BOOK REVIEW

Particulate Systems Technology and Fundamentals

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The papers presented here are collected from the Fine Particle Society meeting held at the University of Maryland, USA, in September 1980. The six major technical areas highlighted at the meeting—gas/particle separation; fluidized bed combustion: liquid/particle separation; dust explosions; instrumentation; and standard particulate reference materials—are covered sequentially in the book by careful selection of the more important papers presented at the conference.

The papers on gas/particle separation start with a review of the Environmental Protection Agency's research programme. This research programme covers the control of particulate emission from the combustion of low sulphur coal; fugitive emission control for particulate sources; application of particulate control techniques to automotive diesel emission and the determination of emission factors for inhalable particulate ambient standard. In addition, the programme is used to evaluate novel concepts and devices. The remaining five papers in this section present both theoretical and experimental work on a variety of filters; glass capillary for non-spherical aerosol particles; electrically enhanced fibrous filters with particular emphasis on the effect of neighbouring fibres on the electric field; electrostatic operation of fibrous filters by a non-ionizing electric field; effects of deposited matter on aerial fibrous filter operation, and basic experimental measurements of the rate of particle accumulation on fine isolated glass fibres (8.5 μm) in the presence of electrostatic fields. Liquid/particle separation is covered by one paper on electrostatics in non-aqueous liquids with particular emphasis on coal liquefaction. It is shown that π–π electron bonding and hydrogen bonding are dominant in the physical state of coal-derived liquids and coal liquifaction slurries and the magnitude of π–π bonding increases with the number of aromatic rings in the molecular structure.

Three papers are presented on fluidized bed combustion, the first of which is a review of the research activities on atmospheric combustion at the Morgantown Energy Technology Centre of the US Department of Energy. The second paper addresses the particulate control problems of pressurized fluidized bed combustors and presents work on a particle profile model which gives consistent projections of solid sizes and loadings from the fluidized bed combustor and throughout the power generation system. The model is applied to a 10 atm combustor for a range of feedstocks so as to examine system sensitivity to some design and operating parameters. In the third paper, data on critical velocity in both horizontal and vertical flow for a range of fluid-solid systems are correlated and factors responsible for data scatter are identified. The correlations are simple and applicable to uniform and non-uniform particle size distribution, though there is some scatter of the data.

The explosive behaviour of dusts dispersed in air is of continuing interest to many industries. One paper describes a temporal variation of light technique to estimate particle size distribution and mass concentration in a dust cloud both of which are necessary for predicting the possible hazard from a primary dust explosion. In another paper a theoretical study of the maximum rate of pressure rise of dust explosion was carried out for application to relief valve design. The study, based on a simple heat transfer/thermodynamic model for uniformly dispersed dust, validated the empirical 'cubical law' between vessel volume and maximum rate of pressure rise. Attempts to control dust hazards by the adsorption of moisture in grain dusts are described in the second paper of the dust explosion section. Increase in moisture content decreases the dispersibility and explosibility of grain dust whilst increasing the lower critical concentration and ignition energy required for an explosion. It was shown that the moisture content of suspended dust could be increased 22% by weight without significantly affecting the moisture content of the grain which must be kept below 14% for safe storage. The two remaining papers in this section discuss ignition of dust dispersed in air. In one the effects of spark discharge duration on ignition energy were examined and found to be of no significance where the absolute minimum is sought for a given dust. In the other paper the development of a high-energy chemical igniter was described. The igniter uses 1.2 g of FFF black powder as the pyrotechnic material giving an energy of 5 kJ. The authors feel that characterization of igniter output should include rate of energy release, peak pressure and ignition delay, as well as output energy.

All engineering and scientific research rests on acceptable measurement techniques which rely on accurate instrumentation and data recording and processing. In the section on instrumentation there are four papers, the first of which describes the performance of an inexpensive particle image analysing system based solely upon the behaviour of shape parameters derived from Fourier analysis of a particle. The remaining three papers cover techniques for particle size analysis from submicron up to 100 μm. There are many methods for particle size determination of which the most rapidly growing method is low-angle forward light scattering, ie Fraunhofer diffraction. A dual optical system incorporating a laser and a tungsten lamp has been developed which utilises forward and 90° scattering to measure particle diameters down to 0.1 μm. A sedigraph particle size analyser measures the sedimentation rates of particles dispersed in a liquid and it proved extremely useful for rapid analysis of 1 μm particles. Good results were obtained for particle sizes ranging between 0.6 and 6 μm. Typical sedigraph times to reach median diameters for ammonium perchlorate in toluene at 34°C with a starting diameter of

70 µm are: 10 µm—1 min 22 s, and 1 µm—11 min 38 s. In the final paper of this section the use of a computer-controlled scanning electron microscope to give approximate analysis of Fe, S, Ca, Si and Al in coal particles in the range 10 to 100 µm is described.

