Spring 2003

Center for Innovative Sintered Products

CISP

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Highlights of PIM 2003 International Conference

Randall M. German – Director

This was the thirteenth convening of the PIM community, organized and hosted this time by CISP in State College. Logistics for the program were provided by Innovative Material Solutions (a CISP member company) and followed the successful model used in prior meetings. This year the program co-chairs were Robert Howells (Osprey Metals), Hideshi Miura (Kumamoto University), and Rand German (CISP). To kick off the meeting, a tutorial program on 16 March provided a quick introduction for both practicing engineers and Penn State students. Each day included an informal event: wine and cheese party on Sunday, demonstrations and tour on Monday, and a very successful tabletop exhibit on Tuesday. These proved valuable in fostering extended discussions and information exchanges while providing a means to catch up on new materials, businesses, technology trends, applications, and important process offerings. The scale and success of the program is a testimonial to the valuable role now played by CISP for this segment of the sintered materials community.

Some introductory statistics:

- papers presented and participants at the meeting were from around the world – USA, United Kingdom, Japan, Korea, Canada, Singapore, Austria, Germany, Malaysia, Chech Republic, China, France, Switzerland, India, Thailand, Brazil, Israel, and others
- CISP was well represented both by researchers from Penn State and by member companies
- over 30 parts makers participated, one of the best showings ever at this meeting
- users and potential users attended looking for support in new projects that included applications such as cell telephone parts, biomedical implants, aerospace components, fiber optical components, rocket nozzles, oil-well drilling components, high-intensity lighting, firearms, automobile components, watch components, and military parts
- representation by the major industry segments was very balanced, including a diversity of powder and feedstock suppliers, molding machine fabricators, furnace and mixer vendors, parts producers (both captive and custom), users, university researchers, and the legal community

highlights continued on back page

PENNSTATE
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CISP Research Projects Identified

CISP Industry Members recently identified a suite of research projects to begin 1 July 2003. The Center affords members the opportunity to pool research dollars in support of precompetitive research projects, thus encouraging greater technical challenges the members could not or would not tackle alone. These projects are focused on using research as an education tool to involve students in contemporary problems associated with sintered materials while providing new findings for the members. All member companies are encouraged to become familiar with and take advantage of or mentor any research project. To mentor a project contact Sharon Elder (cisp@psu.edu).

project listings on pg 2 (top)

Upcoming Events

May 21-22, 2003
PIM Tutorial
State College, PA

June 8-12, 2003
MPIF–PM^{2}TEC
Las Vegas, NV

July 14, 2003
MPIF–Basic Short Course
University Park, PA

September 14-17, 2003
Sintering 2003
University Park, PA

September 24, 2003
PM Fracture Short Course
DuBois, PA

October 20-21, 2003
CISP Industry Member Meeting
University Park, PA

PIM Mold Filling Simulation

The CAE software PIMsolver®, which has been developed by the CISP member company CetaTech, is a good example of a highly developed simulation tool with a wide variety of applications for modeling and optimizing PIM processes. Figure 1 shows the pressure distribution in a 316L PIM tensile bar during mold filling as obtained from a simulation. During molding many of the defects are formed that later become evident in the final component. In an ongoing effort by CISP, CetaTech, and Austrian Research Centers, critical input parameters are identified using a dimensionless sensitivity analysis and are related to the output parameters. Figure 2 shows a sensitivity analysis for the maximum injection pressure and indicates that the injection pressure is more sensitive to feedstock properties than to processing parameters: an important result when it comes to troubleshooting during production. Contact Seong Jin Park (sup13@psu.edu), Rudi Zauner (rudolf.zauner@arcs.ac.at) or Sundar Atre (sva101@psu.edu).

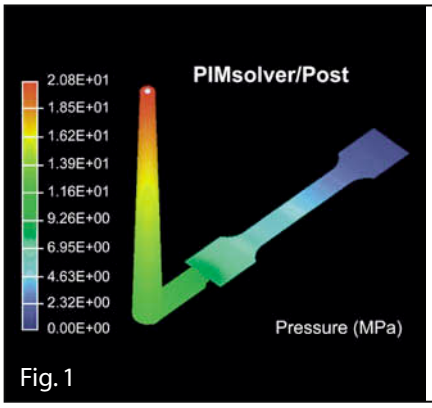


Fig. 1

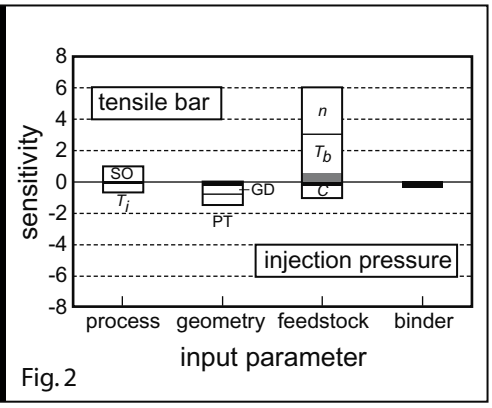


Fig. 2

CISP Research

CISP Research Projects Identified

continued from front

1. Fundamental limitations and capabilities of high-density P/M
2. Multiple-axis *in situ* monitoring of dimensional changes in debinding, delubrication, sintering, and heat treatment (continuing project)
3. Defect avoidance during compaction and delubrication of P/M components (continuing project)
4. Crack detection in green parts (continuing project)
5. Application of full-density hard coatings to ferrous P/M materials
6. Net-shaping of refractory metals (continuing project)
7. Product design and process optimization for powder injection molding

