The PTF Newsletter

Getting technical contributions for the newsletter has been a continuing challenge, and understandably so since it is not a peer-reviewed publication that can be cited. In order to "prime the pump" a bit, starting with this issue we are inviting research groups or entities from academia, industry and government to share overviews of their research activities with the PTF community. The editorial board will select one (or two maximum) groups to highlight in each issue. As exemplified by the section on Prof. Al Weimer's research group in this issue, the overview is followed by contributions from graduate students and post-docs in the group. It an excellent way for budding researchers to showcase their research thrusts, expanding the audience for their work and hopefully opening future opportunities in academia and industry. It is a win-win situation. If you are interested in highlighting your research group's work in the future, or just sharing quick research outcomes or new activity in the field, please contact me.

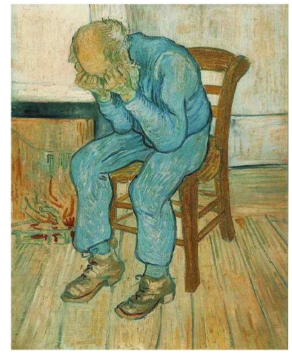
Additionally, many of you have agreed to join the PTF newsletter effort as featured contributors of technical shorts. I would welcome more volunteer authors. The expectation is a short technical article (~4 pages) each year in an area of your technical expertise, and something of broader interest. The overarching vision is to collect these articles into a useful collection for practitioners of particle technology.

Shrikant Dhodapkar, Dow Chemical

Editor, PTF Newsletter

In this issue…

Letter from the "Chair"



I hope that you had an enjoyable yet productive Summer. The PTF Executive Committee (EC) has been busy last few months. EC members have been discussing several important topics, such as, instituting PTF Student Travel Awards for attending the AIChE annual meetings, simplified format for PTF group programming meetings during the AIChE annual meetings, continued revisions to the PTF Awards nominations and selection process, and recording the AIChE-PTF history. During next few months, we plan to make related announcements while seeking additional sponsorship for PTF events, including the student awards and ways to engage more students at our annual meetings. If you have any comments or suggestions regarding any of these topics, including sponsoring any of these activities, please feel free to contact me or other EC members whose contact information can be found towards the end of this Newsletter.

Please note that the AIChE Annual Meeting is in October this year. As usual, we will have the PTF EC meeting on Sunday and the PTF General Meeting on Monday. You can check the program for time and location. I want to clarify that both meetings are open to PTF members, although only the EC members can vote as required during the EC meeting. We particularly welcome past PTF Chairs and EC members to attend. Let me know if you plan to attend or if you have questions. On a separate topic, Bruce Hook has planned an exciting PTF Dinner along with a tour of particle technology companies with help from Willie Hendrickson. Please make sure you purchase your tickets early since the event has been sold out last two years.

Another exciting event that PTF community can look forward to is the **8th World Congress on Particle Technology (WCPT 8),** April 22-26, 2018, in Orlando, Florida. I hope you will attend since Ray Cocco and his colleagues have planned an impressive conference.

Thank you for your time and stay tuned.

Rajesh N. Dave, NJIT

Chair, PTF

PTF Awards Selection Report

As we passed our first full implementation of the new awards process some members voiced their concerns and some issues were also identified that need our attention. First let's recap what was approved by EC and implemented this year.

The Particle Technology Forum gives out 7 awards. For all but one, the Executive Committee felt that prior membership of the awardee in the Particle Technology Forum was a requirement. The 3 year membership requirement was considered to be reasonable and not onerous to achieve by an award winner. The lone exception was the George Klinzing Best PhD award, which goes to current or recent students who may not yet be PTF members, but may join in the year of their nomination or awarding. No one is allowed to win multiple PTF awards in a single year, and there is a 3 year waiting period between winning a PTF award and being eligible for another.

For each of the awards, a nomination package is expected that states how the nominee fulfills the award criteria, their PTF membership status and a relevant bibliography. At least three and no more than five supporting letters are expected as a part of the nomination package. The Executive Committee felt that nominators should also be PTF members and mandated that at least one of the support letters must be from a PTF member if the nominator is not.

The seven PTF Awards are listed below with any specific requirements or criteria for that award.

Elsevier PTF Lifetime Achievement Award -- This award recognizes a forum member's lifetime outstanding scientific/technical contributions to the field of particle technology, as well as leadership in promoting scholarship, research, development, service and/or education in this field. An outstanding contributor to the field of particle technology who has also made significant lifetime contributions to PTF through their scholarship, service and enthusiasm for the field. In this specific case, one of the support letters must be from a former PTF Lifetime Achievement Award winner.

Shell Thomas Baron Award in Fluid-Particle Systems -- This award recognizes an individual's recent outstanding scientific/technical accomplishment which has made a significant impact in the field of fluid particle systems or in a related field with potential for cross fertilization with relevance to the topics of interest to PTF community. The nominee made a significant impact in the field of fluid particle systems or in a related field with potential for cross fertilization with relevance to the topics of interest to PTF community

PSRI Lectureship Award in Fluidization -- This award recognizes an individual's outstanding scientific/technical research contributions with impact in the field of fluidization and fluid-particle flow systems. Nominee should have made an outstanding contribution advancing fluidization or fluid-particle flow systems

SABIC Young Professional Award -- This award recognizes outstanding and internationally recognized contributions in particle technology by a young professional under 40 years old. The nominee should have provided outstanding contribution to the field of particle technology, such as innovation, breakthrough research demonstrated through patents and publications, as well as service to the particle technology community by way of education, leadership, stewardship and collaboration with other disciplines of engineering and science. Receipt of last degree must be within the past 7 calendar years during the year when Award may be made.

Dow Particle Processing Recognition Award (formerly Fluidization Process Award) -- The award recognizes a Particle Technology Forum member who has made significant contribution to the science and technology of particle processing in its commercialization, and who has shown leadership in the engineering community. This award is given only in odd-numbered years.

George Klinzing Best PhD Award -- This award recognizes an outstanding dissertation by an individual who has earned a doctoral degree with relevance to particle technology, and is based only on the contributions made during the course of PhD. The dissertation can be in any discipline in the physical, biomedical or engineering sciences, with particle science and engineering as its focus. Nomination should include a critical review stating the value of the dissertation in terms of its originality, significance, and potential applications in the field of particle science and technology. It should also convey how doctoral research contributed to a significant advance or breakthrough in particle technology that will last for a long time. This award is the only one that does not have a 3 year PTF membership requirement, but the nominee must have received a doctoral degree within the last three calendar years prior to the year the award is given.

ANSYS Particle Technology Forum Service Award -- This award recognizes outstanding service to AIChE Particle Technology Forum and the field of particle technology. This award is selected by the Executive Committee and nominations must be made by a member of the PTF EC, although others can make recommendations to EC members.

All of the EC Liasons participated in the award selection process this year, and particular care was taken to prevent conflict of interest between the selection committee, the award sponsor and the nominees.

Our efforts to standardize these award criteria has been to make sure that those receiving the awards are deserving, but that we don't have a "revolving door" of a few awardees. That being said, it is up to the PTF community to nominate those they deem worthy of such awards.

The issues that were brought up were the 3 year PTF membership requirement, eligibility and the timing of the nominations acceptance . We have tried some web-based submission/nomination forms, with mixed success. We will further discuss whether these are as effective as publicizing a fixed email address to use for submitting nomination packages.

In order to make sure PTF awards process is the most efficient it can be, a sub-committee will be formed to review the process and make suggestions. This will happen by consulting with past PTF chairs and some of our active members . If you are interested in participating in the process, just let us know. We commit to having this worked out by the beginning of next year to smooth the nomination process.

Please feel free to contact me with any questions that you may have. Stay tuned for further communication about the progress.

Bruce Hook

2017-2018 PTF Chair-Elect.

PTF Membership

To continue receiving the PTF newsletters (3 issues per year) and stay current with particle technology events and news, please make sure to renew/start your membership by either:

- Checking Particle Technology Forum when renewing your AIChE membership annually.
- Become a PTF lifetime member so that you don't have to renew membership every year.

Become a PTF only member

(annual $15, lifetime $150)

If you don't see the PTF membership in your renewal screen, you can choose "Update Membership Options" and add PTF to your order.

You can also contact AIChE customer service at 800-242-4363 (US); +203-702-7660 (Outside the US); or email customerservice@aiche.org for membership questions and help.

PTF Membership Committee

Industrial Perspectives

The International Fine Particle Research Institute (IFPRI) History and Current Direction

Willie Hendrickson

IFPRI

The International Fine Particle Research Institute (IFPRI) was founded in 1979 when 12 companies identified a need for an industrial group to provide focused input to academia on industrial significant and relevant areas of particle processing. In the initial meeting held in Wilmington, DE the soon-to-be members agreed to a program focusing on five areas: particle flow; particle formation; wet particle systems (focused on dispersions and separation); particle characterization; and particle grinding. Since that time Systems Engineering (processing involving multiple unit operations) has been added. The specific funded programs have changed over the years to reflect the state of particle technology and industry member interest. Since 1979 IFPRI membership has fluctuated from 14-41 companies and is currently back in a growth mode with 32 member companies. IFPRI meets twice a year, once in the winter for a Business Meeting (this coming year in Boston, January 2017) and once in the summer at our Annual General Meeting (AGM) (this past year in Philadelphia, PA, USA June 2017 and this coming year in Edinburgh, UK June 24-28, 2018). At the winter meeting members go over the current business status of the organization focusing on finances, recruiting, current academic program, and future opportunities for new academic programs. There is also an update on current projects and questions on the projects such as: are the academics following the road map that was agreed upon; or is there a new direction that may be more beneficial for both industry and the academic contractor? At the summer meeting, or AGM, there are 2 short business meetings during the 5 day meeting, but the majority of the meeting focused on project updates or final reports from the academic contractors, invited speakers on current interest topics and reviews in particle technology, and seminar series of 3-4 presentations on a focused particle technology area that is followed by a poster presentation session of 30-40 posters from academics or particle technology companies. One day of the meeting is devoted to small group breakout discussions where members, invited academics and guests work on defining areas of research for future IFPRI programs. On the final day of the meeting the members vote and chose those programs that will be funded for the following year. Recently, IFPRI has sponsored a number of Workshops on topics members feel deserve more time and strategic consideration. Workshops are typically added as two day options prior to the start of the AGM.

