



Bryan J. Ennis, Ph. D.

E&G Associates, Inc., *President & Owner*
Chattanooga, TN, August 1993 – Present
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Curriculum Vitae

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BIOGRAPHY

Dr. Bryan J. Ennis is a founder of E&G Associates, Inc, an engineering consulting and contract research firm specializing in particle processing, powder technology, solids training & continuing education workshops, contract research, and powder characterization. A recognized expert in the field of agglomeration and solids handling, Dr. Ennis has four decades of experience in solids manufacturing, and has consulted and undertaken contract research for over 100 clients, including many major pharmaceutical, agricultural and industrial chemical, food, energy and consumer products companies, including US consortia, the FDA, and the Departments of Defense and of Energy. Dr. Ennis has over 5000 citations of his work & research, with several invited contributions and plenary lecturers on particle processing, including presentations to National Science Foundation, and a Section Editor and contributor to the solids processing sections of Perry's Chemical Engineer's Handbook (7e, 8e), "Theory of Granulation: An Engineering Perspective", in Handbook of Pharmaceutical Granulation (2e,3e,4e), and The Science & Engineering of Granulation Processes.

Engineering projects include resolving a variety of solids processing challenges encountered in solids-handling storage, material transfer and feeding, mixing and segregation, agglomeration and grinding, and powder formulation, and has involved unit operations such as granulation (fluid-bed, mixer, pan, drum) spray drying, fluid-bed drying, encapsulation, and compaction (roll pressing, tableting and paste extrusion. This work also includes solids architecture design work and optimization for additive manufacturing, paste extrusion and solids handling of plastics, energetics, pharmaceutical, grain feedstock, and hydrogen sorbents for fuel cells, supported by several SBIR and matching state funding of \$2.7 MM dollars from the U.S. Department of Defense (NAVSEA, NAVAIR), the U.S. Department of Energy, prime contractors, U.S. national laboratories and industry. With extensive powder characterization and processing expertise, E&G offers its clients an industry-unique comprehensive approach to problems aimed at manipulating both powder properties and process design to resolve processing and product development challenges. Services are supported by extensive bulk powder and particle characterization instruments bench scale and pilot plant facilities, instrument sales, a CNC-fabrication facility, government and university collaboration and continuing-education courses, with characterization and processing equipment valued at over \$2 MM dollars.

Dr. Ennis previously led granulation research, solids handling and powder characterization programs of DuPont Engineering and DuPont Agricultural Products, and served on the chemical engineering faculty of the University of Tennessee and Vanderbilt University. He received his B.S. in Chemical Engineering from Rensselaer Polytechnic Institute, and Ph.D. from The City College of The City University of New York (CCNY). Dr. Ennis is a founder and previous Technical Vice-Chair of the Particle Technology Forum (PTF) and previous Chair of the Programming Groups of the American Institute of Chemical Engineering (AIChE). His honors include two national AIChE awards for service to the profession, a Deutscher Akademischer Austausch Dienst Award (Germany), the Stanley Katz Memorial Award (City College of NY) and a Visiting Research Fellow of Technical University of Delft (Netherlands).

**INDUSTRIES &
EXPERTISE*****Key Expertise:***

- Understanding particle/bulk powder and process equipment interactions, and using this information to design, optimize & manipulate powder formulations and process equipment, especially in the areas of granulation, compaction, additive manufacturing and bulk solids handling.
- Development of company personnel and laboratory functionality in powder characterization and processing.
- Manufacturing technology support, including solids training, collaboration, and solids process scale-up and control, with design and construction of instrumentation, both lab and in-process.
- Engineering solids design, including CAD, structural design & fabrication, including bins, feeders, chutes, screws, transfer equipment, novel feeding and dosing methods, powder production and recycle, and instrumentation.
- Academic and government leveraging of resources, through consortia, universities, student/professor exchanges and other laboratories.
- Author, contributor and editor of eight engineering books related to granulation and agglomeration, with over 5000 citations of research, with several recent invited, keynote lectures for AIChE, Sandia National Lab, Livermore National Lab, International Fine Particle Research Institute, and U.S. Navy. Invited contributor to trade and professional journals: *Chemical Engineering Progress*, *Chemical Engineering Magazine*, and the *Agglomeration Column of Powder & Bulk Engineering*.
- Extensive solids characterization equipment: rotary shear cells (powder cohesion, flowability, powder and paste friction, wall-die-screw friction); Johanson Indicizers, hopper flow rate, fluid-bed and permeability cell; dilatometry (thermal softening and dilation); laser diffraction, microscopy and imaging (particle size distribution and shape, both wet and dry); moisture sorption; surface area; pycnometry; inverse gas chromatograph and drop goniometer (surface energy, wetting); dissolution apparatus; capillary and die rheometry; die forces; electrostatic characterization.
- Extensive solids processing equipment: fluid-bed, mixer and drum granulation; drum coating; paste extrusion; Prester mechanical tableting replicator; roll press; milling; fluid-bed drying; test development vehicles for powder bed fusion 3D printing and powder formulation development.
- Pilot scale production train, with particle production reactor and in-situ and post processing (homogenizer, filtration, drying, classification, and blending), for additive manufacturing and other feedstocks.
- Significant experience in patent review and technical litigation, ranging from consumer products to pharmaceuticals, in all areas of powder processing and manufacturing, with emphasis on wet/dry agglomeration methods and powder characterization.

