ChE educator

Jim White-

Tennessee's Apostle Of Polymer Engineering

SUBMITTED BY HOMER F. JOHNSON
University of Tennessee
Knoxville, Tennessee 37916

THE DEVELOPMENT of new engineering materials from polymers in recent years has been a tremendously exciting and dynamic area, especially now when we are in the era that the volume of polymers produced every year exceeds that of metals. One can today produce synthetic fibers with the strength of steel and injection mold enormous sized rigid light weight parts. The opportunities for the young polymer engineer are fascinating." Jim White was talking with characteristic enthusiasm of his views of polymer engineering. "And, frankly, the most invigorating place I know of to be right now is in our own laboratories, classrooms and seminars."

Jim White, Professor-in-Charge of Polymer Engineering at the University of Tennessee, has spent much of the last decade building a research and academic program in polymer engineering which has won recognition for the university as one of the world's major institutions in the polymer discipline. Polymer engineering is a materials oriented discipline which emphasizes the basic engineering sciences needed to specify the fabrication, structure and performance of polymers. It involves working knowledge of areas as diverse as non-Newtonian fluid mechanics, x-ray diffraction, organic and physical chemistry and solid mechanics.

The University of Tennessee today offers Master of Science and Doctor of Philosophy Programs in polymer engineering in a department containing independent degree programs in chemical, metallurgical, and polymer engineering (and having that name). Polymer engineering includes six faculty members as of this writing, five of them permanent, five research associates and twenty-three graduate students. Generally four graduate level courses in polymer engineering are taught each quarter throughout the academic year.

There is close contact with the three polymer chemist members of the chemistry department and the university textile community. In practice this doubles the size of the effective polymer faculty, making the University of Tennessee one of the largest polymer centers in America.

Jim has long been an enthusiastic history buff especially of the industrial revolution. He has traced the recorded steps of James Watt through 18th century Glasgow where Watt conceived the separate condenser for his steam engine.

Largely through Jim White's efforts, the program has developed strong industrial support from most of America's leading polymer companies including Allied Chemical, American Enka, Celanese, Diamond Shamrock, Dow, DuPont, Gulf, Monsanto, Owens Corning, Phillips Petroleum, Tennessee Eastman, Union Carbide and Whirlpool. Support has also come from the National Science Foundation and the U.S. Department of Defense.

Jim White has marched from professional technical meetings to industrial research laboratories to university lecture halls as well as government agencies on three continents, spreading the message and accomplishments of the polymer program of the University of Tennessee.

Traditionally, polymer based educational programs in the United States have been weak and without government encouragement. Chemistry departments have usually discouraged faculty members from polymer interests and engineering departments have regarded it as a narrow specialty. It should not be surprising that the major polymer science academic program is in Japan at Kyoto University and in polymer engineering in West Germany at the Institut fur Kunststoffverarbeitung (IKV) of the Technische Hochschule of Aachen. Japan and Germany have benefited enormously from these institutions which act as intellectual resources and training centers. American programs in polymer science and engineering have developed in more recent years and often in adverse circumstances. This has, however, made them tough and aggressive. They have generally developed as graduate programs. The University of Akron and Case-Western Reserve University were the first to develop, followed by the University of Massachusetts in the late 1960s. The University of Tennessee joined the ranks in the 1970s. It is the only one of these polymer graduate programs with a strong engineering emphasis.

BEGINNINGS IN BROOKLYN

JIM WHITE WAS BORN in Brooklyn in 1938, the son and grandson of Scottish American entrepreneurs who jointly ran a jobbing machine shop. The Brooklyn he remembers was a combination of ethnic neighborhoods, and his acquaintances and friends were all the children of immigrants from Scandinavia and eastern and southern Europe. He grew up in a neighborhood which he now considers "more Norwegian than Oslo." He attended the public schools of Brooklyn and the prestigious Brooklyn Technical High School to which he traveled back and forth every day in New York's subway system during "rush hours." It was in this period that he first became aware of polymers and their applications, largely through the efforts of representatives of companies such as DuPont, who lectured and gave demonstrations conveying the development and excitement in their laboratories.

Following his graduation he returned to the subways and commuted to the Polytechnic Institute of Brooklyn, obtaining a Bachelor of Chemical Engineering degree (summa cum laude) in 1959. As a student, he was the editor-in-chief of the college newspaper. His interests in polymers were sharpened by the activities of Brooklyn Poly's Polymer Research Institute led by Professor H. Mark. He also had become fascinated with the subject of non-Newtonian fluid behavior, an area he determined to pursue in graduate school. This led him as a senior into correspondence with Profesor A. B. Metzner of the University of Delaware, one of the leading researchers of this area, and an eventual decision to attend graduate school there.