The focus of IFPRI is to have a group of companies with particle technology interests combine their resources in programs that will benefit their own companies in areas that are of broad industrial interest. Member companies typically send 1-5 representatives to the AGM meetings and along with the contractors, academic consultants, students, and invited speakers the resulting meeting is a high concentration of some of the best particle technology minds (both industrial and academic). Unlike AICHE or World Congress meetings, IFPRI is a concentrated one-track meeting with many opportunities for meetings and discussions among the attendees. The members and the academic attendees come away from the meetings energized, broadened, and armed with new technology and resources. During the year many of the attendees will be in contact discussing individual concepts or projects where industrial to industrial discussions are occurring along with industrial and academic discussions.

The current research program of IFPRI for the 2017-2018 year is listed below:

Title	**Research Associate**	**Institution**
Research Programs		
Die Filling of Aerated Powders	C. Wu	University of Surrey
Development of Grindability tests	J. Ooi	University of Edinburgh
Molecular Self Assembly	U. Weisner	Cornell University
Crystal Shape Prediction	M. Doherty	UCSB
Creating Tuneable Agglomerates via 3D Printing	K. Hapgood	Monash University
Relating Compaction Performance and Behavior to Process Conditions	A. Zavaliangos	Drexel University
Spray Drying at High Temperatures	A. Bayly	University of Leeds
Flowability Assessment of Weakly Consolidated Powders	C. Hare	University of Surrey
Prediction of Segregation	J. McCarthy	University of Pittsburgh
Dry Powder Rheology	K. Daniels	North Carolina State University
Scaling Rules for Powder Mixing	I. Govender	University of KwaZulu-Natal
On the Long-Term Stability of Colloidal Gels	W. Poon	University of Edinburgh
Deliquoring of Sovent Wetted Cakes	U. Peuker	University of Freiberg
Model-Based Control of Crystallization	Z. Nagy	Purdue University
Collaborations 2017-2018		
Spray Drying Materials Science	Bayly and Shutyzer (Leeds and Wageningen)	
Non-Local Rheology of Intermediate Granular Flows	Daniels and Vriend (NCSU and Cambridge)	
Experimental Validation of Segregation	McCarthy and Hill (Pittsburgh and Minnesota)	
Reviews for 2017-2018		
Methods (Experimental and Numerical) for Describing Wall Boundary Layers in High Shear Systems (Extruders)	R. Bonnecaze	University of Texas Austin
Use of Grinding Aids in Dry Systems	TBD	TBD
Relative Humidity and the Flowability of Hydroscopic Powders and Granules	TBD	TBD
Workshop		
Suspension Slurries – Insights from New Physics	June 2018	University of Edinburgh
Round Robin Study		
Round Robin Exercise on Calibration of DEM Simulations	TBD	TBD

Project Briefs for New Projects 2017-2018		
Effect of Material Properties on the Adherence of Powders to Metal Processing Equipment During Compaction	TBD	TBD
Characterization of Spray Drying Nozzles at Industrial Relevant Conditions	TBD	TBD
Flow at Boundaries – Spreading in Thin and Uniform Layers	TBD	TBD
Investigation of Particle Characteristics on High Solids Rheology	TBD	TBD
Wetting, Dispersion, Distribution of Powders and Packed Beds: Reconstitution of Organic/Biological Materials	TBD	TBD
Predicting and Characterizing of Surface Modifications During Milling	TBD	TBD

I joined IFPRI in 1987 when I was still employed at 3M. By training I am a chemist and had, at the time, little exposure or understanding of particle technology. I had been given the assignment of building a particle technology group in 3M's Corporate Research Group. Fortunately for me 3M had been an original IFPRI member and I was tasked with attending IFPRI meetings as part of my new responsibilities. At that first meeting I was exposed to superb particle technology and the some of the best individual academic and industrial researchers. After getting over being stunned with the richness of the meeting, I used the IFPRI model to grow my group at 3M. Without the input from IFPRI I am sure that I would not have been as successful at 3M as I was. In 1994 I took the opportunity to leave 3M and start my own company, AVEKA, Inc., that focuses on particle technology. Once again, my experience with IFPRI provided me with academic and industrial contacts that helped grow my business from 3 initial employees to the current 250 employees. After 3M I did continue my interaction with IFPRI first as a member and, officially as of September 1, 2013, the President of IFPRI. I have been associated with IFPRI for over 30 years and I am hard pressed to think of any other organization that has done more for me at 3M, AVEKA, or with my personal development as IFPRI has done.

The strength of IFPRI is the members, contracting academics, and consultants with a special thanks to the current IFPRI Members and Consultants listed below:

AbbVie	Almatis	AVEKA
Chemours	Corbion	Corning
DuPont	Duracell	DSM
Eli Lilly	Evonik	F. Hoffman-La Roche
Johnson Matthey	Keurig Green Mountain	Merck
Mondelez	Nestle	Nippon Steel & Sumitomo Metal
Novozymes	Pfizer	Procter & Gamble
Sandia National Labs	Syngenta	Unilever
UOP		

Associate Members:

Freeman Technology	Granutools	Horiba
Hosokawa	Particle Analytics	Paul O. Abbe
PSE		

Consultants:

Mojtaba Ghadiri (University of Leeds)
Norm Wagner (University of Delaware)
Michel Louge (Cornell University)
Jim Litster (University of Sheffield)
Satoru Watano (Osaka Prefecture University)

From the list of members, consultants, and academic researchers it is clear that IFPRI reaches an international audience and is relevant to industries ranging from pharmaceutical, chemical, food, to specialty materials. I urge you to contact me directly for more information on IFPRI programs and membership (whendrickson@aveka.com or 651-730-1729) or take a look at the IFPRI website at www.ifipri.net.

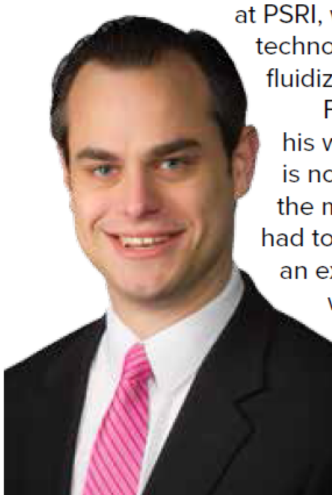
AIChE—35 Under 35 (Chemical Engineering Progress, August 2017)

Congratulations Ben !

Ben Freireich, PhD, 33
Technical Director
Particulate Solids Research, Inc. (PSRI)

It is probably safe to conclude you were born to be an engineer if you, like Freireich, have "used a system of differential equations to determine how many pizzas to order." The technical director at Particulate Solids Research, Inc. (PSRI), Freireich has an enthusiasm for science, engineering, and learning that brings to mind Bill Nye's character on his namesake science program.

With a background in mechanical engineering, Freireich found his way to chemical engineering through his specialization in particulate mechanics. In his current role, he is responsible for guiding all of the research programs at PSRI, which focus on the application of particle technology fundamentals with a specific focus on fluidized systems.



Freireich describes the satisfaction of seeing his work verified in real-world operations: "There is not a single more satisfying feeling than when the model fits the data." In one such scenario, he had to exercise his engineering judgment to quickly develop a process model for an extreme and difficult-to-measure process, and found plant performance to be within 10% of the model predictions.

For someone who has found much academic and professional success, it may be surprising to learn that Freireich struggled to read, finding out in high school that he was reading at an elementary-school level. Although he was discouraged from applying to a competitive engineering program, his convictions and lots of reading helped him to overcome this obstacle.

FUN FACT >> Freireich communicates best through pictures, and he keeps at least two colored pens on him at all times.