Recent Clients & Interactions (Last 4 Years):

Albermarle, Alcresta Therapeutics, Alkermes, Aprelia Pharmaceuticals, AstraZeneca, Bristol-Myers Squibb, Collins Aerospace, Columbia BioGas, Denso Corporation, Folger Coffee, Foxall, General Electric Research, GE-Roper, Hewlett Packard Enterprise, Hewlett Packard Inc., Hewlett Packard Federal, JM Smuckers, JR Automation (Wright Industries), J-Star Research, LaFarge (Holcim Inc.), MeadWestvaco, Merck, MS Industries, National Laboratories (Idaho, Lawrence Livermore, Sandia, Oak Ridge), Prince Minerals, Procter & Gamble, Schein Pharmaceutical, U.S. Navy (NAVSEA Command - Indian Head, NAVAIR Command - China Lake, Office of Naval Research), U.S. Department of Energy, Westvaco, WestRock, WR Grace.

**REPRESENTATIVE
CONTRACT &
INDUSTRIAL
EXPERIENCE
(Last 4 Years)**

Development of Explosive Feedstock for COTS 3D Printers

NAVSEA (Indian Head), U.S. Navy, \$1.35 MM w/state matching, 2017-2020

Commercial-off-the-shelf (COTS), industrial scale 3D printing of explosives, propellants, pyrotechnic utilizing HP Multi-jet powder bed fusion and pilot plant design & construction for polymer and energetics production. Development of novel formulations and production methods of polymer bound energetics with key material properties needed for successful powder bed fusion, including test development vehicles to assess printing performance of flow, dosing, spreading, inking and fusion, as well as energetic performance, safety and sensitivity. Supported by pilot-scale production and test development vehicles to assess feedstock performance in additive manufacturing processes.

Links: Phase II <https://www.sbir.gov/sbirsearch/detail/1625191>

Phase I & Option: <https://www.sbir.gov/sbirsearch/detail/1472543>

HP Multi-Jet 3D: <https://www8.hp.com/us/en/printers/3d-printers.html>

Alternative Mixing Technologies for High-Energy, Solid Materials for Large Gas Generator Propellant

Strategic Systems Program (NAVAIR China Lake), U.S. Navy, \$125 K, 2018

Detailed survey and technical evaluation of mixing technologies suitable for production of high energetic solid materials for large gas generator propellants, with initial development of a novel, alternative mixing process design based on paste extrusion for modernization of solid propellant production.

Link: Phase I <https://www.sbir.gov/sbirsearch/detail/1602849>

Development of Novel Compaction Regimes for Hydrogen Storage Materials

Office of Basic Energy Sciences, U.S. Dept. of Energy, \$2.25 K w/match, 2018

Fuel cell electric vehicles are an emerging technology for improving energy efficiency and reducing pollution emissions related to transportation and at-site power storage. However, improving on-board hydrogen storage is a key challenge. Novel compaction and agglomeration methods have been developed that improve densification of sorbent materials (e.g. carbon, metal-organic-frameworks) while maintaining their high available surface area and ability to retain large amounts of hydrogen. Both dry and paste extrusion methods allow high volume hydrogen storage in a small footprint, making hydrogen powered vehicles more feasible.

Link: Phase I <https://www.sbir.gov/sbirsearch/detail/1505057>

Powder Feedstock Formulation & Solids Architecture Design for 3D Printing

Additive manufacturing (AM) integrates several established solids processing unit operations. 3D printers are essentially a miniaturized manufacturing facility in a box, with identical challenges to traditional solids processing methods (e.g. agglomeration, extrusion, solids handling). Full-scale solids processing plants often have poor efficiencies and large sensitivities to feedstock material property variations. Powder and extrusion-based AM technologies have not proven to be an exception. Solids architecture design techniques, and methods for powder formulation have been developed to drive feedstock material properties towards those required for successful, robust AM processing, and which minimize production build and part failures in practice.

Work supported by extensive powder characterization (powder cohesion, powder and wall friction, permeability, particle size & shape distribution (PSSD), triboelectric charging, wetting characteristics, compaction characteristics, and melt phase and paste extrusion rheology; bench and pilot scale reactor and related post-processing, and test development vehicles to assess powder spreading, wetting and fusing.

**REPRESENTATIVE
INDUSTRIAL
EXPERIENCE
(continued)
(Last 4 Years)**

Solids Handling Design

Designed mass flow retrofits and replacement silos for several plant line rebuilds for roasted whole bean, ground, and instant coffee, to eliminate bean segregation and ground coffee density swings. Included novel bin designs as well as the design and fabrication of proprietary silo inlet feed distribution systems, along with structural simulations. Substantial long-term savings and improved operation resulting from minimization of needed weight overfills in packaging.

Material handling applications at the solid dosage form scale, for both storage, dosing and dispersion. Applications include in-process manufacturing release specifications for vial filling operations, design of tablet formulations for consumer food products, additive manufacturing of pharmaceutical tablets, and elimination of triboelectric charging in intravenous cartridges. Additional applications include drier optimization, bin design and material property characterization and instrument design for testing of agricultural products, as well as ink cartridge design for commercial printers, and mixer and homogenization control.

Material handling work relies heavily on powder characterization, powder engineering design principles, and test lab evaluations.

Agglomeration Processing

Ongoing development of scale-up methodologies for control of wet granulation systems based upon formulation properties. This framework has set new standards for the approaching wet granulation problems, and has been employed in the resolution of many manufacturing issues, ranging from scale-up failures to subtle shifts in raw ingredient specifications.

Paste extruder design studies to optimize paste mixing and subsequent extrudate quality. Work guided by extensive paste, shear cell, screw and barrel friction and other powder characterization, as well as paste rheology and formulation studies.

Powder formulation for compaction for rapidly dissolving tablets and compacts produced by traditional tableting and additive manufacturing.

