EDUCATOR

DARSH WASAN

of the Illinois Institute of Technology

DAVID EDWARDS,* DIMITRI GIDASPOW, MARY DAWSON
Illinois Institute of Technology
Chicago, IL 60616

"In his lectures, he's a spellbinder, an honest-to-goodness twentieth century Indian snake charmer,"

is how one former colleague describes Illinois Institute of Technology's Darsh Wasan. Professor Octave Levenspiel, now at Oregon State University, understands the students' enchantment. He says,

"Darsh is an exciting teacher because he is concerned with young people—his students—and he is in love with his subject. Research ideas bubble from him, and students flock to work with him. He works them hard, with evening and weekend conferences, but they love it. I'd say that close to half the students in the department did their theses with him."

Wasan's love for teaching and his ability to inspire his students were evident right from the start of his academic career. He came to the Illinois Institute of Technology in Chicago in 1964 after receiving his PhD from the University of California, Berkeley, and by the academic year 1966-67, all of his undergraduate and graduate classes had nominated him for the university's Excellence in Teaching Award, which he received that spring. In 1967 he was also promoted to associate professor and, in 1970 to full professor.

Through the years since then he has received numerous awards for teaching, including (in 1972) the American Society for Engineering Education's Western Electric Fund Award for Excellence in Instruction of Engineering Students.

Teaching and research seem so natural for Darsh, it is hard to imagine that he did not set out to become an educator, but at nineteen he thought he wanted to be a physician. One of eight children in his family, he had completed some pre-med courses and had even been accepted into a medical school in his native Bombay. But then his oldest brother, Madan (who was studying for his doctorate in mathematical statistics in the United States), proposed what proved to be an irresistable alternative for Darsh: chemical engineering. Madan had discussed his younger brother's math and chemistry talents with the admissions counselors at the University of Illinois Champaign/Urbana (UI), and they offered to admit Darsh to their undergraduate chemical engineering program.

Darsh turned out to have an aptitude *and* an enthusiasm for chemical engineering. At the UI he studied under Tom Hanratty, John Quinn, Jim Westwater, Daniel Perlmutter, and Max Peters (department chairman at that time). He did a senior-year project on fluid mixing under Quinn and during the summers served as an assistant in the research laboratories of Hanratty and Harold Johnstone. Intrigued with turbulent diffusion after a project under Hanratty, Darsh later chose this as his doctoral dissertation topic at Berkeley.

* Massachusetts Institute of Technology, Cambridge, MA 02139

Harold Johnstone introduced him to colloids and interfaces. Wasan worked with Johnstone on an aerosol science project related to acid rain during 1959-60. The importance of interfacial and colloidal phenomena in chemical engineering processes and operations helped convince Wasan to focus his later research efforts in this area.

In August of 1960, after completing his undergraduate degree in chemical engineering, Wasan moved to California to enter graduate school. At Berkeley, he studied under Andy Acrivos, John Prausnitz, C. Judson King, Charlie Tobias, Eugene Petersen, Don Hanson, Charles Wilke, and Chang-Lin Tien (now Chancellor at Berkeley). While in grad school he began publishing, co-authoring two papers in turbulent transport ("Law of the Wall") with Tien, who was teaching mechanical engineering.

Wasan's doctoral thesis research under Wilke, in the field of mass and momentum transfer in turbulent flow, was the subject of the ASEE Chemical Engineering Division 3M Lecture that Wilke delivered at the 1964 annual meeting. Exactly twenty-seven years later, Wasan himself gave the 3M Award Lecture—this time on "Interfacial Transport Processes and Rheology: Structure and Dynamics of Thin Liquid Films.*

In the summer of 1966, Wasan returned to Bombay and married Usha Kapur, a lovely and gracious woman with a degree in history and a flair for the culinary arts. They began their married life in a faculty apartment on the IIT campus, but after a few years and two sons (Ajay and Kern) they moved to a nearby suburb where they raised their sons (both now in college) and where they recently celebrated their twenty-fifth wedding anniversary. Both Darsh and Usha became naturalized citizens of the United States in 1974.

Wasan's love for teaching and his ability to inspire his students were evident right from the start of his academic career . . . all of his graduate and undergraduate classes (have) nominated him for the university's Excellence in Teaching Award . . .

A Wasan tradition that his students and colleagues especially relish is the annual Indian feast that Usha prepares at the end of each summer. Darsh invites his research group of ten to twenty master's and doctoral students, as well as post-doctoral fellows and his professional colleagues, to share the good food, informal and genial conversation, and a spirited game of volleyball. Such occasions are only one of the ways Darsh encourages camaraderie among his students, many of whom regard him not only as an adviser but also as a friend and mentor.