BENEFITS AND IMPACT ANALYSIS OF DOE/NETL MULTIPHASE FLOW SCIENCE VIRTUAL RESEARCH

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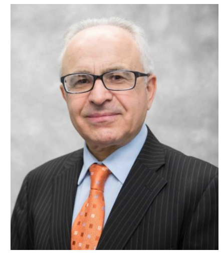
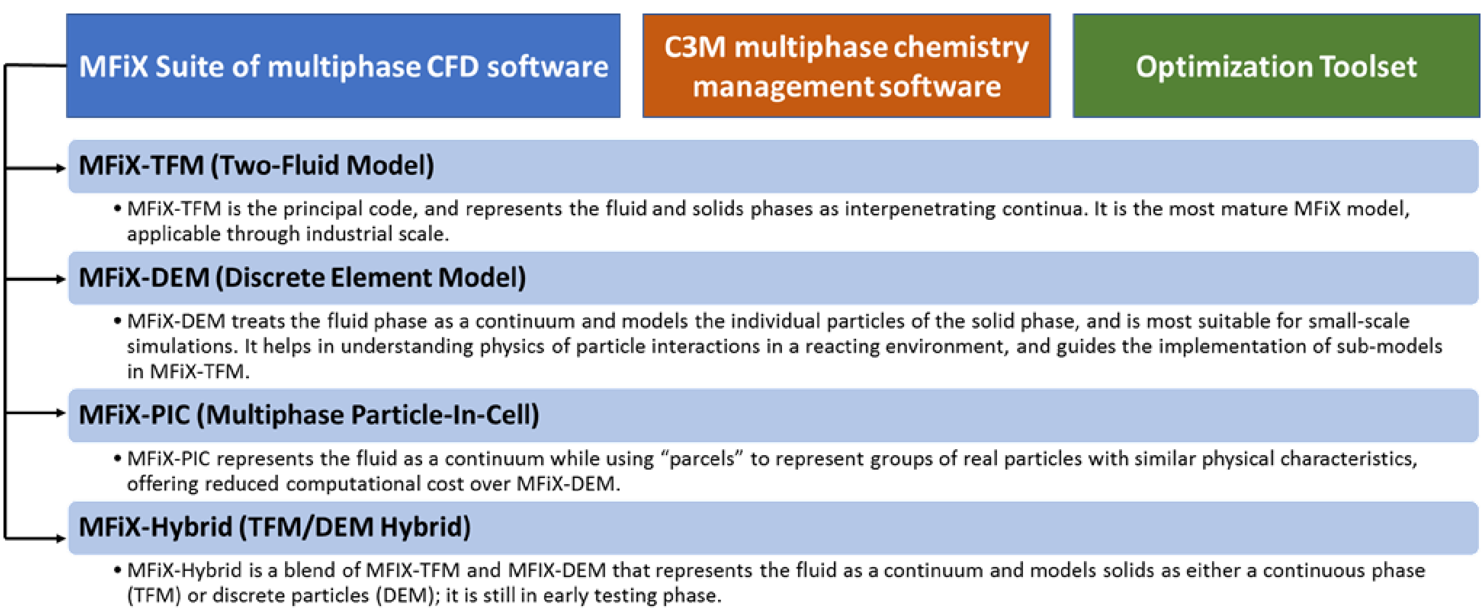



Introduction

The U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) has a key role in development of energy technology, which includes tackling challenges in understanding the behavior and characterizing the performance of energy conversion processes. NETL's Multiphase Flow Science (MFS) Group focuses on multiphase flow reactor modeling and simulation, experimental validation, and high-performance computing to foster development of energy conversion and chemical process equipment such as combustors, gasifiers, and emissions and environmental control process units. NETL has developed a computational fluid dynamics (CFD) code, called MFiX. The MFiX suite includes C3M for chemistry modeling, and the Optimization Toolset, which uses MFiX for determining optimal reactor designs, and demonstration and validation of optimal designs. The suite has become a standard for comparing, implementing, and evaluating multiphase flow constitutive models, and has been applied to an extremely diverse range of applications involving multiphase flows.

Over the three decades of development history of NETL's open-source suite of software tools, a considerable investment was made in time and effort to code, validate, demonstrate, and leverage this valuable portfolio in beneficial applications. Characterization of the resulting benefits is given in more detail below.



MFS Physics-based Modeling Tools

The MFS Group's software portfolio features physics-based modeling tools to guide the design, operation, and troubleshooting of reacting multiphase systems. The principal open-source software tools are as follows:

The MFS Group has seen a steady increase in the user base of its tools, with over 4,000 users having registered to download them as of 2016 (see Figure 1). Also, the MFS Group reviews the published literature for work citing MFiX, which provides some measure of the increasing relevance/value of the MFS Group software codes (see Figure 2).

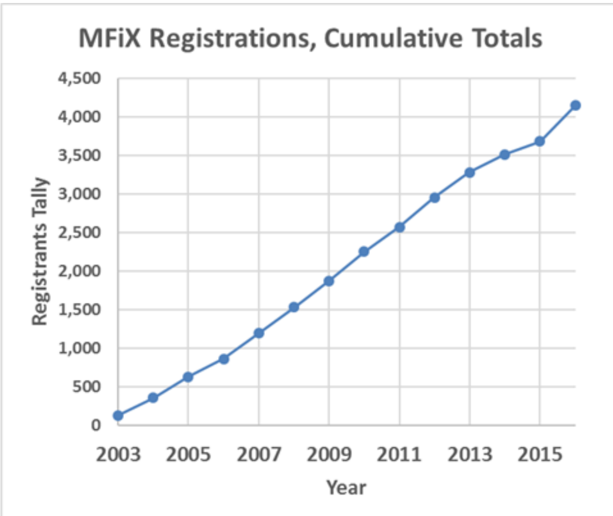


Figure 1.

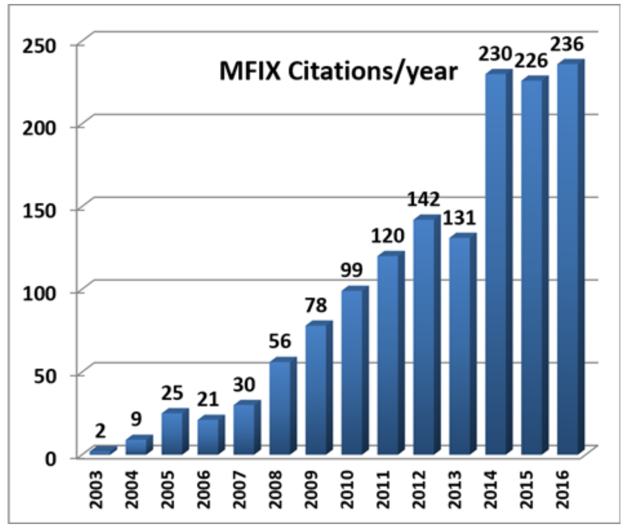


Figure 2

MFS Experimental Activities

The MFS Multiphase Flow Analysis Laboratory includes several cold-flow and low-temperature reacting experimental circulating and bubbling fluidized bed units representing a broad range of sizes and fluidization conditions. With these, the NETL MFS program generates well-characterized multiphase flow data at different length and time scales to aid in understanding complex fluidization behavior in reactors, underpinning the development of mathematical models and validating software code. Physical model data from MFS experiments are made available to the research community as an integral part of MFS outreach activities.

High-performance Computing

NETL is a leader in applying high-performance computing to computationally demanding multiphase flow science problems, including challenging industrial-scale problems. For example, MFiX modeling of KBR and Southern Company's TRIG™ gasifier underpinned the scale-up of transport gasification technology to commercialization. In a recent ongoing effort, MFS has been modeling fluidized bed reformers in the Integrated Waste Treatment Unit (IWTU) at the Idaho Cleanup Project for treatment and disposal of radioactive sodium-bearing liquid waste. Simulations have been used to understand the chemical and hydrodynamic behavior inside the vessels and provide data to assist the IWTU project. Such simulation data complement available test data, and are being used to better understand the complex processes that occur in the IWTU and have helped troubleshoot problems with operation of the scaled-up unit. This is helping to expedite the start of operation of this facility.

Characterizing Benefits

The products of the MFS group—open source codes, experimental data, and application studies—have generated value by helping DOE meet its mission and by advancing multiphase flow science, which ultimately translates into increased economic value across a wide range of relevant industries, particularly the energy sector.

Generally, using CFD instead of traditional build and test methods for relevant engineering and design applications translates into consistent time savings in design, and fewer labor hours incurred. These time savings tend to be dramatic (approximately 30 – 90 percent savings for representative examples).

As an example of NETL researchers' simulation work on the TRIG™ gasifier mentioned above, a CFD simulation that could be accomplished in two weeks at a cost of about $10,000 provided the same information that would otherwise require physical modification and testing using an actual gasifier, which would take 14 weeks at a cost of about $6 million.

NETL has helped DOE's Office of Environmental Management to resolve technical issues with the Hanford Tank Waste Treatment and Immobilization Plant (WTP), which will process and stabilize 56 million gallons of radioactive and chemical waste currently stored at the Hanford Site. The total cost of this project currently stands at over 12 billion dollars with an expected lifetime of operation of over 40 years. The experimental work at NETL involved construction of geometrically similar pulse jet mixer (PJM) vessels operating under prototypic conditions to improve the understanding of PJM vessel mixing with spargers under a wide range of solids loading for both Newtonian and non-Newtonian conditions. Also, NETL conducted small-scale testing in a manner that would allow WTP to reduce the magnitude of their full-scale test program, potentially saving the government millions of dollars in full-scale testing.

The small-scale testing at NETL took place over 20 months at roughly a total cost of 2 million dollars. The WTP project used NETL data to reduce the number of full-scale tests that were necessary to determine positions of the spargers, testing to determine sufficient number of tests to ensure adequate repeatability, and testing to determine the impact of spargers on blending in a full-scale PJM vessel. Full-scale testing at WTP requires hundreds of thousands of gallons of various water mixtures, thousands of pounds of solid material, and weeks to prepare for a single test. A conservative estimate of the reduction in testing possible because of NETL's work is roughly 12 – 30 full-scale tests. Conservatively estimating the cost of each full-scale experiment to be on the order of 1 million dollars, the cost savings of not conducting these tests is between 12 – 30 million dollars, resulting in at least a six-fold return on investment.

Summary

The MFS Group's capabilities—open-source software, data, and expertise—contribute towards DOE's mission, provide useful tools for industry, and help to educate the next generation of engineers. In addition to expanding the knowledge base in multiphase flow science, examples show that DOE's investment in the MFS program has resulted in significant benefits and cost savings in application of solving complex real-world problems. For more information, please visit: https://mfix.netl.doe.gov/

References

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2. Syamlal, M., C. Guenther, A. Cugini, W. Ge, W. Wang, N. Yang, and J. Li, "Computational Science: Enabling Technology Development," Chemical Engineering Progress, no. January 2011, pp. 23-29, 2011.