Elimination of defects in a variety of dry powder coating applications, ranging from high-voltage electrostatics applications to granule coating to high temperature sintering of coatings.

Powder Characterization & Instrument Design

Ongoing development and/or utilization of a variety of characterization tools to assess surface chemistry, surface hardness, particle size and shape distribution, adsorption behavior, thermal softening, powder cohesion & friction, solids flow rate, permeability, triboelectric charging, particle strength, wetting behavior and powder spreading and fusion, and paste rheology, as related to a wide range of solids processes and additive manufacturing.

Design and commercialization of a state-of-the-art powder shear cells and fluidization permeability cells to assess powder friction, cohesion, and permeability properties. Incorporated into development work and in-process manufacturing specifications of several clients, including Alkermes, Aprelia Pharmaceuticals, Bristol-Myers Squibb, Schering Plough, Merck, Hewlett Packard, and Idaho National Laboratory.

**TEACHING
EXPERIENCE
(Last 4 Years)**

E&G Powder School

Franklin, TN, 1994 – Chattanooga, TN, 2013 to Present

Conduct regular external and in-house continuing education courses in powder flow, solids handling, powder processing & characterization, solids mixing and granulation and compaction for an extensive range of industries, national laboratories, and other government participants.

Also conducted the semi-annual *E&G Powder School*, and has taught continuing education and in-house courses for thirty years, for over hundreds of companies and thousands of participants.

Recent companies (last 4 years) include Alkermes, Astec, Aprecia Pharmaceuticals, BASF, Bristol-Myers Squibb, Chattem Chemical, Denso Corporation, Folger Coffee, Foxall, GE-Roper, Hewlett Packard Enterprise, Hewlett Packard Inc. (Barcelona Spain, San Diego, Vancouver, Corvallis, Aguadilla PR), JM Smuckers, MeadWestvaco, National Laboratories (Idaho, Lawrence Livermore, Sandia), Prince Minerals, U.S. Department of Energy, Westvaco, WestRock, Woodbridge, WR Grace, NASA.

Developed workshops include:

Powder Flow I: Measuring Powder Flowability & Its Applications (2 days)

An intense introduction to powder flow covering solids handling, segregation, feeding, roll pressing and tableting. Team design problems & hands-on measurements by shear & permeability cell, fluidization/segregation testing, roll pressing and tableting demonstrations.

Powder Flow II: Industrial Solids Handling & Mixing (3 days)

A follow-on companion workshop treating industrial practice and commonly encountered operational issues of powder systems and mixing. Topics include unassisted mass/funnel flow; flow promoting devices, aeration and vibration; feeders; conveying of powders; solids segregation, blending & mixing.

Granulation & Compaction for Enhanced Product Performance (3 days)

This agglomeration workshop is a relatively advanced course drawing heavily on the interaction between powder properties and unit-operations, covering a variety of granulation (fluid-bed, discs, pans, mixers) and compaction processes (roll pressing, tableting, extrusion) as well as formulation techniques. It emphasizes the marriage between formulation properties, characterization techniques, and engineering scale-up in controlling granule & compact quality.

Introduction to Powder Processing (2 days)

A first powder technology workshop addressing unique attributes of powders, and the complexities of solids processing. Topics include characterization; segregation & powder sampling; and an overview of key unit operations of mixing, grinding, agglomeration, classification, fluidization, drying & handling.

An Introduction to Wet Dispersions (3 days)

An introduction to processing of wet dispersions. Foundational concepts include the colloidal size domain, the interface: surface area, energy, curvature, adsorption and surface chemistry, surfactancy, powder wetting and dispersion, and stability of interfacial systems. Industrial methods of practice treated include particle incorporation, pre-dispersion, fine dispersion and quality.

**TEACHING
EXPERIENCE
(continued)**

The University of Tennessee at Chattanooga (UTC)

Chattanooga, TN, 2013 to 2016

Associate Professor in Chemical Engineering at the University of Tennessee at Chattanooga. Research and teaching interests included control system dynamics; advanced engineering math analysis; development of industrially applicable, remotely deployable unit operations laboratories; solids, pharmaceuticals and biologicals processing; and particulate/granular flows and characterization.

Key service activities include Faculty Senate, University Technology Budget Committee, University Workload Committee, Faculty Handbook Committee, Faculty Technology Committee, University Curriculum Committee, and the Advisory Board of the Walker Learning Center.

Scholarly works include an individual monograph (Science & Engineering of Granulation Process w/J. Litster, 289 citations), contributions to seven other reference books, editor of three conference proceedings, and section editor and contributor to two editions of Perry's Chemical Engineers Handbook, the preeminent reference manual of chemical engineers, and the Handbook of Pharmaceutical Granulation (2e, 3e, 320 citations, 4e pending). Dr. Ennis has an h-factor of 25 (citation impact), w/ a career total of over 5000 citations, and 135 scholarly contributions (peer reviewed papers, monographs, reference handbooks, and workshops).

Vanderbilt University, Adjunct Professor

Nashville, TN, January 1995 – August 1999

Adjunct Professor in Chemical Engineering with teaching responsibilities in engineering economics and operations research. Collaborative research areas in granulation science, including growth kinetics, modeling and control, and wetting of porous media. Collaborations with Abbott Labs and the University of Queensland.

**EDUCATION,
HONORS &
ACTIVITIES**

The City College of the City University of New York, New York, NY

Doctor of Philosophy, Chemical Engineering, May 1990

Master of Science, Chemical Engineering, May 1990

Rensselaer Polytechnic Institute, Troy, NY

Bachelor of Science, Chemical Engineering, May 1985

Minor, Finance Economics

American Institute of Chemical Engineering Professional Award (1)

For leadership & service to profession as Secretariat of the First International Particle Technology Forum, Denver, August 1994.