In his twenty-eight years at IIT, Wasan has supervised about a hundred graduate students, including forty-five doctoral dissertations. Table 1 lists the names of his former PhD students and the professional colleagues with whom he shared some of them. Observations from his former students range from "He's always been more than just a professor to us; he genuinely cares about us," to "He has always been a very busy person—more so now that he has advanced in the IIT administration; but even now he always makes time for his students."

Many former students laud Wasan's ability to train his students in communication—in effectively presenting their ideas. Several remember Wasan's insistence on good presentations and good project proposal writing. "As an alumnus of his laboratory, I consider *that* as important as the research training I received under his tutelage," Raju Borwankar (a former student) says.

TABLE 1
PhD Students of Darsh Wasan

N. Aderangi	W. Jones	R. Ramakrishnan
R. Alexander	J. Kaellis	M. Ranade
B. Baker[1]	R. Kao	S. Randhava
R. Borwankar	M. Krawczyk	F. Rasouli[1]
J. Bouillard[1]	C. Lee[1]	J. Rosenfeld
C.W. Chi	L. Ting[3]	J. Rudin
C.V. Chi[2]	Y. Liu[1]	S. Shah
P. Chowdiah[1]	Y. Lo[1]	S. Sheth[2]
S. Chung	L. Lobo	Y. Shih[1]
N. Djabbarah	A.K. Malhotra	S. Zheng[4]
D. Edwards[3]	H. Maru	S. Suneja
L. Gupta	V. Menon	F. Tavakoli[2]
R. Gupta[1]	A. Mukherjee[1]	C. Thomas
D. Huang	J. Perl	M. Vora
U. Jayaswal[1]	A. Pintar	W. Wnek[1]

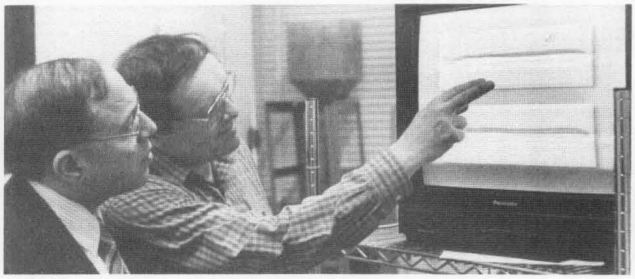
With • [1] D. Gidaspow [2] R. Peck [3] H. Brenner [4] R. Beissinger

AS A RESEARCHER

Asked to comment on Wasan as a researcher, one of his close associates, Bill Krantz (University of Colorado), cites Wasan's prolific contributions to fundamental chemical engineering and credits him with "an exceptional ability to apply his research to

* Published in *Chem. Eng. Ed.*, **26**, 104, (1992)

practical engineering problems."



Darsh and his colleague Dimitri Gidaspow examine computer model results for particle dispersion.

Several industrial colleagues characterize Darsh as a man who has good intuition and who exploits it to the maximum. One commented, "He is the master of the scheme of things and decides to work on problems which he thinks are relevant. He always directs his efforts to real problems encountered by industry and does this research in collaboration and consultation with the related industrial scientific community."

One of the first academics to promote the concept of joint industry/university research programs, Darsh set up an Industrial Technical Advisory Committee in 1978 that has since been providing direction for his ongoing basic research program at IIT. Wasan himself describes his research philosophy simply as that of a true engineer. "I try to attack problems that *need* to be solved rather than choosing a problem that *can* be solved," he says.

Wasan's research activities span several separate but interrelated fields, focusing particularly on the importance of interfacial transport processes and rheology. This research has resulted in over two hundred and thirty publications, including seven research monographs, twelve book chapters, a textbook, and three U.S. patents.

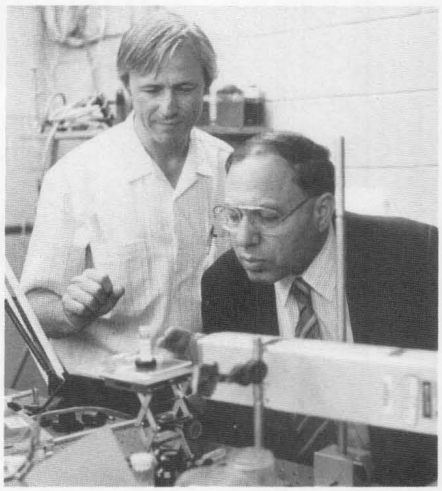
Darsh has maintained extremely good ties with industry and academic researchers in the U.S. and with researchers in Eastern Europe (especially Bulgaria), even in times when such collaborations were rare. Recognition of his collaborative work includes the Bulgarian Academy of Sciences' presentation of the Asen Zlatarov National Award in chemical sciences to Wasan and his collaborators for their research publications in thin liquid films.