Benefits of MFS Group CFD Codes

- *High-performance computing*
- *Customizable open-source code with no licensing requirement*
- *Critical experimental data for code validation*
- *Shorter timelines to develop equipment and processes*
- *Risk reduction and design validation*
- *Cost savings by running simulations instead of building and revising expensive prototypes or full-scale tests*

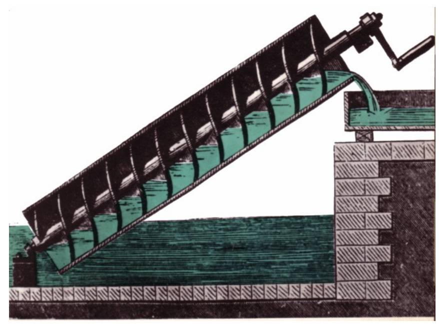
Technical Primer: How Screws Work?

Lyn Bates

Managing Director

AJAX Equipment, Bolton, UK

The first recorded use of helical screws by Archimedes was for lifting water from the holds of king Heiro's ships.



Over the last century, their use has proliferated in industry in many forms for solids handling and processing. Despite the antiquity of the basic principle, new developments in the field are still coming forth in elevating and feeders. The applications of screws may be considered according to their primary function:

Handling	Transfer mechanism	Features
Conveyors	Horizontal, gravity mode	Limit 45% cross sectional fill
	Inclined, gravity mode	Effective limit 30^0 inclination
Elevators	Dynamic Mode	high speed, Limited self-clearing
	Flood mode	Low speed, Will not self-clear
	Wall friction, Static screw	Low intake, Will not self-clear
Feeders	Hopper Dischargers	Determines extraction pattern
	Flood mode	Forward and reverse facility
	Metering, Flood mode	Feed rate and condition control

Process functions can be combined with any of the above duties**.** e.g, as a plug barrier seal against pressure, high temperature or noxious gases, compaction, mixing, de-watering, heat transfer, lump breaking and de-clumping, granulating, drying and dust conditioning.

Conveyors.

Gravity mode conveying involves the unconfined product slipping down the inclined face of the screw flight. The axial transfer capacity is inhibited by 'spillage' and 'leakage' that increases disproportionally at cross-sectional loading over 45% and very progressively at inclinations exceeding the angle of casing friction. Rotational speeds may be fixed or variable, according to conveying rate with typical working speeds in the range of 15 to 100 rpm. At high rotational speeds the flow capacity is impaired by dilatation of the bulk material.

US publications by CEMA provide substantial information on the constructional and performance features of standard screw conveyors. BS.1440 gives particulars of UK standard sizes. Horizontal screw conveyors are widely used in industry for solids and paste handling in a range of standard sizes. A principle feature is that the amount of material transported is controlled by prior equipment. Machines are generally constructed with screw flights of uniform diameter and pitch. Screw conveyors are made in lengths from under a meter to over 50 meters. Multiple inlets and outlets can be accommodated. Intermediate bearings are required for long machines, other than for special applications where the screw runs on the trough or on liner plates.

Inclining the screw axis has three effects. Firstly, the screw face inclination on which the material has to slip is lowered. This is especially significant for the coarser helix angle of the flight adjacent to the shaft. If the slope of the flight face falls below the angle of sliding friction of the material resting on the blade the product is carried over the shaft to fall into the preceding pitch space.

Secondly, as the dynamic repose of the material remains unaltered, the volume of material being conveyed between the flight pitches is reduced. Short pitch screws are more efficiently at moderate inclinations, but conveying rates reduce to about 30 % of its horizontal capacity when the casing is inclined at 30 degrees and falls off very rapidly thereafter.

The third effect is that 'back leakage' increases through the clearance between the screw flight and the machine casing. This has a working clearance on the underside of the screw but increases at a level with the shaft centreline as the vertical face of the conveyor side diverges from the radius of the screw flight. This leakage is especially pronounced when the conveyor inclination exceeds the wall friction value and the clearance layer slips back.

The combination of these features results in a progressive reduction in the elevating capacity of an inclined screw in a gravity mode of conveying in a 'U' trough casing. Whilst the performance is material dependent and material can convey at steeper angles the situation is aggravated with fine powders that tend to dilate to a loose state and behave like a fluid.

Screw Elevators.

To overcome the inclination limitations of gravity mode conveying, screws are enclosed in circular casings and run at faster speeds of rotation. Rotation of the mass of material within the casing gives rise to outward radial pressure due to centripetal forces. Restraint to material rotation developed by friction on the inner wall of the casing causes the material to elevate in a helical path determined by the friction on the face of the screw blades. The casing friction does not influence the direction of motion, and hence it's conveying efficiency, but determines the power needs. Screw elevators run at all inclinations up to the vertical. Intermediate bearings are not good practice so the overall length is limited by the stiffness of the single span centre tube, normally to less than an 8 meters.

The supply hopper has to be of good flow design to deliver sufficient overpressure to overcome the tendency for material to be thrown off the screw by centripetal force. Poor flow material frequently presents difficult feed problems into screw elevators.

Except for very crude applications, screw elevators should not be expected to perform metering duties. Not only is the feed rate sensitive to minor features of geometry and material properties, but speed variations do not provide a linear response. The use of short screw feeders, directly injecting material into the inlet of a screw elevator, is useful to overcome feed difficulties, provide accurate feed control via a high capacity hopper in limited headroom

The main effect of low speed, steep screw inclinations is that the fall back of product fills the cross section of the casing at the inlet. Providing that further material is fed to the machine, and the inlet hopper is of good flow form, the screw will extract from the inlet and convey material along and up the axis in a flooded mode. In this form of material transfer the screws act as flood feeders, but there are various drawbacks compared with horizontal feeders.

When the feed to the inlet stops, the material falls back into the empty space moved clear by the screw rotation and conveying effectively stops, with the screw turning full of material. Steep conveyors will not self-clear of product, so slow speed screws are not generally used at steep inclinations.

Re-starting torque can be particularly high, as the settled material attains much higher shear strength due to the total confinement of the casing, than when in a dilated dynamic condition as conveyed. It can also take some time for the high loading to fall off if further material enters to replace material carried away. For long elevators, it is good practice to utilise one or more increases in pitch of the screw from the inlet to give a better mechanical advantage for clearing the settled material and ensure that it is expanded away by the following flight region. If practical, screw elevators should run for a short period before fresh feed is offered to the machine in order to allow the inlet region to clear the settled product. An alternative is to employ a short feeder at the inlet that will provide a positive, controlled supply to the elevator and can start a short period after the elevator commences. This also enables a lower pick-up for loading and more flexibility of feed hopper size and capacity.

Static Screw Elevator

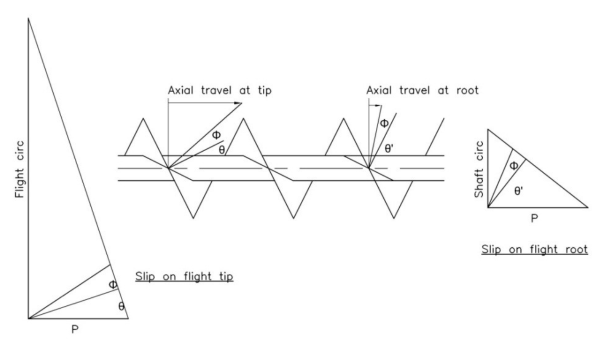
A recent development of a static screw elevator works by rotating the casing and using wall friction to drive the product round the spiral blade of the screw flight. The process is aided by scoops formed in the casing at the inlet section, a feature that enables a very low and positive entrainment of material to the elevator. Centrifugal force seals the flight tip clearance with product and forms a high internal friction boundary for elevating the media. This results in high bulk transfer capacities but the machine is not self clearing at the end of a run.

Feeders

The term 'Screw Feeder' can be applied to any screw type machine that controls the rate of feed that it dispenses but they fall into two main categories; those with a prime function of providing reliable discharge from a storage facility and those designed to dispense a controlled amount of product to a subsequent process. These functions place differing demands on the equipment. As described below.

Bulk material occupies the whole cross section of a screw feeder at the inlet section so the contents no longer slip down the flight face but moves in a spiral manner according to the helix angle of the flight, **Φ**, and the contact friction value on the screw flight face, **θ.** The flight helix angle varies from the flight tip to shaft contact (see figure below) so the theoretical advance of material in the screw cross section differs according to its radial location. It will also be seen that the axial transfer efficiency decreases with pitch increase and a limit is reached at which longer pitches transfer less, rather than more.

While there are substantial flow and operating advantages in elongated slot inlets that have 'live' extraction over the total length, this required a continuous increase in the axial transfer capacity of the screw. As the initial section clears product directly, whereas subsequent regions only extract the incremental difference is axial transfer capacity, the design of screw construction for a relatively uniform extraction rate over an extended length is material dependent and quite demanding. For example, an irregular input that draws more from the output end of the hopper can result in the terminal discharge rate being less than design as it depends on the screw section that remains covered with material.



Variation in axial transfer with radial location

Hopper Dischargers

Bin dischargers, are normally designed as integral features of a storage facility. Their essential function is to provide a reliable discharge of the stored contents at a controlled rate, but a prime feature is the extraction pattern they develop from a slot outlet. Uniform pitch screws have a very limited 'live' inflow region, but are used for short inlets, clearing long outlet such as for plate filters and dust collecting hoppers, non-mass flow duties and conventional reversing feeders.

The total amount of material taken from the hopper is determined by the screw construction at the outlet end of the hopper interface and the restraint offered by the clearance in the casing as the screw leaves this region. A 'saddle' shaped portion is normally fit above the screw in 'U' casings to form a 'choke section' extending at least one screw diameter along the casing to prevent 'through flow'. A flat 'choke plate' across the casing adjacent to the hopper end wall is an economical alternative, but is less effective in holding back material in a dilated condition. It should be noted that no screw or choke section prevents the escape of a fully fluidised material.