American Institute of Chemical Engineering Professional Award (2)

For commitment & dedication in the founding of the international AIChE division of the International Particle Technology Forum, 1994.

Deutscher Akademischer Austausch Dienst Directstipendium

Universität Erlangen-Nürnberg, West Germany, February 1990.

Visiting Research Fellow

Delft Technical University, The Netherlands, October 1997.

Stanley Katz Memorial Award

For outstanding doctoral dissertation in chemical engineering, April 1990.

**EDUCATION,
HONORS &
ACTIVITIES
(continued)**

American Institute of Chemical Engineers

- Keynote Plenary Lecture: Frontiers in Particle Science & Technology, 2020
- AIChE and Particle Technology Forum member & regular presenter
- Chair, Group 3A, Particle Production & Characterization, 2019-Present
- Co-Chair, Group 3A, Particle Production & Characterization, 2018
- Session Chair, 2013 to Present
- Two international service awards

American Association of Pharmaceutical Scientists, Annual Meetings

International Fine Particle Research Institute

- Keynote Lecture: 30 Years of Particle Science & Technology
- Annual meetings

Research Journal & Grant Reviewer, and Trade Journals

- National Science Foundation
- *AIChE Journal*
- *Powder Technology*
- *Chemical Engineering Education*
- *Computers in Chemical Engineering*
- *Chemical Engineering Process*
- *Powder & Bulk Engineering*
- *Chemical Engineering Magazine*

Chattanooga Business Community Memberships:

- Chattanooga Chamber of Commerce
- Chattanooga Technology Council
- Chattanooga Regional Manufacturing Association, Sponsor
- Chattanooga Engineers Club

Numerous conference and university presentations, including invited lectures.

**INVITED REVIEWS,
LECTURES & BOOKS**

See attached publication list for updates.

Engineering Particles for Successful Additive Manufacturing: The Basics Engineers Should Already Know, **Keynote Plenary Lecture, B.J. Ennis**, Presented at Frontiers in Particle Science & Technology, 2020.

Development of Energetic Feedstocks for Commercial-of-the-Shelf Printing, **Invited Lecture, B.J. Ennis**, Lawrence Livermore National Laboratory, 2020.

Learning in Solids Architecture in HP Multi-Jet Powder Bed Fusion, **Invited Lecture, B.J. Ennis**, Presented at Hewlett Packard Federal, 2020.

Looking Back on Thirty Years of Particle Science & Technology, **Keynote Plenary Lecture, B.J. Ennis**, International Fine Particle Research Institute, 2019.

3D PBF – “A Miniaturized Solids Processing Plant in a Box” Key Aspects of Powder Handling, **Invited Lecture, B.J. Ennis**, Presented at HPC4MFG, Hosted by Lawrence Livermore National Laboratory, 2017.

Perry's Chemical Engineers Handbook 8th Ed: Sect 21: Solids-Solids Processing & Operations, **Section Editor, B. Ennis**, McGraw-Hill, 2007. (Powder Processing and Unit Operations). **(citations 105)**

Perry's Chemical Engineers Handbook 7th Ed: Sect 20: Size Enlargement & Size Reduction, **B. Ennis** (Size Enlargement), McGraw-Hill, 1996. **(citations 222)**

**INVITED REVIEWS,
LECTURES & BOOKS
(continued)**

Handbook of Pharmaceutical Granulation Tech., 4th Ed., Dilip Parikh (ed.), Chap. 2. Theory of Granulation: An Engineering Perspective, **B. Ennis**, In preparation.

Handbook of Pharmaceutical Granulation Tech., 3rd Ed., Dilip Parikh (ed.), Chap. 2. Theory of Granulation: An Engineering Perspective, **B. Ennis**, Inform Healthcare, 2009. **(citations 261)**

Handbook of Pharmaceutical Granulation Tech., 2nd Ed., Dilip Parikh (ed.), Chap. 2. Theory of Granulation: An Engineering Perspective, **B. Ennis**, Inform Healthcare 2004. **(citations 104)**

The Science & Engineering of Granulation Processes, (Book link), James Litster & **Bryan Ennis**, Kluwer Academic, 2004. **(citations 255)**

What Exactly is Powder Flowability? *Tablets & Capsules*: Invited Powder Flow Editorial, **B.Ennis**, May 2006.

Nucleation, growth & breakage phenomena in wet granulation processes: A review, *Powder Technology*, 117 (2001) 3-39. **(citations 872)**

Fluidization, Solids Handling, & Processing, Yang (ed.), Chap. 6: Fluidized Bed Coating & Granulation, R.Turton, G.Tardos & **B.Ennis**, Noyed (1999). (cit. 60)

Plenary Lecture: Unto dust shalt thou return, *Powders & Grains 97*, Behringer & Jenkins (eds), Balkema, Rotterdam (1997) 13-23. (citations 22)

Agglomeration & Size Enlargement Session Summary Paper, *Powder Technology*, 88 (1996) 203-225. (citations 53)

Conference summary paper: Control of Particulate Processes III, *Powder Technology*, 82 (1995) 3-12.

Special Issues on Control of Particulate Processes III, *Powder Technology*, 82 (1995) 3-12, and *Particle Characterization*, 10(1993), May, No.5, B.Ennis & A.Boxman (invited eds.).

Proceedings of the First Annual Particle Technology Forum, B. Ennis (ed.), AIChE (1994).