Crack Detection in Green Parts

The problem of crack detection in green parts has confronted the P/M industry for decades. A novel technique for the detection of cracks in green compacts has been developed using ultrasonic surface waves. A sharp-edged surface wave mediator technique utilizes a through-transmission setup featuring a minimal no-couplant line contact area with the part in order to find cracks through signal amplitude reduction and increased time delays. A prototype mediator and sensor arrangement placed on a small green-part gear is shown in Figure 1. Unlike other ultrasonic techniques, the surface wave mediator technique does not use water or oil as a coupling medium, thus eliminating the introduction of potential contaminants on a part's surface before sintering. Scanning results for parts such as gears can be displayed as circumferential amplitude profiles to show the location and often severity of the defect area within the part. A sample circumferential profile on the gear is shown in Figure 2 for 15 data acquisition segments around the circumference. Cracks are easily detected. The technique is well suited for parts with a case history of cracking in a specific region and can be easily automated in a quality control system during on-line production. Work remains to customize the sensor design and fixturing for crack detection for specific components. For additional information contact Joe Rose (jlresm@engr.psu.edu).

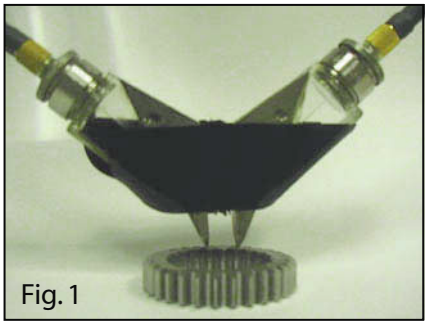


Fig. 1

Mediator and Sensor Prototype

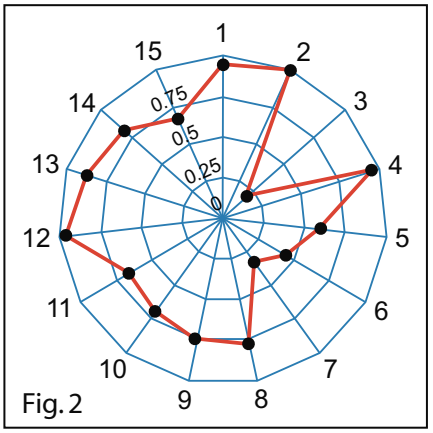


Fig. 2

Circumferential Data Acquisition

Figure 1. Mediator and sensor prototype on a green-part small gear.

Figure 2. Circumferential data acquisition results showing amplitude versus angle. Crack defects were observed at positions 3, 5, 6, and 7.

Development Center – All-Electric Battenfeld Arrives

Battenfeld of Kottingbrunn, Austria has consigned an all-electric molding machine to PSU for the study of powder injection molding. This machine is unique in that it is equipped with three screws and barrels – 22 mm, 18 mm, and 14 mm. These smaller screws and barrels and the electric control have been selected to obtain greater control for smaller parts on the scale of milligrams. CISP plans to continue development of powder injection molding for the small component size ranges. The machine is available to companies for experimental purposes. Contact Donald Heaney (dfh100@psu.edu).

Left to right: Tom Butthoff, Battenfeld of America; Christian Kukla, Battenfeld Austria; Don Heaney, CISP; Christian Gornik, Battenfeld Austria; Rand German, CISP.

Changes to Fee/Benefits Structure

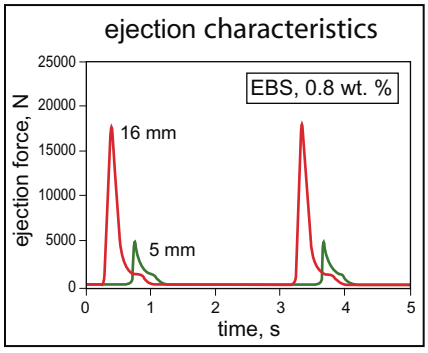
For the past three years the Center has been supported by membership dues and a one million dollar grant annually from the Commonwealth of Pennsylvania under the Department of Community and Economic Development's Ben Franklin Technology Development Authority (BFTDA). The intent of the BFTDA grant was to offer start-up funds for an industry that is very important to Pennsylvania. We are now moving to self-sustainability. During our first three years we achieved remarkable progress by:

- placing great emphasis on workforce education through workshops, seminars, and tutorials at a subsidized cost
- offering undergraduate and graduate educational and training opportunities to approximately 50 students each year through an average of 11 pre-competitive projects aimed at common problems
- providing a unique forum to network
- providing discounts on training seminars and service requests
- providing technology briefs at the semi-annual member meetings
- offering copies of theses, papers, and advance publications to our member companies
- attracting interest both locally and nationally, thus enabling our members to compete effectively with other processing technologies

From 1 June 2003 the Center will offer only 3 levels of membership (Partner, Associate, and Affiliate). The fees are $25,000, $7,500 and $2,500 respectively. The three-year Senior Partner level has been eliminated. For additional information visit the web at *www.cisp.psu.edu* or contact Sharon Elder (814-865-1914 or cisp@psu.edu).