To secure the flow benefit of a slot the length over which live flow is taking place should be at least three times the wide of the slot. Apart from providing extra storage capacity, the elimination of gullies and of uniaxial convergence allows the wall inclination to be reduced, either for mass flow design or for the ultimate self-clearing of a non-mass flow hopper. Other benefits include less headroom requirements, enhanced rectification of segregation and better de-aeration characteristics.

For a bin of mass flow design it is essential that the total area of the outlet is active when the screw is extracting material, otherwise there will be a dead area that prevents a zone of the hopper from moving, whatever its form. To provide this continuous extraction over the full axial length of the feeder the screw geometry must be such as to generate a progressively increasing transfer capacity. It is not necessary to generate uniform increments per unit length.

This is rarely practical as the section of screw furthest from the outlet will move material away from this end and refill its full cross section from above, whereas all other regions will only be able to absorb the incremental transfer capacity of the screw as material from prior regions are moved along the axis. However, this encourages flow down the end wall of the bin and a degree of attenuation of theoretical extraction rates prevails by virtue of the shear strength of the material transferring filling pressures from area of high flow velocity to adjacent regions where the flow is lower.

Reversing Feeders

It is not good practice to fit two separate outlets to a bulk storage hopper as this creates 'dead' regions of storage and eccentric flow patterns. A space saving alternative to using a two-way valve and bifurcated chutes is to employ a reversing feeder that can deliver to either of two outlets. Unfortunately conventional designs of screw that are used to secure the flow and operating benefits of an extended 'live' flow outlet preclude the facility to reverse so the much of the advantage of being able to feed two different points from the hopper were not previously available. A recent development exploiting the mechanics of screw feeding now enables these benefits to be secured. (2). The is possible because changes in the contact friction that are made to the 'working' face of the screw flight to modify the axial transfer capacity incrementally along the axis in one directing of movement become irrelevant when the screw is reversed. Different regions of screw flight can thus be modified to product incremental extraction in the opposite direction of travel. This enables uniform pitch flights to be utilised that generate incremental extraction in both the forward and reverse direction. The form of screw geometry and surface treatment utilised are designed to resist 'clogging' and the effect of wear.

A further feature that permits the 'live' extraction length to be doubled and either outlet to be served individually or both at the same time is to use two screws end to end in a common casing with separate drives. Each are arranged to run at full speed when delivering to their nearest outlet and at half speed when moving product onto the other screw. The discharge rate to both of the outlet is therefore unchanged, whether one or both outlets are receiving material.

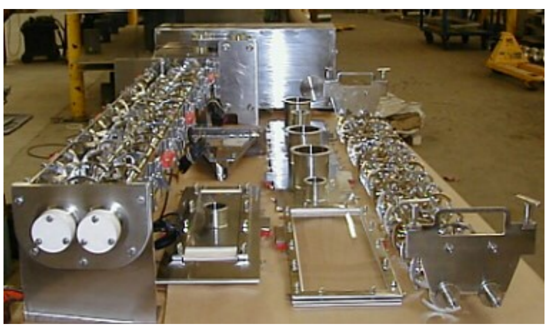
Dispensing Feeders

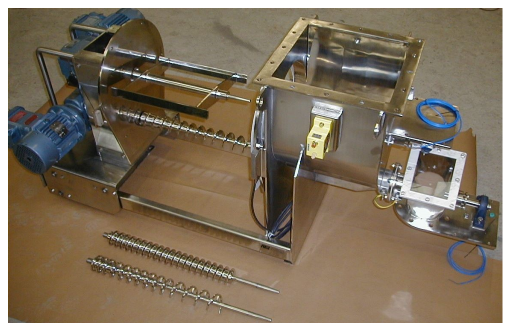
Metering Screws have the prime objective of securing a reliable, predictable and controllable rate of solids flow and are usually at a smaller scale than hopper dischargers. Two main types are available: - volumetric and gravimetric feeders. Discharge fluctuations can arise with ether type from cyclic effects of the screw pitch, 'cohesive overhang' or 'repose avalanching', but these can be minimised by various design techniques.

Gravimetric have the virtues of enabling corrections to fluctuations in the supply and the ability to record the machines performance, but are considerably more expensive than volumetric feeders. Volumetric feeders demand close attention to hopper and screw interface design to secure reliable, consistent and predictable discharge. This calls for a mass flow design, unless the media is free flowing and of a regular bulk density. Gravimetric feeders can achieve reliable and accurate results, especially with granular materials that rapidly settle to a stable and consistent density. The two circumstances that demand gravimetric control are where a record of performance is required and when the density of the bulk material is subjected to uncertain variation. Separate flow measurement devices with drive feedback may be used in such cases to retain the simplicity of volumetric feeding.

The most common form of gravimetric feeder: - the Loss-in-weight type, utilised a screw feeder with a small hopper mounted on a load cell. The cell reading is compared with a diminishing weight at the rate desired and any difference is used to compensate the feeder output by a suitable screw speed variation.

When the remaining material in the feeder hopper reaches a low value the system locks the feeder speed to deliver volumetrically whilst a fresh batch of product is quickly loaded into the feeder hopper. The load value is then reset and gravimetric control re-established. Whilst clever electronics produce good accuracy, a key feature for consistency is avoiding large changes in bulk density during the make-up process. The required ancillary feeding equipment to provide a re-supply to the batch process, adds to the complexity, headroom and expense of the system.





Academic Perspective: Prof. Al Weimer's Research Group

Professor Alan W. Weimer

H.T. Sears Memorial Professor

Chemical and Biological Engineering

University of Colorado, Boulder

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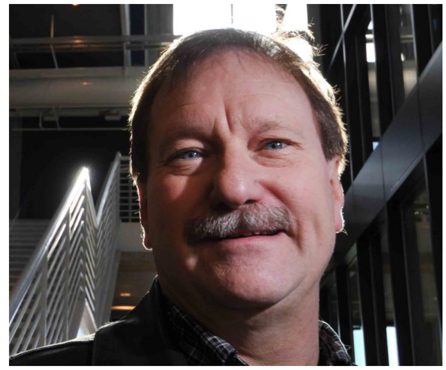


Professor Al Weimer (hometown – Youngstown, OH; B.S. ChEN, University of Cincinnati; Ph.D., University of Colorado) joined the Chemical and Biological Engineering Department at the University of Colorado (CU) in 1996 after a 16-year career with the Dow Chemical Company (Midland, MI). His 40-year career has involved particle synthesis and surface functionalization processing; including fluidized bed, moving bed, and transport tube chemical reactors operating at both high temperatures and/or low pressures. Upon joining Dow's Hydrocarbon and Energy Department in 1980, Weimer developed a high pressure (2000 psig) fluidized bed reactor process for Fischer-Tropsch synthesis and mixed alcohols. Later he was the first process engineer to work with nearly 25 materials scientists, inorganic chemists, and ceramicists to start a new business in ceramics and advanced materials. His R&D included invention of a 2000^{o}C graphite transport tube reactor and process to carry out fast carbothermal reduction processing to commercially synthesize fine ceramic powders. He learned from his scientific colleagues the importance of being able to control particle surface chemistry in order to fabricate high quality parts from the fine powders.

At CU, his research mimics his industrial experiences (http://www.colorado.edu/lab/weimer/). He carries out research in two distinct areas: (1) high temperature chemical processing and (2) atomic layer deposition (ALD) to modify the surface chemistry of primary fine particles (i.e. Particle ALD).

For the former, he uses concentrated sunlight to achieve the high temperatures conventionally achieved using electrical resistance. His solar thermal research effort is the largest such academic effort in the United States, 2nd in the world. He is an Adjunct Professor at the Australian National University in Canberra, where a key interest is to exploit solar thermal chemical processing for eventual commercial applications. For solarthermal water splitting, water is split into O_2 and H_2 in two steps using an active redox material such as a spinel or perovskite. As seen in the attached Figure 1, a reduction is typically carried out at a high temperature typically above 1200^{o}C with O-vacancies forming in the active materials structure. The reduced active material is then oxidized, typically at a lower temperature, with steam to fill the O-vacancies and release H_2 in the process. The process can also be simplified by operating isothermally within a solar cavity as shown in Figure 2 as long as the active redox materials can be effectively reduced and oxidized at nearly the same temperature. Weimer's research is focused on solarthermal chemical reactor design and the development of key aspects of the process including active and robust particulate redox materials, reactor containment materials, and efficient methods to separate and recycle critical inert gas.

For Particle ALD, he co-founded ALD NanoSolutions, Inc. in 2001 (www.ALDNanoSolutions.com) with an objective being to create jobs for his students and to see his research efforts commercialized. His industrial background provides for a unique perspective and appreciation for intellectual property. With ALD on particles, one is able to carry out self-limiting chemical reactions at the surface in order to coat the individual particles with conformal pinhole-free films of inorganic or even hybrid organic/inorganic materials (Figure 3a). This is a platform technology. Applications for these materials are numerous and include battery cathode and anode materials, passivating films for active LED lighting materials, catalysts, personal care products, and many more. The process is carried out with agitated particles and was originally scaled-up using a fluidized bed reactor as shown in Figure 3b. The process is low-cost since particle surfaces are coated with nearly perfect films allowing minimal chemical precursor to be used and with nearly no waste of precursor chemicals. The process is currently in the commercial market development phase for several large-scale applications. Many applications for Particle ALD have not yet been discovered as interest in the technology is expected to grow as commercial products come on-line.

