Engineering Research Center for Particle Science and Technology

University of Florida

A National Science Foundation Engineering Research Center since 1994

Applying particulate systems expertise to develop cost-effective and environmentally sound industrial products and processes

Particle technology deals with the production, characterization, modification, handling, and utilization of organic and inorganic powders, in both dry and wet conditions. Particulate systems as a core technology impact a number of industries including advanced materials, chemical, energy, environmental, mineral, agricultural, pharmaceutical, biotechnology, and food processing. Industrial processes involving particles are complex and, due to inadequate understanding of multiphase processing schemes, rarely reach more than 60 percent of the design capacity. The National Science Foundation Engineering Research Center (ERC) for Particle Science and Technology was established at the University of Florida to address these issues.

The vision of the ERC is to develop innovative particulate-based systems for next-generation processes and devices that sustain and improve the economic well-being of the nation and contribute to the quality of the environment and public health.

The mission of the ERC is to create a national center of excellence by conducting innovative fundamental research, educating students in the engineering practice of particle science and technology, and promoting academic/industry/government collaboration.

The goals of the ERC are: (1) to create the underlying scientific knowledge and invent and demonstrate the technological feasibility of innovative methodologies and systems governing particulate processes; (2) facilitate the transfer of research discoveries, theories, and inventions between the ERC and industry; and (3) develop and implement an interdisciplinary education program that will produce well-prepared scientists and engineers in the field and foster the goals of the ERC.

The current strategic research plan emphasizes a top-down approach where the research needs for the next-generation processes and devices in the marketplace inspire the Center-wide engineered systems research goals. Knowledge- and/or technology-oriented deliverables are targeted for completion to meet goals. Testbeds are organized to prove the feasibility of next-generation engineered systems concepts by integrating the outcomes of different research projects. Testbeds also serve as important tools to educate students and faculty members about the complexity of integrating dynamic systems and to augment their skills to work in teams. In the past, testbed results have revealed the need to pursue further research.

The organization of the research program is driven by the following engineered system goals that are to be achieved over the next few years:

ERC Graduate student and CRIT Engineer conducting research on an ERC-developed particle classifier using an on-line particle sizer.

Goal I: Scalable Process to Separate Micro- to Nanoscale Particles down to Parts per Billion Levels

Goal II: Engineered Particulate Systems for Enhanced Performance in Chemical, Electronic, and Pharmaceutical Applications

Goal III: Significant Increase in Reliability/Efficiency of Cohesive Powder Transfer through Mechanical, Pneumatic, and Physiochemical Processes

Goal IV: Nanoparticulate Systems for Toxicity Reversal of Overdosed Drugs (This goal was added as a logical outgrowth of Goal II's advances in engineered particle synthesis and developments in competitive adsorption achieved by Goal I.)

To achieve these goals, projects are organized to overcome specific knowledge and technology barriers. Intellectual resources for completion of projects and major tasks are drawn from the following thrusts as well as an outreach program to other experts in the field.

Advanced Separation Processes: Development of the knowledge base for improving the efficiency of particulate and molecular species attachment/detachment/separation processes through control of surface and fluid dynamic forces

Cohesive Powders Transfer: Development of design and analysis tools for predicting the flow behavior of dense systems of granular materials and cohesive

powders in complex geometries, including interstitial gas and microstructure effects

Dispersion, Agglomeration and Consolidation: Development of the knowledge base and predictive methodologies for control of the dispersion, agglomeration, and consolidation behavior of multiphase and polydisperse particulate systems

Engineered Particulates: Development of engineered particulates and/or slurry systems which enhance the performance of the systems in chemical, electronics, or pharmaceutical applications.