His research contributions can be clustered into the following three areas:

Particle-Fluid Separation • Darsh and his colleagues were the first to simultaneously consider both hydrodynamic and molecular forces for the capture of small particles by fibrous and granular media, and the role of colloid chemistry in modeling deep-bed filtration, cross-flow electrofiltration, and lamella electrosettling for separating suspended particles from aqueous and non-aqueous media.

Synthetic liquid fuels derived from coal, shale, and tar sands contain particles of unreacted solids (ash-carbonaceous residue) which impede downstream processing. The complex nature of colloid chemistry in non-aqueous media makes removal of these particles difficult. With support from the Amoco Corporation, the Department of Energy, and the National Science Foundation, Wasan and his IIT colleague Dimitri Gidaspow invented two practical devices based on electrokinetic phenomena (a cross-flow electrofilter and a lamella electrosettler) to separate colloidal particles from synthetic liquid fuels derived from coal, shale, and tar sands. These methods, significantly more energy-efficient than conventional techniques, have applications in upgrading other synthetic crudes, heavy residual oils, fluid catalytic cracking slurry oil, hydraulic oil, and other organic liquid slurries.

Darsh and research associate Alex Nikolov examine microstructure formation in colloidal dispersions



In 1986 the National Science Foundation awarded Wasan and Gidaspow a Special Creativity Award for their work on electrokinetic phenomena in non-aqueous media. More recently, their research group has been developing a dry electrostatic process for separating a powder mixture into its components based on their work functions, and they have successfully applied their new method to mineral beneficiation.

Interfacial Rheology and Thin Liquid Surfactant Films • Many separation processes utilize surfactants, *i.e.,* substances which are interfacially active. In 1988, Wasan edited the first book on surfactants—*Surfactants in Chemical/Process Engineering.* His quest to develop new instruments for measuring dynamic properties of fluid-fluid interfaces containing surfactants and the dynamic behavior of thin liquid films formed from surfactant solutions put him at the frontier of dispersion science and

Wasan's research was the first to identify the significant role of the coalescence phenomenon in the oil bank formation and propagation rate processes in porous media and the stability of emulsions in optimizing oil recovery in both conventional and enhanced oil recovery processes.

Wasan's present research team.

technology, contributing to advances in areas such as emulsification/demulsification, foaming/antifoaming, wetting, surfactant liquid membranes, and enhanced oil recovery.

Noting that the field of interfacial rheology (and its application to emulsion stability, thin film drainage and rupture, and enhanced oil recovery by surfactant/polymer processes) has developed as a science largely in the past twenty years, Bob Schechter (University of Texas) credits Wasan and his students for a significant part of this recent progress. He cites the Wasan team's development of precise, reproducible, and meaningful methods for measuring interfacial viscoelastic properties. "His work significantly improved the deep channel surface viscometer, and his group has published more comprehensive studies than any other group," Schechter notes.

A commercial version of Wasan's interfacial shear viscometer is now used worldwide as the primary tool in emulsion and foam stability research. A second instrument for measuring dynamic interfacial tension (an expanding drop tensiometer) is under development.

After developing reliable measurement techniques, Wasan published a series of papers clarifying the role of surface viscosity and elasticity in stabilizing thin liquid surfactant films. These studies, fundamental to an appreciation of both foam and emulsion stability, provided the theoretical groundwork whereby interfacial rheological considerations can be included in coalescence phenomena and interfacial mass transfer processes. Consequently, industry now recognizes the potential influence of interfacial rheological behavior in the design of many engineering processes involving dynamic fluid-fluid interfaces in dispersed multiphase systems, such as suspension and emulsion polymerization processes. Wasan summarizes this work in his recent textbook, *Interfacial Transport Processes and Rheology,* written with his former doctoral student, David Edwards, and Professor Howard Brenner.