Al's current research group includes ten advised or co-advised Ph.D. students, one postdoctoral Research Associate, two Professional Research Assistants, and five undergraduates (U/Gs) supporting the Ph.D. student research. His projects are focused on the splitting of water using concentrated sunlight to produce renewable hydrogen, the synthesis of magnesium metal by carbothermal reduction, and Particle ALD with applications for catalysis, corrosion reduction, and 3D printing, among others. With the change in administration in Washington DC, he is moving swiftly into new research areas like nuclear energy, defense, and even cement (infrastructure spending). He avoids areas where substantial research effort already exists – e.g. batteries, fuel cells, and photovoltaics. Since 1996, he has graduated 24 Ph.D.s with 100% job placement, including 4 academics. He and his research team have published more than 190 peer-reviewed research papers and have 38 issued U.S. Patents, almost all licensed to industry. He has also mentored over 100 U/Gs in his lab, appoximately 25 have gone on to earn Ph.D.s or are currently enrolled in Ph.D. programs. He has gotten the fun back! He lives it through the research efforts of his Ph.D. students who he advises.

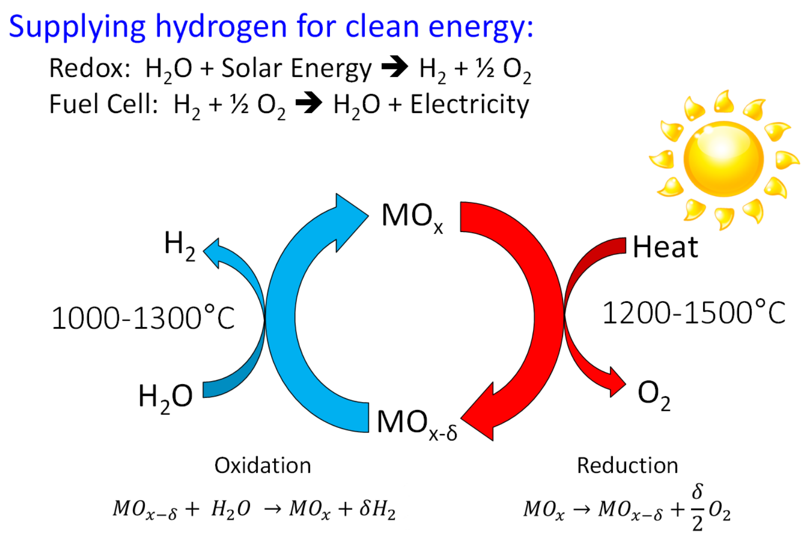


Figure 1. Solar Thermal Water Splitting Cycle

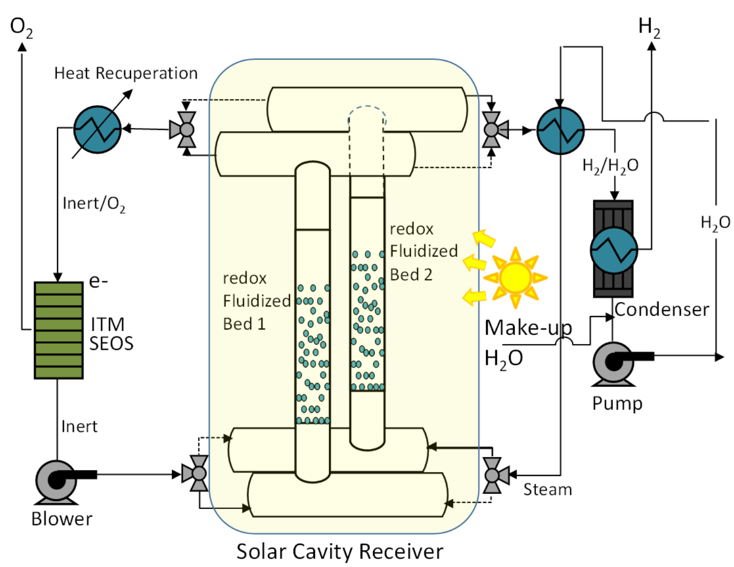
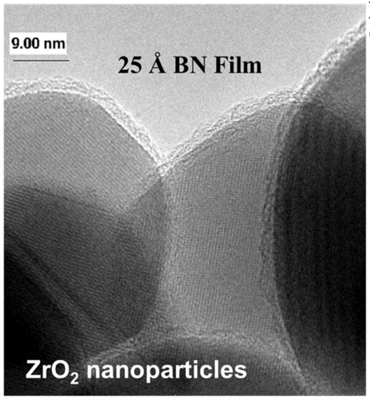
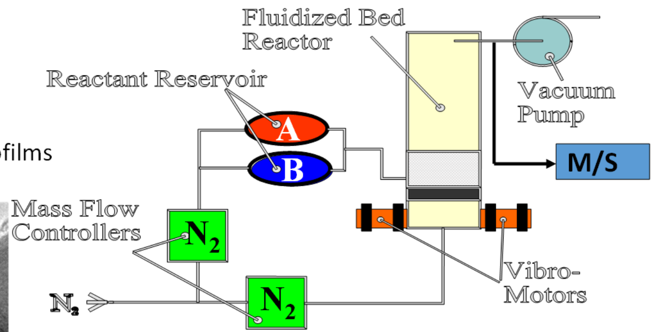


Figure 2. Near-isothermal Single Cavity Dual Fluid Bed System for Solar thermal splitting of water using redox reactions

a) Nanopowders coated with nanofilms by ALD



JD Ferguson et al., Thin Solid Films, 413, 16 (2002)



b) Particle ALD carried out in a fluidized bed reactor

Figure 3. Coating large quantities of powders by ALD using fluidized beds

Team Weimer

Aaron Palumbo

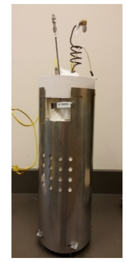
Novel Magnesium Metal Production and Spinoff NewCo: As part of a $3.6M DOE ARPA-E award, the Weimer research group investigated a novel carbothermic method for extracting magnesium metal from ore. The technology is preceded by a World War 2-era commercial process. However, the Weimer research group began from fundamental principles of reaction kinetics and condensation behavior in order to deduce a set of operating conditions that allow the process to run continuously at high metal recoveries, an unprecedented advancement of magnesium smelting. From this work, two patents are pending, five peer-reviewed publications have been issued, and a spin-out company, Big Blue Technologies, was formed having raised an additional $420k for commercial activities.

Aaron Palumbo is a post-doctoral research associate in the Weimer lab, the CEO of Big Blue Technologies, and the Executive Vice President at Nevada Clean Magnesium (TSX:NVM.V). He graduated from the University of Colorado at Boulder in 2014 with his Ph.D. in Chemical Engineering. He grew up in Fort Collins, Colorado, and obtained his B.S. in ChEN from Colorado State University.

Amanda Hoskins

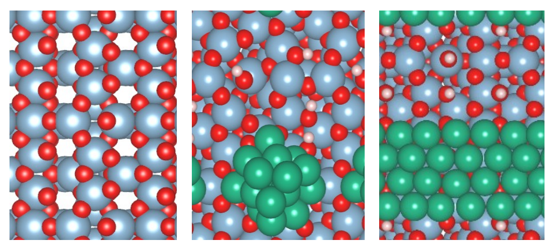
ALD Films to Reduce High-temperature Steam Oxidation of SiC: Silicon Carbide (SiC) is an ideal material for many high-temperature applications due to its resistance to thermal shock and high thermal conductivity. However, SiC degrades in water-rich environments limiting its applications in extreme oxidative environments such as combustion engines, heat exchangers, and high temperature reactor materials. We are exploring the use of atomic layer deposition (ALD) to generate nano-scale films that are dense, crack-free, and chemically bonded to the surface to prevent the steam oxidation of SiC and materials like it. We have found that the application of nanostructured ceramic films grown with ALD significantly improves the oxidation resistance of SiC in extreme environments with a film much thinner than standard applications. Computational modeling of oxygen diffusion through these films allows identification of promising coatings to further extend the lifetime of SiC. We expect to use this understanding to develop more advanced stabilizing coatings for SiC and the myriad of other applications that require high-temperature oxidation resistant materials. Amanda Hoskins is developing improved chemically resistant nanofilms for protecting SiC advanced materials from high temperature steam oxidation. Amanda is a 3rd year Ph.D. student from Newfield, NY and received her B.S. ChEN from the Rochester Institute of Technology.

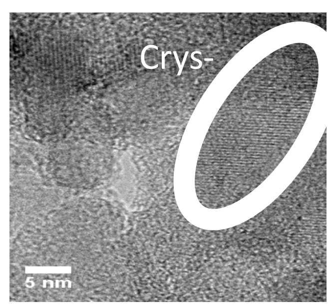
Ibraheam Alshankiti



Improving Efficiency for Solarthermal Water Splitting Using High Temperature Oxygen Transport Membranes: A comprehensive solar-to-hydrogen (STH) thermodynamic efficiency model is being developed for the solarthermal water splitting cycle to determine the effects of various parameters on the overall efficiency. The method of achieving low O_2 partial pressure in the reduction step, vacuum pumping or recycled inert gas sweeping, has been identified to have a significant impact on the STH efficiency. The calculations showed that currently available vacuum pump technologies are unlikely to provide high STH efficiencies due to low pump efficiencies, especially at low reduction pressures. Meanwhile, a recycled inert gas sweep with a high temperature separation step showed to maintain high STH efficiencies with 10% thermodynamic separation efficiency. In collaboration with Ceramatec®, a high temperature Ion Transport Membrane was built as shown in the figure to study the energy requirements for separating O_2 from inert gas. The membrane was shown to reduce the O_2 content in an inert gas from 1% down to 15 ppm operating at 850°C with 12% thermodynamic separation efficiency. This processing is an efficient alternative to conventional O2 removal systems since it requires high temperatures to operate and the STH process is already at such temperatures. Ibraheam Alshankiti is investigating the redox reaction kinetics for solar thermal hydrogen production and efficient methods for separating produced byproduct O_2. Ibraheam is an employee of SABIC (Jeddah, Saudi Arabia) on leave to obtain his Ph.D. He received his B.S., ChEN University of Tulsa, and his M.S. in Chemical Engineering from the University of Colorado.