Jim White with Kyoto University polymer professors Masao Horio, Hiromichi Kawai, Michio Kurata and Shigeharu Onogi.

THE DELAWARE YEARS

FOLLOWING HIS graduation, Jim worked for three months with DuPont at its Pioneering Research Laboratory in its Experimental Station

near Wilmington. This experience made a strong impression and developed a strong permanent interest in synthetic fibers. He was able to observe some of DuPont's top chemists such as Paul Morgan and Stephanie Kwolek, who were in coming years to develop the Nomex® and Kevlar® fibers.

In September 1959, he entered the University of Delaware, where in his graduate research he worked with A. B. Metzner, now department chairman there. His M.S. and Ph.D. research was on the rheology and mechanics of viscoelastic polymer fluids. This was the period in which this subject passed from the mathematicians who had initiated the area to engineers. White and Metzner were in the forefront of the effort during the early 1960s. In the second half of the decade, researchers from other universities were to become involved. The key ideas developed by Jim White in this period were the utility of a rheological model of viscoelastic fluid behavior now called the White-Metzner model and the introduction of a dimensionless group known as the Weissenberg number (for the late Karl Weissenberg) which represented the intensity of the viscoelastic characteristics during flow.

Jim White's years at Delaware were, however, distracted from purely academic studies. Delaware was culturally a southern state and its racial discrimination was incompatible with his conceptions of inalienable rights of equal opportunity. Segregated restaurants were the most obvious example of this and he was soon leading a student group pressing for desegregation. This was the age of the Civil Rights movement and Jim (together with Duane Nichols, another graduate student who is now a faculty member at the University of West Virginia) was in the midst of the efforts, first in Newark, the home of the university, and later throughout Delaware. Jim received in this period a letter of support and encouragement from the Kennedy White House. These activities led, however, ultimately to his arrest and jailing after a sit-in in Dover, the state capital. The barriers to segregation gradually fell throughout the state and the Civil Rights Law of 1964 successfully culminated the nationwide struggle for equal rights.

At the birthplace of James Watt in Greenock, Scotland on the Firth of Clyde.

U.S. RUBBER COMPANY

IN SEPTEMBER 1963, Jim White left the University of Delaware and joined the U.S. Rubber Company (now Uniroyal) at their Research Center in Wayne, New Jersey. He was hired to work on the rheological behavior and processing of elastomers. He was hired to continue U.S. Rubber's traditions of strong efforts in rheology begun by Melvin Mooney. This was to take up most of his energies for the next four years. Here he came into contact with the entire range of the polymer industry from synthetic chemists to design specialists to salesmen to factory troubleshooters. He saw and became involved in the product development programs unique to the polymer industry. Long hours were spent in product and instrument development and following manufacturing operations in the carbon black mists of tire factory mill rooms from Chicopee, Massachusetts to Opelika, Alabama to Los Angeles. In 1966, Jim was transferred to the U.S. Rubber Tire Company in Detroit where he first worked on quality control and later became a group leader in the area of new materials for tires.

It was in these years that Jim White came to realize the weaknesses inherent in the traditional engineering discipline. He found that while engineering approaches were critically needed,

he and others with engineering backgrounds were trained to ask the wrong questions. Mechanical engineers were unaware and frightened of chemistry and chemical structure. Chemical engineers had no comprehension of materials and the ability to develop structure in the solid state.

Jim White's closest colleague at U.S. Rubber was Noboru Tokita, a polymer physicist from Japan. Together they published several papers on the rheological characterization and processing of rubber. Tokita introduced him to Yoko Masaki, a Japanese Flower Arranger also from Sapporo who was stationed in New York City by the Sogetsu Ikebana school as their American representative. She was to become Mrs. White in November 1966. Yoko is the daughter of a retired medical professor at Hokkaido University. This developed in him an interest in Japanese cuisine and history. It was also from Tokita that Jim White learned of the Japanese polymer community and met leading Japanese academic and industrial polymer scientists.