In 1986, Darsh and his colleagues discovered a new mechanism for the film stability induced by the formation of "ordered" surfactant micelle structures inside the film over distances of the order of 100nm or 1000A° and ushered in a new era of research on understanding the nature of interactions within supermolecular fluids such as concentrated suspensions of Brownian particles, surfactant micellar solutions, and microemulsions. They showed that the phenomenon of multilayer structuring or stratification (*i.e.,* internal layering of micelles) in thinning liquid films is much more universal than previously thought. Stratification can also be observed in concentrated submicron particle suspensions such as those of polystyrene latexes and silica hydrosols with narrow size distribution and prevailing repulsive forces. The formation of long-range ordered structures inside thin films has many implications of both fundamental and practical significance—for example, the dynamic process of stratification in submicron thin liquid films can serve as an important tool for probing the long-range structural or interaction forces in concentrated particle suspensions and colloidal dispersions. The rheology of dispersions containing stratifying films is quite different.

In 1988, when NSF recognized Wasan's discovery of "ordered microstructures in thin liquid films" of concentrated colloidal dispersions with another Special Creativity Award, he became the first engineering scientist to receive the award twice.

Enhanced Oil Recovery • After the oil embargo of 1973, Darsh was one of the first academics to embark on a basic research program aimed at improving oil recovery. He sought understanding of the fundamental mechanisms by which the oil is displaced in porous media for successful applications of

surfactants/alkali, and foam processes. This program, initiated and funded under the auspices of NSF-RANN (Research Applied to National Needs), has also received financial support for the Department of Energy and industrial sources.

Wasan's research was the first to identify the significant role of the coalescence phenomenon in the oil bank formation and propagation rate processes in porous media and the stability of emulsions in optimizing oil recovery in both conventional and enhanced oil recovery processes. This basic research program was also the first to elucidate the effect of the presence of oil on foam performance. Wasan discovered the importance of "pseudoemulsion" film (*i.e.,* water film between the oil and gas), which had not previously been recognized, in controlling the foam stability. His pioneering use of differential interference microscopy to investigate film stability, contact angles, and wetting and spreading phenomena, has now been adopted by industry.

In 1978, Wasan's research on "Improved Oil Recovery" was one of the three research programs featured in the Annual Report of the NSF to President Jimmy Carter. This research was selected from 834 NSF grants in force at the time in the Engineering Division of NSF.

In 1989, the Chicago Section of the American Institute of Chemical Engineers presented Darsh with the Ernest W. Thiele Award for outstanding contributions through the practice of chemical engineering. He was cited for his "innovative research in particulate separations, petroleum recovery, and interfacial phenomena as well as his contributions as an inspiring teacher and dynamic leader of IIT."

WASAN AS AN ADMINISTRATOR

Wasan's contributions to engineering education not only include award-winning teaching and research accomplishments, but also academic leadership as IIT's chemical engineering department head (1971-77, 1978-87), College of Engineering dean (acting, 1977-78 and 1987-88), vice president for Research and Technology at IIT and IIT Research Institute (1988-91). In 1991 President Lewis Collens tapped Darsh for the post of provost, noting that "Darsh will bring great energy, enthusiasm, and insight to the process of creating a new IIT for the 21st Century."

A former colleague, Larry Tavlarides, credits Darsh with a "strong and positive influence in the growth and stature of the chemical engineering department at IIT during the decade of the seventies and on a cadre of faculty who grew professionally during that period." He notes that "the group included those of us who moved on: Jim Vrentas, Herb Weinstein, Tom Fitzgerald, and me," and adds that, "Those who remained are among the pillars of the current department: Dimitri Gidaspow and Rob Selman. It took an enormous amount of skill, sincerity, and good will so that we could all grow in stature in a harmonious way."

As a long-term department chairman, Wasan was responsible for keeping both the graduate and undergraduate curricula relevant for the changing needs of society. He did this by establishing an Industrial Advisory Council for the department and appointing such distinguished chemical engineers and IIT alumni as Jim Oldshue and John Sachs, who are both former presidents of AIChE. He also established premier laboratories in the department for undergraduate teaching and graduate research.

As acting dean of IIT's Armour College of Engineering, he recruited an engineering faculty recognized for its excellence and developed cross-disciplinary specialized minors (which generally consist of five courses) to enhance students' professional breadth and potential for advancement.

As vice president for research and technology, Wasan was the motivating force behind the creation of the National Center for Food Safety and Technology, housed at IIT's Moffett Campus. This unique center brings together academia, industry, and government to do research in new food processing and packaging technologies, with the goal of increasing consumer food safety. Established in 1989 with a gift from CPC International, Inc., of a five-building, seven-acre facility including an industrial-scale pilot plant, the center was initially funded with a $3.7 million cooperative agreement between IIT and the U.S. Food and Drug Administration (FDA). That agreement, recently renewed at $2 million per year, supplements funding from fifty leading food-industry related member-companies. Today, research at the Center is being conducted by forty scientists from the FDA, faculty from both IIT and the Department of Food Science at the University of Illinois at Urbana-Champaign, scientists from IIT Research Institute, and from the member companies.