Jacob Clary

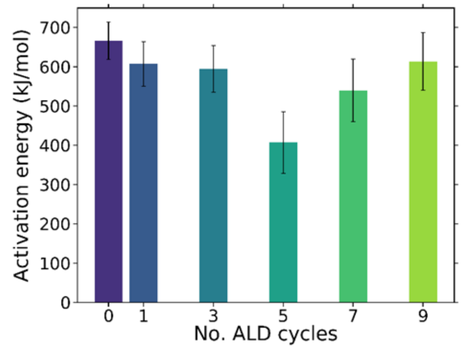




ALD Fischer-Tropsch Catalysis: Atomic layer deposition (ALD) was used to create cobalt/alumina catalysts for Fischer-Tropsch Synthesis (FTS) to make liquid hydrocarbons. The ALD chemistry allows cobalt to deposit in a highly dispersed manner across the surface of the support. These catalysts were active for FTS, with the support playing a significant role in altering activity. High resolution imaging showed cobalt grew discontinuous planar layers on the surface instead of small nanoparticles. DFT was used to predict the most favorable cobalt morphology on the support surfaces.

Jacob Clary, Knoxville, TN; B.S., Chemical Engineering, Auburn University (2014); 3rd year Ph.D. student

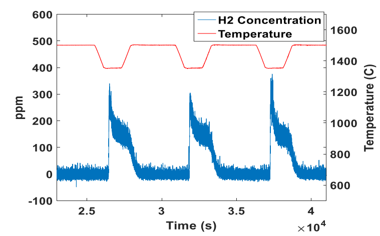
Rebecca O'Toole

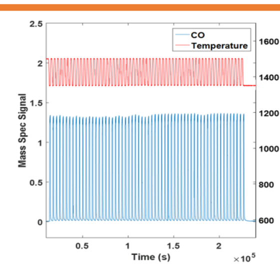


Ceramic Secondary Phase Addition by Particle ALD: The Weimer research group has been studying the use of particle atomic layer deposition (ALD) to incorporate secondary ceramic phases into advanced ceramic materials. Specifically, the addition of sintering aids to primary ceramic particles can reduce the temperature required for full densification of ceramic parts. Sintering aids are conventionally added by mechanical mixing, which can lead to an inhomogenous distribution of secondary phase particles and deleteriously affect dense part properties. An alternative method for sintering aid addition is by ALD, which conformally coats each primary particle with a thin film of the sintering aid material, ensuring a homogenous distribution.

Yttria-stabilized zirconia (YSZ), a commonly used solid oxide fuel cell electrolyte material, is typically mixed with a small amount of alumina to reduce the sintering temperature. By conducting densification experiments on YSZ with 0-9 alumina ALD cycles and extracting the activation energy for the intermediate sintering stage, an optimal amount of alumina ALD was found to be 5 cycles. Future work will include comparison of ALD to mechanical mixing and similar experiments on different primary/secondary phase ceramic systems. Rebecca O'Toole is a 2nd year Ph.D. student at the University of Colorado, Boulder. She grew up in Toledo, Ohio and received a bachelor's degree in chemical engineering from Case Western Reserve University.

Samantha Millican



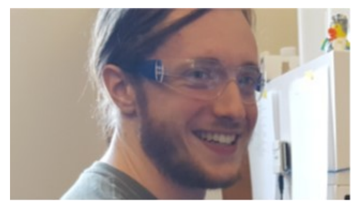


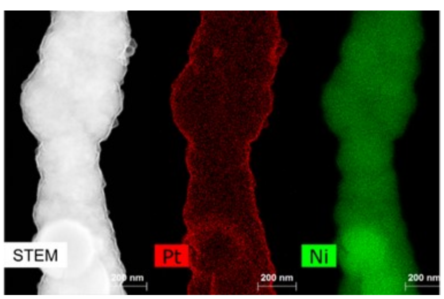
Active redox Materials Discovery and Experimental Validation. While solar energy is the most abundant renewable energy resource, the capture, storage, and distribution of it remains a challenge. Solar thermochemical water splitting (STWS) provides a promising route for efficient utilization of this disperse resource since it allows for use of the entire solar spectrum to convert water to an energy dense fuel, H_2. In order to commercially realize this technology, several challenges must be overcome including an energy efficient reactor design, stable reactor and heat exchanger materials, and robust redox active particles. Current research in the Weimer group is focused on developing a fundamental understanding of and improving each of these elements. In order to be viable for economic hydrogen production, materials must have high hydrogen productivity, fast reduction and oxidation kinetics, low thermal reduction temperatures, and long term stability and reactivity. We use a computationally accelerated and experimentally validated approach with advanced machine learned models to accelerate the discovery of new, durable perovskite and spinel metal oxides for STWS. *Ab initio* methods are utilized to screen new redox materials for thermodynamic viability, hydrogen capacity, and kinetic viability. Promising materials are subsequently synthesized using a modified Pechini method and tested for STWS capability in a stagnation flow reactor (SFR). Using the SFR, cobalt doped hercynite ($Co_{0.5}Fe_{0.5}Al_2O_4$) was shown to be highly stable with no loss in reactivity from between redox cycle 100 and 200, as shown in figure above. Samantha Millican is focused on active redox materials discovery and experimental validation for splitting water. She is from Idaho Falls, ID. She is a 3rd year Ph.D. student receiving her B.S. ChEN from University of Notre Dame. Prior to her graduate program, she worked 3 years with General Electric.

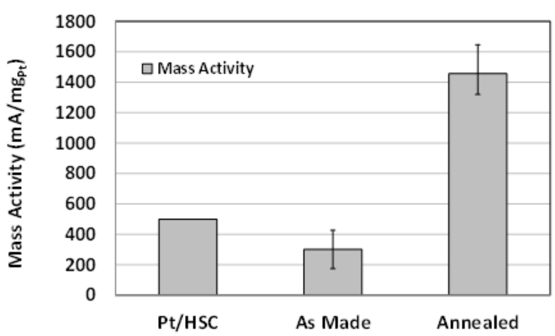
Boris Chubukov

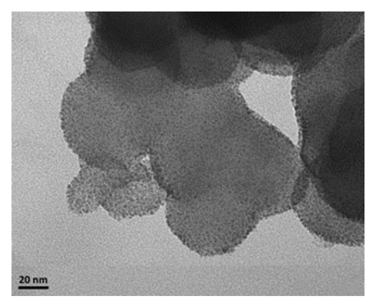
Magnesium Carbothermal Reduction CFD and Kinetics: Boris Chubukov (hometown –Madison, WI) earned his B.S. in Chemical Engineering and Molecular Biology from the University of Wisconsin – Madison. His project focuses on redeveloping a process for sustainable and economic magnesium metal production. A small pilot scale prototype reactor (100 g/hr of Mg) was designed, constructed, and operated. Theoretical work uses computational fluid dynamics and kinetic modeling to predict reactor behavior. He is a cofounder of *Big Blue Technologies, LLC* which aims to commercialize the process **.** Boris is a 4th year Ph.D. student.

Wilson McNeary





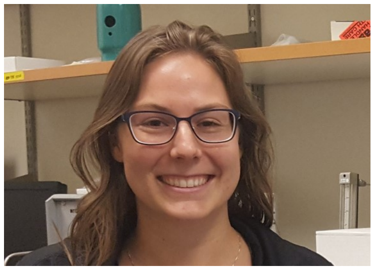




ALD for Fuel Cell Catalysts: Wilson McNeary is focused on the development of novel fuel cell catalysts using ALD. A major component of this work is a collaboration with the National Renewable Energy Laboratory to produce extended surface electrocatalysts via Pt ALD on Ni nanowires substrates. These materials have shown superior activity and durability vs. benchmark Pt nanoparticle catalysts and the use of ALD allows for scalable and reproducible synthesis.

Additional work is focused on utilizing ALD to improve traditional Pt nanoparticle catalysts. It has been previously shown that functionalized carbon black substrate can be used with Pt ALD to create finely dispersed Pt/C catalysts; however, residual surface functional groups decrease hydrophobicity of the catalyst layer and negatively impact fuel cell device performance. Current work is focused on creating metal oxide nanostructures with ALD to remove the residual functional groups and prevent agglomeration and sintering of catalytic Pt during fuel cell voltage cycling. Wilson is a 3rd year Ph.D. student from Charleston, MO and received his B.S. ChEN from the University of Missouri.

Sarah Bull



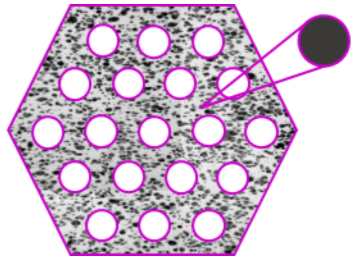


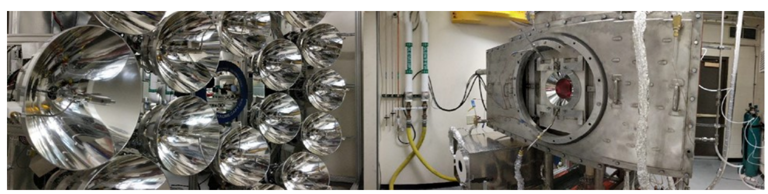
Figure 1: Graphic highlighting areas targeted for ALD of protective barrier coatings. Fill image from Haas et al. Energy Convers. Manag. (2008).