The Legacy of Neglect in the U.S., *Chem. Engineer. Progress*, April (1994) 32. **(citations 150)**

TRADE JOURNALS

Controlling Compaction Pressure in Roll Presses, *Powder & Bulk Engineering*, Agglomeration Advisor Column, June 2011.

To Spray or Not to Spray: Controlling Wetting in Wet Granulation, *Powder & Bulk Engineering*, Agglomeration Advisor Column, October 2010.

Agglomeration Technology: Equipment Selection, *Chem. Engineering Mag.*, May 2010.

Agglomeration Technology: Mechanisms, *Chem. Engineering Mag.*, March 2010.

Visualizing Pharmaceutical Manufacturing as an Integrated Series of Particle Processes, *Interphex Conference*, New York, NY, March (1995).

A Microlevel-Based Study of Granulation, *Proceedings of Powder & Bulk Solids*, May (1991).

The Legacy of Neglect in the U.S., *Chem. Engineer. Progress*, April (1994) 32. **(citations 150)**

**PUBLICATIONS &
PRESENTATIONS,
SELECT
(reverse by year)**

Engineering Particles for Successful Additive Manufacturing: The Basics Engineers Should Already Know, **Keynote Plenary Lecture, B.J. Ennis**, Presented at Frontiers in Particle Science & Technology, 2020.

3D PBF – “A Miniaturized Solids Processing Plant in a Box” Key Aspects of Powder Handling, **Invited Lecture, B.J. Ennis**, Presented at HPC4MFG, Hosted by Lawrence Livermore National Laboratory, 2017.

Solids Metrics for Successful 3D Printing of Energetic Feedstock, *Proceedings of AIChE National Meeting*, Orlando, FL, Nov. 2019

Powder Permeability as a Measurement Surrogate for Triboelectric Charging, *Proceedings of AIChE National Meeting*, Orlando, FL, Nov. 2019

Solids Metrics for Successful 3D Printing of Energetic Feedstocks, *Proceedings of AIChE National Meeting*, Pittsburg, PA, Nov. 2019

Revisiting the Measurement of Powder Permeability Under Applied Load, *Proceedings of AIChE National Meeting*, Pittsburg, PA, Nov. 2019

Powder Permeability As a Measurement Surrogate for Triboelectric Charging, *Proceedings of AIChE National Meeting*, Pittsburg, PA, Nov. 2019

Revisiting Johanson's Rolling Theory of Granular Solids, *Proceedings of AIChE National Meeting*, Salt Lake City, UT, Nov. 2015

Finite Element Simulations of Granular Compaction Part 1: Roller Compaction, *Proceedings of AIChE National Meeting*, Salt Lake City, UT, Nov. 2015

Finite Element Simulations of Granular Compaction Part 2: Paste Extruder, *Proceedings of AIChE National Meeting*, Salt Lake City, UT, Nov. 2015

Simulations of an Unwound Paste Extruder Flight, *Proceedings of AIChE National Meeting*, Salt Lake City, UT, Nov. 2015

On Characterizing Particle Shape, *Proceedings of AIChE National Meeting*, Atlanta, GA, Nov. 2014.

Learnings & Future Challenges for Granulator Control and Optimization, *Proceedings of AIChE National Meeting*, Atlanta, GA, Nov. 2014.

Labs & Experiments At a Distance, w/J. Henry, *Proceedings of AIChE National Meeting*, San Francisco, CA, Nov. 2013.

Measuring the distribution of density & tableting force in pharmaceutical tablets by chemical imaging, *Journal of Pharmaceutical and Biomedical Analysis*, 48 (2008) 1–7. **(citations 57)**

Note on the interpretation of powder shear test data, *Powder Technology*, 182 (2008) 486–492. **(citations 6)**

Nucleation, growth & breakage phenomena in wet granulation processes: A review, *Powder Technology*, 117 (2001) 3–39. **(citations 872)**

Model-based control of a granulation system, *Powder Technology*, 108 (2000) 192–201. **(citations 43)**

A new approach to modeling granulation processes for simulation & control purposes, *Powder Technology*, 108 (2000) 202–209. **(citations 34)**

Unifying Approach to Modeling Granule Coalescence Mechanisms, *AIChE Journal*, 43 (1997) 927–934. **(citations 88)**

Fundamental studies of granule consolidation: Effects of binder content & viscosity, *Powder Technology*, 88 (1996) 15-20. **(citations 186)**

Population balance modelling of drum granulation of materials with wide size distribution, *Powder Technology*, 82 (1995) 37-49. **(citations 116)**

Evaluation of the Johanson Indicizer as an Alternative Powder Flow Tester, *Bulk Solids Handling*, No.1 (1994).

Practical evaluation of the Johanson Hang-Up Indicizer, *Proceedings of Reliable Flow of Particulate Solids II*, August (1993). **(citations 34)**

Drum Granulation of Fertilizers: Modeling & Circuit Simulation, *Proceedings of Agglomeration 93*, November (1993).

On wear as a mechanism of granule attrition, *Tribology International*, 26 (1993) No.5, 319-327. **(citations 24)**

Habit Modeling and Verification for Glutaric Acid, *J. Physics D: Appl. Phys.*, 26 (1993) B35. **(citations 4)**

Measuring Granule Size On-Line for Agricultural Products, *Chemical Engineering Newsletter*, Dupont, 34 (1992) No.1, Pg. 4.

On the Mechanics of Granulation, Ph.D. Thesis, The City College of CUNY, B. Ennis. **(citations 5)**

A microlevel-based characterization of granulation phenomena, *Powder Technology*, 65 (1991) 251-272. **(citations 489)**

A Microlevel-Based Classification of Granulation Regimes & Mechanisms, *Proceedings of the 2nd World Congress of Particle Technology*, Kyoto, Japan, Part III (1990) 409.