GROWTH OF THE TENNESSEE POLYMER PROGRAM

IN THE SUMMER of 1967, Jim White left the U.S. Rubber Company and joined the faculty of the Department of Chemical and Metallurgical Engineering at the University of Tennessee. Don Bogue, a faculty member who had known him as a fellow graduate student working on rheological problems with Art Metzner at the University of Delaware, was instrumental in bringing Jim White to Tennessee. At Tennessee, the rheological research now increasingly evolved to the study of polymer melts. Jim White developed more broadly based polymer research and laboratories. Seeing the necessity of studying the processing product performance problem, White induced Joe Spruiell, a metallurgical engineering faculty member, to help initiate studies of structure development in fibers.

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Jim put in an enormous effort developing course sequences in polymers, and shortly a polymer science and engineering specialization program with the Department of Chemistry was developed. The educational efforts eventually led to the conceptualization and establishment of M.S. and Ph.D. programs in Polymer Engineering. In the early 1970s, Jim White organized a consortium of polymer companies to support polymer activities at the university and began leading visits to major polymer suppliers and fabricators to obtain financial support. Support and students began to grow, and new faculty were hired. Jack Fellers came from the Ford Motor Company to join the faculty to lead research in polymerization and mechanical properties of glassy plastics. Ed Clark came from the DuPont Experimental Station to do research on the influence of processing on the crystalline morphology of polymer and crystallography.

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Contacts developed rapidly with the Japanese polymer community following a visit of Bogue and White to Japan in 1968 to attend an International Rheological Congress. Bogue was later to spend more than two years at Kyoto University and White to make two subsequent three-week visits. One of the best friends and supporters of Bogue and White has been Kyoto University's Professor Shigeharu Onogi, one of Japan's leading polymer scientists. They later joined in supporting Onogi and were among the founding members of the Japanese Society of Rheology. Several distinguished Japanese scientists from universities and industrial laboratories have come to Tennessee as visiting professors, notably including the late Misazo Yamamoto of Tokyo Metropolitan University, Tadao Kotaka, now of Osaka University, and currently Yasushi Oyanagi of Kogakuin University. There have also been numerous Research Associates from Japan. Onogi's Assistant, Takayoshi Matsumoto, is currently among the research associates. Relationships developed with Japanese as well as American companies and

led to research grants at the University of Tennessee. Scientists from Fuji Photo Film, Japan Synthetic Rubber Company, Ube Industries and Unitika have come to Tennessee to do research under Jim White's direction. The Tennessee Polymer Engineering faculty is probably the only American engineering faculty in which the majority consider raw fish a delicacy and delight in "sushi" and "sashimi."

Jim White has also made several trips to Europe where ties have been developed with scientists

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in various countries. In recent years, R. S. Lenk from England and A. Plochocki from Poland have occupied senior research positions at Tennessee where they have worked with Jim White. Jim spent a week in Poland as the guest of the Polish Chemical Ministry last year. Ties have been developed especially with West Germany's Institut fur Kunststoffverarbeitung (IKV) and Professor George Menges at the Technische Hochscule of Aachen. Research Associate Wolfgang Dietz from Aachen is currently in the Tennessee laboratories. Jim White will spend the latter half of 1977 at the IKV in Aachen as a Humboldt Foundation Senior Scientist.

The University of Tennessee has become in the 1970's one of the major locations for important polymer meetings with organizations such as the Society of Plastics Engineers, the American Chemical Society, the Society of Rheology and the National Science Foundation, which have held major polymer applications conferences. The Fiber Society meets there in 1978 and the Society of Plastics Engineers returns for a Divisional Technical Conference in 1979.

RESEARCH PROGRAM

AT TENNESSEE, Jim White's areas of research have covered a wide range of studies. Much of his efforts have concentrated on polymer processing, especially related to rheological and structure development aspects of fiber and plastics processing. The studies on fibers have been carried out in recent years with Joe Spruiell and currently involve Research Associates David Juist and Toshio Kitao and a team of five graduate students. These studies on fibers have included the rheology of flow in spinnerettes to spinline dynamics, orientation development during spinning, and structural changes during drawing and twisting processes. With Jack Fellers, Research Associate Hiroshi Aoki and four students, studies are being made on the related topic of polymer liquid crystals and their fabrication. Together with Ed Clark's researches on high strength fibers and Don Bogue's work on rheology, these programs have led all the major American synthetic fibers companies to keep in contact and financially support the research. Gulf Chemicals and a Japanese company Unitika have kept a research engineer at the Tennessee laboratories during the past year.