Atomic Layer Deposition on Nuclear Fuel

Nuclear powered engines and electricity generating stations, both terrestrial and beyond Earth's atmosphere face harsh conditions which materials must be designed to endure. This problem has the potential to be overcome by advanced coatings using atomic layer deposition (ALD). The Weimer lab is currently investigating environmental barriers to protect fuel in nuclear thermal propulsion engines from hydrogen embrittlement by reducing diffusion of hydrogen through the coating and preventing interaction of hydrogen and uranium. The goal is to use ALD to coat both fuel particle microspheres as well as fuel element segments (shown in Figure 1). As of now, state of the art coatings on these structures are deposited via chemical vapor deposition (CVD) which in addition to depositing thick, porous films, CVD cannot deposit in the high length/diameter (L/D) aspect ratio pores and instead clogs the entrance to them. Therefore, the channels are currently exposed directly to hydrogen flow. ALD is not line of sight dependent and precursors easily diffuse through pores to deposit even coatings over the entire substrate. This is paramount since hydrogen flow channels reflect L/D ratios of 1m/1-3mm. Currently, research is centered around computational modeling of the coatings using density functional theory (DFT) and molecular dynamics (MD).

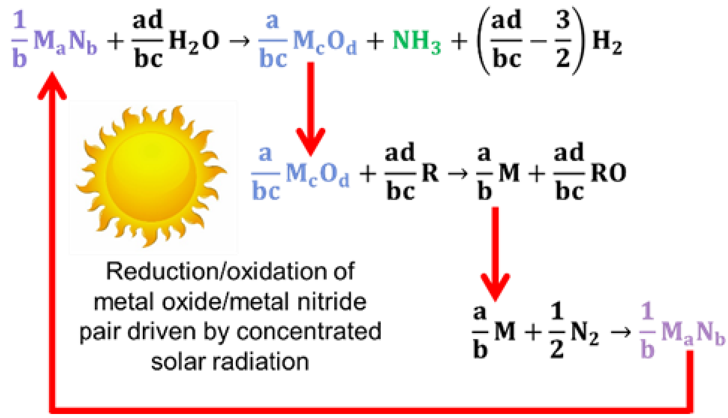
Sarah Bull is a 2nd year Ph.D. student working on nuclear applications of ALD in the Weimer lab. She received her B.S. in chemical engineering from Yale University in 2016 and is originally from Paradise Valley, AZ.

Scott Rowe



CU High-flux Solar Simulator and Hybrid Solar/electric Receiver: Scott Rowe is exploring the utility of advanced process control in conventional and renewable chemical processes. For renewables, a $1.2M solar pilot facility has been constructed that uses high-powered lamps to mimic concentrated solar heat, heat that is used to drive chemical reactions. These lamps can be used to reproduce weather transients (cloud cover) that cause a total loss of energy, extraordinary disturbances that demand excellent control. Conventional control studies involve the simulation of hydrocarbon chemical plants in Aspen/HYSYS. Within these testbeds the latest in cooperative control is being compared to distributed control. Scott is a 4th yr Ph.D. student from Tucson, AZ and received his B.S. ChEN from the Univesity of Texas.

Chris Bartel



Renewable Ammonia from Sun, Water, and Air: Chris Bartel is using computational chemistry and machine learning to identify ceramic materials which enable the renewable production of ammonia in a process termed solar thermochemical ammonia synthesis. In this process, a metal nitride is oxidized by water to yield ammonia and a metal oxide. Concentrated solar radiation is then used to heat a reactor tube to > 1200 °C in the presence of nitrogen which transforms the metal oxide back to the metal nitride and allows for the cycle to be repeated. Density functional theory and machine learning are being used to rationally design the optimal metal nitride/oxide material which mediates the conversion of air, water, and concentrated sunlight into the valuable product, ammonia.

Chris Bartel is a 3rd year PhD student from Mandeville, Louisiana who graduated from Auburn University in 2014 with a B.S. in Chemical Engineering.

Advanced Powder Technology

An Elsevier Journal

I would like to make the PTF community aware of Advanced Powder Technology (APT) that is a well-established journal. Starting 2017, this Elsevier managed journal is publishing 12 issues per year and has seen a dramatic increase in its popularity, along with an improvement in its Impact Factor (IF). For 2016, it enjoys the IF of 2.659, and CiteScore of 2.70, making it a very attractive vehicle for publishing your late-breaking research. The editors of APT, in particular, the US Editorial Board members, are cordially inviting you to submit your latest research or state-of-the-art review articles. Please contact me or any US Editor of APT if you have questions or specific ideas for new submissions.

Currently, there are eight Editors in the US Editorial Board, and our plans are to expand the board in next 2-3 months. I encourage you to nominate your colleague who may be interested in serving on this board. An ideal candidate is an Associate or Full Professor, who is able to commit time to manage several articles per year as an editor, and has expertise in one or more sub-fields of particle technology. We are particularly seeking new members with expertise in material science, catalysis, characterization, energy, sustainability and computational methods as related to the general field of particle technology. Please feel free to send me (dave@njit.edu) nominations (including self) soon for consideration. Expected tenure for each editor is 2-4 years.

Rajesh N. Dave

Executive Editor, US Editorial Board,

Advanced Powder Technology

WORLD CONGRESS ON PARTICLE TECHNOLOGY

Expanding Boundaries 2018

APRIL 22 - 26, 2018
ORLANDO, FL

ORLANDO WORLD CENTER MARRIOTT

A BRIEF HISTORY OF THE WCPT8

Held every 4 years since its inception in 1990, the World Congress on Particle Technology rotates between North America, Europe and Asia. In 2018, it returns to Orlando, Florida, USA where it will be hosted by the AIChE. Held April 22—26, 2018, the WCPT8 will be co-located with the 2018 AIChE Spring Meeting and 14th Global Congress on Process Safety. We invite you to participate, learn, teach and collaborate at this prestigious event.

OBJECTIVES OF THE WCPT8

→ Stimulate discussions on the forefront of research in particle science & technology.

→ Address both the fundamental and applied aspects of particle technology.

→ Allow for interaction with leading researchers from around the world.

→ Share ideas and gaps that span beyond individual research areas in particle technology.

→ Provide an opportunity to network and collaborate with engineers involved in topics beyond particle technology:

- 2018 AIChE Spring Meeting
- 14th Global Congress on Process Safety
- 30th Ethylene Producers' Conference
- and more

18 AIChE Spring Meeting | 14th Global Congress on Process Safety | ORLANDO FLORIDA 2018

WHO SHOULD ATTEND?

- Advanced Materials Manufacturers
- Catalyst Developers
- Engineering & Licensing Companies
- Equipment Suppliers
- Modeling & Software Providers
- New & Green Process Technology
- Particle Characterization & Analysis Providers
- Petrochemical & Chemical Manufacturers

Learn more at wcpt8.org

CONFERENCE FORMAT

→ Plenary speakers for inspiration

- Industrial View in Research in Particle Technology
  - **Karl Jacob**, *The Dow Chemical Company*

- Contact Charging in Granular Materials
  - **Heinrich M. Jaeger**, *University of Chicago*

- Nature-Inspired Chemical Engineering - a Pathway to Innovation in Particle Technology
  - **Marc-Olivier Coppens**, *University College London*

- Mesoscience: Opening a New Paradigm of Particle Technology
  - **Jinghai Li**, *Chinese Academy of Sciences*

→ Keynote speakers dedicated to their research

→ A technical program that spans on all aspects of particle technology from the newest fundamental concepts to industrial applications from all over the world.

- Application of Particle Technology for Pharmaceuticals
- Applications of Solids Processing Unit Operations
- Applications with Sustainable Energy & Environment
- Education
- Fluidization & Multiphase Flow
- Handling & Processing of Granular Systems
- Particle & Bulk Powder Characterization
- Particle & Nanoparticle Functionalization
- Particle Classification
- Particle Design
- Particle Interactions
- Particle-Based Separations: Fundamentals & Applications
- Particle Safety
- Special Topics in Particle Technology

→ Time for networking and space to allow for one-on-one discussions.

→ A reception and banquet for relaxation among friends.

→ Best papers to be published in reviewed high-impact journals.

→ Student poster award.

Learn more at wcpt8.org

SUPPORT THE WORLD CONGRESS ON PARTICLE TECHNOLOGY

WHY SHOULD YOUR FIRM BE A CONFERENCE SPONSOR?

Sponsoring this conference shows your company's support and leadership in the field of particle technology. It allows you to connect and communicate your message with experts and leaders working in this field. All levels of sponsorship are customizable to meet your budget and goals for the meeting.

Choose from sponsorship options that best meet your needs.

- Branding-oriented sponsorships provide your company with high presence and visibility, specifically around one aspect of the meeting.
- Messaging sponsorships allow your company to communicate its vision to a broad, or specific, group of conference attendees.
- General sponsorships give your company a high level of recognition throughout the meeting.

EXHIBIT AT THE WCPT8

Exhibiting will expose your company to:

- 1,000 engineers and scientists work in various areas of particle technology.
- Key decision makers who are attending the meeting to learn about new technologies and products that can help to improve their work.
- Leaders in the particle technology field whose work and processes are looked at by the larger community as a standard to aspire to.

Exhibit Booth Package Includes:

- 10'x10' (or larger) Booth
- 1 Full conference registration
- 2 Exhibit only registrations
- 1 Wireless lead retrieval device
- 1 Identification sign showing company name

Global Sales Manager | evanf@aiche.org | 646.495.1381

Learn more at wcpt8.org

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Learn more at wcpt8.org

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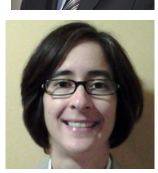

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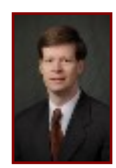

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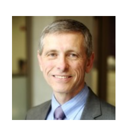

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