In the last few years, the Center's research activities have resulted in several knowledge and technological advances:

- Development of the site blocking agent concept, which has been commercialized by Engelhard
- A new concept for stabilizing nanoparticles using the steric component of self-assembled surfactant molecules in aqueous media
- Development of models for the role of nanoscale roughness in adhesion in dry and humid atmospheres
- Development of a 3-D discrete element simulation of cohesive powder flow
- Development of the Atomic Flux Coating Process (AFCP) which is being used for coating drugs for slow release
- Development of a novel cost-effective and environmentally friendly deinking technology
- Development of coatings for filter media for removal of viruses and bacteria from aqueous streams
- Completion and testing of the first prototype Multi-Angle, Multi-Wavelength Analyzer (MAMW) optical bench for joint property determinations
- Development of the Boundary Layer Momentum Transfer (BLMT) - Cyclone for high throughput and sharp cut classification of fine particles
- Development of Evanescent Wave Light Scattering (EWLS) with 3D optical trap as a technique to measure static and dynamic forces between a colloidal particle and a surface
- Development of Laser Induced Breakdown Spectroscopy (LIBS) for Elemental Characterization of Particulates for rapid direct elemental analysis of solids.

Education

The education of students and professionals in the engineering practice of particle science and technology is an integral part of the mission of the ERC. The educational philosophy of the Center is to develop innovative educational approaches that foster interdisciplinary, systems-related learning.

A high priority is the recruitment of top-quality students, including women and underrepresented minorities. Graduate Research Assistantships provide students with an unparalleled opportunity to work closely with faculty investigating fundamental issues relevant to developing next-generation processes and devices. Scholarship and Award Programs for exceptional undergraduate students provide opportunities to become involved in a research environment early in their professional training.

The Education Program is integrated with the ERC's Industrial Partners Program to provide opportunities for students to meet with industrial representatives and visit industrial facilities to gain a practical perspective early in their careers. Industrial Partners serve as mentors to ERC students and can serve on thesis and dissertation committees. A Research Experiences for Undergraduates (REU) program is offered to extend ERC research opportunities to students from other institutions.

The Visiting Eminent Scholars Program brings world-renowned experts to the Center for extended visits, allowing ERC faculty and students to interact with their global peers and further enhance their research and educational skills. The Center also offers short courses and workshops on current topics in particle science and technology.

Industrial Collaboration

The ERC recognizes that its success depends on industry support for its research and education programs and rapid transfer of technology to industry. As one avenue of active industrial collaboration, the ERC maintains an Industrial Partners Program (IPP) to establish partnerships with companies that play an important role in achieving the Center's goals. The IPP promotes a meaningful exchange between the ERC and Industrial Partners from small, medium, and large companies who meet at the Center semi-annually to discuss and guide current and future research activities. Partners enjoy benefits such as substantial leveraging of their investment (the ERC has over $4M invested annually in on-going research programs); early access to research results and highly trained students; nonexclusive, royalty-free rights for in-house use of inventions; academic and industrial researcher networks from over 20 industries; opportunities to guide the ERC's research, education, and industrial collaboration programs; a discounted overhead rate for additional sponsored research; industry/student research projects addressing specific industrial needs; reduced rates in short courses, workshops, and conferences; and priority access to the ERC's testbed and laboratory facilities.

In addition to the pre-competitive research undertaken by the ERC in support of its Strategic Research Plan, the results of which are shared with all Industrial Partners, ERC researchers also undertake industrially sponsored research of a proprietary nature. Companies are encouraged to submit focused research projects to the ERC for which the sponsoring company gains access to ERC world-class researchers and facilities and proprietary rights to research results.

CRIT Facility

The Characterization Research Instrumentation and Testbed (CRIT) Facility assists ERC research groups with particulate system characterization and provides testbed facilities for validation and demonstration of process/product developments by research teams.

The CRIT includes state-of-the-art instrumentation for particle analysis, processing, and characterization. The facility encompasses over 17,000 square feet with six analytical laboratories and a high bay area equipped with a crane, compressed air, and other necessities required to conduct pilot scale operations. Analytical equipment includes a variety of particle size and zeta potential analyzers, spectrometers, rheometers, and associated equipment needed to characterize surface and bulk properties of powders. Optical and electron microscopy, X-ray diffraction, X-ray photoelectron spectroscopy (XPS), and additional surface analytical techniques are available through the ERC.

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