Agglomeration of particle systems in fluidized beds: Low temperature granulation, *International Fine Particle Research Institute*, Final Reports: FRR-0805, February (1989), and FRR-0806, February (1992).

The Influence of Viscosity on the Strength of an Axially Strained Pendular Bridge, *Chem. Eng. Sci.*, 45 (1990), No. 10, pp. 3071-3088. **(citations 184)**

Closed loop controlled integrated hot gas cleanup, *Commission of the European Community*, Contract #EN#F-0028, NL (GDF), Periodic reports ending November (1987), and June (1988). **(citations 13)**

**REFERENCES &
PERSONAL**

Papers & references available on request.

U.S. Citizenship
Born: May 19, 1962 in Missouri, USA.

Children: Brandon, Bryan-Keegan, Benjamin, Bailey, Barrett
– All five boys have Eagle Scout Award.
Grandchildren: Eileen, Leopold

Recreation/other: Church activities, Scouts, backcountry backpacking, skiing, camping, oil painting.

Bryan J. Ennis, Paper & Scholarly Work Citations, ending 4 November 2018 (Web Sci & Google Scholar)

Works, by citations (h-index: 24; Career: 4720; From 2013-2018: 1964): Books in red	Rank #	Citations (Career)	Citations (2013-15)	Citations (2013-18)	Publication Year
Totals papers and citations:	135	4720	921	1964	1994-2018
Invited: Nucleation, growth & breakage phen. in agitated wet granulation processes: a review	1	991	232	499	2001
A Microlevel-Based Characterization Of Granulation Phenomena	2	514	87	161	1991
Perry's ChE Handbook 8th Ed: Sect 21	3	492	80	295	2007
Invited Special Issue (1995). Control of Particulate Processes III. Powder Technology, 82(1)	4	344	35	61	1995
Handbook of Pharmaceutical Granulation Tech., 3E, Chap. 2. Theory of Granulation (2016)	5	320	73	184	2016
Handbook of Pharmaceutical Granulation Tech., 3E, Chap. 2. Theory of Granulation (2010)	5	0	--	-	2010
Handbook of Pharmaceutical Granulation Tech., 3E, Chap. 2. Theory of Granulation (2009)	5	0	--	-	2009
The Science & Engineering of Granulation Processes (2013)	6	289	93	170	2013
The Science & Engineering of Granulation Processes (2011)	6	0	--	-	2011
Perry's ChE Handbook 7th Ed: Sect 20 (2000 Release)	7	231	54	94	2000
Perry's ChE Handbook 7th Ed: Sect 20 (1997)	7	0	--	-	1997
Fundamental studies of granule consolidation: 1.Effects of binder content & binder viscosity	8	197	43	80	1996
The Influence Of Viscosity On The Strength Of An Axially Strained Pendular Liquid Bridge	9	191	22	50	1990
Coalescence of deformable granules in wet granulation processes	10	186	45	77	2000
Invited. The Legacy Of Neglect In The United-States	11	143	20	30	1994
Population Balance Modeling Of Drum Granulation Of Materials w/ Wide Size Distribution	12	121	11	23	1995
Proceedings of the First International Particle Technology Forum	13	104	17	30	1994
Unifying approach to modeling granule coalescence mechanisms	14	92	15	26	2005
Fluidization, Solids Handling, & Processing, Ch. 6: Fluidized Bed Coating & Granulation	15	68	20	35	1998
Measuring distribution of density & tableting force in pharmaceutical tablets by chemical imaging	16	59	15	33	2008
Agglomeration and size enlargement - Session summary paper	17	54	2	9	1996
Handbook of Pharmaceutical Granulation Tech., 2E, Chap. 2. Theory of Granulation	18	53	16	37	2005

Model-based control of a granulation system	19	46	12	23	2000
Practical Evaluation of the Johanson Hang-Up Indicizer [R]	20	38	5	9	1994
Fluidized bed coating and granulation	21	37	8	12	1998
A new approach to modeling granulation processes for simulation and control purposes	22	35	4	8	2000
On wear as a mechanism of granule attrition	23	24	1	1	1993
Invited. Unto dust shalt thou return, Powders & Grains 1997	24	22	2	4	1997
Closed loop controlled integrated hot gas clean up (1988)	25	13	0	0	1988
Thesis. On the mechanics of granulation	26	13	0	3	1991
Invited. Review Feature Agglomeration Technology: Mechanisms	27	7	4	5	2010
Note on the interpretation of powder shear test data	28	6	1	1	2008
Measurement particle material properties & their relation to attrition phenomena in solids handling	29	6	0	0	1994
A micro-level-based classification of granulation regimes & mechanisms (2nd WCPT)	30	6	0	0	1990
Fundamental Studies of Granule Consolidation (CHEMECA)	31	5	0	0	1995
Habit Modeling And Verification For Glutaric Acid	32	4	1	1	1993
Invited. Review Feature Agglomeration Technology: Equipment Selection	33	3	3	3	2010
Invited. Control Of Particulate Processes III. Santa-Barbara, Jan. 24-29, 1993 - Preface	34	2	0	0	1995
Invited. Conference Summary Paper - Control Of Particulate Processes III	35	2	0	0	1995
A Microlevel-Based Study of Granulation (International Powder & Bulk Solids)	36	2	0	0	1992
IFPRI: Agglomeration of Particle Systems in Fluidized Beds-1986 Final Report. High Temperature	37	0	0	0	1986
IFPRI: Agglomeration of Particle Systems in Fluidized Beds: Granulation. Interim Report	38	0	0	0	1986
Closed loop controlled integrated hot gas clean up (1987)	39	0	0	0	1987
IFPRI: Agglomeration of Particle Systems in Fluidized Beds: Granulation. Interim Report	40	0	0	0	1988
IFPRI: Agglomeration of Particle Systems in Fluidized Beds: Granulation. Final Report: FRR-0805	41	0	0	0	1989
IFPRI: Agglomeration of Particle Systems in Fluidized Beds: Granulation. Interim Report	42	0	0	0	1990

