERMET and AMPM technical sessions, two luncheons, exhibit, Closing Event, POWDERMET and AMPM proceedings, and registration bag with handouts)

<table>
<thead>
<tr>
<th>Category</th>
<th>Advance Paid by May 10</th>
<th>After May 10</th>
<th>On-Site Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPIF-Member Company Employees</td>
<td>$1,600</td>
<td>$1,700</td>
<td>$1,850</td>
</tr>
<tr>
<td>MPIF-Member (Speakers/Session Chairmen)</td>
<td>1,500</td>
<td>1,700</td>
<td>1,850</td>
</tr>
<tr>
<td>APMI Member</td>
<td>1,700</td>
<td>1,800</td>
<td>1,950</td>
</tr>
<tr>
<td>APMI Member (Speakers/Session Chairmen)</td>
<td>1,600</td>
<td>1,800</td>
<td>1,950</td>
</tr>
<tr>
<td>Non-Member</td>
<td>2,000</td>
<td>2,100</td>
<td>2,250</td>
</tr>
<tr>
<td>Non-Member (Speakers/Session Chairmen)</td>
<td>1,900</td>
<td>2,100</td>
<td>2,250</td>
</tr>
<tr>
<td><strong>NEW! Metal AM Tutorial (Optional)</strong></td>
<td>200</td>
<td>300</td>
<td>400</td>
</tr>
</tbody>
</table>

Explore the opportunities associated with developing a metal AM manufacturing facility.

### EXHIBITOR REGISTRATION
(for exhibitor booth staff)

<table>
<thead>
<tr>
<th>Package</th>
<th>Advance Paid by May 10</th>
<th>After May 10</th>
<th>On-Site Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhibitor Package 1</td>
<td>$875</td>
<td>$900</td>
<td>$925</td>
</tr>
<tr>
<td>(Opening Night Reception, PM Evening Alehouse, Opening General Session, two technical sessions, two luncheons, Closing Event, and registration bag with handouts)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhibitor Package 2</td>
<td>375</td>
<td>400</td>
<td>425</td>
</tr>
<tr>
<td>(Opening General Session, PM Evening Alehouse, two technical sessions, two luncheons, and registration bag with handouts)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spouse Registration</td>
<td>500</td>
<td>525</td>
<td>550</td>
</tr>
<tr>
<td>(Includes Opening Night Reception, PM Evening Alehouse and Closing Event)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Registration</td>
<td>200</td>
<td>250</td>
<td>300</td>
</tr>
<tr>
<td>(Opening General Session, PM Evening Alehouse, technical sessions, two luncheons, exhibit, POWDERMET and AMPM proceedings, and registration bag with handouts) (For details and to determine eligibility, visit POWDERMET2019.org.)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Opening Reception and Closing Event purchased separately.

### Daily Registration
(Includes technical sessions and exhibit only, plus registration bag with handouts.)

<table>
<thead>
<tr>
<th>Day</th>
<th>Advance Paid by May 10</th>
<th>After May 10</th>
<th>On-Site Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>$850</td>
<td>$900</td>
<td>$950</td>
</tr>
<tr>
<td>Tuesday</td>
<td>850</td>
<td>900</td>
<td>950</td>
</tr>
<tr>
<td>Wednesday</td>
<td>850</td>
<td>900</td>
<td>950</td>
</tr>
</tbody>
</table>

Opening Reception and Closing Event purchased separately.

### Exhibit-Only Admission
Free to qualified PM parts manufacturers only (contact MPIF for details). Exhibit is included with full or daily packages above.

### POWDERMET2019 or AMPM2019 Digital Conference Proceedings
(Included with full-conference and student registration, cost for additional copies)

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWDERMET2019 or AMPM2019 Digital</td>
<td>$750</td>
</tr>
<tr>
<td>Conference Proceedings</td>
<td></td>
</tr>
</tbody>
</table>

### Meal Tickets
(Meals are available only to full conference registrants, spouses, students, and exhibitor personnel)

<table>
<thead>
<tr>
<th>Day</th>
<th>Event</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td>Opening Night Reception</td>
<td>$150</td>
</tr>
<tr>
<td>Monday</td>
<td>PM Design Excellence Awards Luncheon</td>
<td>80</td>
</tr>
<tr>
<td>Tuesday</td>
<td>Industry Luncheon</td>
<td>80</td>
</tr>
<tr>
<td>Tuesday</td>
<td>Closing Event—Rhinestone Rodeo!</td>
<td>375</td>
</tr>
</tbody>
</table>

### APMI Golf Tournament (Sunday)

<table>
<thead>
<tr>
<th>Category</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tournament Fee</td>
<td>$140</td>
</tr>
<tr>
<td>Club Rental</td>
<td>50</td>
</tr>
</tbody>
</table>
The potential of powder metallurgy is only limited by one’s imagination…

GKN Hoeganaes is a world leader in the development and production of metal powders.

Over 65 years, our commitment to innovative technologies spans critical applications from Automotive to Additive Manufacturing.

GKN Hoeganaes has expanded our global footprint to meet our customers’ needs, with powder production facilities in North America, Europe and Asia.
PROGRAM & REGISTRATION INFORMATION

June 23–26, 2019
Sheraton Grand • Phoenix, Arizona

For program details visit: POWDERMET2019.org or AMPM2019.org