January 2002

CISP

Center for Innovative Sintered Products

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Message from the Director

Randall M. German

I send you warm greetings and best of luck in this new year. We have just closed one of the darkest years in the history of the world. Without a doubt the world is maneuvering through tougher times and our industry is no exception. Although many challenges loom, there are still opportunities for growth. It is possible to use the present conditions to get in shape in terms of people, training, equipment, processes, and business direction.

Over the past few months we have been assessing our operation and charting some new directions. Research will remain the driver that defines CISP and its impact and values to sponsors. One of our major changes is a move from a structure based on "activities" – education, research, outreach, and technology transfer – to an industry-government-university center with a structure largely based on "goals". We plan on joining in national proposal teams to bid on large projects based on the just completed powder metallurgy and particulate materials industry roadmap. We are expanding our current research emphasis to include designer materials, microminiature device fabrication and biomedical devices. In early August 2001 the Center was awarded 3,500 square feet (325 square meters) of additional space. A Development Center is being created in this space to serve a more central role in the development of technology – pilot productions, expert assistance on faculty-student research projects, service activities for companies, short course training programs, and undergraduate hands-on laboratory courses will be facilitated through this facility.

The Center continues to work effectively despite the fragmented structure of the industry. As we position ourselves for another year, we will continue to help our members identify opportunities in addition to expanding into new areas.

Multi-Axial In-situ Monitoring Laser Dilatometer

The Multi-Axial in-situ Monitoring (M.A.I.S.M.) Laser Dilatometer is a high precision, non-intrusive tool by which dimensional change can be observed. Traditional dilatometery is intrusive – leading to interaction with the sample, such as local deformation. It can also be inconsistent, due to the thermal expansion and contraction of the physical mechanism of the device.

In an effort to eliminate these problems, a laser dilatometer is being developed. A wide laser beam is continuously passed from the laser transmitter over the sample and the shadow created is cast on the laser receiver. *(continued on page 2)*

PENNSTATE

Center for Innovative Sintered Products

Upcoming Events

February 25-26, 2002
Industry Member Meeting
University Park, PA

March 6, 2002
Ferrous Powder Metallurgy
Ridgway, PA

March 18-20, 2002
PIM 2002
San Diego, CA

March 21, 2002
PIM Tutorial
San Diego, CA

April 17-18, 2002
Metallography and Microstructure Analysis
University Park, PA

April 29-30, 2002
PIM Tutorial
University Park, PA

May 13-15, 2002
Binders & Lubricants Workshop
Vienna, Austria

Metallography & Microstructure Analysis Workshop

CISP is offering a workshop on Metallography and Microstructure Analysis at the PSU University Park campus on 17 & 18 April 2002. Under the direction of Lou Campbell, CISP Senior Research Technologist and Tom Murphy, Hoeganaes, this workshop will include one day of lecture and a second day of hands-on laboratory experience where attendees will have the opportunity to do polishing, etching, and micrographs.

Contact: Helen Edson (hle2@psu.edu)

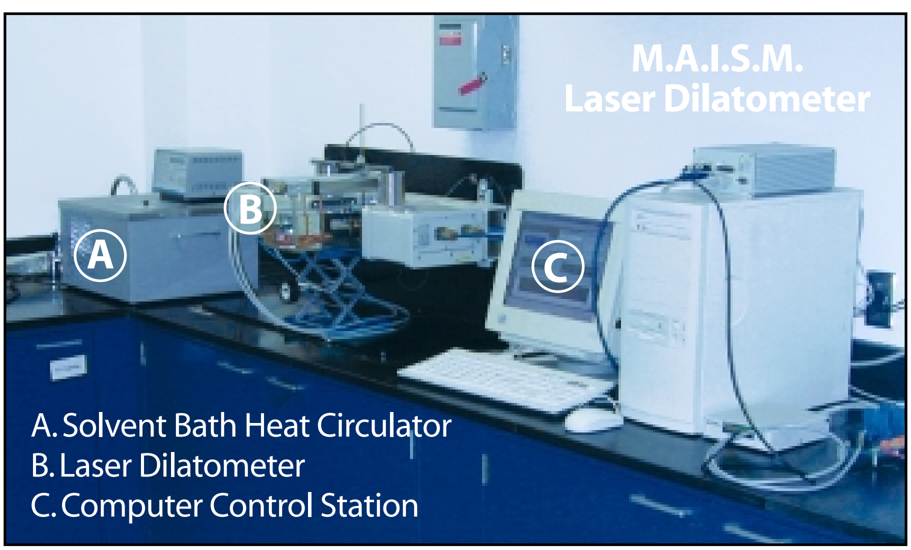
Multi-Axial In-situ Monitoring Laser Dilatometer *(cont.)*