IFPRI: Agglomeration of Particle Systems in Fluidized Beds: Granulation. Interim Report	43	0	0	0	1992
IFPRI: Agglomeration of Particle Systems in Fluidized Beds: Granulation. Final Report: FRR-0806	44	0	0	0	1992
Measuring Granule Size On-Line for Agricultural Products	45	0	0	0	1992
Invited. Control of Particulate Processes. 3. Santa-Barbara (Boxman)	46	0	0	0	1993
Caking of Crystalline Solids (International Powder & Bulk Solids)	47	0	0	0	1994
Kinetic Effect in the Adsorption Of C12E6 below the CMC to the Water-Vapor Interface	48	0	0	0	1994
Invited: Controlling Flowability of Fine Powders & Influence of Friction & Adhesion (CHEMECA)	49	0	0	0	1995
Visualizing Pharmaceutical Manufacturing as an Integrated Series of Particle Processes	50	0	0	0	1995
in-House Course: Procter & Gamble, Cincinnati, OH (1995), Granulation & Compaction Processes	51	0	0	0	1995
in-House Course: Univ. of Queensland, Gold Coast, Australia (1995), Granulation & Compaction Processes	52	0	0	0	1995
in-House Course: Faulding, Adelaide, Australia (1996), Granulation & Compaction Processes	53	0	0	0	1996
in-House Course: PCS Phosphate, Aurora, NC (1998), Granulation & Compaction Processes	54	0	0	0	1998
in-House Course: Dow-Elanco, Indianapolis, IN (1998), Granulation & Compaction Processes	55	0	0	0	1998
in-House Course: Merck, West Point, NJ (1998), Granulation & Compaction Processes	56	0	0	0	1998
in-House Course: Abbott, Abbott Park, IL (2000), Granulation & Compaction Processes	57	0	0	0	2000
in-House Course: State of MN, Steel Processing Consortia, Mt. Iron, MN (2000), Granulation & Compaction	58	0	0	0	2000
in-House Course: Pharmacia, Skokie, IL (2001), Granulation & Compaction Processes	59	0	0	0	2001
Evins Mill: Design & Optimization of Granulation & Compaction Processes, October 2002	60	0	0	0	2002
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, October 2004	61	0	0	0	2002
in-House Course: Cabot, Billerica, MA (2002), Granulation & Compaction Processes	62	0	0	0	2002
in-House Course: Novozymes, Copenhagen, Denmark (2002), Granulation & Compaction Processes	63	0	0	0	2002
in-House Course: Bristol-Myers Squibb, New Brunswick, NJ (2004), PF I: Measuring Powder Flowability (2)	64	0	0	0	2002
Evins Mill: Design & Optimization of Granulation & Compaction Processes, June 2004	65	0	0	0	2004
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, April 2004	66	0	0	0	2004

in-House Course: Amgen, Thousand Oaks, CA (2004), PF I: Measuring Powder Flowability	67	0	0	0	2004
Evins Mill: Design & Optimization of Granulation & Compaction Processes, November 2005	68	0	0	0	2005
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, June 2004	69	0	0	0	2005
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, November 2005	70	0	0	0	2005
in-House Course: Pfizer, Morris Plains, NJ (2005), PF I: Measuring Powder Flowability	71	0	0	0	2005
Invited. What Exactly is Powder Flowability?	72	0	0	0	2006
Evins Mill: Design & Optimization of Granulation & Compaction Processes, April 2006	73	0	0	0	2006
Evins Mill: Design & Optimization of Granulation & Compaction Processes, October 2006	74	0	0	0	2006
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, April 2006	75	0	0	0	2006
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, October 2006	76	0	0	0	2006
in-House Course: Amgen, Thousand Oaks, CA (2006), Granulation & Compaction Processes	77	0	0	0	2006
in-House Course: Bristol-Myers Squibb, New Brunswick, NJ (2006), PF I: Measuring Powder Flowability	78	0	0	0	2006
in-House Course: Merck, West Point, NJ (2006), PF I: Measuring Powder Flowability	79	0	0	0	2006
Evins Mill: Design & Optimization of Granulation & Compaction Processes, October 2007	80	0	0	0	2007
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, October 2007	81	0	0	0	2007
in-House Course: Merck, Whitehouse, NJ (2007), Granulation & Compaction Processes	82	0	0	0	2007
Evins Mill: Design & Optimization of Granulation & Compaction Processes, January 2009	83	0	0	0	2009
Evins Mill: Design & Optimization of Granulation & Compaction Processes, April 2009	84	0	0	0	2009
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, January 2009	85	0	0	0	2009
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, April 2009	86	0	0	0	2009
Evins Mill: An Introduction to Powder Processing, January 2009	87	0	0	0	2009
Evins Mill: An Introduction to Powder Processing, April 2009	88	0	0	0	2009
Evins Mill: Ind. Solids Handling & Mixing- Plant Design Principles & Operation, January 2009	89	0	0	0	2009
Evins Mill: Ind. Solids Handling & Mixing- Plant Design Principles & Operation, April 2009	90	0	0	0	2009