Research programs in plastics processing emphasizing extrusion and injection molding processes and studies of the influence of processing on performance are being carried out by Jim White with Ed Clark, Jack Fellers, Yasushi Oyanagi and Research Associate Wolfgang Dietz and a team of seven graduate students. Basic studies of injection molding, structural foams, and the development of new rubber modified plastics. This program has also gained industrial support.

Jim White has also carried out extensive researches on the rheology and progressing of elastomers and rubber compounds, especially studying the influence of carbon black. His research interests have also included polymer characterization and polymerization.

Usually Jim White with colleagues co-author about fifteen papers describing their researches each year which appear in various American and foreign polymer applications and rheological journals.

Throughout the years, Jim White has received the first M. E. Brooks Outstanding Professor Award of the University of Tennessee College of Engineering and has been appointed an Alumni Distinguished Service Professor. He has been an invited speaker at various national and international meetings and at universities, including Alan P. Colburn Lecturer at the University of Delaware. He recently was elected Fellow of the Textile Institute of the United Kingdom.

OTHER ACTIVITIES

JIM WHITE HAS SPENT large amounts of time on the road attending meetings and visiting companies. Through his wife Yoko's influence, he has become a connoisseur of Japanese food and because of his travel, of Japanese restaurants in America. He rates New York and Honolulu as tops, San Francisco as very good. Chicago has some good places.

Active in polymer professional societies, he is a member of the Board of Directors of the Engineering Properties and Structure Division of the Society of Plastics Engineers and is active in various other societies including the Society of Rheology and the Polymer Engineering section within the AIChE. He is a member of numerous foreign professional and technical societies. Jim is a member of the Editorial Board of the Journal of Applied Polymer Science, Transactions of the Society of Rheology, and the Journal of Non-Newtonian Fluid Mechanics.

Jim White has long been an enthusiastic history buff, especially of the industrial revolution. He has sought out the locations and visited sites of the plants and laboratories which created the foundations of our present society including the first rubber manufacturing plant which is still operating in Manchester, England and Robert Owen's New Lanark Cotton Spinning Mills. He has traced the recorded steps of James Watt through 18th century Glasgow where Watt conceived the separate condenser for his steam engine. Many of his investigations have been presented at meetings or published in his papers.

His interests in history, though, go far beyond this to studies of the history of the dark ages and medieval period in Scotland and the German Hansa cities and Meiji Japan. However, his greatest interests have often been influenced by his own family background in trying to develop perspectives of Scottish history through the Industrial Revolution to modern times. This has led him through rainy Scotland and its moors, ancient battlefields and graves of Celtic scints usually accompanied by his wife Yoko who, essentially more intelligent than her husband, brings an umbrella.

This, then, is our enigmatic "Apostle of Polymer Engineering." A refugee from Brooklyn's subways to the bright sun of Tennessee, who bursts with enthusiasm to develop a new engineering discipline and establishing his program at Tennessee as a leading polymer education and research center. □

ChE book reviews

RATE PHENOMENA IN PROCESS METALLURGY

by Julian Szekely and Nicholas J. Themelis
Wiley-Interscience, New York, 1971

Reviewed by Ben. F. Oliver, U. of Tennessee

Rate Phenomena in Process Metallurgy is a textbook for the senior level or first-year graduate level. Actually, depending upon the subject being covered, the text may be used as a reference text both at lower and more advanced levels of Process Metallurgy and Chemical Engineering.

The text is divided into three main parts: Part I—the Review of Transport Phenomena, Part II—Techniques of Process Analysis, and Part III—Metallurgical Reaction Systems. This division is somewhat deceptive since the review in Part I is most extensive covering fluid mechanics, heat, diffusion and mass transfer. This review takes up some thirteen quantitative chapters. These chapters include important examples and mathematical techniques. This provides a chemical engineering base quite appropriate to the objectives of the book. Numerous process examples of a metallurgical nature are described and related to quantitative basic transport examples. Tables and graphs put the wide range of parameters, such as thermal conductivity, viscosity, diffusivity, etc., into a good perspective. While this reviewer finds units used in the text both convenient and comfortable, they certainly are not SI; but then again, neither is the wealth of information from which the book draws examples. There are numerous specific numerical examples used throughout the book. These put many things in proper perspective, including the problem of units.

The general format of the equations, notations and text appear very comfortable and particularly clear. The discussion of similarity and dimensionless groups is complete but not overdone. The blast furnace and BOF examples are both interesting and informative.

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