In the final section some recent developments in particulate standard references are presented. From 1977 to 1980 a new American Society of Testing and Materials Coordinating Committe (S-21) was formed with the purpose of obtaining cooperation between industry and the National Bureau of Standards in the certification of Standard Reference Materials for particle size metrology. These SRM's are used in the calibration of particle sizing equipment. Three methods for measuring size distribution of microscopic spherical particles—light scattering, electron microscopy and flow counting—form a complementary set of techniques used at the National Bureau of Standards for calibration purposes. Precision of reproducibility of particle counters is improved through the use of high quality calibration standards which need to be selected, manufactured and labelled with great care. Although particle counters are capable of generating data rapidly and reproducibly, the data reported are sometimes questionable due to the lack of clearly defined methods and calibration materials. ASTM Standard F-50 specifies the use of spherical particles of known size and physical properties whereas ISO 4402 requires the use of an ill-defined non-spherical 'Arizona road dust'. Both materials are widely used for instrumentation calibration but yield vastly different calibration data.

The Fine Particle Society meeting was most interesting and the selected papers presented in this book are very useful.

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Published, price $69.95, by Hemisphere/McGraw-Hill. Hemisphere Publishing Corporation, 79 Madison Avenue, New York, NY 10016, USA

Heat Conduction

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The level at which this book is written varies from elementary to esoteric. For example, Fourier's Law is stated first at school-textbook level as a formula for the heat transfer by conduction through a plane slab. Then a page or two later an expression for the thermal conductivity tensor for an anisotropic medium is written down, though not followed up. Steady one-dimensional heat conduction withoug heat source through plane, cylindrical and spherical walls, and through such walls in series, is dealt with at length, as it might be in a rather pedestrian introductory undergraduate course; and is followed by chapters on the various sophisticated (but well-known) mathematical methods for obtaining analytical solutions to multi-dimensional and unsteady-state problems. In the early pages, there is a short account of the principles of thermodynamics, but it is superfluous to those familiar with the subject and too condensed for those who are not. What readers then do the authors have in mind? In their own words, 'the material presented has evolved from a series of lecture notes developed by the authors when teaching a graduate course in heat conduction over a period of years': there is a looseness of wording here that does not inspire confidence in the outcome of this evolutionary process of development. They continue, 'this book is written for both engineering students and engineers practicing (sic) in areas involving the applications of heat diffusion problems': many readers would prefer the proposed form of contract between the authors and themselves to be shorn of this woolliness.

The concept of thermal resistance is introduced and applied in simple terms, but the scope and limitations of the concept are not made clear. The solution of Laplace's equation for steady two-dimensional heat conduction is discussed solely in analytical terms, while the practically useful concepts of curvilinear squares (and their sketching) and of shape factor seem to be ignored (they are certainly not indexed). The chapter on unsteady-state conduction makes no reference to the excellent book of 'Temperature response charts' by P. J. Schneider. But perhaps the most unsatisfactory part of the book is the chapter on numerical solutions. The finite-difference method presented for disecretizing the partial-differential equations is inferior to the finite-domain method (described for example in S. V. Patankar's book 'Numerical Heat Transfer and Fluid Flow'). The use of matrix inversion for solving the resulting linear algebraic equations is presented as though it were an acceptable alternative to Gaussian elimination, which it is not, and the statement that the 'Crank–Nicolson method is stable ... and converges' is misleading, since in some cases it may converge to a false solution, and the fully-implicit method is more generally reliable and economical and is easier to program.

As there are several other books which deal with heat conduction thoroughly from an analytical point of view, and others which present it in the practical context of heat transfer as a whole, and as computer methods have become dominant in meeting the needs of engineers in this field, there seems little reason for the present book. The type-face is bleak without serifs, perhaps reproduced from a type-script, and is unpleasing to the eye.

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Published, price $37.50, by Hemisphere Publishing Corporation, 79 Madison Ave, New York, NY 10016, USA, 391 pp.