Invited Column. To Spray or Not to Spray: Controlling Wetting in Wet Granulation	91	0	0	0	2010
Invited Column. Controlling Compaction Pressure in Roll Presses	92	0	0	0	2011
Evins Mill: Design & Optimization of Granulation & Compaction Processes, June 2011	93	0	0	0	2011
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, June 2011	94	0	0	0	2011
Evins Mill: An Introduction to Powder Processing, June 2011	95	0	0	0	2011
Evins Mill: Solids Mixing, Blending & Handling, June 2011	96	0	0	0	2011
in-House Course: Bristol-Myers Squibb, New Brunswick, NJ (2011), PF I: Measuring Powder Flowability	97	0	0	0	2011
in-House Course: Green Mt. Coffee, Waterbury, VT (2012), Granulation & Compaction, Powder Flowability	98	0	0	0	2012
in-House Course: Novozymes, Franklinton, NC (2012), Granulation & Compaction Processes	99	0	0	0	2012
Labs & Experiments at a Distance (AIChE 2013)	100	0	0	0	2013
Evins Mill: Design & Optimization of Granulation & Compaction Processes, August 2013	101	0	0	0	2013
Evins Mill: Measuring Powder Flowability & Its Applications – A Hands-On Workshop, August 2013	102	0	0	0	2013
Evins Mill: An Introduction to Powder Processing, August 2013	103	0	0	0	2013
Evins Mill: Solids Mixing, Blending & Handling , August 2013	104	0	0	0	2013
On Characterizing Particle Shape (AIChE 2014)	105	0	0	0	2014
Learnings & Future Challenges for Granulator Control and Optimization (2014)	106	0	0	0	2014
Powder Flowability & Its Applications, University of TN at Chattanooga, Chattanooga, TN, October (2014)	107	0	0	0	2014
Solids Handling & Bin Design Part I, Folgers Coffee & J.M.Smuckers Co., New Orleans, LA (2014)	108	0	0	0	2014
Solids Handling & Bin Design Part II, Folgers Coffee & J.M.Smuckers Co., New Orleans, LA (2014)	109	0	0	0	2014
Finite Element Simulations of Granular Compaction Part 1: Roller Compaction (AIChE 2015)	110	0	0	0	2015
Finite Element Simulations of Granular Compaction Part 2: Paste Extruder (AIChE 2015)	111	0	0	0	2015
Simulations of an Unwound Paste Extruder Flight (AIChE 2015)	112	0	0	0	2015
Revisiting Johanson's Rolling Theory of Granular Solids (AIChE 2015)	113	0	0	0	2015
Powder Production, Processing & Handling for 3D Printer Design, Hewlett Packard, San Diego, CA (2015)	114	0	0	0	2015

Powder Production, Processing & Handling -- 3D Printing, On-line Version, HP Barcelona, SPAIN (2015)	115	0	0	0	2015
Powder Production, Processing & Handling -- 3D Printing, On-line Version, HP, Vancouver, WA (2016)	116	0	0	0	2016
Solids Processing & Handling -- 3D Printing, Hewlett Packard, Corvallis, OR (2016)	117	0	0	0	2016
Solids Handling & Mixing Pilot Plant Design, Hewlett Packard, Aguadilla, Puerto Rico (2016)	118	0	0	0	2016
PhI. Development of Explosive Feedstock for COTS 3D Printers, 60-day Report, U.S.Navy	119	0	0	0	2017
3D PBF -- "A Miniaturized Solids Processing Plant in a Box", HPC4Mfg, Austin, TX, August 2017	120	0	0	0	2017
3D PBF -- "A Miniaturized Solids Processing Plant in a Box", LLNL Webinar, October 2017	121	0	0	0	2017
3D PBF -- "A Miniaturized Solids Processing Plant in a Box", Sandia National Lab, October 2017	122	0	0	0	2017
Solid Metrics for Successful 3D Printing of Energetic Feedstocks (AIChE 2018)	123	0	0	0	2018
Powder Permeability as a Measurement Surrogate for Triboelectric Charging (AIChE 2018)	124	0	0	0	2018
Revisiting the Measurement of Powder Permeability Under Applied Load (AIChE 2018)	125	0	0	0	2018
PhI. Development of Explosive Feedstock for COTS 3D Printers, 120-day Report, U.S.Navy	126	0	0	0	2018
PhI. Development of Explosive Feedstock for COTS 3D Printers, Final Report, U.S.Navy	127	0	0	0	2018
PhI Option. Development of Explosive Feedstock for COTS 3D Printers, Interim Report, U.S.Navy	128	0	0	0	2018
PhI. Alternative Mixing Technologies for [Energetics] for... Propellant, 75-day Report, U.S.Navy	129	0	0	0	2018
PhI. Alternative Mixing Technologies for [Energetics] for... Propellant, 120-day Report, U.S.Navy	130	0	0	0	2018
PhI. Alternative Mixing Technologies for [Energetics] for... Propellant, Final Report, U.S.Navy	131	0	0	0	2018
PhI. Development of Novel Compaction Regimes for Hydrogen Storage Materials, Final Report, DOE	132	0	0	0	2018
PhI. Development of Compaction Regimes for Hydrogen Storage Materials, Final Report, Launch TN	133	0	0	0	2018
PhI Option. Development of Explosive Feedstock for COTS 3D Printers, Final Report, U.S.Navy	134	0	0	0	2019
3D PBF -- "A Miniaturized Solids Processing Plant in a Box", GE Global Research, 2019	135	0	0	0	2019