The diameter of this shadow is sent to custom-designed software, which continuously displays, records, and graphs sample diameter, sample temperature, and solvent temperature. For the current use in a heated solvent, the precision of diameter measurements is ±7mm, the accuracy of temperature measurement is +/- 0.5°C, and the precision of the isothermal solvent bath is +/- 0.1°C.

While there exists a wide range of applications in which the laser dilatometer could be used effectively, CISP is currently using it to observe and evaluate the mechanisms of solvent debinding of powder injection molded components, while future goals for the dilatometer include observation of dimensional change during thermal debinding and sintering. Any effort to increase the precision of PIM components must account for possible changes in dimension throughout the entire production cycle. Obvious changes occur due to thermal expansion during molding and shrinkage during sintering. Significant dimensional change of components also occurs during solvent debinding as polymers interact with the solvent.

The dimensional change due to the two-stage swelling/dissolution sequence of binder polymers, as well as thermal expansion, has been previously observed, but measurements have always been recorded using tools that involve physical contact with the sample at a single point. By using the laser dilatometer, non-intrusive measurements can be made to monitor in-situ dimensional change along two axes during solvent debinding to observe and evaluate the mechanisms of solvent debinding.

The preliminary results of CISP research show far more swelling at the initial stage of solvent debinding than previous studies. The results acquired from the laser dilatometer lead to the assumption that this contrast in experimental observations can be attributed to the non-intrusive design of the laser dilatometer in comparison with the traditional means by which dimensional change during solvent debinding has been observed. It appears that previous research failed to recognize the concentration gradient of the dissolving polymer, as well as the extent of the wave of polymer swelling that follows the penetration of the PIM component by the solvent. This dimensional change will be thoroughly investigated in ongoing research, which should yield a more thorough understanding of the mechanisms of solvent debinding, as well as a sufficient model by which solvent debinding can be explained and predicted.



Multi-Axial In-situ Monitoring Laser Dilatometer

Computer Simulations

CISP is focusing on the 2D simulation of sintering. Comparing the variants on the basic constitutive equation has shown that the sensitivity of the simulation results to viscosity is very high. The current simulation uses an Arrhenius-type equation to model a Newtonian response viscosity. Finite element analysis with this model shows that an apparent viscosity in the range of 109-1010 Pa-s gives reasonable results for isothermal sintering of 17-4 PH stainless steel. Response of this Newtonian model to a sinter cycle comprised of ramps and holds is being investigated. Meanwhile, a new model named Bingham flow response, is being formulated to include a yield strength parameter. Contact:

Yunxin Wu (yxw21@psu.edu)