Practical Aspects of P/M Lubricants

A joint project between CISP and the Center for Powder Metallurgy Technology has focused on understanding the performance of P/M lubricants. Recent work has focused on quantifying the ejection response of FC0205 bushings and gears produced in limited production quantities using ethylene-bis-stearamide. The key variables explored were component density, height, and lubricant amount. The work will subsequently be used to compare the performance of alternative lubricant delivery systems (die-wall spray and mechanically fluidized mixing) in collaboration with Gasbarre Products and Lodige Process Technology. Components fabricated during this project will be used to understand the microstructural origins of defect formation during ejection and delubrication. This portion of the work will be performed by Ravi Kumar Enneti for a Ph.D. thesis under a grant obtained from the National Science Foundation. CetaTech will support the work by analyzing compaction response and crack formation using their design software, PMSolver. Contact Sundar V. Atre (sva101@psu.edu).

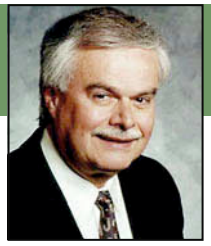


Highlights of PIM 2003 *continued from front*

In spite of war rumors, the community showed great enthusiasm for the future. Here are some highlights from the meeting:

- microminiature PIM is coming on strong and several presentations showed impressive progress with miniature motors, water jets, biomedical or surgical components, and telecommunication devices with dimensions below 1 mm
- large components are moving into production, with one 2 kg superalloy piece on display that will be flight qualified in April 2003
- PIM sales have passed $800 million per year, but marketing PIM is still frustrating since the technology continues to serve a broad array of industries from aerospace to wireless communication; a new sophistication refines the PIM marketing message by looking at the user's needs
- many of the PIM firms are moving into titanium; new developments were reported on titanium supplies, binders, and sintering; price reductions for PIM titanium will occur as volume increases; CISP has a $2.3 million research proposal for titanium PIM before a federal funding source
- demonstrations over a wide range of new materials were provided, including aluminum and niobium, but stainless steels still dominate
- computer models are building on a sound science base; PIM is in a unique position where the computer simulations are accurate and provide significant engineering support
- new tooling and molding machine construction materials were introduced based on extensive wear testing; likewise, new molding concepts were introduced based on the faster response of today's equipment
- new sintering concepts, especially useful for continuous microminiature sintering, were introduced
- mixing technologies continue to evolve and a new high-intensity feedstock compounder was introduced that avoids external heating
- golf clubs remain a favorite demonstration for the technology, and now there are production orders from the golf industry
- there are dramatic geographical differences in the growth pattern, with Europe showing the fastest growth and ceramics in the USA showing the lowest growth
- much discussion was given to some important legal issues, including new chemical policies in Europe, intellectual property portfolio management, and employment contracts
- preview copies of the new design book *Powder Injection Molding – Design and Applications, A User's Guide* were on display and created much interest

Overall, a very successful meeting with much valuable interchange between participants. One of CISP's missions is to foster industrial growth via the dissemination of technology. In that regard, the annual PIM program is very successful. The next offering will be 21-24 March 2004 in Orlando. For CISP, successful programs like this are demonstrations that we are on the proper track to foster industrial growth, while training students to support that growth and providing the knowledge to accelerate member company progress. As evidence, the last two MS students from CISP were successfully placed in the PIM industry. It is our objective to sustain this effort so the whole industry can move forward.



Faculty Profile

Joseph Rose

Dr. Rose is the Paul Morrow chaired professor in the Engineering Science & Mechanics Department of Pennsylvania State University. Dr. Rose received his PhD from Drexel University in 1970. He has received a variety of awards and was a finalist in the 1995 Discover Awards for technological innovation in Aviation and Aerospace for the development of a hand-held probe for aging aircraft inspection. He received a University Faculty Scholar Medal for achievement in Engineering in 1996, an outstanding research award in 1997, and a premier research award in 2002. He was also the ASNT Mehl Honor Lecture recipient in 2001. Dr. Rose is a fellow of ASNT and ASME.

Dr. Rose holds over ten patents and has written four textbooks and over 400 articles on ultrasonic NDE, wave mechanics, medical ultrasound, adhesive bonding, concrete inspection, pipe and tubing inspection, and composite material inspection. He has served as principal advisor to over 40 PhD students. He is the principal investigator on the CISP project Crack Detection in Green Parts and is developing new innovative techniques for crack detection in green parts as well as sensor development for *in situ* monitoring to optimize the sintering profiles.

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CISP Newsletter
Published four times per year

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