As provost, Wasan quickly took a bold step, crossing traditional boundaries between engineering and science at IIT— he moved the departments of biology, chemistry, computer science, mathematics, and physics out of the College of Liberal Arts and Science into a new, combined College of Engineering and Science. His goal in this realignment was to bring an interdisciplinary focus to engineering and science education at IIT. To that end, he encouraged the environmental

engineering department to add an environmental engineering baccalaureate program that builds on the strengths of its graduate program, and initiated several five-year, double-degree (BS and MS) interdisciplinary programs, including medical engineering, computer systems engineering, manufacturing engineering, food safety and technology, and environmental engineering.

He has also embarked on a university-wide campaign to revamp undergraduate curricula to prepare students for significant careers in the 21st Century. Quality, creativity, ethics, and leadership will be taught across the curriculum. He is working closely with advisers from Motorola University to introduce these four critical elements and strengthen the development of students' communications skills throughout the curricula. "We are in a sense redefining and sharpening the tradition of a liberal arts education in the context of an institution focused on technology and the professions," says IIT President Collens.

Wasan is also developing a new undergraduate internship program with industry. The goal of the program is more than just hands-on experience. Educational objectives are to be set for each internship period, and companies are being asked to identify appropriate employees to serve as mentors to the interns. Ultimately, the mentor will determine the educational objectives in cooperation with the intern's faculty adviser, and work with the faculty adviser in evaluating the student's performance.

SERVICE TO THE PROFESSION

Wasan's zeal for chemical engineering education and research extends to scientific communication in general and to the institutions that facilitate it. He has chaired the ASEE Publications Board of *Chemical Engineering Education,* the technical program of the AIChE's 69th Annual Meeting, and the Interfacial Phenomena and Transport Processes research committees of the AIChE. In addition, he served on the AIChE Education and Accreditation Committee and Ad Hoc Visiting Committee of ABET and was president of the Fine Particle Society. In 1986 he and Bill Krantz organized an NSF Workshop on Interfacial Phenomena in New and Emerging Technologies.

Wasan has chaired some forty research symposia at various national and international meetings and, over the years, has delivered more than one hundred lectures and seminars in academia and industry. He has served as: a member of the Engineering Advisory Committee for the Chemical and Process Engineering Division at NSF; member of the advisory committees for the Department of Energy's Oak Ridge National Laboratory Chemical Technology Division and National Institute for Petroleum and Energy Research in Bartlesville, Oklahoma; member of the review committee for the Argonne National Laboratory Energy System Division; member of the Executive Committee of the Governor's Science Advisory Committee for the State of Illinois; consultant to the United Nations Development Program in India. In addition, he has served as a consultant to several industries, including Exxon Research and Engineering Co., Stauffer Chemical Co., American Cyanamid, ICI of America, and Nelson Industries.

In recognition of all his accomplishments, ASEE gave him the 1991 Chemical Engineering Division 3M Lectureship Award. The official citation reads, in part:

> *The 3M Lectureship Award is presented to Darsh T. Wasan for his outstanding contributions to the field of chemical engineering. As a teacher, he has been an inspiring and enthusiastic instructor, helpful to students inside and outside the classroom. As a researcher, he has been creative, innovative and has been a pioneer in advancing the frontiers of knowledge on interfacial phenomena and utilizing this knowledge to solve energy and environmental problems. As an administrator, he has contributed to the drive for excellence of his department, the College of Engineering, and IIT as a whole. As a professional engineer, he has contributed to the solutions of industrial problems as a consultant to industry as well as promoted the growth of knowledge by organizing current state-of-the-art symposia at professional meetings and by identifying the future directions of research.*

In summarizing Wasan's contributions to education, research, academic administration, the profession, and collaborative efforts, many of his friends and colleagues are struck with the exceptional balance that he has maintained throughout his academic career. Cynthia Hirtzel, in presenting Wasan with the Donald Gage Stevens Distinguished Lectureship Award of Syracuse University in 1991, expressed what many of Darsh's friends feel when she said, "When I think of Wasan, many adjectives—mostly superlatives—come to mind. One quality which will always be foremost in my mental picture of him is his phenomenal energy. His energy for his work, for education, for research, for his students and colleagues, is prodigious and almost intimidating to those of us who would strive to emulate his examples. It is truly a privilege and a joy to know him."

ACKNOWLEDGMENT

A number of Darsh's colleagues and former students contributed significantly to the preparation of this article, and their kind and generous contributions are very much appreciated. ❐