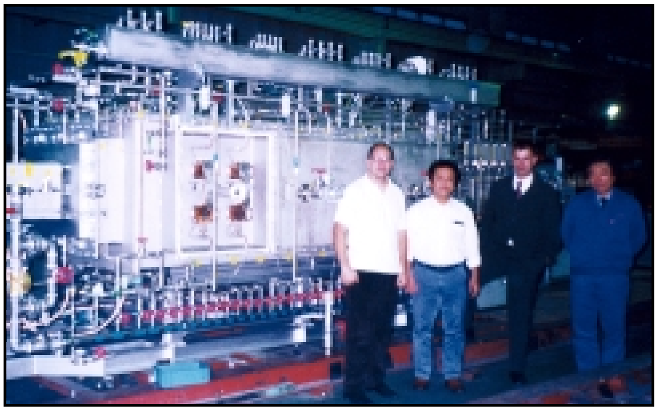
Struers High-Precision Cut-Off saw

CISP recently acquired a Struers high-precision cut-off saw for metallographic sample preparation. Capable of cutting with bonded abrasive or diamond wheels, it features precise control of cutting force, feed rate, wheel speed, and sample rotation, minimizing sample damage induced by cutting.

The saw is being utilized for lab services and research work in preparation of difficult materials including cemented carbides, metal matrix composites, heat-treated tool steels, P/M diluted bronze bearings, and presintered parts. Metallographic studies made possible by this saw include a study of green density gradients in pressed stainless steel parts.

Lou Campbell (lgc102@psu.edu)

KYK Oxynon Furnace Coming Soon

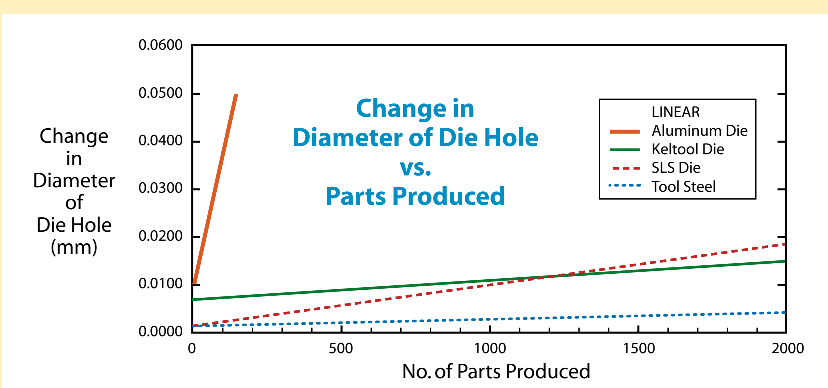


Pictured L. to R.
T. Potter - CISP
S. Mizuguchi - KYK
D. Heaney - CISP
K. Kanda - KYK

Kanto Yakin Kogyo (KYK) furnaces of Japan has committed to the future of powder materials processing by placing a 10" belt furnace that is capable of 2000 °C sintering at CISP. The interesting aspect of this furnace is that no flammable gases such as hydrogen are used in its operation; instead the parts are reduced by the use of a proprietary technology that reduces the partial pressure of oxygen to levels that are typical for vacuum furnaces. The furnace is the first in the US and will be available for material trials and prototype production runs by March 2002. Contact: *Don Heaney (dfh100@psu.edu)*

Time Compression Technologies

Time to market, and economic manufacture of small batch quantities is critical to success of companies. Our current research is looking into rapid tooling as a component of time compression technologies, in an effort to reduce the time to go from print to tooling to product. In the first phase of this research, we are evaluating the current rapid tooling technologies such as Keltool, Selective Laser Sintering, LENS and high speed machining for applicability to uniaxial powder compaction and powder injection molding (PIM). Compaction dies made with these processes were tested and experimental performance was documented. Initial results indicate that these processes are viable for powder compaction tooling, with the Keltool process showing the most promise. The current generation of rapid tooling processes still have limitations of size and surface finish, and require additional finishing operations. Ongoing work is experimentally documenting the applicability of these processes to PIM dies and exploring ways to address the limitations of current technology. We are seeking partners to investigate complex rapid tooling applications or to explore new ideas for time compression. Contact: *Sanjay Joshi (sjoshi@psu.edu) or Paul Cohen (phc3@psu.edu)*



Chemical-Vibro-Mechanical Mass Finishing/Polishing

Chemical-mechanical surface finishing has been widely used in the manufacturing of silicon wafers, optical glasses, computer hard discs and machine components. In these processes, the chemical-mechanical synergic effects play a key role in the removal of the surface materials. Experimental evidence in these finishing processes has suggested that the desirable chemical-mechanical synergy-induced material removal is likely to be the process of overcoming the binding energy of surface molecules. The chemistry works with the surface materials to weaken the molecular bonds while the mechanical action delivers the energy that is needed to break the bonds, thereby removing the surface material on molecular and nanoscales.

CISP is currently working to develop a quantitative model of binding-energy related material removal. Using the theory of contact mechanics and nano-tribology, we can calculate the frequency of media-workpiece contact and pressure. This calculation leads to the determination of the mechanical energy delivered to individual atoms when acted upon by a media particle. On the other hand, using the diffusion theory and chemical kinetics, we can calculate the extent of the chemical reaction between the polishing chemicals and the workpiece surface. We can then calculate the binding energy of surface atoms/molecules using chemical-thermodynamics. Our preliminary model calculations have shown meaningful results, and we hope to provide insight into various materials and operating parameters on the rate of material removal and surface finishing.

Liming Chang (lxc20@psu.edu)

Visiting Researcher

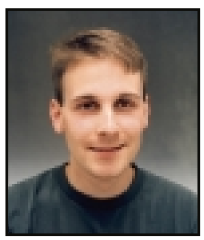
Dr. Jupiter Palagi de Souza

Jupiter Palagi de Souza is a visiting researcher from Brazil where he is a Professor in the Food Science Engineering Department at the Federal University of Rio Grande do Sul. His research covers supercritical extraction, metallic food packaging and modified atmosphere. He recently released the first book on this subject in Brazil showing the influence of packaging materials and gas mixtures on the shelf life of foods - "Aumente o tempo de conservação dos alimentos e obtenha maiores lucros". Several aspects of food technology have direct relevance to particulate materials processing. Professor de Souza has found ways to apply some of these principles to binders, debinding and functional metallic structures at the Graduate Metallurgical Engineering Program. During his one year at CISP, Prof. de Souza will be working in the area of powder injection molding, studying some basic aspects of mixing, water-soluble binders and debinding mechanisms.

CISP Profiles

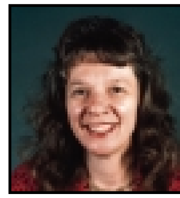
Ravi Bollina

Ravi Bollina recently defended his master's thesis titled "Effect of Heating Rate on Densification and Distortion in Liquid Phase Sintering of Tungsten Heavy Alloys". He will be continuing his PhD studies under Dr. Randall German. He has an undergraduate degree in metallurgical engineering and materials science from the Indian Institute of Technology, Bombay, India. He is seeking an internship opportunity in industry this summer.



David Houser

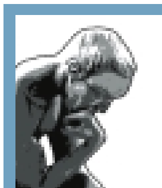
David Houser is a M.S. student at CISP. He has an educational background in engineering mechanics with focuses on flexible matrix composites and P/M. He also has completed multiple internships with varying responsibilities including data analysis, mechanical design, software requirements, and failure analysis. David's thesis defense is scheduled for January, 2002.



Executive Director
Sharon L. Elder

I am looking forward to another year and encourage you to come forward with your ideas, opinions, and proposals. After just 18 months of operation, we have made remarkable progress. Our education program remains strong and we are seeing good progress in our current research projects. We have secured broad industrial support from over 90 companies, ranging from very small firms to some of the largest manufacturing firms in the world. We are now targeting increased participation where there is large potential impact, such as; functionally designed structures, biomedical components, specialty refractory materials, microminiature components, optical and electronic packaging, rapid tooling, precise structural materials, designer materials, defense and aerospace systems, and sporting equipment. During the upcoming year we will focus on adding additional visionary partners, including multi-national corporations, federal funding agencies, national laboratories and other universities to secure longer-term funding. These steps will ensure that our research and education programs are world-class.

Sharon L. Elder (cisp@psu.edu)



Thinking of Joining CISP ?

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